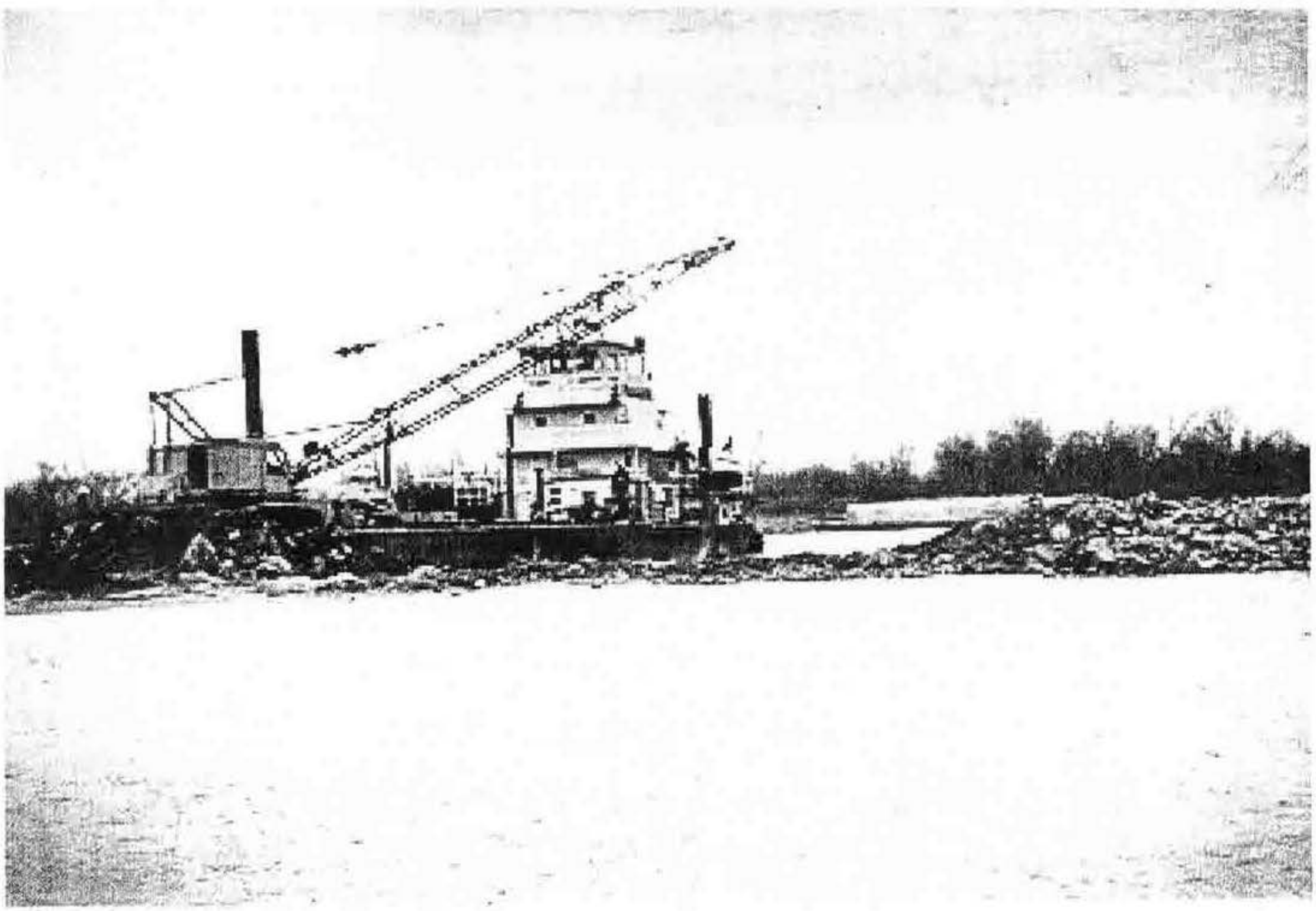
MELVIN PRICE LOCKS AND DAM

UPPER MISSISSIPPI RIVER BASIN
MISSISSIPPI RIVER MISSOURI AND ILLINOIS

PROGRESS REPORT 1998



DESIGN MEMORANDUM number 24
AVOID AND MINIMIZE MEASURES

US Army Corps
of Engineers
St. Louis District®

"Good engineering enhances the environment"

December 1998

AVOID AND MINIMIZE MEASURES

DESIGN MEMORANDUM #24

PROGRESS REPORT --1998

MELVIN PRICE LOCKS AND DAM
MISSISSIPPI RIVER--MISSOURI AND ILLINOIS

Prepared by:

U.S. Army Engineering District--St. Louis

1222 Spruce Street

St. Louis, Missouri 63103-2833

December 1998

Avoid and Minimize
Environmental Impacts Program
St. Louis District--Mississippi Valley Division
Progress Report--1998

In October of 1992, the U.S. Army Corps of Engineers issued Design Memorandum No. 24, "Avoid and Minimize Measures, Melvin Price Locks and Dam, Upper Mississippi River--Missouri and Illinois". The document was developed as a result of the commitment made in the Record of Decision (1988) attached to the Environmental Impact Statement for the Second Lock, Melvin Price Locks and Dam. The St. Louis District set aside Operation and Maintenance (O&M) funds from 1989 to 1995 to implement some measures recommended by the study team (Table I). Implementation of measures in this early part of the program was reported in the 1995 Progress Report. In 1996, O&M funds were received to begin full-scale implementation on recommended measures. The planning, implementation and monitoring team consists of staff from the St. Louis District, U.S. Fish and Wildlife Service (FWS), Rock Island Field Office, Illinois Department of Natural Resources (IDNR), River Industry Action Committee (RIAC), Missouri Department of Natural Resources (MDOC), and the Long Term Resource Monitoring Station (LTRM/MDOC) at Cape Girardeau, Missouri. Each group contributes staff time; to plan and attend meetings, collect field data as part of a monitoring program, develop materials for grant funds and donate time to develop alternatives for construction of measures at the micro-model lab located at the District Service Base. In some instances, biological staff work in the field, with engineers during construction of measures.

A&M 1) Work in the open river for 1998 consisted of modification of the upper closure structure at Marquette Chute (river mile--53 to 47L) across from Cape Girardeau, Mo. The St. Louis District and the A&M team, received a grant from the F&WS under their "Fisheries Habitat Restoration Partnership Program". The Cape LTRM/MDOC field station continued monitoring in Schenimann and Santa Fe Chutes. Marquette chute was micro-modeled during fiscal year 1997. In the 1997 A&M report, it was discussed that due to the river wishing to take a shorter route down Marquette Chute and not pass in front of Cape Girardeau and their port facilities, that only minimum work could be performed to force more water down the chute. The model study revealed that if too much water was forced down the chute the navigation channel would be lost. The river engineers recommended that two 300 foot wide by 10 feet deep notches could be cut into the upper closure structure without consequence to the navigation channel. The District's motor vessel Pathfinder with a derrick barge and dragline with a 3/4 yard bucket began work in February 1998 to remove rock from the closure structure. Due to low water and the size of the rock in relationship to the size of the bucket, only one notch was cut before the allotted A&M funds ran out. During a July rise in the river above flood stage, the staff of the LTRM station at Cape monitored the

TABLE I

DESIGN MEMORANDUM NO. 24

AVOID AND MINIMIZE MEASURES RECOMMENDED FOR IMPLEMENTATION

NUMBER	MEASURE
A-3	Designate locks approach waiting areas--provide on-bank anchor points or mooring buoys.
A-10	Reduce open water dredge material disposal--create recreation beaches.
A-11	Reduce open water dredge material disposal--create wetlands.
A-13	Place dredge material in the thalweg.
A-16	Continue dike configuration studies (i.e.., notched dikes, chevron dikes and bullnose dikes.
A-17	Place off-bank revetment on islands.
A-19	Monitor bendway weirs.
B-8	Study reduction of tow waiting times.

amount of scour. The sand displacement was not satisfactory. F&W staff obtained a grant to send the District construction crew back to the chute to cut a deeper notch. After high water in 1999, success or non-success will be known (See Appendix A).

A&M 2) The 1997 A&M Progress Report noted that a "prototype" mid-channel mooring buoy was to be built by Bollinger Shipyards, Inc., Lockport, La. for the River Industry Action Committee. Orgulf Transport Co. transported the buoy to the District Service Base and RIAC presented the buoy to the St. Louis District. The buoy, with 180 feet of chain and 10 ton anchor, was set below L&D 25 in swift water immediately below the dam near the left bank. Mr. Tommy Seals of Brown Water Towing, and co-chair of RIAC, took the responsibility of preparing a handout questionnaire for the tow captains who had utilized the buoy. In summary, they liked the new buoy much more than the old round buoys. Some problems did develop: 1). the buoy was turned over twice--the first time occurred at night and no one knows who did it or why it turned over. The second time occurred when a tow ran over the buoy almost one barge length. 2). In swift water, when a tow ties off, the buoy has a tendency to dive under in the front. This was not a problem when the gates were closed from an open river position. During the winter of 1999 the Pathfinder will pick up the buoy and tie one of the old round buoys on the anchor. A retrofit will occur during the winter and the buoy will be lengthened, the keel lengthened and a shield fitted to the front to reduce the tendency to dive. The prototype will be placed below L&D 25 during the spring of 1999. When the buoy performs to everyone's satisfaction, and the design is correct, each Corps District in the Upper Mississippi River Basin will place mooring buoys, as funds become available.

A&M 3). In A&M 1996 several rock structures were recommended by the A&M team for construction. Problems with the rock contractor prevented three of the planned structures, in the pools, from being built. The team wished to complete the work in the pools during the 1998 fiscal year. During the 1997 fiscal year, rockwork was performed in Santa Fe Chute, in the Middle River. We ran out of money before all of the stub dikes were completed. The team also wished to complete the work in Santa Fe chute during the 1999 fiscal year. The 1996 plan involved the construction of bull nose dikes on the upstream end of islands, a field of 5 small chevron dikes and an experimental structure of rock called round points. In 1998, the job was completed in Pool 25 including the bullnose dike on the upper end of Slim Island (mile 267 left bank). In the planned chevron field, at mile 250.2L only one chevron was completed due to shallow water. The A&M team had already approved the construction of chevrons at mile 266R which had deeper water. Members of the team were contacted by e-mail and phone and they agreed that construction should proceed. Only 1 1/2 chevrons was completed before we ran out of funds. The job will be completed in FY 1999. At mile 265.7L, a round point structure was constructed. This experimental structure consists of an underwater dike with 6 "points" above pool level on 80 to 100 ft. centers. The structure is expected to react as a deeply notched dike. In 1996, preconstruction physical and biological sampling was conducted. During the 1998 fishery sampling season, Mr. Butch Atwood, IDNR, conducted electrofishing around the structure on two occasions and found a blue sucker around the structure during each sampling. Further physical sampling will occur in fiscal year 1999 to determine the type and quality of habitat that was created by the structure (see Appendix B).

A&M 4) The Bolters Bar reach of Pool 26, rm 227 to 222 is one of the most troublesome areas for dredging in the St. Louis District. The reach is only two miles above the confluence of the Illinois and Mississippi Rivers. The Illinois has built up a high area of alluvial materials as the current of the Illinois slows at the more wide confluence. As a result, in the divided channel, Bolters Bar reach, the velocity of water in the thalweg slows and sandy bed load drops out. The A&M team decided to build a micro-model of the reach to see if a plan could be developed to reduce dredging in the reach by utilizing environmental river engineering techniques. Several problems had to be overcome to develop a plan. Pool 26 is the most important recreational pool on the Upper Mississippi River. The side channel behind Bolters, Iowa and Enterprise islands contain several large marinas. Thus, standard closure structures could not be utilized. The sandy "bumps and humps" built by dredging (some of the sand islands are considered the best sand beaches in the St. Louis area) can be valuable shallow water habitat. Because the blunt nosed chevrons dikes in Pool 24 have provided such good fisheries habitat the team wanted dredge material filled chevrons to be utilized to force more flow into the main channel. The draft plan developed from the model study will reduce dredging from 30 to 60 percent and provide valuable habitat at the same time (see Appendix C)

A&M 5) The tow waiting time study was completed this year and will be updated on an annual basis. The study identifies and evaluates non-structural alternatives, i.e., small scale improvement measures for both their systemic impact on the river environment and their reduction of tow waiting times at mooring sites above and below lock facilities on the Upper Mississippi River System (UMR). This study complements and incorporates the work of the Upper Mississippi River and Illinois Waterway System Navigation Study. Environmental impacts from random mooring was evaluated by biologists from MDOC in Design Memorandum #24, A&M Measures. They estimated a habitat suitability index of 3 (1 to 10) for random mooring impacts. With designated mooring areas the habitat suitability index, within a given reach, increases to a 7 because of less areal disturbance. Effective and economically efficient non-structural improvement measures can lessen impacts. In place, in the St. Louis District, are 4 reveted on-bank anchor locations and two mid-channel mooring buoys. The qualitative evaluation process, quantitative results and conclusions for non-structural measures are detailed in the study in Appendix D.

A&M 6) Fiscal Year 1998 was the third year of the St. Louis District/A&M Program and Fish and Wildlife Service pallid sturgeon study. Staff from Southern Illinois University-Carbondale, Illinois is conducting the field research. The primary objective during year three was to continue studying habitat use and movement of wild pallid sturgeon in the Middle Mississippi River and whether variables such as temperature, habitat availability and discharge affect such use. Further description of the study is in Appendix E.

A&M 7) Environmental Pool Management has been practiced by the District Water Control staff and the hardworking staff at locks and dams 24, 25 and 26 since 1993. The staff at the locks and dams have to conduct numerous gate changes for the management plan to work. This environmental operation practice has been successful for 5 years. The staff of MDOC has conducted biological monitoring. The Fish and Wildlife Service forwarded funds, in 1997, to SIU-C to begin a fishery study in the vegetation areas which resulted from regulation of pool levels to enhance the environment. The A&M team voted to continue and fund the study during 1998. The objectives of the work are as follows:

A. Characterize the plant community associated with water level management and quanitify production of seed biomass.

B. Quantify the aquatic invertebrate community response to increased annual wetland vegetation production.

C. Determine the responses of fish to water level management and vegetation production.

D. Characterize waterbird/waterfowl use of food resources produced by water level management.

E. Monitor the effects of vegetation produced from water level management on water quality.

Please see Appendix F for more information.

A&M 8) As in past years, agency staff and natural resource partners continued physical and biological monitoring of A&M structures and Corps operation and maintenance procedures. One of the major objectives this year was to continue to utilize the Biosonic hydroacoustic system which had been placed on a District survey craft, the motor vessel Boyer. Data is presented in Appendix G.

Avoid and Minimize Environmental Impacts Program Plans for 1999.

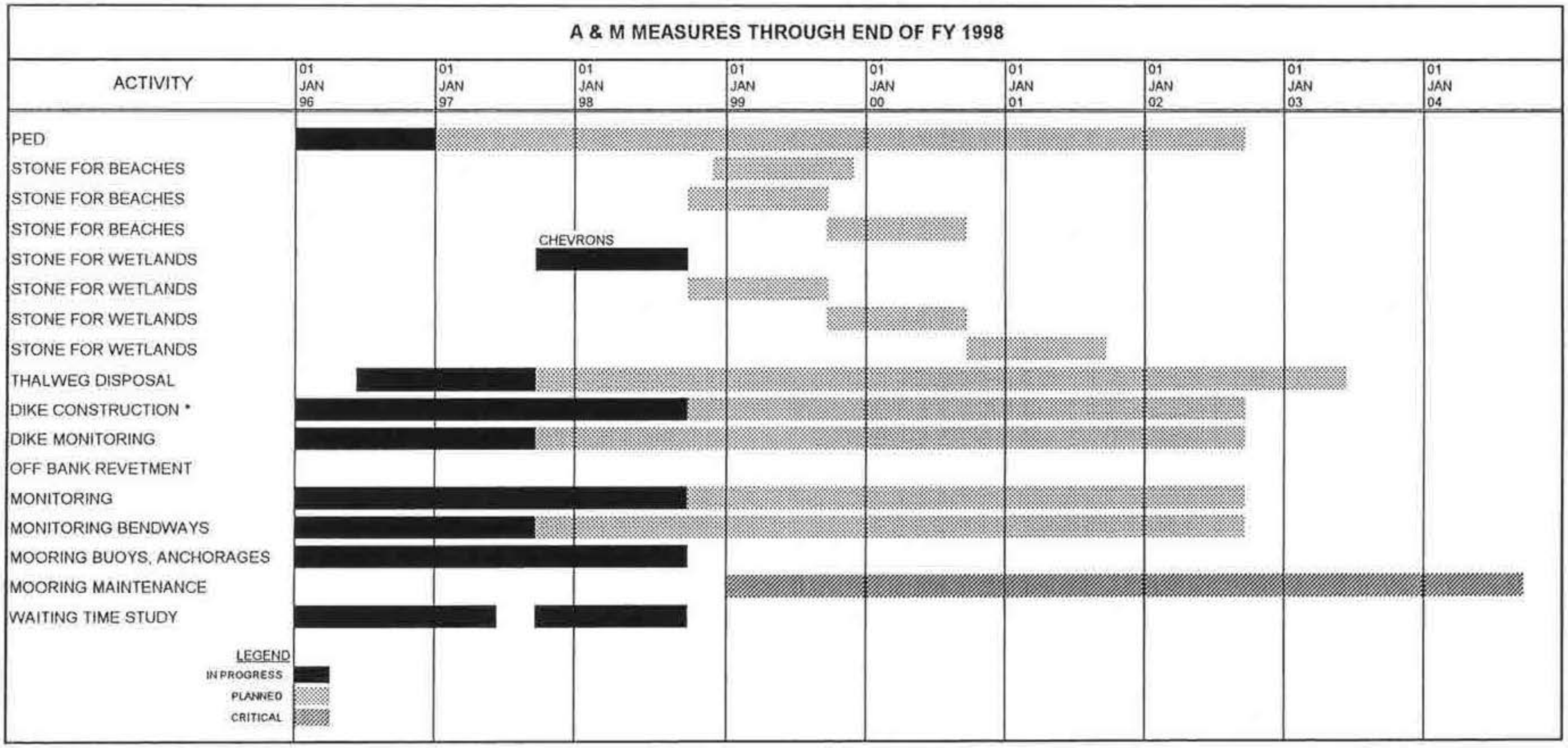
The A&M team voted to continue construction on unfinished projects. First, the three stub dikes in Santa Fe chute and the chevron dike field in Pool 25. Construction contracts have been let and placement of rock will occur during high water in the spring of 1999. The dredging problem at Cottonwood Bend will be addressed by the building of a micro model. Model cost will be split with the dredging budget. The team will then choose the best environmental river engineering alternative for construction.

The hydroacoustic equipment has worked very well and the team is pleased with the results. The manufacturer of the equipment has developed an improved split-beam transducer which improves the signal and also allows the biologist to be able to tell if the fish are moving up- or down-stream. This equipment has been ordered because the team became interested in utilizing the equipment to research the passage of fish at Corps dam sites. The issue of fish passage though the gates of the mainstream dam facilities has always been of high concern to the state and federal natural resource agencies. The A&M study will be initiated during the spring of 1999 to determine if fish are moving upstream through the gates and if operation of the gates can be modified to improve fish passage. The initial effort is designed to collect both velocity and fish passage information through gate 17 (left bank) at Lock and Dam 25. The split beam transducer will collect fish length, the depth of the fish in the water column and data on the direction a fish is swimming.

Budgets

The St. Louis District budget for the foreseeable future will be $1M a year. That does not include grants or other funding provided by the partners. Corps staff hired labor comes out of the $1M but the partners provide their own labor and travel costs. Approximately 50% of the funding is for construction of river training structures that provide environmental benefits. At this time, the A&M program will extend to 2007 unless the yearly budget is increased, which is unlikely. A budget timeline, to 2004, is attached.

CORPS OF ENGINEERS, ST. LOUIS



* DIKE CONSTRUCTION WORK INCLUDES $20,000 GRANT FROM USFW

12/29/1998

AVOID AND MINIMIZE TEAM

NAME	ORGANIZATION
Tamara Atchley	Corps of Engineers--Proj. Mgr.
Ron Yarbrough	Corps of Engineers--Tec. Mgr.
Chuck Surprenant	U.S. Fish and Wildlife Service
Tommy Seals	Brown Water Towing (RIAC)
Dan Erickson	Corps of Engineers
T. Miller	Corps of Engineers
Bob Clevenstine	U.S. Fish and Wildlife Service
Jenny Frazier	Mo. Dept. of Conservation (LTRM)
Bob Hrabek	Mo. Dept. of Conservation (LTRM)
Joyce Collins	U.S. Fish and Wildlife Service
Claude N. Strauser	Corps of Engineers
Gordon Farabee	Mo. Dept. of Conservation
Rob Davinroy	Corps of Engineers
Dave Gordon	Corps of Engineers
Maryette Smith	Corps of Engineers--MVD
Roger Myhre	Corps of Engineers
Ed Henleben	Orgulf Transport (RIAC)
Tracy Butler	Corps of Engineers
Steve Redington	Corps of Engineers
Mike Kruckeberg	Corps of Engineers
Leonard Hopkins	Corps of Engineers
Butch Atwood	Ill. Dept. of Natural Resources
Ken Dalrymple	Mo. Dept. of Conservation
Ken Brummett	Mo. Dept. of Conservation
Brian Johnson	Corps of Engineers
Bob Sheehan	SIU-Carbondale
Dave Kelly	Corps of Engineers

26 August 1998

AVOID AND MINIMIZE PROGRAM

RIVER TRIP MEETING, MV Pathfinder

AGENDA

Progress for 1998

Introduction--Ron Yarbrough & Maryette Smith, MVD

Mooring Buoy--Tommy Seals, Brown Water Towing & RIAC
Ed Henleben, Orgulf Transport, Port Captain.

Construction--Claude Strauser
Round Points--Pool 25
Chevron Dikes--Pool 25, First Site, Second Site
Bull Nose Dike--Pool 25

Boulters Bar Model--Rob Davinroy. 204 Program--RY, Tracy Butler.

Least Tern Recommendation, Riverlands--Dan Erickson

Hydroacoustic Work--Thalweg disposal sites, Pools--Brian Johnson, Roger Myhre
Hydroacoustic Trials--Johnson, Myhre

Notch Cut, Closure Structure, Marquette Chute--Bob Hrabik, Rob Davinroy

Notch--further adjustment--Bob Hrabik, Rob Davinroy, Tracy Butler.
MV Pathfinder available first week of Sept.
FWS Fisheries Habitat Grant--Joyce Collins & Chuck Surprenant
Additional A&M funds--RY

Biological Monitoring--T. Miller and Brian Johnson
Pallid Sturgeon Contract SIU-C--with F&W--Bob Clevenstine, T. Miller
Ecosystem Monitoring--Pool 25, Environmental Pool Management

Proposed 1999 A&M Program

Budget--Tamara Atchley, Project Manager, Ron Yarbrough, Environmental Mgr.

Construction--Claude Strauser, Complete Santa Fe Chute, $300k+-
Complete Chevrons Pool 25, $200k+-

Biological Monitoring, Side Channel Model, Ft. Chartres--T. Miller.
A. Hydroacoustic work B. Continuation of Pallid Sturgeon Contract
C. Fish Passage Concept--Miller, Johnson, Myhre, Strauser

CEMVS-ED-HP September 15, 1998

MEMORANDUM FOR RECORD

SUBJECT: Annual Meeting of the Middle Mississippi Coordination Team

1. Following is a list of the individuals in attendance for one or both days of this meeting.

Leonard Hopkins	CEMVS-ED-HPR	314-331-8348
Steve Cobb	CEMVD-PM-R	601-634-5854
Clarence Thomas	CEMVD-ET-ET	601-634-5912
Rob Davinroy	CEMVS-ED-HPR	314-263-4714
David Gordon	CEMVS-ED-HPR	314-263-4230
Dan Erickson	CEMVS-CO-N	314-899-2600
Joyce Collins	USFWS	618-997-3344
Jenny Frazier	MDC-LTRMP	573-243-2659
Ken Brummett	MDC - Hannibal	573-248-2530
Bob Hrabik	MDC-LTRMP	573-243-2659
Steve Redington	CEMVS-ED-HPR	314-331-8354
Tracy Butler	CEMVS-CO-D	314-263-4708
Claude Strauser	CEMVS-ED-HP	314-331-8341
Chuck Surprenant	USFWS-Marion, IL	618-997-6869
Mike Thompson	CEMVS-PM-M	314-331-8039
Chris Morgan	CEMVS-CO-N4	573-242-3524
Bill Bertrand	IDNR	309-582-5611
Dan Ragland	CEMVS-PD-A	314-331-8461
Mike Cochran	IDNR	309-543-3316
T. Miller	CEMVS-PD-A	314-331-8458
Tom Seals	RIAC	314-892-0194
Ed Henleben	Orgulf Transport	314-638-5279
Ken Dalrymple	MDOC	573-858-5906
Dave Busse	CEMVS-HPW	314-331-8330
Joan Stemler	CEMVS-HPW	314-331-8330
Karen Watwood	CEMVS-CO-NC	573-242-3724
Wayne Porath	MDOC	573-751-4115 (x141)
John Zimmerman	CEMVS-CO-CN	573-8985-5356
Gordon Farabee	MDOC	573-751-4115 (x353)
Stan Ebersohl	CEMVS-CO-N	314-355-6585
Maryette Smith	CEMVD-ET-PR	601-634-5840
Ron Yarbrough	CEMVS-PD-A	314-331-8460
Brian Johnson	CEMVS-PD-A	314-331-8146

APPENDIX A

1). Minutes of Marquette Chute Meeting--Applied River Engineering Center, Service Base--10 July 1998--by Robert Hetrick.

2). Photo of St. Louis District equipment working at the upper closure structure, Marquette Chute.

3). Report of habitat enhancement work at Marquette Chute--by Jennifer Frazier and Robert Hrabik, MDOC/LTRM.

4). Interagency Grant from U.S. Fish and Wildlife Service.

5). Biological Report--Santa Fe Chute Habitat Improvement Project--by Jennifer Frazier, MDOC/LTRM.

6). Biological Report--Schenimann Chute Habitat Improvement Project--by Jennifer Frazier, MDOC/LTRM.

From: Robert Hetrick
To: ModelTeam
Date: 7/10/97 8:00am
Subject: Minutes of Marquette Chute Meeting

The following were attendance at the Marquette Chute Meeting held at AREC on 9 July 1997:

Ron Yarbrough
Jerry Rapp
Phil Eydmann
Rob Hetrick
Bob Hrabick
Jenny Frazier
Bob Clevenstine
Butch Atwood
Joyce Collins
Dan Witter
Tracy Boaz

The model was discussed and each alternative was described in detail. Discussion followed and it was resolved that:

1. One notch in the upper closure structure, in addition to the existing notch, would be created this year. The location of the notch would be below the first dike extending from the closure structure, at a "weak point" in the closure structure.

2. After favorable results from the first notch are seen, sometime in the next year or two, one more notch could be placed in the upper closure structure downstream of the second dike extending from the closure structure, again in a "weak spot."

3. Plan O, two dikes approximately 500 feet each in length, would be placed on the left descending bank of the chute below the lower closure structure. These dikes would create a minor channel to allow access to the scour hole below the closure structure from the main channel.

4. Rob H. would perform one additional test, raise the existing dike below the chute in an attempt to create a channel similar to Plan O. If this test proved successful, this plan would be implemented rather that Plan O, because of reduced costs. The results of this final plan will be discussed on the boat trip later this month.

5. It was suggested that placement of woody structure throughout Marquette chute is important. This woody structure could be in the form of driven piles or anchored trees. No firm resolution was reached because of the concern of availability of trees or piles. Individuals are persuing various aspects of this concept.

The meeting was closed just in time for lunch..........

Rob H.

A synopsis on habitat enhancement work in Marquette Chute, September 1998: A cooperative project of the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Illinois Department of Natural Resources, Missouri Conservation Department, and the Long Term Resource Monitoring Program

Jennifer J. Frazier and Robert A. Hrabik
Missouri Department of Conservation
Long Term Resource Monitoring Program
Open River Field Station

December, 1998

Marquette Chute is located between Upper Mississippi River (UMR) miles 47.0 and 53.0. It forms an indefinite boundary between the states of Missouri and Illinois. The side channel supports important aquatic habitat for many obligate and commensurate riverine organisms. Of the remaining side channels in the Middle Mississippi River (MMR), Marquette Chute is generally believed to have one of the higher substrate and depth diversities. From a fisheries standpoint, the side channel is very important because federal and state listed species have been captured in it, including pallid sturgeon (*Scaphirhynchus albus*), lake sturgeon (*Acipenser fulvescens*), sicklefin chub (*Macrhybopsis meeki*), sturgeon chub (*M. gelida*), blue sucker (*Cycleptus elongatus*), and Ohio shrimp (*Macrobrachium ohione*).

Biologists, long recognizing the need to enhance side channel habitat in the MMR, identified Marquette Chute for micro modeling in 1995. Micro modeling is physical sediment modeling on an extremely small (micro) scale. The simulated hydrographic/sediment response of any alluvial system, including detailed engineering analysis, is conducted on a table top flume. The river banks in these models are generally fixed. The micro modeling technology allows biologists and engineers to evaluate a variety of in-stream environmental design alternatives and determine which have the most positive effect on bed configuration (sediment transport response) and flow patterns within the study area. The goal is to create desirable biological diversity while ensuring a safe and reliable navigation channel.

Marquette Chute is an old mainstem channel of the Mississippi River. Because of the position of the chute in relation to the river, the Mississippi attempts to recapture the old channel. To ensure this doesn't happen and to divert sufficient water to the mainstem to maintain navigation, the inlet to the side channel has been closed off by an extensive rock structure. Results of the micro modeling showed little could be done to improve aquatic habitat over most of the upper 2/3 of the chute because so little water can be allowed to flow through the channel (Davinroy et al. 1997). However, Open River Field Station (ORFS) biologists have captured several fish species of concern immediately below the inlet closing structure, where openings (herein referred to as "notches") have scoured deep holes and deposited rare gravel bars. Blue suckers, river darters (*Percina shumardi*), and other species with specific habitat requirements have been sampled in these areas.

Realizing that such habitats are rare in the MMR, the U.S. Fish and Wildlife Service (USFWS) secured special funding in the form of a grant for habitat enhancement work in Marquette Chute. The USFWS grant was combined with funds from the U.S. Army Corps of Engineers' (COE), Avoid and Minimize Program (A&M) and the design and planning stages of the Marquette Chute habitat enhancement project began.

On August 25-27, 1998, a meeting was convened in conjunction with the St. Louis COE annual dredge spoil placement boat trip, in which project alternatives for the Marquette Chute work were discussed. Participants were interested in meeting two objectives: 1. improve habitat diversity, and 2. experiment with COE equipment to carry out habitat objectives. In the past, much of this kind of work was contracted out. It was decided the *M.V. Grandtower* would be used to maneuver the work barge in lieu of the *M.V. Pathfinder* because the latter was not as maneuverable and its operational costs are higher.

One alternative discussed was to cut a deep notch above an existing notch where the river was already creating a depression in the closing structure (Figure). The idea was to enhance flows through the closing structure in an area where the river was naturally doing it anyway. By cutting a deep notch similar to the natural notch (Figure), it was hoped that gravel and cobble could be deposited along and downstream of the scour hole. Another alternative was to notch the wingdam upstream of the existing notch (Figure) to allow water to remove the sand plug filling the notch. The existing notch was created in February 1998 by the COE to possibly aid in removing a small portion of a sand bar and create more depth diversity in the chute. It was decided at the meeting an on-site inspection was needed to determine if these proposals were feasible, and if not, where a notch(es) could be placed to meet the objectives of the project.

On August 31, 1998, Dave Gordon (COE), Lesly Conaway (ORFS), and J. J. Frazier (ORFS) met the crew of the *M.V. Grandtower* for an on-site inspection and evaluation of project alternatives. The team made the following observations and recommendations: 1. the wingdam (Figure) was too short to effectively notch and probably would have only limited effect on the sand plug; and, 2. a series of shallow notches would probably create more depth and substrate diversity than a single deep notch. The decision was made to create a series of shallow notches based on a series of bathymetry maps showing three scour holes that have apparently persisted over the years. The scour holes were created by small natural notches in the closing structure. The deepest notch produced the shallowest scour hole. Mr. Gordon concluded the increased head differential between the river elevation and the elevation of the river behind the structure provided more energy to create deeper scour holes. Given this, a plan was developed to create a series of notches of differing elevations by enhancing existing natural notches in the closing structure. The idea was to create a "string of pools", which may someday connect to each other downstream of the closing structure. A series of seven notches were laid out by the team. Two notches were designed to enhance about a half-acre, shallow pool located on the adjacent sand bar (Figure). The intent was to increase the wetted edge of this seasonal, temporary habitat for wading birds and provide more water for amphibians and reptiles.

Work began on September 1 and concluded on September 4, 1998. The river stage fell from 22 feet to 17 feet (Cape Girardeau gage) during this period. Early in the week, additional areas were identified for notching, but lowering river levels impeded access to some sites. At projects end, eight notches were cut in the closing structure (Figure and Table). The crew of the *M.V. Grandtower* provided valuable input regarding logistics and the work load given the equipment and time available.

A clam bucket was used to create notches in the closing structure. The crane operator was able to grab rock and place it onto the existing structure instead of dragging rock into the river. This prevented filling of deep water areas and may create a nozzle effect through the newly created notches at appropriate river stages (in excess of 26 feet, Cape Girardeau gage). In the February, 1998 project, a drag line was used to remove rock, which had to be deposited in the river. The clam bucket was much more efficient than the drag line, however, efficiency of the bucket declined sharply when attempts were made to remove rock below the surface of the water. Hydraulic equipment not currently available to the St. Louis COE is needed to efficiently remove rock from below the water surface. Because the team removed rock from depression areas in the closing structure, fewer rocks had to be displaced to create a notch at a desired elevation. Work progressed quickly using this approach.

Table. Estimated notch dimensions and river stage elevations (Cape Girardeau) when notches begin accepting river flow in Marquette Chute, September, 1998. Notch 4 consists of two depressions forming a "saddle" in the closing structure.

Notch	Depth of Material Removed (feet)	Width of Notch (feet)	Stage (feet)
1	1.5	12	25.0
2	3.0	12	22.0
3	4.0	10	20.4
4	N/A N/A	25 20	17.6 17.6
5	N/A	25	19.4
6	3.0	7	21.4
7	3.0	25	21.4

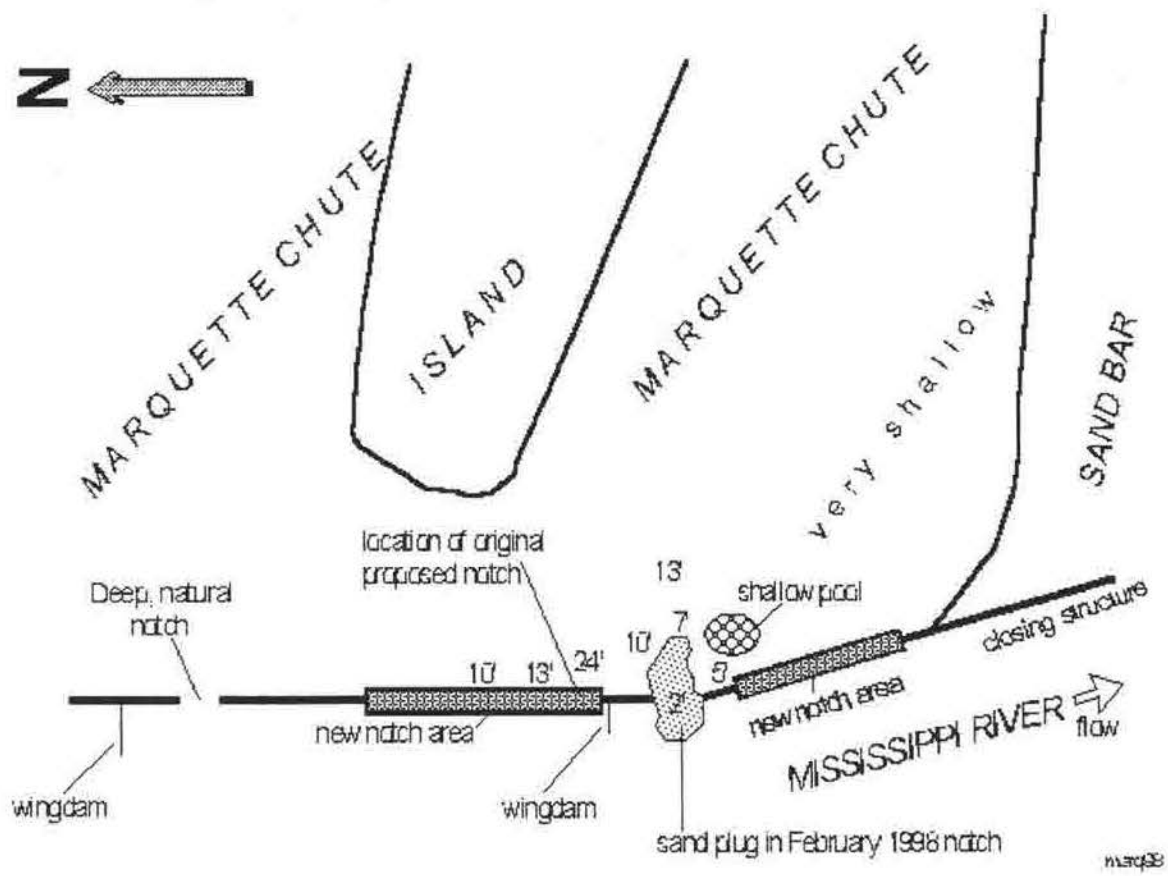
Note: February, 1998 notch lies between notches 5 and 6 and is estimated to be 100' wide. Water flows through at 18.4 feet.

Funds for the project were made available through the St. Louis COE, Avoid & Minimize Program and a grant by the U.S. Fish and Wildlife Service. The consulting on-site engineer was Dave Gordon (St. Louis COE); consulting on-site biologist was Jenny Frazier (ORFS). Lesly Conaway (ORFS), Bob Hrabik (ORFS), and Steve Dierker (St. Louis COE) were also present throughout phases of the construction.

Literature Cited:

Davinroy, R. D., D. C. Gordon, and R. D. Hetrick. 1997. Sedimentation study of the Mississippi River, Marquette Chute, hydraulic micro model investigation. Technical Report M3, U.S. Army Corps of Engineers, St. Louis District, Hydrologic and Hydraulics Branch, Applied River Engineering Center, St. Louis, Mo. Final Report, December, 1997.

Figure. Inlet area of Marquette Chute showing physical features and select depth measurements as of 18 August 1998. River stage at Cape Girardeau was approximately 20 feet. Map not to scale and all areas approximate.



CEMVS-PM-M

16 July 1998
Atchley/8044

MEMORANDUM FOR OC

SUBJECT: Interagency Grant from Fish and Wildlife Service

1. The Avoid and Minimize program has been funded $20,000 from the Fish and Wildlife Service for notch work at Marquette Chute. The project was micro-modeled and the first notch started by the Corps of Engineers. As work progressed and funds were exhausted, FWS agreed to provide additional funds to continue the work.

2. The attached is the inter-agency agreement and documentation. Our feeling is that this should be signed by the DE. Please review this document and provide comments.

Tamara Atchley

Tamara L. Atchley, P.E.
Project Manager

Colonel Thomas J. Hodgini
District Engineer
St. Louis District, Corps of Engineers
1222 Spruce Street
St. Louis, Missouri 63103-2833

Dear Col. Hodgini,

I am pleased to announce the award of a $20,000 grant from the U.S. Fish and Wildlife Service to the St. Louis District, Corps of Engineers for the purpose of constructing an additional notch in the upper closing structure of the Middle Mississippi River's Marquette Side Channel.

Funding for this work has been made available through the U.S. Fish and Wildlife Services's Fisheries Habitat Restoration Partnership. Cooperator matching will be made available through your Avoid and Minimize Program, and in-kind matching by the Illinois Department of Natural Resources and the Missouri Department of Conservation.

The Avoid and Minimize Program is a cooperative effort between the Corps of Engineers, the U.S. Fish and Wildlife Service, the Illinois Department of Natural Resources, the Missouri Department of Conservation, and the River Industry. The Program experiments with operations and maintenance practices on the Mississippi River and monitors biological and physical results. Since 1992, the Avoid and Minimize Program has: restored aquatic habitat in Santa Fe Chute, created Least Tern nesting habitat, monitored pallid sturgeon habitat utilization, and micro-modeled restoration options for other side channels, including Marquette Side Channel.

This project and others like it have fostered a new spirit of cooperation between the Federal and State Agencies involved, which will continue and expand as we address this and other restoration projects. We look forward to working with you to bring this project to a successful conclusion

Your contact is Chuck Surprenant, Project Leader, USFWS-Carterville, IL Fishery Resources Office, 618-997-6869. His E-MAIL address is Chuck_Surprenant@mail.fws.gov.

Sincerely yours,

William Hartwig
Regional Director

cc:

Director, Illinois Department of Resources
Director, Missouri Department of Conservation

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Bishop Henry Whipple Federal Building
1 Federal Drive
Fort Snelling, MN 55111-4056

IN REPLY REFER TO:

FWS/ABA-CGS
14-48-0003-98-1034

July 8, 1998

Ms. Tamara Atchley
U.S. Army Corps of Engineers
St. Louis District (A&M--PM)
1222 Spruce Street
St. Louis, Missouri 63103-2833

Dear Ms. Atchley:

Enclosed you will find Inter-agency agreement number 14-48-0003-98-1034 between the U.S. Army Corps of Engineers, St. Louis District and the U.S. Fish and Wildlife Service. This agreement represents the project "Restore scouring flows to marquette side channel - Middle Mississippi River". Please provide the required signature on the agreement and return it to me as soon as possible.

If you have any questions regarding this agreement, please contact me at (612) 713-5274. If you have any questions regarding the administration of the agreement, please contact Mr. Charles Surprenant at (618) 997-6869.

Sincerely,

Susan F. Kozarek

Susan F. Kozarek
Contracting Officer

Enclosures

[redacted]

MAY 2 9 1998

Planning Division

Mr. William F. Hartwig
Regional Director
U.S. Fish and Wildlife Service
Bishop Henry Whipple Federal Building
1 Federal Drive
Fort Snelling, Minnesota 55111-4056

Dear Mr. Hartwig:

Thank you for your letter notifying us that we are receiving a $20,000 grant from the Service's Fisheries Habitat Restoration Partnership for habitat enhancement in Marquette Side Channel of the Middle Mississippi River. I am pleased that we can be partners in the St. Louis District's efforts to improve and enhance fisheries habitat in the side channels of the Middle Mississippi River.

The St. Louis District's Avoid and Minimize Program has been a highly successful, cooperative effort among the conservation agencies of Illinois and Missouri, the Service, the River Industry Action Committee, the Long Term Resource Monitoring Program and the Corps. We are especially pleased that this partnering group is a leader in the effort to preserve and enhance the 23 side channels in the open river portion of the St. Louis District. These unique habitats are vital to the overall health of the aquatic communities of the open river ecosystem.

The St. Louis District is committed to a course of action through the Avoid and Minimize Program that will identify the current habitat characteristics, ownership and enhancement opportunities of each side channel. We can then move forward with our partners in a cooperative effort to provide structural and other modifications necessary to improve and/or enhance the existing habitat.

We expect the modification of the Marquette Chute closing structure to be completed later this summer. Your point of contact will be Mr. T. Miller, Ecologist, Environmental Planning Branch, Planning Division, at 314-331-8458. The e-mail address is millert@smtp.mvs.usace.army.mil.

Sincerely,

Signed
Thomas J. Hodgini
Colonel, U.S. Army
District Engineer

Thomas J. Hodgini
Colonel, U.S. Army
District Engineer

AVOID AND MINIMIZE PROGRAM
BIOLOGICAL REPORT

Santa Fe Chute Side Channel Habitat Improvement Project
Summary of Observations and Progress, October 1997 - September 1998

December 1998

Jennifer J. Frazier
Missouri Department of Conservation
Long Term Resource Monitoring Program
Open River Field Station
Jackson, Missouri 63755

The Santa Fe Chute habitat enhancement initiative began in January 1996. Various design alternatives were tested using the St. Louis Corps of Engineers micro model technique. The chosen alternative consisted of nine alternating dykes (hardpoints) placed off the left and right descending banks within the upper one half of the side channel. This configuration was expected to increase thalweg sinuosity, and improve depth and substrate diversity in the side channel. Due to budget constraints, only 6 of 9 structures were built in April 1997. The structures were built to only one half their original specifications.

In September 1998, Dave Gordon (St. Louis Corps) and Open River field station (ORFS) staff flew over Santa Fe Chute (as well as other A&M project sites) to document physical developments in the side channel. Corps hydroacoustic soundings showed scour hole development off the end of the hardpoints and a developing thalweg meander. A build up of bed material was observed in the middle of the side channel. The extent of the bar could not be determined from the air. ORFS staff reported the development of the bar to A&M participants. The upper end of the side channel has become increasingly difficult to access, and rock "spilled" by the contractors during construction of the dykes made navigation more difficult. This bar and misplaced rock were clearly seen from the helicopter during the September 1998 flight. The lower end of Santa Fe Chute remains accessible and has not seemed to change from past years.

Santa Fe Chute has been sampled for fish community data continuously since 1991. In 1998, fishery sampling began in June as part of our routine monitoring program. A full compliment of gear were fished, except seining. River stages were generally too high during the reporting period to seine. One experimental trawl sample was taken during mid-summer. In early summer, blue catfish catches were unusally good; several large blues were captured weighing up to 40 pounds. Fishery data collected in the side channel have not been summarized to date.

Routine water quality data continued to be collected quarterly in lower Santa Fe Chute. The upper end of the chute is not routinely sampled because it is not generally accessible. To close this data gap, quarterly monitoring of seven randomly selected sites began in fall, 1997. The sites are monitored for routine LTRMP water physical parameters: water temperature, dissolved oxygen, turbidity, pH, conductivity, water depth, secchi disc transparency, and water velocity. In addition, water chemical data is collected at one of the seven random sites, which includes parameters for soluble reactive phosphorous, total nitrogen/phosphorous, metals, phytoplankton, chlorophyl, suspended solids, and nitrite/nitrate.

Other unusual observations in the chute include algal blooms and heavy silt deposition after spates. Algal blooms appeared in scour holes behind the dykes when the river fell to about 17 feet (Cape Girardeau gage). No limnological data were collected in the scour holes during these times. Data loggers were placed behind the inlet closing structure in September and monitored for three days. The water column was oxygen stratified and anoxic conditions were recorded. The extent of these conditions were not determined. The Middle Mississippi River received several summer time spates in 1998. Apparently, high silt loads passed into and through Santa Fe Chute. Minnow fyke nets set in the chute during these spates were often silted in. As much as one foot of newly deposited silt was observed along the banks in the side channel.

At this time, we have insufficient data to assess the project's impact on biological communities and the chute's limnology.

AVOID AND MINIMIZE PROGRAM
BIOLOGICAL REPORT

Schenimann Chute Side Channel Habitat Improvement Project
Summary of Observations and Progress, October 1996 - September 1998

December 1998

Jennifer J. Frazier
Missouri Department of Conservation
Long Term Resource Monitoring Program
Open River Field Station
Jackson, Missouri 63755

Side channels (chutes), and other floodplain bodies of water, are important to the health of a riverine ecosystem, especially when they are connected to the mainstem. These water bodies provide spawning, rearing, resting, feeding, and over wintering habitat for numerous fish species. The 200-mile reach of the open Upper Mississippi River (the unimpounded portion) has lost much of its floodplain water bodies to flood control and navigation improvement projects. Today, only 23 side channels remain in the open river reach.

Schenimann Chute is located between Upper Mississippi River miles 57-63. It lies on the right descending bank approximately 8 kilometers north of Cape Girardeau, in Cape Girardeau County, Missouri. The chute is 6.1 kilometers long, averages 61 meters wide, and contains approximately 37 hectares of aquatic habitat. Schenimann Chute differs from most other open river side channels because water may enter it from the river, from a small intermittent tributary, and from tertiary channels dissecting the island. When the water stage is high, boats may pass between the chute and the main river at both inlets and outlets and through the tertiary channels. All land adjacent to the chute is privately owned.

Schenimann Chute, like many open river side channels, has been affected by river regulation projects. Habitat in the chute is degraded by siltation and, at some water stage elevations, is inaccessible to fish because of closing structures. These structures include four old wooden pile dikes and four stone closing dikes. The closing dikes extend from the mainland to the island and divide the chute into four disconnected "chambers" at mean and low river stages. The stone structures have shallow notches, which allows water to pass between chambers when the stage is above 19 feet (Cape Girardeau gage).

The Schenimann Chute habitat enhancement initiative began in 1996 with the preliminary restoration plan completed in March, 1997. The project was created through the efforts of the Avoid and Minimize team and is being submitted as a Section 1135 project. Enhancement objectives of the team included increasing flow to the side channel under certain hydrographic conditions; structural changes to produce scour and plunge pools; reduce high flow bank erosion; and provide access to the chute during low flows.

Design alternatives were tested by the team using the St. Louis Corps of Engineer's micro modeling technique. The selected design included: 1. cutting notches in three stone dikes to 10 feet LWRP (low water reference plane, St. Louis) and about 10 feet wide; 2. construct 15 short stone dikes or hard points with a total length of approximately 1,225 feet; 3. construct approximately 5,800 feet of stone revetment; and, 4. dredge approximately 75,000 cubic yards of sand at the lower end of the chute. Aquatic habitat diversity would increase because scour holes would be created off the hard points and a sinuous thalweg would develop in the side channel. Other environmental benefits of the design would be increased flow between the chambers and better access by fish to deep, off-channel over wintering habitat. Revetment and dikes will be placed below the ordinary high water mark. Dredge material will be placed in the thalweg of the mainstem river.

It was decided to collect pre- and post-construction physical, chemical, and biological data in the chute to evaluate effects. The St. Louis Corps of Engineers, Environmental Quality branch in cooperation with the ORFS and ARDL, Inc., conducted the initial pre-construction survey in September, 1996 (ARDL 1996), including water quality and fisheries sampling.

Since the initial survey, ORFS staff have led the ensuing pre-construction surveys. For water quality, a fixed sampling site was established in the plunge pool below the closing structure separating the third and fourth chambers. Routine water physical and chemical parameters are monitored bi-weekly at this site. Water physical parameters include: water temperature, dissolved oxygen, pH, conductivity, turbidity, water velocity, secchi disk transparency, and water depth. Water chemical parameters include: total nitrogen/phosphorus, suspended solids, chlorophyl, soluble reactive phosphorus, nitrate/nitrite, and metals. Phytoplankton and zooplankton samples are also taken. Water physical and chemical measurements are taken 0.2 meters below the water surface. Water physical measurements (except water velocity, turbidity, and secchi) are also measured every 0.5 meters to 0.2 meters above the substrate (profile data).

Since 1997, OFRS staff have conducted quarterly water quality surveys throughout the entire chute. One hundred sites are randomly selected in all four chambers. The number of sites/chamber is weighted by percent length of each chamber. For example, chamber 1 comprises approximately 40% of the total length of the chute and contains 40 sample sites. The U. S. Geological Survey, Upper Midwest Environmental Sciences Center (formerly known as the Environmental Management Technical Center) agreed to analyze 10% of the sites for routine chemical parameters at no extra cost. Chamber 1 has four chemical sites, and chambers 2, 3, and 4, have three, one, and two, respectively. One deep water site in each chamber is profiled as described above. Additionally, since 1991, between four and seven randomly selected sites are sampled quarterly through the routine LTRMP stratified random sampling design (SRS). These sites are all located in the first chamber.

Fisheries data has been collected in the chute continuously since 1991, originally through a fixed sampling site design and in recent years through SRS. Similar to water quality SRS, fisheries data is collected only in chamber 1 because the other chambers become isolated and inaccessible during varying times of the year. Since the initial fall, 1996 survey, chamber 4 has been sampled for fish community structure quarterly commensurate with quarterly water quality sampling. Budget and time constraints do not allow for all chambers to be sampled, therefore, inferences about fish community change over time is limited to chamber 4.

Akin to water quality, fisheries sampling employs the standardized methods of the LTRMP. Seines, hoop nets, gill nets, fyke nets, and minnow fyke nets are used to sample the fish community. Electrofishing is not used because the LTRMP standardized electrofishing boat can access chamber 4 only under high water stages, limiting the utility of such data. A typical fisheries survey takes a week to complete and composes 76 units of effort.

Both water quality and fisheries data have been summarized by quarter, but no detailed analyses have been conducted. Both data bases are extensive and represent the most thorough pre-construction data base of all the A&M habitat enhancement projects constructed in the open Mississippi River.

Literature cited:

ARDL. 1996. Mississippi River-Schenimann Chute: review and analysis of aquatic monitoring data, Mississippi River mile 57-62, right descending bank. Prepared for U. S. Army Corps of Engineers, St. Louis District. Contract Number DACW-43-96-D-0506, ARDL, Inc. Volumes 1 and 2. November 1996.

Ron Yarbrough
please distribute
as appropriate

DISSOLVED OXYGEN AT CRITICALLY LOW LEVELS IN SOME ISOLATED SIDE CHANNELS IN THE MIDDLE MISSISSIPPI RIVER

The LTRMP Open River Field Station located near Cape Girardeau, Missouri has six side channels in its 50-mile study reach. Four of the six side channels become isolated from the main channel at various river levels.

On September 4, 1998, two data recorders were placed in Santa Fe Chute below the inlet closing structure (river mile 38.9L). A Hydrolab Datasonde 3 was placed near the bottom and a Hydrolab Minisonde was placed just below the surface in 8.5 meters (28 feet) of water. The recorders were set to record every 30 minutes and were retrieved after three days of continuous monitoring. The results showed that surface dissolved oxygen (DO) had a maximum reading of 9.17 mg/L at 5:30 p.m. on September 5, and a minimum of 2.00 mg/L at 8:00 a.m. on September 8. The bottom DO reading had a maximum of 0.48 mg/L at 3:00 p.m.on September 7, and a minimum of 0.17 mg/L at 6:00 p.m. on September 4. During this period, the river fell about 2.2 feet at the Cape Girardeau gage.

On September 11, 1998, two data recorders were placed in Picayune Chute below a closing structure located near the outlet of the chute (river mile 55.0L). The methods were the same, but the data recorders were in 14.6 meters (48) feet of water. A small amount of flow was filtering through the closing structure. The surface DO had a maximum 12.53 mg/L at 2:30 p.m. on September 13, and a minimum of 7.4 mg/L at 11:30 a.m. on September 14. The bottom DO had a maximum of 0.21 mg/L at 3:00 p.m. on September 11, and a minimum of 0.13 mg/L at 8:00 p.m. on September 12. During this period, the river fell about 0.5 feet at the Cape Girardeau gage.

Open River staff bi-weekly monitors a fixed site located below a closing structure near the outlet of Schenimann (Bainbridge) Chute (river mile 57.6R). At this site, water temperature, pH, conductivity, and DO are measured at the surface (at 0.2 m) and at every 0.5 meter to the bottom. The maximum depth of the site was 7.6 m (25 feet). On September 11, 1998 at 12:30 p.m., DO was 12.6 mg/L at the surface and 0.1 mg/L at the bottom. Surface water temperature was 27.0 °C and bottom water temperature was 13.1°C. Conductivity increased from 630 to 1131 uS/cm, and pH decreased from 7.6 to 6.3, surface to bottom. Stratification began at approximately 2.2 m below the surface. Stratification was not detected in main channel border sites during this period.

These data suggest that some closing structures in Middle Mississippi River side channels have a deleterious effect on the river's limnology. It is speculated that closing structures act as catchments for nutrients, which promote rapid phytoplankton production under optimum environmental conditions. During such conditions, night-time respiration utilizes DO sometimes causing whole water bodies, like those below closing structures, to go near-anoxic. These conditions are stressful for aquatic organisms and could cause significant kills.

For additional information, contact the Open River Field Station at (573) 243-2659.

APPENDIX B

1). Memo and Maps of change in work in Pool 25 due to low water

2). Cottonwood Island Chevron Dike Fisheries Evaluation Update--by Elmer Atwood IDNR.

3). Multiple Round Point Structures, Preliminary Fisheries Evaluation--by Elmer Atwood, IDNR.

CEMVS-ED-HP 19 June 1998

MEMORANDUM FOR AVOID & MINIMIZE TEAM

SUBJECT: A&M work in Pool 25

1. A meeting was held on 18 June 1998 between Claude Strauser, Steve Redington, Leonard Hopkins, T. Miller, and Ron Yarbrough to discuss the construction of chevrons in Pool 25 using A&M funds.

2. Five (5) chevrons have been approved to be constructed at M.R.M. 250.2 (L). After two (2) construction years, only one (1) has been constructed to date. Even with high water events, there has not been enough depth for the construction of the four (4) remaining chevrons.

3. Four (4) chevrons have been approved to be constructed at M.R.M. 266.0 (R), in some out year to be determined.

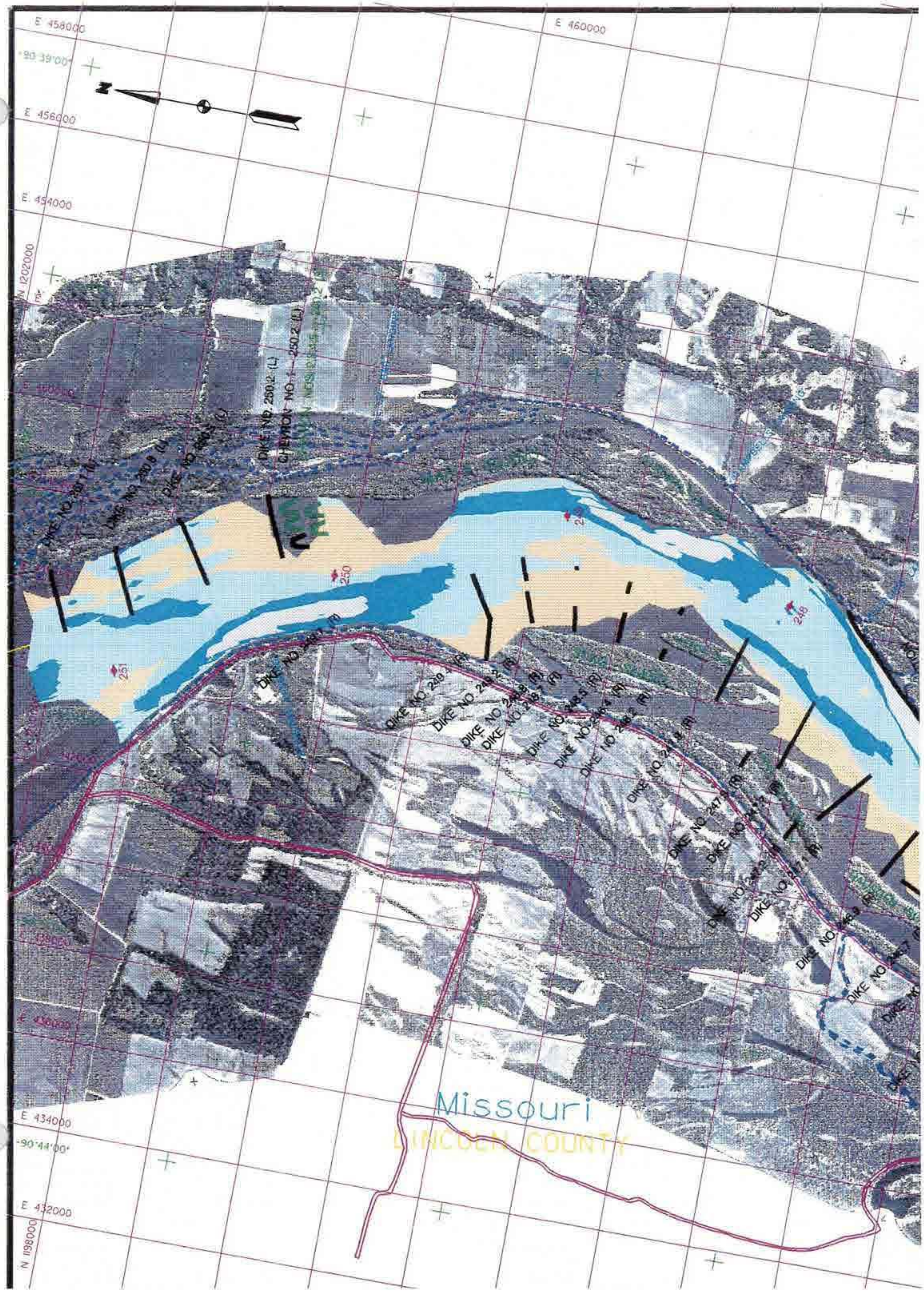
4. Claude Strauser brought it to everybodys attention that chevrons will be built at M.R.M. 266.0 (R) with A&M monies, during the Middle Mississippi Coordination Team meetings, held over the past two years. There were no objections to the construction of these chevrons.

5. It was suggested to proceed with the construction of the chevrons at M.R.M. 266.0 (R) and delay the construction of the chevrons at M.R.M. 250.2 (L) until a later date. There is the likelihood of adequate depth at M.R.M. 266.0 (R) for the construction of the chevrons. It was suggested to construct the chevrons, at M.R.M. 266.0 (R), with each chevron increasing in elevation, as you move from upstream to downstream.

6. These suggestion were agreed upon by all in attendance.

Encl.

Leonard Hopkins
CEMVS-ED-HP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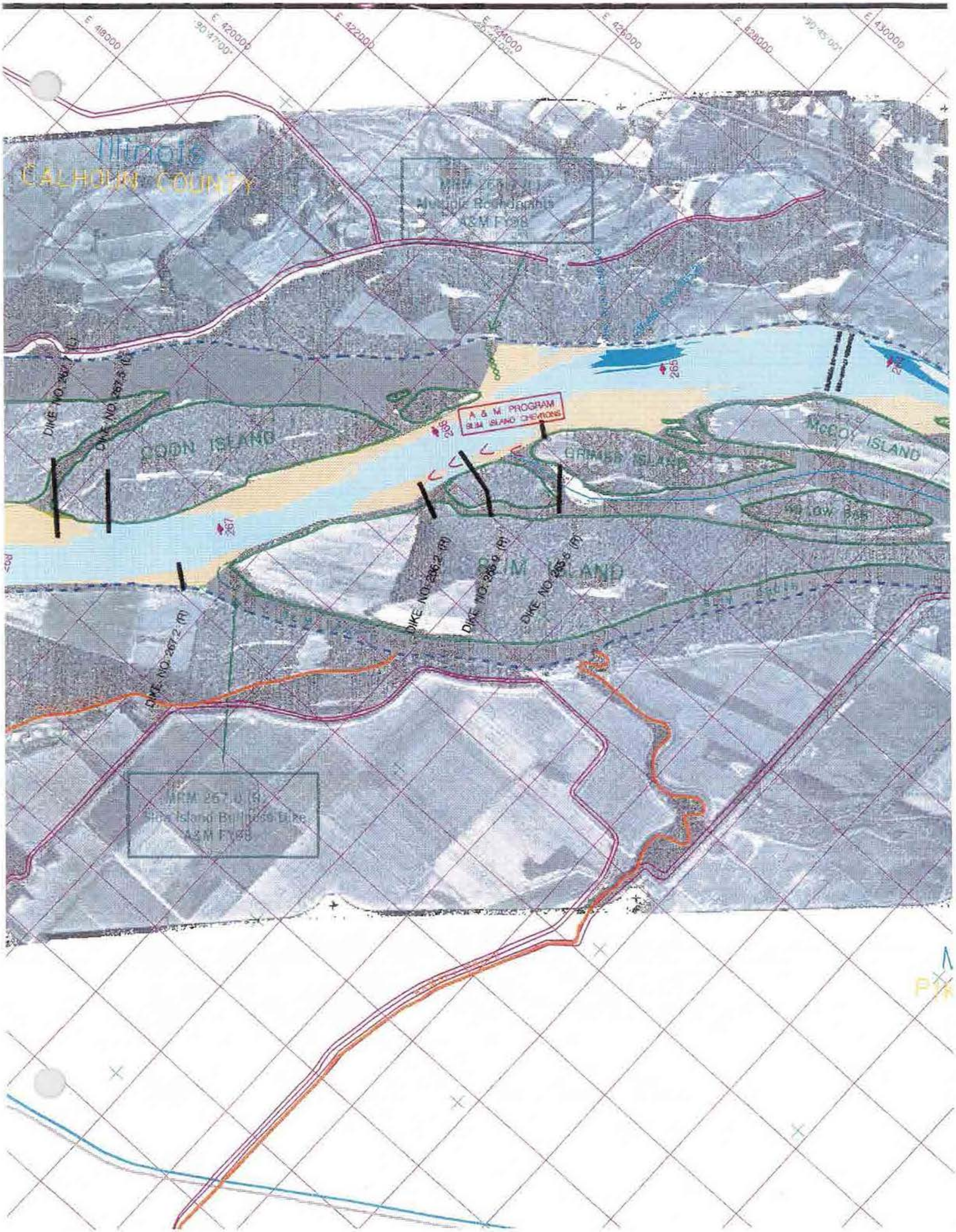
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A & M PROGRAM
SLIM ISLAND CHEVRONS
COON ISLAND
GRIMES ISLAND
McCOY ISLAND
Willow Bar
SLIM ISLAND
DIKE NO. 266.2 (R)
265
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267

Cottonwood Island Chevron Dike
Fisheries Evaluation Update

Prepared for:
U.S. Army Corps of Engineers
St.Louis District

Prepared by:
Elmer R. Atwood
Illinois Department of Natural Resources
Fisheries Division
Boundary River Program

December 1998

Introduction

The Illinois Department of Natural Resources, Division of Fisheries, Boundary Rivers Program, with assistance from the St. Louis District, Corps of Engineers, has conducted fish sampling with A.C. electrofishing (EF) on the Cottonwood Island Chevrons since October 1993. The upstream and downstream most chevrons have been sampled, along with a small backwater slough at Drift Island as a control site. In 1998 two additional control sites (Head of Bay Island and main channel border along Cottonwood Island, adjacent to the upper chevron) were sampled to evaluate for possible inclusion in the study. The dates of sampling for these sites, as well as EF time period for each site are shown in Figure 1.

Methods

The electrofishing unit used in this study consists of a 230 volt, 4000 watt, 3 phase A.C. generator which energizes 3 steel cable electrodes (5/8") suspended from 3 booms projecting off the bow of the boat (18' welded aluminum boat). The electrodes are approximately 5' apart, project about 6' off the bow and project into the water about 4' in depth, thus creating an electric field with an approximate diameter of 10' and reaching a depth of about 6'. Typically 6 - 10 amperes of current are generated within this field. The sampling is conducted by a two person crew, one stationed in the bow of the boat to dip stunned fish with a long handled dip net from the water and into a oxygenated live well, and one operating the motor. Typically, two EF runs are conducted at each chevron, one along the outside of the chevron and one within the inside of the chevron. Rough sketches of the study area and typical chevron sampling runs are attached.

After each EF run the fish are identified to species, weighed and measured, checked for abnormalities and disease, then returned live to the river. Fishes too small to identify in the field are preserved and returned to the lab for processing. Data are tabulated on standard field sheets and later entered into the Department's fisheries database (Fisheries Analysis System).

Results and Discussion

Excluding the two new sites a total of 5360 fishes representing 50 species have been collected during 796 minutes of electrofishing (101.01 fish/15 ef min). When these data are summarized by habitat type (inside, outside, Drift Is.) over all sampling periods (Table 2), the highest catch rate was observed inside the chevrons (144.37 fish/15 min EF), followed by Drift Island Slough (91.50 fish/15 min EF) and outside the chevrons (70.22 fish/15 min EF). The number of species collected was also highest inside the chevrons (40 species) [Table 2], followed by Drift Island Slough (33 species) and outside the chevrons (28 species). Table 3 summerizes fish collections from all sites sampled to date.

When the number of species collected per site are compared (Figure 1), the highest species richness was observed from inside the upper chevron (36 species) followed by Drift Island Slough (33 species), lower inside (28 species), upper outside (27 species) and lower outside (19 species). When catch rates for each site (over all sampling periods) are compared, the upper inside chevron is higher than all other sites with 151.16 fish/15 min EF, followed by lower inside (130.94 fish/15 min) and Drift Island Slough (91.50 fish/15 min) [Figure 2]. These data suggest that the habitat types created inside the chevron dikes are holding more individual fishes and more fish species than either the habitat immediately outside of the chevrons or the slough habitat.

A similar picture emerges when the catch rates by site of selected individual fish species are compared. The catch rates for gizzard shad (Figure 3) and bullhead minnow (Figure 5) were higher inside chevrons than elsewhere. The catch rate for smallmouth buffalo was highest in the slough followed by inside lower and inside upper (Figure 6). The catch rates for channel catfish (Figure 7) and flathead catfish (Figure 8), however, were highest on the outside of the chevrons. The largemouth bass catch rates were highest in the slough, but higher (and similar) inside the two chevrons than from the outsides (Figure 9). The bluegill catch rate in the slough habitat was much higher than elsewhere, but was higher inside chevrons than outside (Figure 10).

A broader and more holistic view, however, is to look at chevrons in their entirety, with habitats inside and outside as an interacting, integrated whole; a continuum, if you will. When observed from this perspective, as a single habitat unit or a chevron dike field, we notice that of the 50 species collected so far in this study effort, 47 are associated with chevrons (Table 2).

An examination of the length frequencies of selected fishes collected from the vicinity of the chevrons (inside and outside) and Drift Island Slough helps illustrate the similarities and differences in the fish populations inhabitating these two habitat types. For instance, although smallmouth buffalo densities associated with the chevrons are considerably less than those in Drift Island Slough, the size range observed for this species is greater in the vicinity of the chevrons than in the slough and it appears chevrons are providing higher quality nursery habitat for these fishes than is the slough habitat (Figures 11 and 12). Largemouth bass and bluegill densities are also much higher in Drift Island Slough and the size ranges are also greater (Figures 13, 14, 15 and 16). Similar to smallmouth buffalo, the proportion of juvenile largemouth bass and bluegill observed in the vicinity of the chevrons is higher than those assosicated with the slough, probably indicating the favorable juvenile habitat conditions provided inside the chevrons.

It's also interesting to look at the density and size differences between lotic fish species collected inside and outside the chevrons, such as channel catfish and white bass, and may help illustrate possible biotic interactions between the inside and outside chevron habitat types.

The channel catfish catch rate was more than 3.5 times higher along the outside of the chevrons than inside (Table 2), suggesting higher densities outside. The size structure of channel catfish collected inside and outside indicates similar sized fishes are utilizing both areas (Figures 17 and 18). The catch rate data coupled with the length frequency data suggests that adult fish are residing most often outside the chevrons and occasional move into the inside. The purpose of such movement is unknown, but at least two possibilities exist: 1) channel catfish use the inside as a temporary resting place from high current velocities experienced on outside, and 2) they are utilizing the slighty higher density of forage fishes and slighter different macroinvertebrate assemblage (Ecological Specialists, Inc 1997) found inside.

Unlike the channel catfish, the catch rate for white bass on the inside was 2.5 times that on the outside and the observed size distribution of these fishes between these habitats is markedly different. The majority of white bass found inside were young of the year fish, while the most of those fish collected on the outside of the chevrons were one year or older, suggesting, again the interior habitat is providing valuable nursery habitat for young fishes.

Conclusion

The data collected thus far in this evaluation strongly suggest that chevron dikes are providing useful and valuable habitat for a variety of riverine fishes. The outside of chevrons have been shown to provide excellent habitat for quality sized channel catfish, flathead catfish, common carp and a variety of minnows and shiners. Smallmouth bass, uncommon within this river reach, have also been collected along the outside of chevrons. From the species composition and the number of young of the year fishes present, the inside of chevrons appear to be providing backwater type habitat (at appropriate water levels) in a reach of river where such habitat is limited.

Table 1. Sampling dates and electrofishing effort for Cottonwood Island chevron dike study.

Sampling date	Station name	Electrofishing effort (min)
14-Oct-93	Lower Chevron Inside	9
14-Oct-93	Lower Chevron Outside	9
14-Oct-93	Upper Chevron Inside	9
14-Oct-93	Upper Chevron Outside	9
21-Jul-95	Drift Island Slough	60
02-Aug-95	Upper Chevron Inside	14
02-Aug-95	Upper Chevron Outside	14
12-Sep-95	Lower Chevron Inside	16
12-Sep-95	Lower Chevron Outside	16
12-Sep-95	Upper Chevron Inside	16
12-Sep-95	Upper Chevron Outside	16
11-Oct-95	Upper Chevron Inside	14
11-Oct-95	Upper Chevron Outside	14
12-Aug-96	Drift Island Slough	60
14-Aug-96	Lower Chevron Inside	15
14-Aug-96	Lower Chevron Outside	15
14-Aug-96	Upper Chevron Inside	15
14-Aug-96	Upper Chevron Outside	15
09-Sep-96	Drift Island Slough	15
09-Sep-96	Lower Chevron Outside	15
09-Sep-96	Upper Chevron Inside	15
09-Sep-96	Upper Chevron Outside	15
08-Oct-96	Drift Island Slough	15
08-Oct-96	Lower Chevron Outside	15
08-Oct-96	Upper Chevron Inside	15
08-Oct-96	Upper Chevron Outside	15
16-Jul-97	Lower Chevron Inside	15
16-Jul-97	Lower Chevron Outside	15
16-Jul-97	Upper Chevron Inside	10
16-Jul-97	Upper Chevron Outside	10
04-Aug-97	Drift Island Slough	60
26-Sep-97	Upper Chevron Inside	15
26-Sep-97	Upper Chevron Outside	15
12-Jun-98	Cottonwood MCB	20
12-Jun-98	Lower Chevron Inside	15
12-Jun-98	Upper Chevron Inside	15
12-Jun-98	Upper Chevron Outside	20
06-Aug-98	Drift Island Slough	60
17-Aug-98	Lower Chevron Inside	15
17-Aug-98	Lower Chevron Outside	15
17-Aug-98	Upper Chevron Inside	15
17-Aug-98	Upper Chevron Outside	15
14-Oct-98	Head of Bay Island	20
14-Oct-98	Upper Chevron Inside	15
14-Oct-98	Upper Chevron Outside	15
	Total effort to date	836

Table 2. Compostition of fishes collected with boat electrofishing at Cottonwood Island Chevron Dikes study area, 1993 - 1998.

	Chevron Inside		Chevron Outside		Chevron Total		Drift Is. Slough		All Stations	
sampling effort (min)	253		273		526		270		796	
Species	N	N/15min	N	N/15min	N	N/15min	N	N/15min	N	N/15min
Shortnose gar	4	0.24			4	0.11	3	0.17	7	0.13
Longnose gar							4	0.22	4	0.08
Bowfin							17	0.94	17	0.32
American eel			2	0.11	2	0.06			2	0.04
Skipjack herring	1	0.06			1	0.03			1	0.02
Gizzard shad	747	44.29	85	4.67	832	23.73	180	10.00	1012	19.07
Threadfin shad	1	0.06			1	0.03			1	0.02
Mooneye			3	0.16	3	0.09			3	0.06
Bighead carp	1	0.06			1	0.03	1	0.06	2	0.04
Goldfish	1	0.06			1	0.03			1	0.02
Carp	26	1.54	84	4.62	110	3.14	96	5.33	206	3.88
Central stoneroller			1	0.05	1	0.03			1	0.02
Suckermouth minnow	5	0.30			5	0.14			5	0.09
Silver chub	7	0.42	11	0.60	18	0.51	9	0.50	27	0.51
Spotfin shiner	79	4.68	162	8.90	241	6.87	3	0.17	244	4.60
Red shiner	6	0.36	15	0.82	21	0.60			21	0.40
Emerald shiner	327	19.39	513	28.19	840	23.95	1	0.06	841	15.85
Silverband shiner	1	0.06			1	0.03			1	0.02
River shiner	46	2.73	28	1.54	74	2.11			74	1.39
Bigmouth shiner			1	0.05	1	0.03			1	0.02
Sand shiner	6	0.36	14	0.77	20	0.57			20	0.38
Channel shiner	64	3.79	30	1.65	94	2.68	1	0.06	95	1.79
Spottail shiner	4	0.24			4	0.11			4	0.08
Shiner spp.	13	0.77			13	0.37			13	0.24
Bluntnose minnow	4	0.24	2	0.11	6	0.17	1	0.06	7	0.13
Bullhead minnow	412	24.43	21	1.15	433	12.35	36	2.00	469	8.84
Bigmouth buffalo	17	1.01			17	0.48	93	5.17	110	2.07
Smallmouth buffalo	58	3.44	25	1.37	83	2.37	197	10.94	280	5.28
Black buffalo	1	0.06			1	0.03	9	0.50	10	0.19
Quillback	14	0.83			14	0.40	1	0.06	15	0.28
River carpsucker	72	4.27	1	0.05	73	2.08	16	0.89	89	1.68
Carpsucker spp.	14	0.83			14	0.40			14	0.26
Shorthead redhorse	4	0.24	9	0.49	13	0.37	2	0.11	15	0.28
Golden redhorse	3	0.18			3	0.09			3	0.06
Channel catfish	27	1.60	106	5.82	133	3.79	21	1.17	154	2.90
Flathead catfish	4	0.24	79	4.34	83	2.37	22	1.22	105	1.98
Freckled madtom			1	0.05	1	0.03			1	0.02
Mosquitofish	15	0.89			15	0.43	40	2.22	55	1.04
White bass	30	1.78	13	0.71	43	1.23	3	0.17	46	0.87
Yellow bass			1	0.05	1	0.03			1	0.02
Black crappie	5	0.30			5	0.14	97	5.39	102	1.92
White crappie	2	0.12			2	0.06	20	1.11	22	0.41
Largemouth bass	35	2.08	4	0.22	39	1.11	65	3.61	104	1.96
Smallmouth bass			4	0.22	4	0.11			4	0.08
Warmouth	1	0.06			1	0.03	4	0.22	5	0.09
Green sunfish	51	3.02	5	0.27	56	1.60	2	0.11	58	1.09
Bluegill x Green sunfish	1	0.06			1	0.03			1	0.02
Bluegill	130	7.71	15	0.82	145	4.13	488	27.11	633	11.93
Orangespotted sunfish	56	3.32			56	1.60	166	9.22	222	4.18
Sauger	3	0.18			3	0.09	1	0.06	4	0.08
Logperch	1	0.06			1	0.03	1	0.06	2	0.04
Mud darter							1	0.06	1	0.02
Freshwater drum	136	8.06	43	2.36	179	5.10	46	2.56	225	4.24
Total No. collected	2435	144.37	1278	70.22	3713	105.88	1647	91.50	5360	101.01
No. Species collected	40		28		47		33		50	

Table 3. Summary of fishes collected with boat electrofishing at Cottonwood Island Chevron Dikes study area, 1993 - 1998.

	Chevrons				Control sites			
	Lower inside	Upper inside	Lower outside	Upper outside	Drift Is. Slough	Head of Bay Is.	MCB	All Stations
sampling effort (min)	85	168	100	173	270	20	20	836
Species								
Shortnose gar		4			3			7
Longnose gar					4			4
Bowfin					17			17
American eel				2				2
Skipjack herring		1				1		2
Gizzard shad	215	532	41	44	180	2	5	1019
Threadfin shad	1							1
Mooneye				3				3
Bighead carp	1				1			2
Goldfish		1						1
Carp	7	19	27	57	96	13	4	223
Central stoneroller				1				1
Suckermouth minnow	3	2						5
Silver chub		7	2	9	9			27
Spotfin shiner	52	27	57	105	3	4	3	251
Red shiner	1	5	5	10		7		28
Emerald shiner	119	208	194	319	1	14	3	858
Silverband shiner	1							1
River shiner	20	26	13	15			2	76
Bigmouth shiner				1				1
Sand shiner		6	1	13				20
Channel shiner	5	59	8	22	1	1	2	98
Spottail shiner		4						4
Shiner spp.		13						13
Bluntnose minnow	1	3		2	1			7
Bullhead minnow	114	298	7	14	36	3	1	473
Bigmouth buffalo	10	7			93	7		117
Smallmouth buffalo	27	31	8	17	197		2	282
Black buffalo	1				9	2		12
Quillback	5	9			1		1	16
River carpsucker	30	42		1	16		3	92
Carpsucker spp.		14						14
Shorthead redhorse		4	4	5	2	1	5	21
Golden redhorse	1	2					1	4
Channel catfish	8	19	56	50	21	4	2	160
Flathead catfish	3	1	27	52	22			105
Freckled madtom				1				1
Mosquitofish		15			40	1		56
White bass	14	16	5	8	3	3	1	50
Yellow bass			1					1
Black crappie	3	2			97	2		104
White crappie		2			20	1		23
Largemouth bass	11	24		4	65	3		107
Smallmouth bass			1	3				4
Warmouth		1			4			5
Green sunfish	4	47		5	2			58
Bluegill x Green sunfish		1						1
Bluegill	23	107	4	11	488	8	1	642
Orangespotted sunfish	23	33			166	3		225
Sauger		3			1			4
Logperch		1			1			2
Mud darter					1			1
Freshwater drum	39	97	18	25	46	2	4	231
Total number fish collected	742	1693	479	799	1647	82	40	5482
Number of species collected	28	36	19	27	33	20	16	50

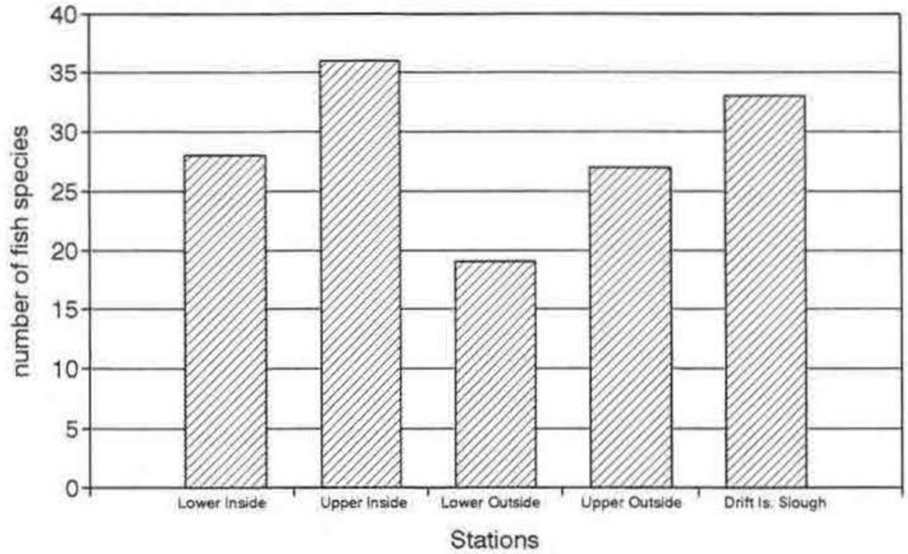


Figure 1. Total number of fish species collected with electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

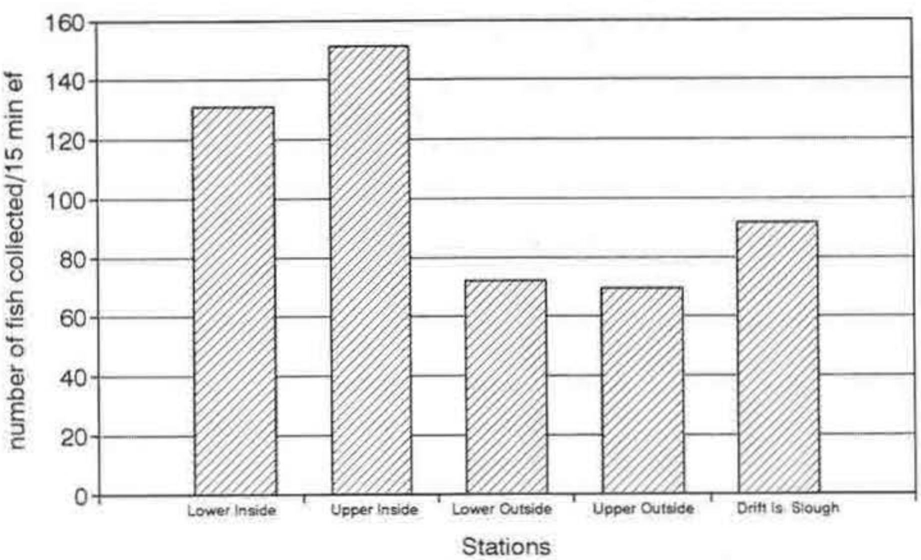


Figure 2. Total number of fish collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

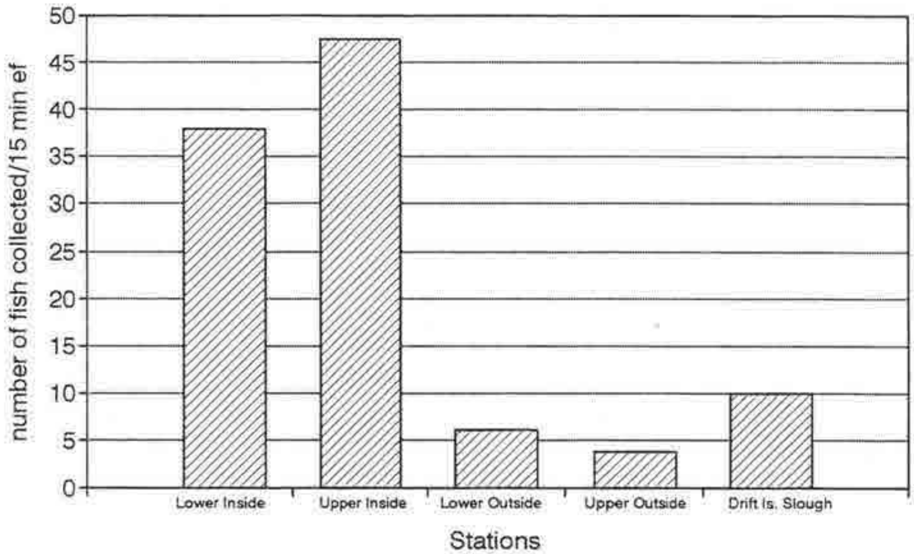


Figure 3. Total number of gizzard shad collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

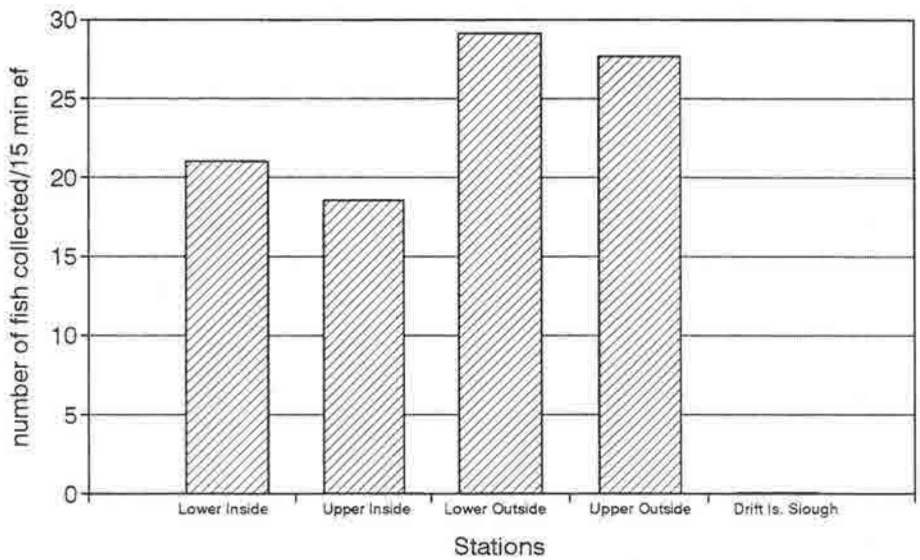


Figure 4. Total number of emerald shiner collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

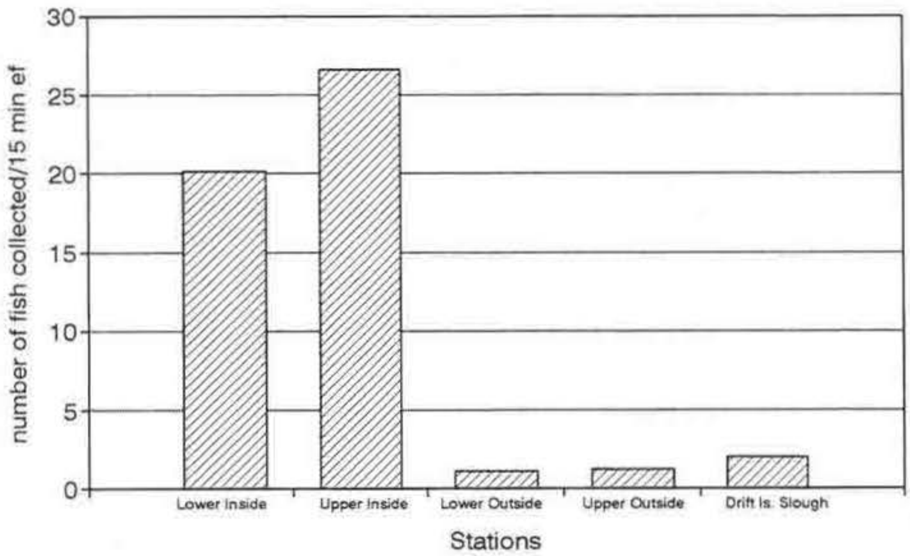


Figure 5. Total number of bullhead minnow collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

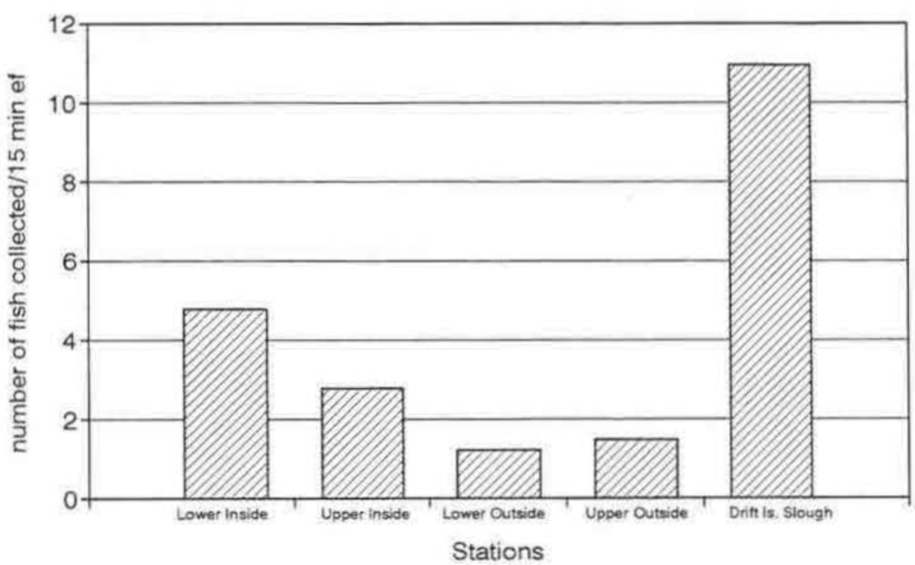


Figure 6. Total number of smallmouth buffalo collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

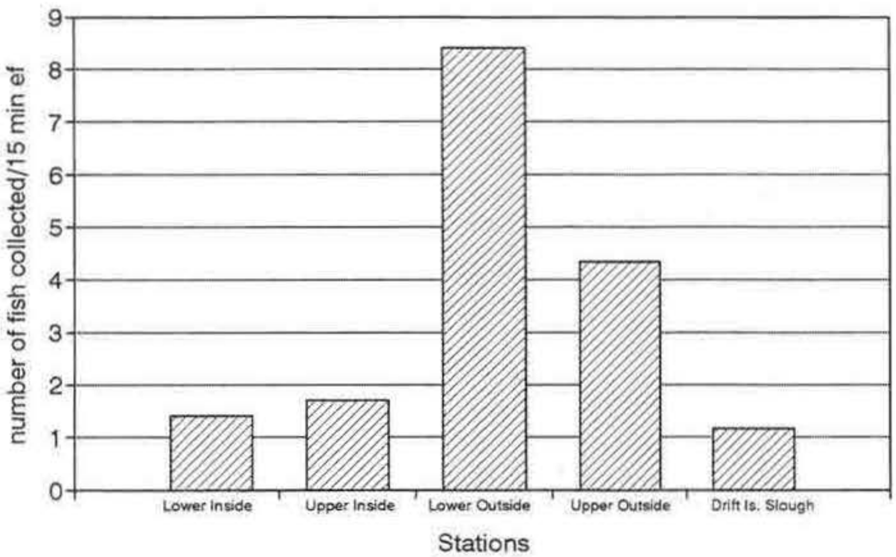


Figure 7. Total number of channel catfish collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

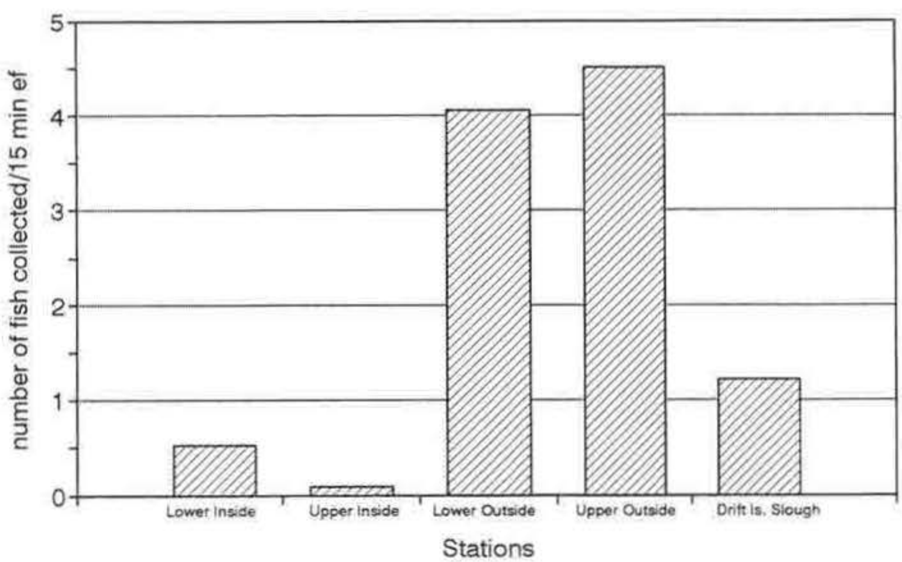


Figure 8. Total number of flathead catfish collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

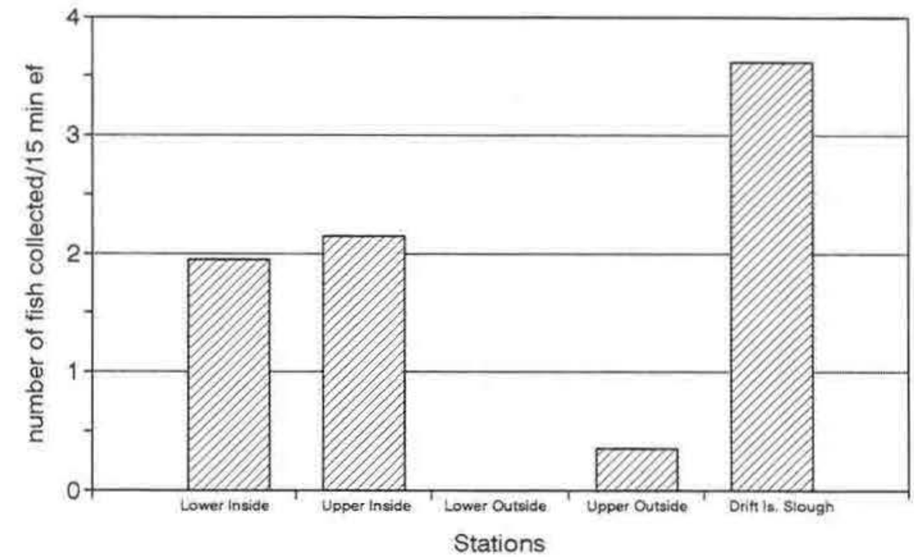


Figure 9. Total number of largemouth bass collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

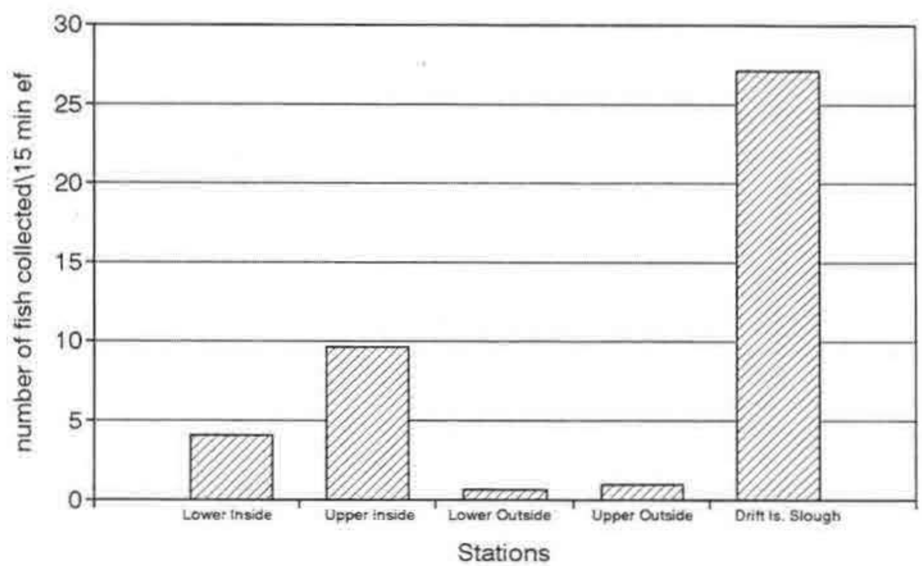


Figure 10. Total number of bluegill collected per 15 min of electrofishing at Cottonwood Island chevron dikes and Drift Island Slough.

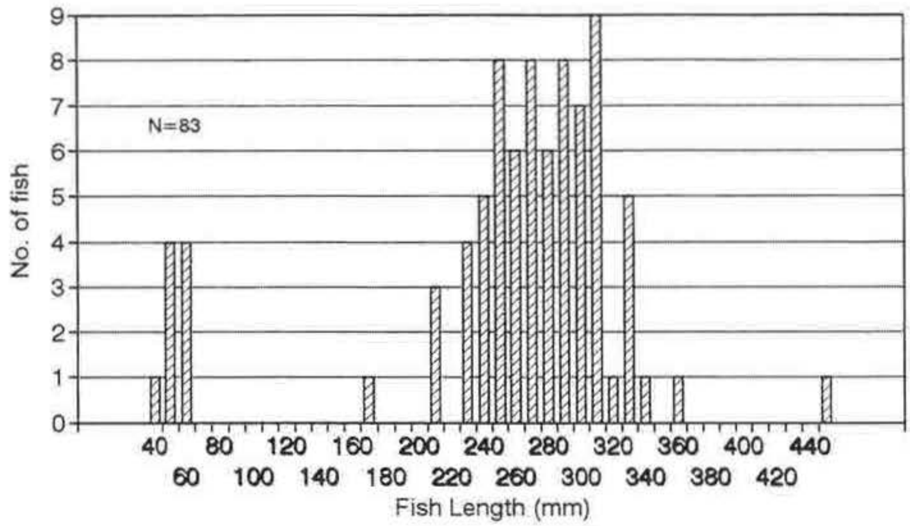


Figure 11. Length frequency of smallmouth buffalo collected inside and outside of Cottonwood Island chevron dikes, 1993 - 1998.

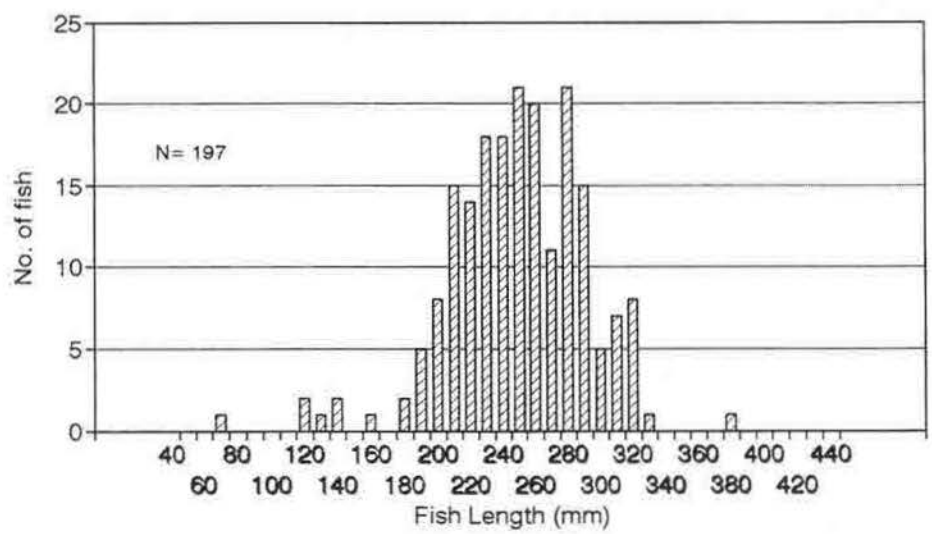


Figure 12. Length frequency of smallmouth buffalo collected at Drift Island Slough, 1993 - 1998.

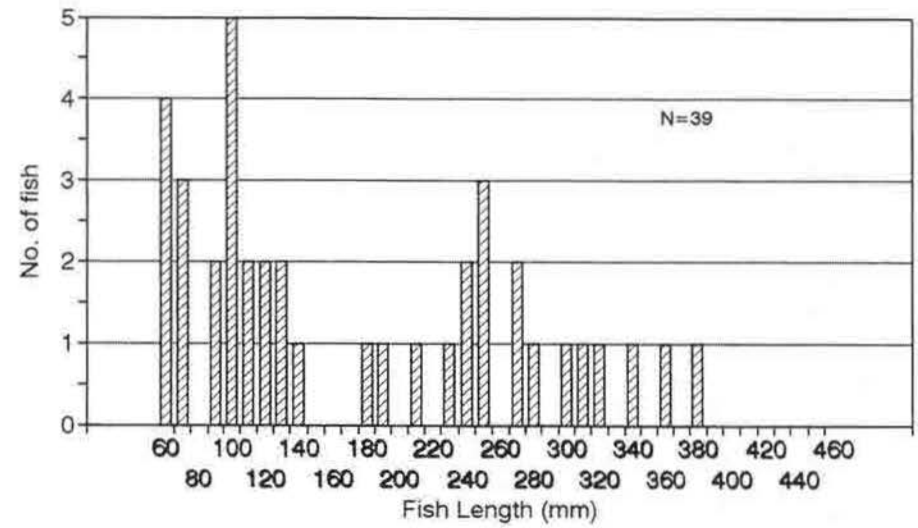


Figure 13. Length frequency of largemouth bass collected inside and outside of Cottonwood Island chevron dikes, 1993 - 1998.

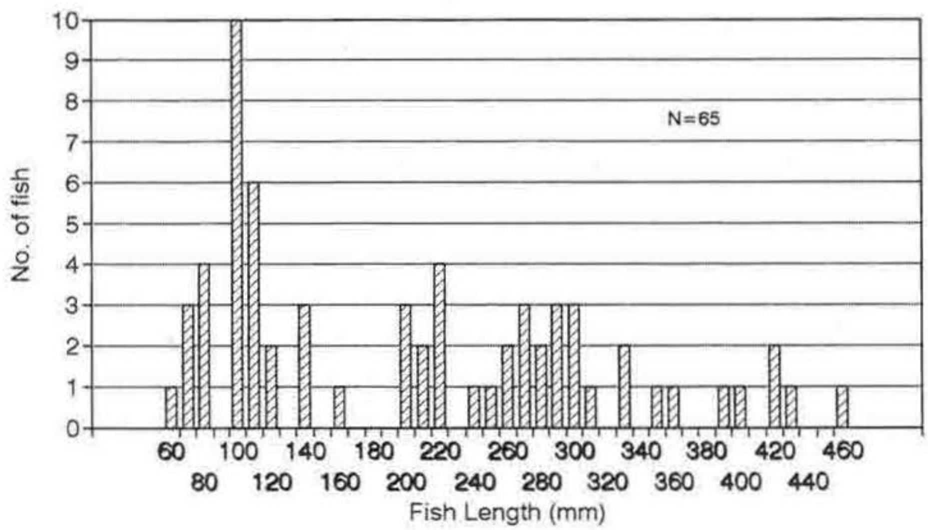


Figure 14. Length frequency of largemouth bass collected at Drift Island Slough, 1993 - 1998.

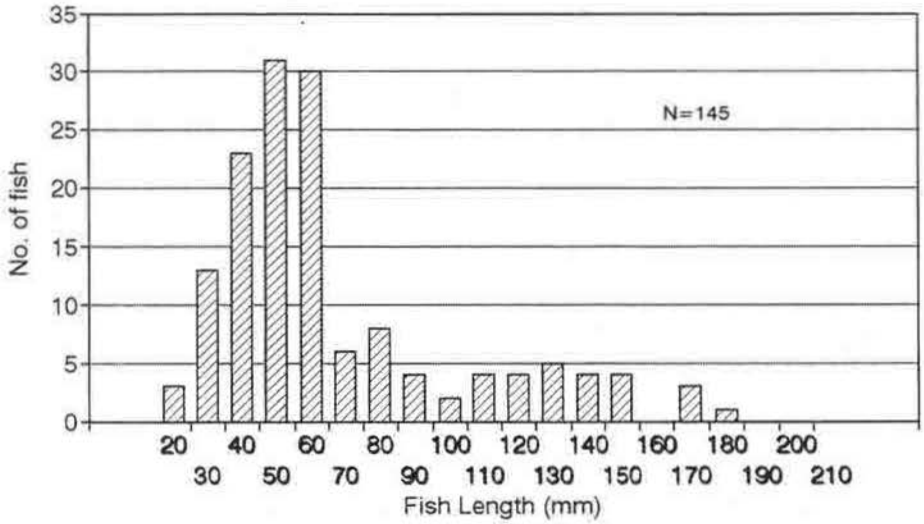


Figure 15. Length frequency of bluegill collected inside and outside at Cottonwood Island chevron dikes, 1993 - 1998.

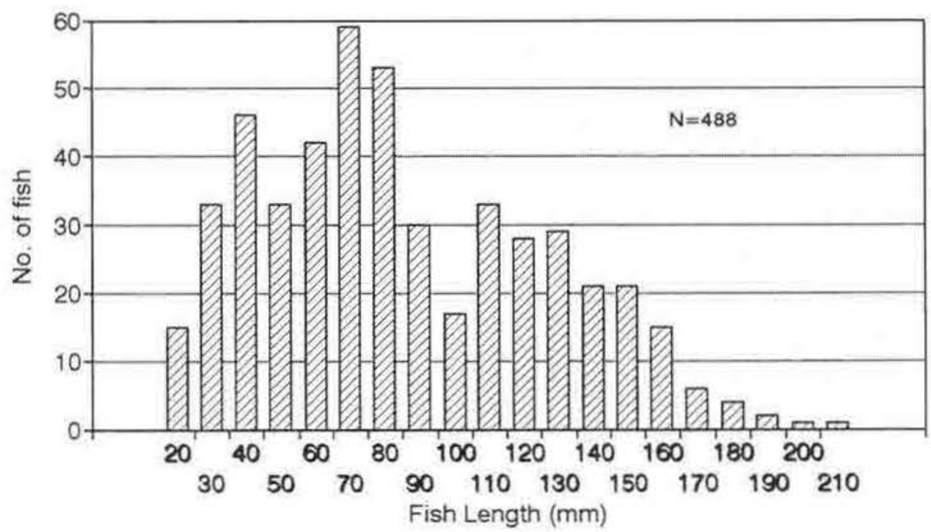


Figure 16. Length frequency of bluegill collected at Drift Island Slough, 1993 - 1998.

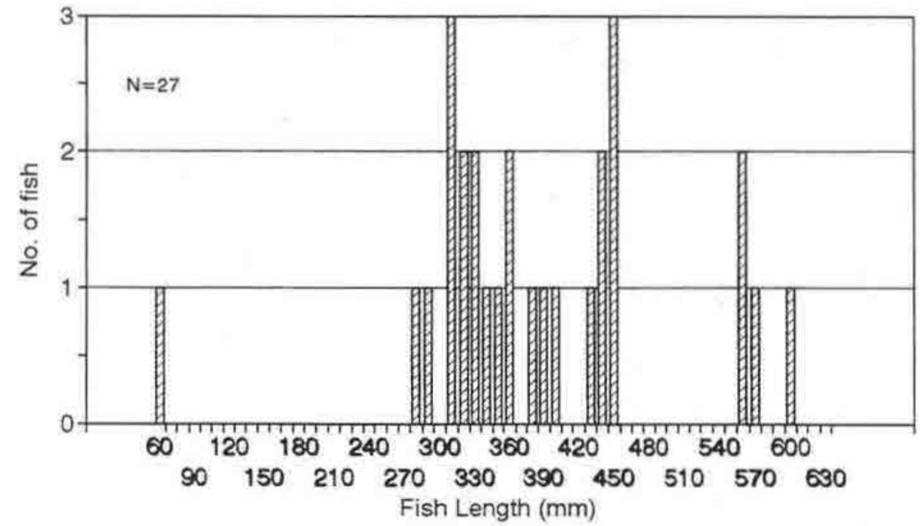


Figure 17. Length frequency of channel catfish collected inside at Cottonwood Island chevrons, 1993 - 1998.

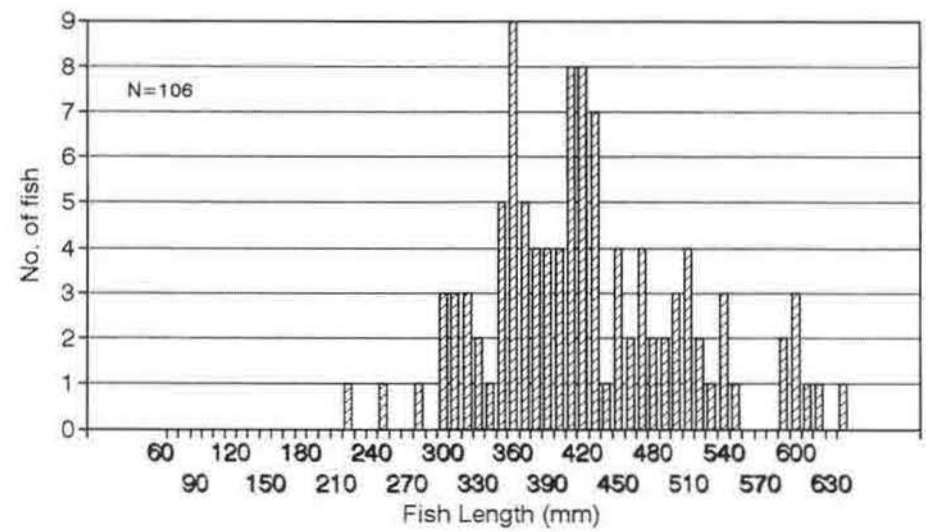


Figure 18. Length frequency of channel catfish collected outside at Cottonwood Island chevrons, 1993 - 1998.

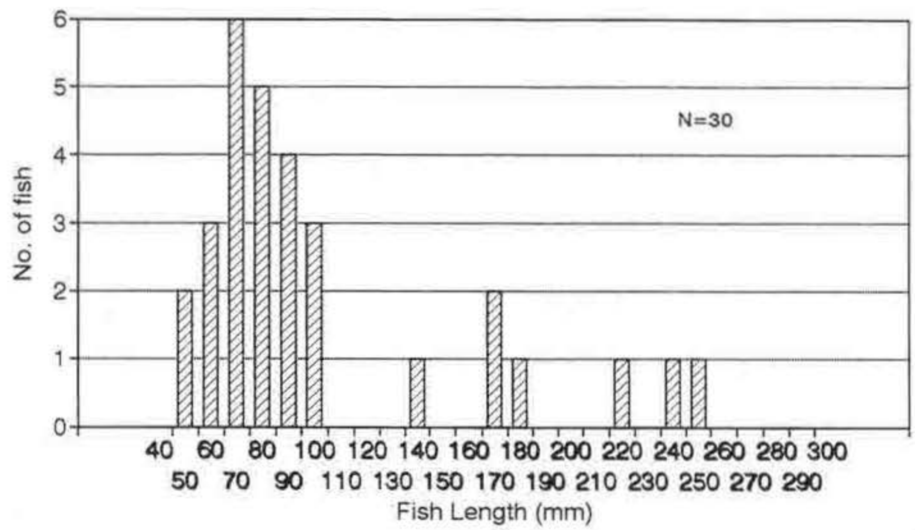


Figure 19. Length frequency of white bass collected inside at Cottonwood Island chevrons, 1993 - 1998.

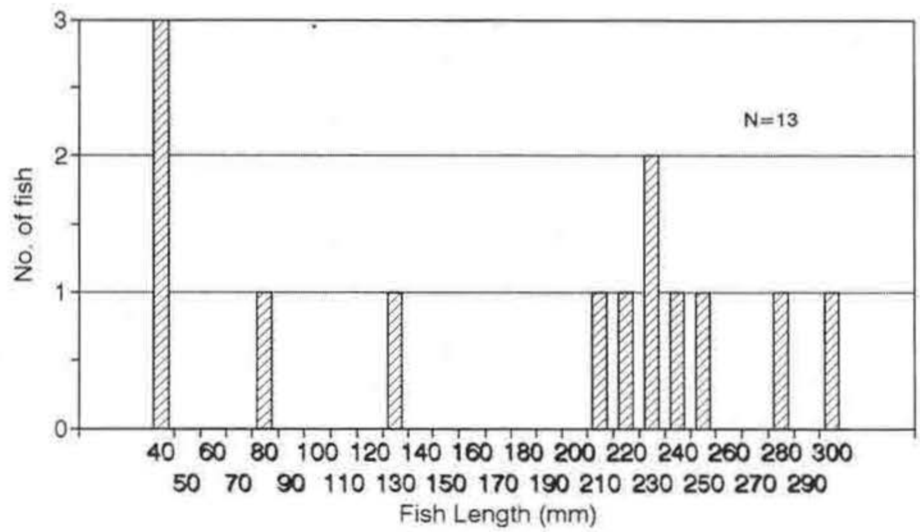
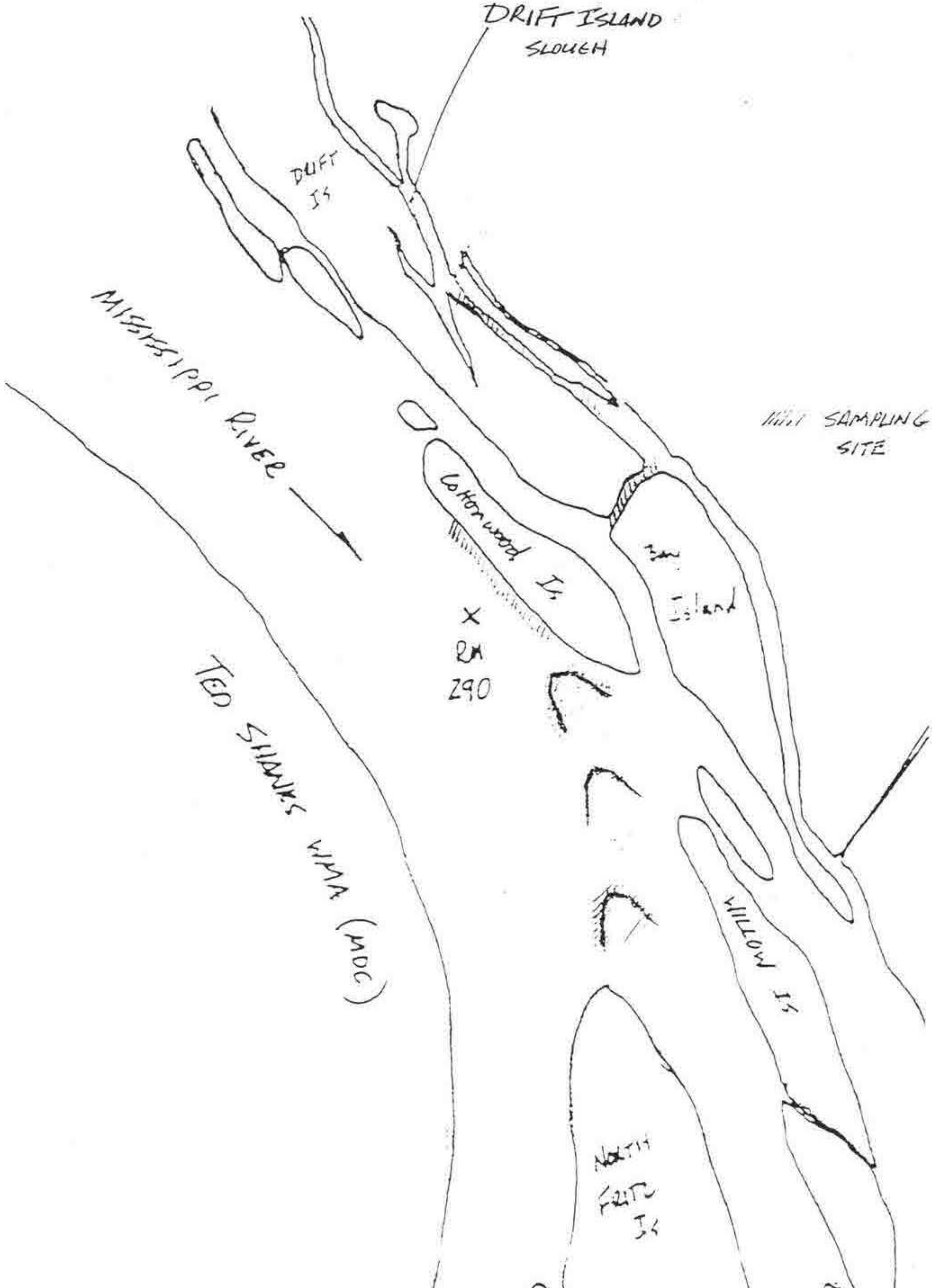
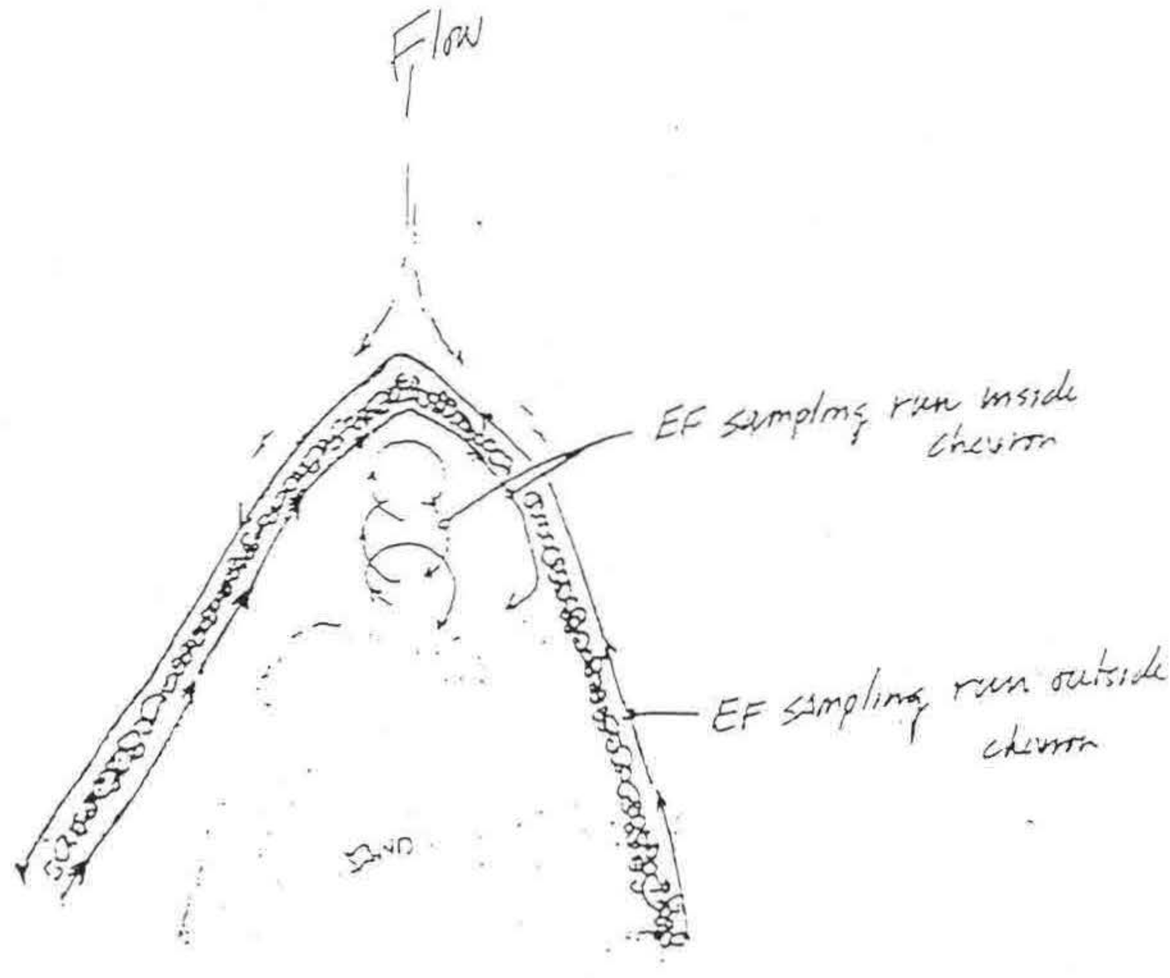


Figure 20. Length frequency of white bass collected outside at Cottonwood Island chevrons, 1993 - 1998.

SKETCH OF COTTONWOOD ISLAND CHEVRON DIKE STUDY AREA



SKETCH OF TYPICAL CHEVRON EF RUNS



Multiple Round Point Structures
Preliminary Fisheries Evaluation

Prepared for:
U.S. Army Corps of Engineers
St.Louis District

Prepared by:
Elmer R. Atwood
Illinois Department of Natural Resources
Fisheries Division
Boundary River Program

December 1998

Introduction

The Illinois Department of Natural Resources, Division of Fisheries, Boundary Rivers Program conducted fish sampling with A.C. electrofishing (EF) on the Multiple Round Point Structures constructed by the St. Louis District, Corps of Engineers at Mississippi River mile 256.6L, on August 8 (22 min) and October 15, 1998 (15 min). The sampling was conducted in order to obtain preliminary information on the composition of fishes utilizing these structures.

Methods

The electrofishing (ef) unit and the sampling methodology used in this sampling effort is the same as that used in the chevron dike study. Each sampling run involved electrofishing around each of the six round points and collecting all fish stunned within the range of the dip net and circling around in attempt to capture stunned fishes originally out of range.

Results and Discussion

A total of 148 fish representing 9 species (60 fish/15min ef) were collected on the two sampling runs (37 minutes total) [Table 1]. Gizzard shad and emerald shiner were the most frequently collected species, followed by flathead catfish and channel catfish.

The length frequency distributions of the flathead and channel catfishes collected in the preliminary sampling effort indicate that both young of year and older individuals of these species are utilizing these structures (Figures 1 and 2).

A notable species collected in this effort is the blue sucker. This big river species is presently uncommon in the Mississippi River and is considered a species of special concern by state and federal natural resources agencies. The collection of a blue sucker on each of the two sampling runs (664mm-2900g on the first run and 500mm-1030g on the second) may indicate that these fishes are seeking the habitat conditions provided by these structures.

Conclusion

The data collected in this preliminary evaluation suggest that multiple round point structures are providing useful and valuable habitat for a variety of riverine fishes. Collection of blue suckers may indicate these structures are providing a unique habitat type, once more common in the river.

Table 1. Composition of fishes collected with A.C. electrofishing at Pool 25 Multiple Round Point Structures, 1998.

Species	Number	No./15min ef
Gizzard shad	52	21.08
Carp	4	1.62
Emerald shiner	49	19.86
Smallmouth buffalo	4	1.62
Blue sucker	2	0.81
Shorthead redhorse	5	2.03
Channel catfish	8	3.24
Flathead catfish	19	7.70
Freshwater drum	5	2.03
Totals	148	60.00

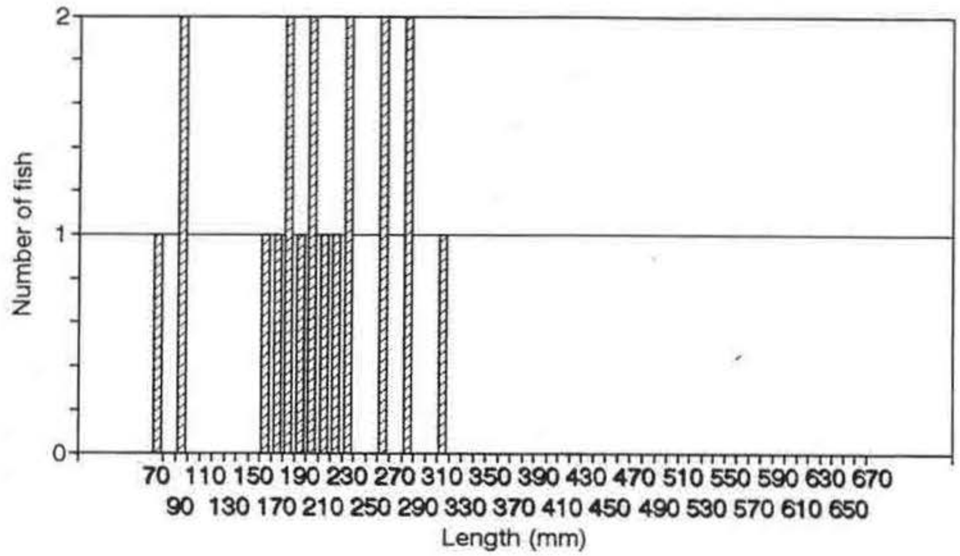


Figure 1. Length frequency distribution of flathead catfish collected at the multiple round point structures at R.M. 265.6, Mississippi River, Pool 25, 1998.

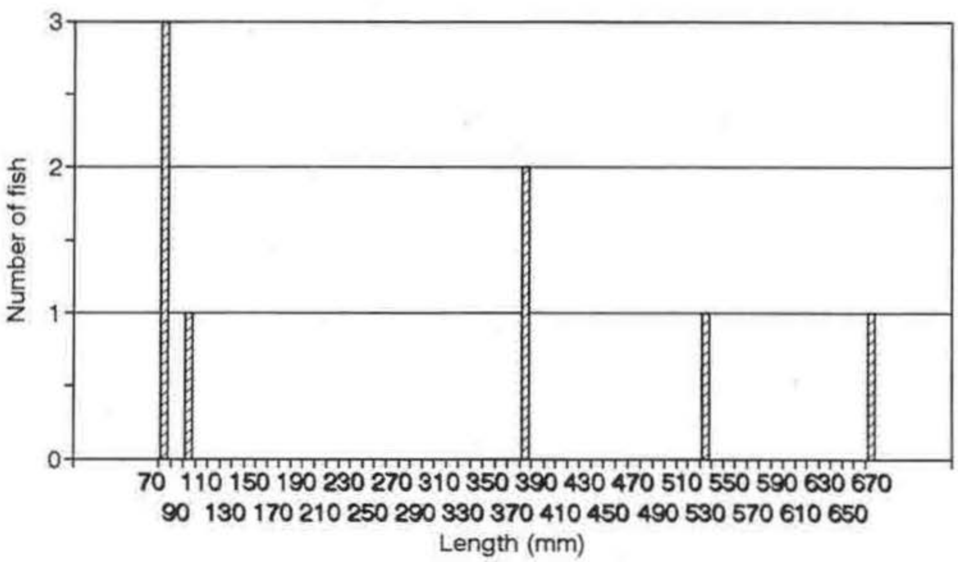
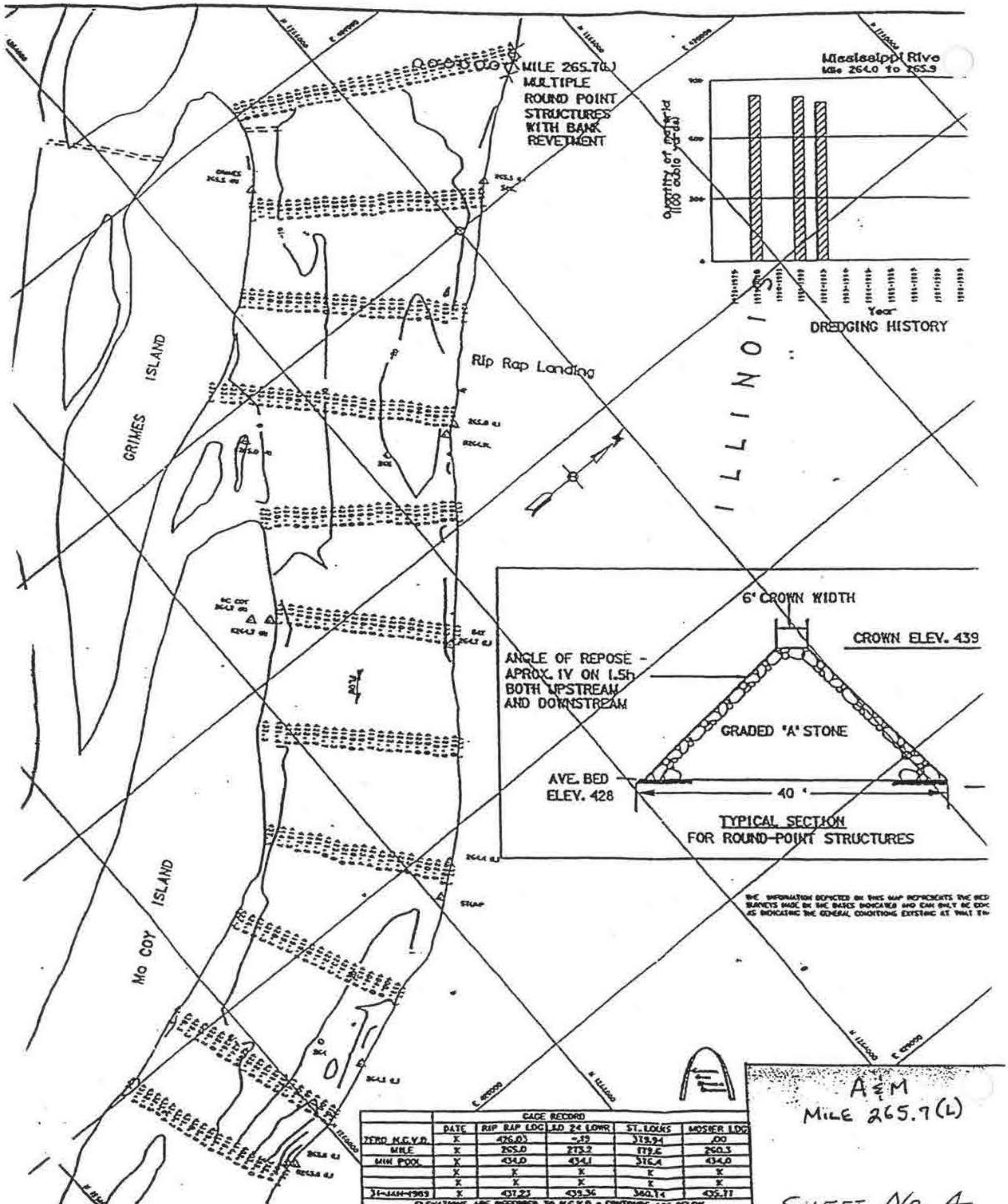


Figure 2. Length frequency distribution of channel catfish collected at the multiple round point structures at R.M. 265.6, Mississippi River, Pool 25, 1998.

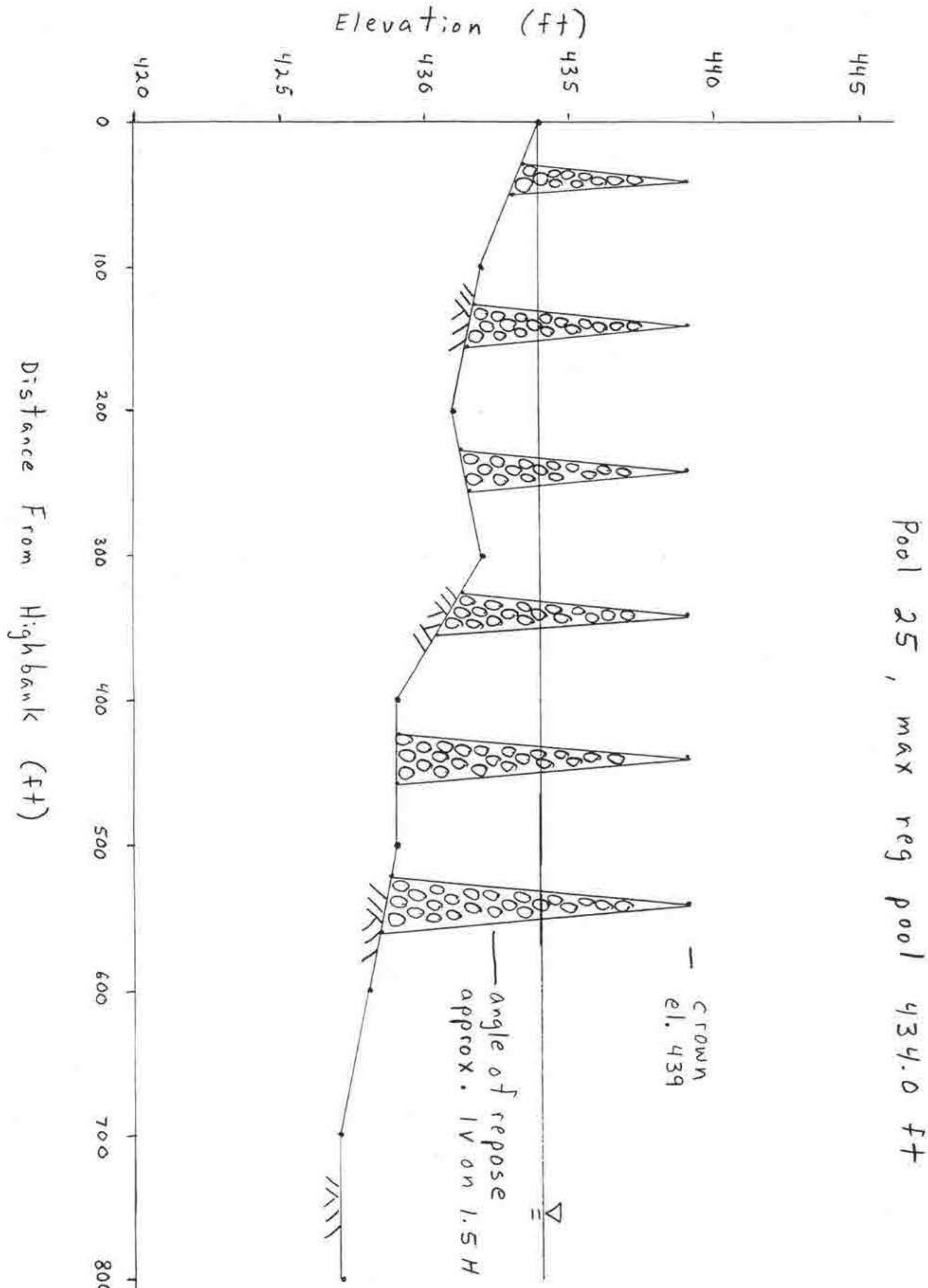


	GAGE RECORD				
	DATE	RIP RAP LDG	LD 24 LOWR	ST. LOUIS	MOSIER LDG
ZERO N.G.V.D.	X	426.03	-.39	379.94	.00
MILE	X	265.0	273.2	179.6	260.3
MIN POOL	X	434.0	434.1	376.4	434.0
	X	X	X	X	X
	X	X	X	X	X
31-JAN-1989	X	437.23	439.36	380.14	435.77

A&M
MILE 265.7(L)

SHEET No. 4

PROJECT Round Point Structure Dike	Page __ of __	COMPUTED BY LLH	DATE 8 Jan 1999
SUBJECT MRM 265.7 (L)		CHECKED BY	DATE



APPENDIX C

1). Memo--Bolters Bar Micro Model.

2). Bolters Bar Area Map of Differences of Deposition and Degradation between the Base Test (Existing Conditions) and Plan I. Existing Dikes on Illinois Bank are to be Removed and Deflection Dike and Four Chevron Dikes are to be Constructed on the Missouri Bank. Model reveals that Degradation now Occurs in the Channel with the Training Structures in Place.

3). Map of Bolters Bar Reach and Scouring of Channel with the Training Structures in Place.

Gordon, David MVS

From: Gordon, David MVS
Sent: Tuesday, January 19, 1999 3:33 PM
To: Yarbrough, Ronald E MVS
Cc: Davinroy, Robert D MVS
Subject: Bolters Bar Micro Model

Ron,

I am mailing you the resultant bed configuration survey of the alternative we are proposing. The bathymetry shows a realigned navigation channel with primary contours. The following is a description of the alternative chosen:

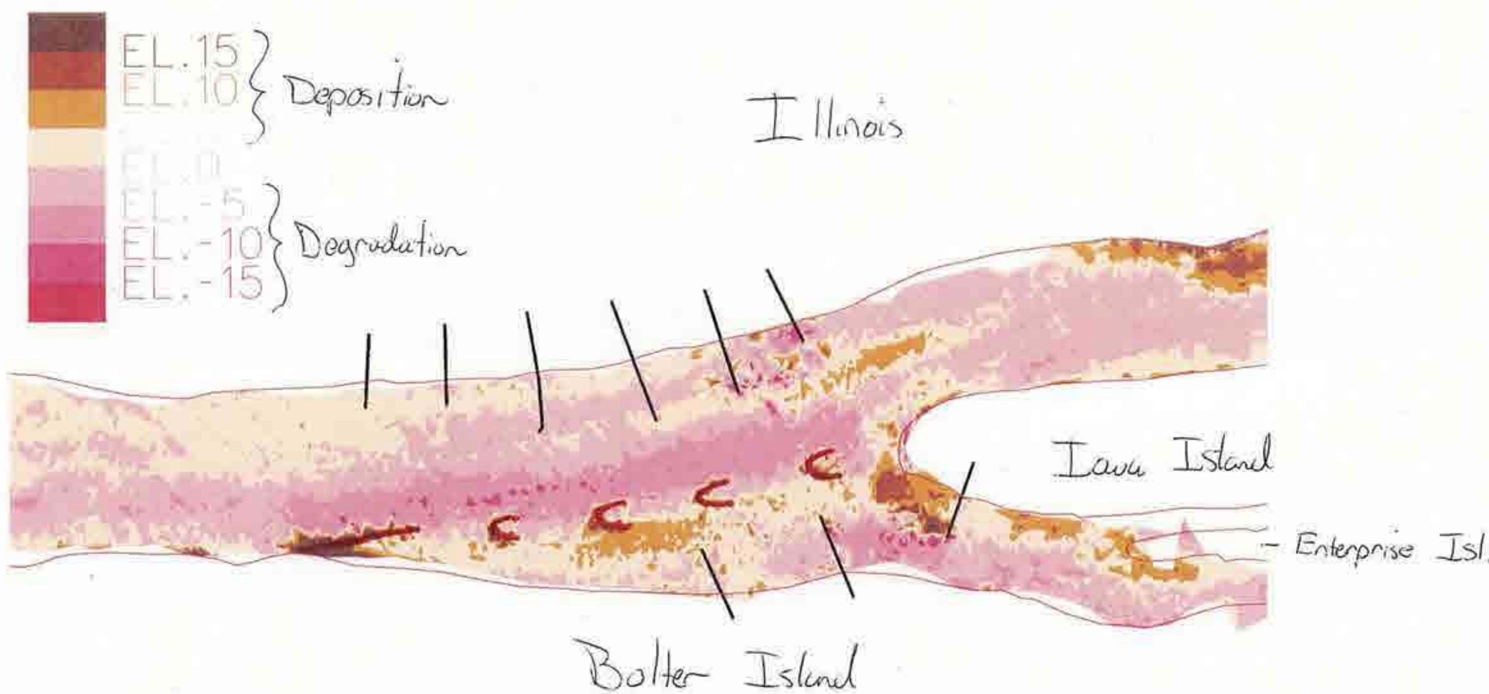
- Removed the remnants of dikes 226.0L, 225.8L, 225.6L, and 225.4L.
- Added a 1200' deflector/longitudinal dike near mile 226.2R
- Added 4 chevrons; each with a length of 270' and width of 200' near miles 225.7R, 225.R, 225.3R, and 225.1R
- Raised and notched closure 226.3R (this has already been completed as part of another job)

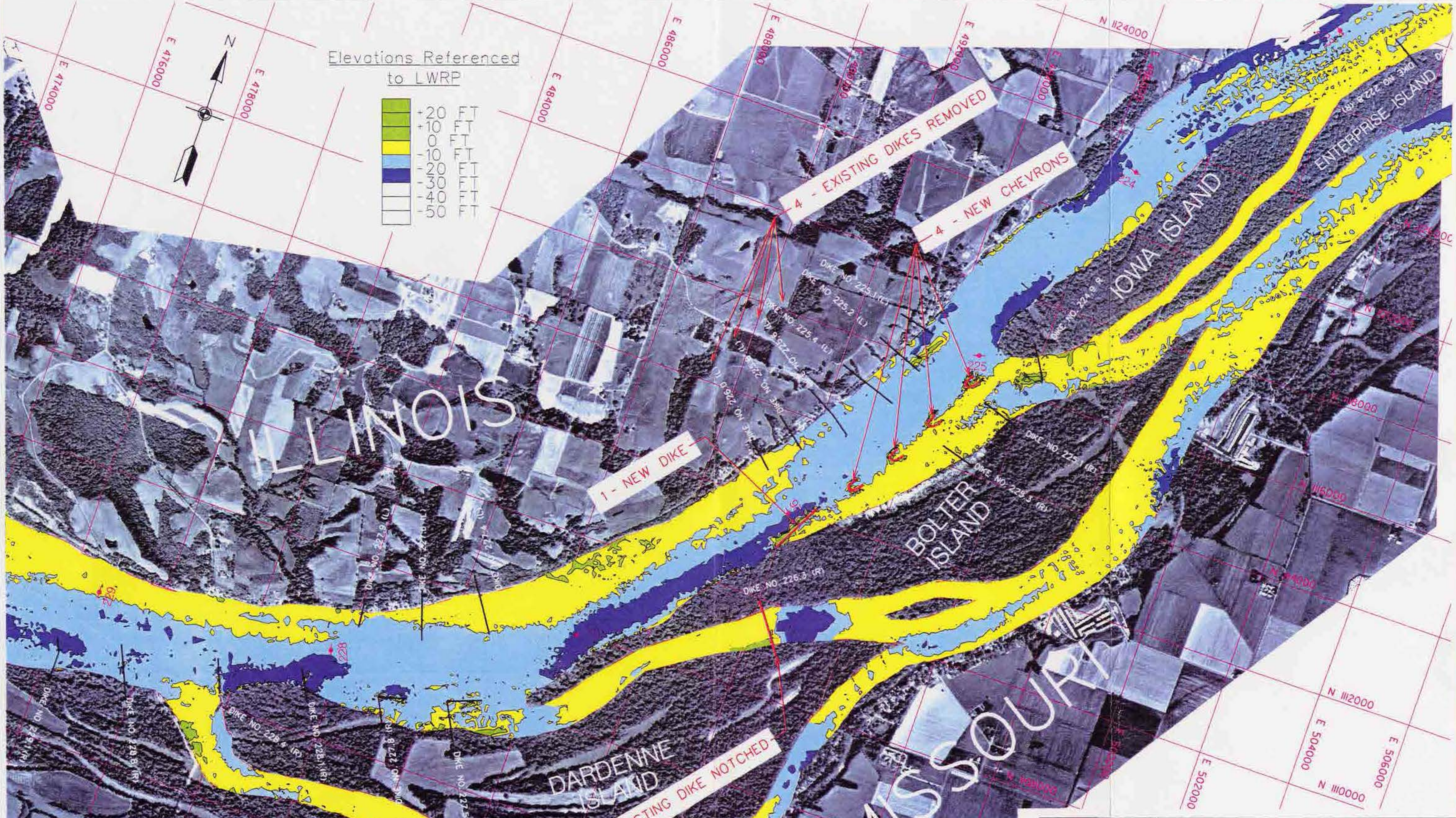
I am also including a difference plot of the area in question. This survey shows where both deposition and degradation occurred in the alternative as compared to the base test. This survey shows that some deposition occurred along the right descending bankline while degradation occurred throughout the middle of the navigation channel. It also showed that the chute between Iowa and Bolter Islands remained relatively unchanged.

Call me if you have any questions.

Dave Gordon
263-4230

Difference Map - Between Base Test + Plan I





U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. GORDON
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

DATE: JANUARY 1999

Bolter Bar / Iowa Island Micro Model Study
Upper Mississippi River Miles 230 - 223

ALTERNATIVE I

2000 1000 0 2000

DESIGN FILE: BTESTLOCH

PLOT SCALE: 2000

PLOT DATE: X

PLATE NO.

APPENDIX D

1). Tow Waiting Time Study

Tow Waiting Time Study

Avoid & Minimize Program

INTRODUCTION

The Tow Waiting Time Study identifies and evaluates non-structural alternatives (i.e., small scale improvement measures) for both their systemic impact on the river environment and their reduction of tow waiting times at lock facilities on the Upper Mississippi River (UMR) System. Small scale measures are defined as either structural or non-structural alternatives not requiring large capital outlays. Tow waiting time at locks, also known as delay time, results in higher transportation costs and environmental degradation both above and below the locks. Waiting time is due to congestion of tows, which largely originates from tow traffic volume or operation issues with the locks. In concurrence with the purpose and scope of the Avoid & Minimize (A&M) Program, small scale measures selected for possible implementation would not only reduce tow waiting times but also avoid and minimize negative environmental impacts on the UMR System. A more efficient and environmentally sensitive river traffic system will result in less waiting time for tow movements and, therefore, less environmental damage. The Tow Waiting Time Study is listed as A&M Measure B-8: *Develop Non-Structural Alternatives to Reduce Tow Waiting Times*, from Design Memorandum No. 24, Avoid and Minimize Measures (October 1992).

The study complements and incorporates the parallel work of the Upper Mississippi River and Illinois Waterway (UMR-IWW) System Navigation Study. Corps and Industry A&M Team members are consulted throughout the study. This includes members of the UMR Corps Districts, UMR Lock Operations, Towing Industry, U.S. Coast Guard, Missouri Department of Conservation, Illinois Department of Conservation, and the U.S. Fish and Wildlife Service. Their contribution and analysis is critical in evaluating small scale measures which reduce tow waiting times while improving or maintaining environmental standards. Additional study sources include existing Corps studies, Lock Performance Monitoring System (LPMS) data, interviews and expert elicitation.

EVALUATION PROCESS

Potential small scale measures are identified and evaluated for possible implementation through the following steps:

1. Identification of all potential small scale measures, both structural and non-structural
2. Qualitative evaluation and screening of all potential small scale measures
3. Quantify environmental, lockage time, and safety benefits for remaining non-structural measures
4. Quantify implementation costs for remaining non-structural measures
5. Quantify benefits and costs for remaining non-structural measures
6. Conclusion and recommendation for remaining non-structural measures

The Corps of Engineers Planning Guidance (ER 1105-2-100, 28 December 1990) defines four decision criteria that are applicable to the evaluation of all Corps projects. These criteria are Completeness, Effectiveness, Efficiency and Acceptability. Additional criteria, consistent with the Planning Guidance, were developed by the UMR-IWW Navigation Study team to qualitatively evaluate the measures most appropriate for further analysis within the scope of the Navigation Study. Qualitative evaluation based on these criteria was employed for this study.

The additional criteria are defined as follows:

1. **Environmental Impacts:** POSITIVE impact if there are environmental benefits or no negative environmental impacts; NEGATIVE impact if there are negative environmental impacts.

2. **Cost:** POSITIVE impact if the measure is relatively inexpensive to purchase, construct or maintain; NEGATIVE impact if the measure is relatively expensive to purchase, construct or maintain.

3. **Time Savings:** POSITIVE impact if the measure shortens lockage time; NEGATIVE impact if the measure does not shorten lockage time.

4. **Implementation:** POSITIVE impact if there are no barriers to industry acceptance or if industry supports the measure; NEGATIVE impact if industry does not support the measure.

5. **Safety:** POSITIVE impact if the measure increases safety; NEGATIVE impact if the measure reduces safety.

6. **Technical Feasibility:** POSITIVE impact if current technology is available; NEGATIVE impact if current technology is not available or significant technological advancements are required.

7. **Industry Cooperation:** Whether the small scale measure should be pursued through industry cooperation rather than through Corps requirements.

8. **Operations and Maintenance Program:** Whether the small scale measure should be addressed through the Corps of Engineers' Operations and Maintenance (O&M) Program.

The Report for the Upper Mississippi River and Illinois Waterway (UMR-IWW) System Navigation Study: General Assessment of Small Scale Measures was instrumental in evaluating potential small scale measures. The September 1994, December 1994 and June 1995 Reports are used. All potential small scale measures are identified and categorized under the following: Scheduling of Lock Operations, Assistance to Lockages, Improvements to Approach Channels, Area-wide Channel Improvements, Tow Configuration and Operations, Lock Operating Equipment and Procedures, Ice Conditions, Recreational Vessels, Cost Allocation and Other Measures (see TABLE 1).

The potential small scale measures listed in TABLE 1 are qualitatively screened through the criteria as well as through the definitive contributions of pertinent Corps, Environmental and Industry disciplines. After this qualitative screening, the thirteen remaining measures are warranted for further quantitative evaluation. These remaining measures and their criteria evaluations are shown in TABLE 2. A PLUS "+", indicating a Positive Impact; a MINUS "-", indicating a Negative Impact; NO MARK ( ), indicating a Neutral Impact or combinations of these indicators are assigned to each criteria for each designated measure. The measures are ranked according to positive potential Environmental Impacts and positive potential Time Savings.

US Army Corps of Engineers

TABLE 1

FIGURE VI-2
SMALL SCALE MEASURE SCREENING

No.	Description	No Delay Reduction	Not Technically Feasible	Not Safe	Not Environ. Acceptable	Economically Inefficient	Not Cost Effective	Industry Cooperation	Corps O&M Program	Recommended
1a.	N-up/N-Down								✘	
1b.	Ready to Serve Policy						✘			
1c.	Self Help Policy									✔
1d.	Scheduling Program									✔
2a.	Helper Boats									✔
2b.	Switchboats									✔
2c.	Endless Cable System w/Extended Guidewalls									✔
2d.	Unpowered Traveling Kevel								✘	
2e.	Powered Traveling Kevel w/Extended Guidewalls									✔
2f.	Hydraulic Assistance								✘	
3a.	Approach Channel Widening/Realignment						✘			
3b.	Adjacent Mooring Facilities									✔
3c.	Funnel-Shaped Guidewalls					✘				
3d.	Wind Deflectors					✘				
3e.	Extend Guidewalls									✔
3f.	Add Guide Cells	✘								
3g.	Reconfigure Bullnose	✘								
3h.	Radar Reflectors	✘								
3i.	Electronic Guidance System					✘				
4a.	Remove/Adjust Bends, One-way Reaches, Bridges	✘								
4b.	Improve Navigation Aids and Channel Markings	✘								
4c.	Innovative Dredging Strategies	✘								
4d.	Water Flow Management Policies	✘								
4e.	Increase Channel Width	✘								
4f.	Isolate Recreational Facilities & Marinas Away from Channel	✘								
4g.	Improve Bridge Operations & Maintenance	✘								
4h.	Dual Channel at Restrictive Bridges	✘								
5a.	Mandate Use of Bow Thrusters						✘			
5b.	Mandate Use of Prototype Bow Thrusters						✘			
5c.	Tow Size Standardization							✘		

TABLE 1

No.	Description	No Delay Reduction	Not Technically Feasible	Not Safe	Not Environ. Acceptable	Economically Inefficient	Not Cost Effective	Industry Cooperation	Corps O&M Program	Recommended
5d.	Cooperative Equipment Sharing/Scheduling							✘		
5e.	Institute Waterway Traffic Management							✘		
5f.	Increase Number and Size of Fleeting Areas	✘								
5g.	Fuel Monitoring & Management	✘								
5h.	Use of Heavy Fuels	✘								
5i.	New Barge and Boat Bottom Treatments	✘								
5j.	Improved Barge and Boat Hull Designs	✘								
5k.	Barge Stacking for Backhauls							✘		
5l.	Container Movement	✘								
5m.	New Backhaul Opportunities	✘								
5n.	Universal Couplers/Hand Winches									✔
5o.	Increase Speed Limits in Restricted Reaches	✘								
5p.	Reduce Liability of Tow Operators for Damage	✘								
5q.	Require Minimum Crew Size and Training									✔
5r.	Mandate Minimum Horsepower							✘		
6a.	Modify Intake Structures					✘				
6b.	Modify Discharge Structures					✘				
6c.	Modify Wall Ports					✘				
6d.	Install Self-Cleaning Trash Racks								✘	
6e.	Centralize Controls								✘	
6f.	Portable Controls								✘	
6g.	Automate Controls								✘	
6h.	Install Floating Mooring Bits	✘								
6i.	Upgrade Valve Operating Equipment								✘	
6j.	Upgrade Gate Operating Equipment								✘	
6k.	Install Gate Wickets in Miter Gates			✘						
6l.	Provide Explicit Operating Guides								✘	
6m.	Fenders, Energy Absorbers	✘								
6n.	Require Vessels to Stay Clear of Emptying/Filling System	✘								
6o.	Operate Dam Gates Based on Lockage								✘	
6p.	Lift Gates at Lock					✘				
7a.	Mechanical Ice Cutting Device								✘	

TABLE 1

No.	Description	No Delay Reduction	Not Technically Feasible	Not Safe	Not Environ. Acceptable	Economically Inefficient	Not Cost Effective	Industry Cooperation	Corps O&M Program	Recommended
7b.	Skin Plates								✘	
7c.	Air Bubbler System								✘	
7d.	Heat Plates								✘	
7e.	Heated Water Jet								✘	
7f.	Clear Ice from Barges		✘							
7g.	Ice Chutes					✘				
8a.	Recreational Vessel Bypass Lifts					✘				
8b.	Scheduling of Recreational Vessel Usage									✔
8c.	License Recreational Craft Operators	✘								
8d.	Recreational Craft Landing Above and Below Lock									✔
9a.	Apply Congestion Tolls									✔
9b.	Allocation of Operations and Maintenance Costs	✘								
9c.	Low Head Hydroelectric Units	✘								
9d.	Privatization of Lock Operations	✘								
9e.	Excess Lockage Time Charges									✔
9f.	Lockage Time Charges									✔
10a.	Increase Lock Staffing	✘								
10b.	Automate Dam Controls	✘								
10c.	Radar at Lock	✘								
10d.	Real-Time Channel Depth and Weather Monitoring	✘								
10e.	Improved Lighting								✘	
10f.	Publish Lockage Times by User									✔
10g.	Create Indraft		✘							
10h.	Operational Philosophy / Industry Attitude							✘		
10i.	Deepen River Upstream of Gates				✘					
10j.	Pilot Communication (Bulletin Board)	✘								
10k.	Closed Circuit Television (CCTV) at Lock	✘								
10l.	Wicket Gates in Dam									✔ Included in Large Scale Assessment
10m.	Automated Lockage System from Queue		✘							
10n.	Specified Navigation Season	✘								

TABLE 2
Small Scale Measure Evaluation*

	Measure Description	Environmental Impacts	Cost	Time Savings	Implement-ability	Safety	Technical Feasibility
1.	Fenders / Energy Absorbers	+	( )	+ , ( )	+	- , ( )	( )
2.	**Electronic Guidance System** **	+	-	+	( )	+	-
3.	Modify Intake Structures	+ , -	-	+	-	-	-
4.	Modify Discharge Structures	+ , -	-	+	-	- , ( )	( )
5.	Modify Wall Ports	+ , -	-	+	-	+	+
6.	Add Guide Cells	+ , ( )	+	+	+	+	+
7.	Ice Chutes	+	-	( )	+	( )	+
8.	**License Recreational Craft Operators**	+	-	+ , ( )	-	+	+
9.	**Improve Navigational Aids and Channel Markings**	+	+	+ , -	( )	+	+
10.	Install Floating Mooring Bits	+	+	+ , -	+	+	+
11.	**Real-Time Channel Depth and Weather Monitoring**	+	( )	-	+	+	+
12.	**Allocation of Operations and Maintenance Costs**	+	-	-	-	( )	+
13.	Low Head Hydroelectric Generators	+ , -	-	-	-	( )	-

* "+" = Positive Impact
"-" = Negative Impact
"( )" = Neutral Impact

** Non-structural measures in Bold

ENVIRONMENTAL EVALUATION

Since the key element of the study is the environmental impact of all potential measures, a quantitative environmental assessment is the next step in the evaluation process. The measures consist of construction, non-construction, site specific and system-wide measures. Since the manner in which the measures could potentially benefit natural resources is so varied, a measure to measure quantitative comparison would be inconclusive. Therefore, Environmental Team members quantitatively evaluated the remaining measures based on their determined natural resource benefits to a spectrum of critical environmental evaluation parameters. TABLE 3 defines the environmental parameters and the seven-point rating scale for each parameter.

TABLE 4 briefly defines each remaining measure and identifies the spectrum of environmental parameters. A panel of Environmental Team members rated the remaining measures against each parameter using the rating scale defined in TABLE 3. Some Environmental Team members were more stringent in their parameter rating assessments. Albeit strict or more conservative ratings, overall the assessments were very consistent and comparable as far as determining each measure's effect on the environmental parameters. The ratings for every parameter are summarized, by measure, in TABLE 5. For reference purposes, TABLE 6 provides the location and characteristics of the UMR locks.

It is emphasized, to stay in compliance with the scope of the A&M Program, of the thirteen remaining measures selected for further quantitative evaluation, only the non-structural measures are further evaluated in this study. In order to avoid overlapping the Navigation Study's efforts, the remaining structural measures receiving favorable environmental evaluations in TABLE 5 will be presented to the Navigation Study team for further evaluation.

Ascribing to the Evaluation Process outlined above, the application of the subsequent Evaluation Process Steps is discussed separately for each of the remaining non-structural measures.

2. ELECTRONIC GUIDANCE SYSTEM

Measure Definition

An electronic guidance system, similar to that found at airports, could be used to assist the lock staff and tow pilot in guiding vessels into a lock.

Description

The electronic guidance system similar to a Differential Global Positioning System (DGPS) would be used as a tow approaches and enters the lock. This system would very accurately determine and display a tow's position with respect to the lock and the gates, providing valuable approach information to the tow pilot. The difference between a fixed point on a miter gate and on the bow of an approaching tow could be transmitted to the tow captain in real time, making lockages more efficient and safe. The real-time position and rotation of the tow could be broadcast over a predetermined radio frequency to the tow pilot. The pilot would adjust the position of the tow accordingly for a more efficient approach and entrance into the lock.

Background and Present Conditions

Most navigation traffic congestion occurs at the lower UMR locks, namely Locks 20 through 27.

TABLE 3

Tow Waiting Time Evaluation Criteria

1. (3 to -3) Threatened or Endangered Species:

Rating (3)- Directly benefits existing populations of State or Federal endangered species by creating or enhancing essential habitat.

Rating (2) - Indirectly benefits existing populations of endangered or threatened species (i.e., an action decreases potential threats to a population or its habitat).

Rating (1) - Measure provides questionable benefits to existing endangered species or creates habitat that could potentially be colonized by endangered species.

Rating (0) - No potential value to endangered species.

Rating (-1) - Measure might have minimal adverse impacts to existing endangered species.

Rating (-2) - Measure indirectly (adversely) impacts existing populations of endangered or threatened species.

Rating (-3) - Measure directly (adversely) impacts existing populations of endangered or threatened species.

2. (3 to -3) Fish & Mussels:

Rating (3) - Direct fishery and mussel benefits as a major project purpose including rehabilitation or creation of habitat.

Rating (2) - Significant improvements to habitats or populations.

Rating (1) - Some improvements to habitats or populations.

Rating (0) - No fish or mussel benefits.

Rating (-1) - Some negative impacts to habitats or populations.

Rating (-2) - Significant negative impacts to habitats or populations.

Rating (-3) - The loss of fish and mussel habitat that is already limited in abundance or the loss of substantial individuals within a local population.

TABLE 3

3. (3 to -3) Wildlife:

Rating (3) - Direct wildlife benefits as a major project purpose including creation of wildlife habitat.

Rating (2) - Significant improvements to wildlife habitats or populations.

Rating (1) - Some wildlife benefits to habitats or populations.

Rating (0) - No wildlife benefits.

Rating (-1) - Some negative impacts to habitats or populations.

Rating (-2) - Significant negative impacts to habitats or populations.

Rating (-3) - The loss of wildlife habitat that is already limited in abundance or the loss of substantial individuals within a local population.

4. (3 to -3) Longevity (Long-term benefits):

Rating (3) - One of the purposes of the measure is to prolong habitat productivity.

Rating (2) - Measure will extend habitat productivity to some degree.

Rating (1) - Habitat not expected to last much beyond natural conditions.

Rating (0) - Measure does not provide any long-term benefits.

Rating (-1) - Measure may slightly decrease the productivity of the habitat.

Rating (-2) - Measure will decrease habitat productivity to some degree.

Rating (-3) - Measure will significantly decrease the productivity of the habitat.

5. (3 to -3) Habitat diversity:

Rating (3) - Major increase in local habitat diversity.

Rating (2) - Significant increase in local habitat diversity.

Rating (1) - Some increase in local habitat diversity.

Rating (0) - No increase in local habitat diversity.

Rating (-1) - Some decrease in local habitat diversity.

Rating (-2) - Significant decrease in local habitat diversity.

Rating (-3) - Unacceptable decrease in local habitat diversity.

6. (3 to -3) Water Quality:

Rating (3) - Directly improves water quality. (i.e., increasing dissolved oxygen, decreases turbidity, etc.)

Rating (2) - Indirectly improves water quality (i.e., measure results in a change in operation or to a location with less impacts).

Rating (1) - Would provide minimal or short-term benefits to water quality improvement.

Rating (0) - No improvement to water quality.

Rating (-1) - Would create minimal or short-term decreases in water quality.

Rating (-2) - Would indirectly decrease water quality (i.e., measure results in a change in operation or to a location with greater impacts).

Rating (-3) - Directly decreases water quality (i.e., decreases dissolved oxygen, increases turbidity, etc.)

7. (3 to -3) Overall Impacts of the Measure:

Rating (3) - Substantial long-term positive impacts result from the measure.

Rating (2) - Positive impacts expected from the measure.

Rating (1) - Some positive impacts (value of the measure on the environment decreases over time).

Rating (0) - Overall the measure will provide no significant positive or negative impacts.

Rating (-1) - Some adverse impacts (mostly short-term construction related impacts).

Rating (-2) - Adverse impacts expected, resulting from such things as altered hydraulics which may actually increase sedimentation rate.

Rating (-3) - Severe adverse impacts resulting from the measure.

TABLE 4

A&M Tow Waiting Time Study: Environmental Evaluations of Thirteen Small Scale Measures

1. Fenders, Energy Absorbers :
Replaceable fenders and energy absorbers could be installed in locks and at critical approach points to ease entry into the chamber for vessels traveling too fast or not properly aligned. Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

2. Electronic Guidance System :
An electronic guidance system, similar to that found at airports, could be used to assist the lockmaster in guiding the vessel into the lock.
Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

3. Modify Intake Structures :
Structures can be modified to reduce air entrainment, increase their hydraulic efficiency and decrease vibration. Modified intakes would be approximately the same

size as they are now. However, the increased efficiency would increase the water velocity through the intakes. Intake structures are located 20 feet below surface inside the guidewalls, just upstream of the upstream miter gates.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

4. Modify Discharge Structures :
Discharges can be modified to divert the discharge water away from a waiting vessel, reducing the turbulence and vibration in that area, allowing quicker water discharge. Modified discharges would be approximately the same size as they are now. However, the increased efficiency will increase the water velocity through the outlets. Discharge structures are located 20 feet below surface, just downstream of downstream miter gates. Discharge structures can be located outside the guidewalls and inside the guidewalls, the latter affecting tows waiting just downstream of the downstream miter gates.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

5. Modify Wall Ports :
Wall ports could be modified to improve the diffusion and hydraulic efficiency of water flow into the lock chamber. Could speed filling and emptying of lock

chamber. Wall ports are located within the lock chamber on both side walls. Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

6. Add Guide Cells :
The installation of guide cells on the riverside would allow an unpowered tow cut to be extracted beyond the bullnose, leaving space for small boats to enter the chamber on the lock chamber turnback. The guide cell may keep the stem of the unpowered cut snug against the guidewall. Construction would impact the environment, yet quicker lockages would result. Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

7. Ice Chutes :
Ice chutes are areas in the dam or spillway that can be opened to let accumulated ice flow downriver. Accumulated ice within the lock approach must be pushed back out and diverted to ice chutes in dam or spillway, since the present ice chutes located within the riverside guidewall are usually too small to be effective.

Rating

TABLE 4

	(+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

8. License Recreational Craft Operators :
A program could be developed to train and license recreational vessel operators.
Commercial vessel operators are licensed by the U.S. Coast Guard.
Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

9. Improve Navigational Aids and Channel Markings :
Additional navigation aids, as well as the timely replacement and repair of missing aids, would greatly assist mariners by marking the channel more clearly.
Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______

3. Wildlife ______

4. Longevity (Long-term benefits) ______

5. Habitat Diversity ______

6. Water Quality ______

7. Overall Impacts of the Measure ______

10. Install Floating Mooring Bits :
Floating mooring bits provide a place for deckhands to secure the barges during the emptying and filling of the chamber. Once the lines are secured, they need only be monitored rather than manually tended. Quicker lockages could result.
Could reduce chance of spill or accident.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

11. Real-Time Channel Depth and Weather Monitoring :
Towboats could make faster transits with better information on the conditions they will experience throughout their trip. Could reduce chance of spill, accident or grounding.

	Rating (+3 to -3)
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______

6. Water Quality ______

7. Overall Impacts of the Measure ______

12. Allocation of Operations and Maintenance (O&M) Costs :
Operations and maintenance costs at the lock could be offset by the allocation of the costs to the users. A non-structural measure which would better allocate the lock operation and maintenance costs to all mariners using the lock system.

	Rating (+3 to -3)
	--------
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

13. Low Head Hydroelectric Generators :
Operational costs of maintaining the lock could be offset by using the lock culverts as a source of hydroelectric power generation. The lock culverts, which connect the intake and discharge structures to the wall ports, are located within the lock chamber walls.

	Rating (+3 to -3)
	--------
1. Threatened or Endangered Species	______
2. Fish & Mussels	______
3. Wildlife	______
4. Longevity (Long-term benefits)	______
5. Habitat Diversity	______
6. Water Quality	______
7. Overall Impacts of the Measure	______

TABLE 5

Summary of Environmental Parameter Evaluations

Small Scale Measures	Environmental Assessment	Environmental Assessment	Environmental Assessment	Environmental Assessment	Environmental Assessment
1. Fenders, Energy Absorbers	9	2	10	9	7
2. **Electronic Guidance System***	9	2	10	9	7
3. Modify Intake Structures	0	-5	-3	-4	0
4. Modify Discharge Structures	0	0	-3	-1	0
5. Modity Wall Ports	8	1	-3	0	0
6. Add Guide Cells	8	1	8	1	7
7. Ice Chutes	0	-10	0	-7	0
8. **License Recreational Craft Operators**	2	1	8	8	1
9. **Improve Navigational Aids and Channel Markings**	8	1	8	8	9
10. Install Floating Mooring Bits	8	1	8	8	1
11. **Real-Time Channel Depth and Weather Monitoring**	8	2	8	8	9
12. **Allocation of Operations and Maintenance Costs**	0	0	0	0	0
13. Low Head Hydroelectric Generators	0	-10	-9	-3	-3

* Non-structural measures in Bold

UPPER MISSISSIPPI RIVER & ILLINOIS WATERWAY SYSTEM NAVIGATION STUDY

TABLE ENG-1: DATA FOR LOCKS AND DAMS - UPPER MISSISSIPPI RIVER

Dam No.	Location	Miles above Ohio River	Lift	Upper Pool	Lower Pool	Locks		Dam Compostion									Dam Total Length
								Roller Gates			Tainter Gates			Concrete	Earth Dams		
						Main	Auxiliary	No.	Type	Size	No.	Type	Size	Spillway	Type	Length	
USA	Minneapolis, MN	853.8	49			56'x400'		0						3584'			
LSAF	Minneapolis, MN	853.4	25			56'x400'		0			4	Non-submergible					
1	Minneapolis, MN	847.6	37.9	725.1	687.2	56'x400'	56'x400'	0			0			570'	None		570'
2	Hastings, MN	815.2	12.2	687.2	675.0	110'x600'	110'x600'	0			20	Non-submergible	30'x20'	None	Non-overflow	3250'	3850'
3	Red Wing, MN	796.9	8.0	675.0	667.0	110'x600'	Upper Gate Bay 110'	4	Submergible-5ft.	80'x20'	0			None	Non-overflow	2590'	3000'
4	Alma, WI	752.8	7.0	667.0	660.0	110'x600'	Upper Gate Bay 110'	6	Submergible-3ft.	60'x20'	18 4	Non-submergible Submergible-2ft	35'x15'	None	Non-overflow	3590'	4720'
5	Minneiska, MN	738.1	9.0	660.0	651.0	110'x600'	Upper Gate Bay 110'	6	Submergible-3ft.	60'x20'	24 4	Non-submergible Submergible-2ft	35'x15'	None	Non-overflow	18155'	19500'
5A	Winona, MN	728.5	5.5	651.0	645.5	110'x600'	Upper Gate Bay 110'	5	Submergible-3ft.	80'x20'	5	Non-submergible	35'x15'	1000'	Non-overflow	19500'	21200'
6	Trempealeau, WI	714.3	6.5	645.5	639.0	110'x600'	Upper Gate Bay 110'	5	Submergible-3ft.	80'x20'	10	Non-submergible	35'x15'	1000'	Non-overflow	2500'	4400'
7	Dresbach, MN	702.5	8.0	639.0	631.0	110'x600'	Upper Gate Bay 110'	5	Submergible-3ft.	80'x20'	9 2	Non-submergible Submergible-2ft	35'x15'	1000'	Non-overflow	7350'	9300'
8	Genoa, WI	679.2	11.0	631.0	620.0	110'x600'	Upper Gate Bay 110'	5	Submergible-3ft.	80'x20'	8 2	Non-submergible Submergible-2ft	35'x15'	2000'	Non-overflow	15275'	18650'
9	Lynxville, WI	647.9	9.0	620.0	611.0	110'x600'	Upper Gate Bay 110'	5	Submergible-3ft.	80'x20'	6 2	Non-submergible Submergible-2ft	35'x15'	None	Non-overflow Overflow	8100' 1350'	10300'
10	Guttenberg, IA	615.1	8.0	611.0	603.0	110'x600'	Upper Gate Bay 110'	4	Non-submergible	80'x20'	6 2	Non-submergible Submergible-3ft	40'x20'	1200'	Non-overflow	4450'	6510'
11	Dubuque, IA	583.0	11.0'	603.0	592.0	110'x600'	Upper Gate Bay 110'	3	Submergible-8ft.	100'x20'	13	Submergible-8ft.	60'x20'	None	Non-overflow	3540'	4820'
12	Bellevue, IA	556.7	9.0'	592.0	583.0	110'x600'	Upper Gate Bay 110'	3	Submergible-8ft.	100'x20'	7	Submergible-8ft.	64'x20'	None	Non-overflow Overflow	6320' 1200'	8370'
13	Fulton, IL	522.5	11.0'	583.0	572.0	110'x600'	Upper Gate Bay 110'	3	Submergible-8ft.	100'x20'	10	Submergible-8ft.	64'x20'	None	Non-overflow Overflow	11360' 1650'	14080'
14	Le Claire, IA	493.3	11.0'	572.0	561.0	110'x600'	Old Canal lock 80'x320'	4	Submergible-8ft.	100'x20'	13	Non-submergible	60'x20'	None	Non-overflow	1360'	2700'
15	Rock Island, IL	482.9	16.0'	561.0	545.0	110'x600'	110'x360'	9 2	Non-sumergible Non-sumergible	100'x26' 100'x21.75'				None			1200'
16	Muscatine, IA	457.2	9.0'	545.0	536.0	110'x600'	Upper Gate Bay 110'	4	Non-sumergible	80'x20'	12 3	Non-submergible Submergible-3ft	40'x20' 40'x20'	1700'	Non-overflow Overflow	415' 725'	3940'
17	New Boston, IL	437.1	8.0'	536.0	528.0	110'x600'	Upper Gate Bay 110'	3	Submergible-8ft.	100'x20'	8	Submergible-8ft.	64'x20'	None	Non-overflow Overflow	720' 1555'	3200'
18	Gladstone, IL	410.5	9.8'	528.0	518.2	110'x600'	Upper Gate Bay 110'	3	Submergible-8ft.	100'x20'	14	Submergible-8ft.	60'x20'	None	Non-overflow Overflow	3470' 2200'	7020'
19	Keokuk, IA	364.2	38.2'	518.2	480.0	110'x1200'	None	0			0	The dam is Non-Federal and includes a hydropower plant		4400'			4650'
20	Canton, MO	343.2	10.0'	480.0	470.0	110'x600'	Upper Gate Bay 110'	3	Non-submergible	60'x20'	34 6	Non-submergible Submergible-3ft	40'x20' 40'x20'	None			2300'
21	Quincy, IL	324.9	10.5'	470.0	459.5	110'x600'	Upper Gate Bay 110'	3	Sumergible-8ft.	100'x20'	10	Submergible-8ft.	64'x20'	None	Non-overflow Overflow	490' 1400'	2960'
22	Saverton, MO	301.2	10.5'	459.5	449.0	110'x600'	Upper Gate Bay 110'	3	Sumergible-8ft.	100'x25'	9 1	Non-submergible	60'x25'	None	Non-overflow Overflow	460' 1600'	3080'
24	Clarksville, MO	273.4	15.0'	449.0	434.0	110'x600'	Upper Gate Bay 110'	0			15	Submergible-8ft.	80'x25'	None	Overflow	2800'	4280'
25	Cap au Gris, MO	241.5	15.0'	434.0	419.0	110'x600'	Upper Gate Bay 110'	3	Sumergible-5ft.	100'x25'	14	Submergible-7.5ft.	60'x25'	None	Overflow	2566'	4078'
Mel Price - Alton, IL		200.8	16.0'	419.0	395.0	110' x 120	110' x 600'	0			9	Non-submergible	110'x42'	None	Overflow	2000'	
27	Granite City, IL	185.0		395.0	varies	110' x 120	110' x 600'	0			0			None	Chain of Rocks Dam		N/A

Approach methods and approach conditions are usually particular to each lock. The experience of tow pilots and their knowledge of lock characteristics and river conditions for each lock site is critical to safe, efficient lockages. A one-degree rotation of a quarter-mile long tow and a fifteen barge configuration can constitute a sideways movement of as much as five feet, indicating how critical proper alignment is for a lockage approach.

The tow mate and deckhands currently ascertain needed information for a pilot to guide the tow into the forebay of a lock, and river conditions can change quickly. Therefore, good communication between the mate on the head of tow and the tow pilot is vital. The mate and deckhands are essentially the "eyes and ears" for the tow pilot. However, there is a large turnover in this line of employment, resulting in a significant number of inexperienced deckhands assisting the tow pilot during the approach and lock entrance. Inexperienced deckhands may be less certain of approach conditions and tow location, thereby reducing the efficiency of the lockage.

Sometimes gate hits occur when a tow is entering the lock. As a loaded tow enters the lock chamber a considerable amount of water is displaced. Occasionally, as the tow is completing its entry into the chamber and nearing the far miter gates, displacing such a considerable amount of water in the chamber can result in the tow surging forward and hitting the far gates. An electronic guidance system determining a tow's real-time position may reduce such gate hits.

Environmental Effects

An electronic guidance system received very favorable environmental parameter assessments and would reduce accidents (see TABLE 5).

Benefits

An electronic guidance system could be very beneficial to tow pilots. Knowledge of tow location is crucial given changing river and wind conditions as well as other factors such as outdraft, weather and nighttime lockages. This system would effect safer and more efficient lockages, both beneficial to the environment.

Cost Estimates and Implementation

Implementation of an electronic guidance system would be very expensive. Configuring UMR tows and locks with the necessary electronic guidance equipment would cost millions of dollars.

Conditions Affecting Implementation

An electronic guidance system would require additional electronic equipment on tows and training for tow personnel and lock operations personnel.

Conclusion

It is not recommended to install an electronic guidance system due to its very high installation and implementation costs. The Navigation Study is currently evaluating the standardization of tow crew training. The possible implementation of such crew training could make the current method of experienced tow pilots, mates and deckhands guiding tows in and out of locks even more effective and efficient. Incidentally, the Navigation Study team is also evaluating several small scale measures, both structural and non-structural, designed to improve lock efficiency, which would consequently reduce the waiting time for tows. Their evaluation efforts involving lock efficiency include the following categories: towboat power, tow haulage equipment, adjacent mooring facilities, crew elements, and approach channel improvements.

8. LICENSE RECREATIONAL CRAFT OPERATORS

Measure Definition
A program could be developed to train and license recreational vessel operators. Commercial vessel operators are licensed by the U.S. Coast Guard.

Description
This measure assumes licensed recreational watercraft (i.e., rec. craft) operators would help make the navigation system more safe and possibly more efficient. A program would be created to administer examinations and issue licenses. Each operator would be required to pass an examination on rules of the waterway and lockage safety procedures prior to receiving a license to operate a rec. craft. Also, a fee could be assessed to help support the licensing program. The fee would need to be minimal to be accepted by rec. craft users. However, different fees could be assessed depending upon whether the rec. craft operator wished to take his craft through locks or not. Another consideration would be to require a license but assess a fee only if a rec. craft operator intended to use the locks. Otherwise, a fee would not be assessed. Any rec. craft lockage would require proof of operator license. State govemments would be responsible for administration, enforcement, and prosecution of violators of the licensing system. The license examination could be administered every ten years with an annual renewal fee.

The Coast Guard currently offers rec. craft courses designed to increase safety on waterways throughout the nation, but the courses are not mandatory. They are offered prior to the rec. craft season and are free of charge. Few states require mandatory completion of such courses for rec. craft registration (see TABLE 7).

Background and Present Conditions
There are currently few restrictions on rec. craft operators. Also, any rec. craft operator willing to brave the commercial navigation waterways may do so. Certain rules apply to lockage tums for rec. craft, but some rec. craft operators are unaware of the rules and may inadvertently use the lock out of tum. Some rec. craft operators may also be unaware of proper lockage procedures, thereby causing unnecessary delay as lock operations personnel instruct them through the lockage process. The lockage priority order is: govemment vessels, commercial vessels, recreational vessels. However, rec. craft can take advantage of lock chamber tumbacks when conditions are appropriate, and many rec. craft can lock at one time. Also, some rec. craft operators not properly educated about channel markings have inadvertently strayed from the channel and damaged structures in the river such as wing dams.

Environmental Effects
Licensing recreational craft operators received very favorable environmental parameter assessments and would reduce accidents and improve overall safety (see TABLE 5).

Benefits
A licensing program would be beneficial to lock efficiency, waterway safety and reduce accidents. The degree of benefit from such a program would be particular to each lock. Certain lock sites have considerably more recreational traffic and recreational lockages than others. Benefits cannot be accrued for recreational lockages. However, an increase in rec. craft lockage efficiency would benefit commercial vessels awaiting lockage.

TABLE 7

U. S. COAST GUARD AUXILIARY

DEPARTMENT OF BOATING

The following table is from _SMALL CRAFT ADVISORY_, June/July 1997, Copyright 1997, The National Association of State Boating Law Administrators, Box 11099, Lexington, KY 40512-1099. (used with permission)

State	Number of Regist. Boats	Educat. / Licensing Required?	Min. Age for Licensing	Min. Age for PWC Operation	Boating Education offered in Schools?	Mandatory PWC Education?
AL	261,351	Yes	12	12	Yes	Not specifically
AZ	150,000	No	N/A	12	No	No
AR	178,185	1/1/2001	14 or younger in 2001	14 in 2001	Yes if schools want it	new law in 2001
CA	810,283	No	No	12; or over 10hp	Yes	No
CO	95,140	Yes, mand. Youth ed as of 1/1/98	?	16 as of 1/1/98, unless 14-16 w/safety card	Yes as requested	Yes as of 1/1/98 for ages 14-16
CT	101,133	Yes	None	12 if alone	Yes	2 hr min
DE	42,856	Yes	19	16	Yes	Yes, anyone under 18
FL	731,991	Yes	Those born after 9/30/80	14	Yes	Yes
GA	302,874	No	N/A	12	No	No
HA	15,277	No	No	15	Yes, select high school	No
ID	80,682	PWC renters, 2nd offenders, 1st BUIs	None	None	Yes	Rental Only
IL	366,378	Yes, Under 18	10 to take course	12	No	No
IN	211,462	Licensing - yes	15	15	Yes	No
Iowa	200,000	No	12 for education	12	Yes	No
KS	100,180	Yes (PWC solo operators 12/15)	Yes, 12	12	Yes	Yes

TABLE 7

KY	156,666	No	No	No	No	No
LA	320,941	No	No	13	Yes	No
ME	127,905	No	N/A	12	Yes	No
MD	194,000	Yes	No	Yes	Yes	No
MS	141,000	Yes, 16 or younger for motorboat	12	16	Yes	16/17 yr olds
MI	945,817	Yes	12-16	12-16 w/certification; no rentals under 16	Yes	No
MN	758,666	Yes, for operators 12-17 to op. boat 25hp w/o adult 21 or older on board	13 w/o permit and adult supervision; 14-17 w/permit	13 w/o operator permit & adult watching 14-17 w/operator permit	Yes	No
MS	240,000	Beginning 7/1/97	No	Yes	Yes	Same as motorized vessels
MO	311,607	No	No	12 currently; 14 as of 9/1/97	Yes	No
MT	46,474	No	13	13	N/A	N/A
NB	70,458	No	10 for certification	14	Some	No
NV	55,626	No	N/A	12	If requested	No, rental operators must explain operation
NH	86,672	No	Yes	16	No	No
NJ	192,365	Yes	13-16; w/certain specifics	16	Yes	Yes
NM	55,615	No	No	Yes	Elem.	No
NY	458,092	10-17	10	10	No	No
NC	321,150	No	No	No	Yes	No
ND	38, 713	Yes	12-15	12-15	Some	Yes
OH	398,388	No	N/A	12; only if adult age 18+ is aboard. 16 may operate solo	Optional	No
OK	220,667	No	No	12 for solo Operation	Yes	No

TABLE 7

OR	195,080	No	No	14	Yes	No
PA	337,201	No	No person 11 or under may operate a boat 10hp or more unless w/16 or older	12-15 may not operate a motorboat over 10hp w/o boating certif. unless 16 or over	Yes	No
RI	37,608	No, except for PWC operators	Cert. for under 16 required	-	Some	Yes
SC	418,000	Yes	16	No	Yes	No
SD	46,575	No	N/A	14	No	No
TN	298,734	No	Yes	12	Yes, but very few	Rentals only
TX	602,000	Yes	13	13	Yes	No
UT	71,688	No	12	Under 16 must have adult o/b; 12-15 must be educated and visually supervised 16-17 must be educated	On request	Yes
VT	38,932	Yes if born after 1/1/74	No	16	36 public schools	No
VA	229,233	No	Yes	14	No	No
WA	250,000	No	N/A	14	Yes	No
WV	52,314	No	N/A	16	Yes	No
WI	540,835	Yes, 12-15 to operate	12	12;16 for rentals	Yes, some	No
WY	24,906	No	N/A	16	No	No
Wash. DC	5,700	Education - yes	13 for certif.	13 if certif.	No	No
PR	38,376	Yes	16	Those born after 7/1/72	yes, some	No
VI	5,000	No	No	18	Yes	For operators 14-18 mand. education
Guam	3,000	No	N/A	16, must be visually supervised	Yes, as requested	No

Cost Estimates and Implementation
The cost includes developing and maintaining a program for licensing rec. craft operators on the UMR.

First costs: $464,375 per system*
Annual cost: $236,500 per system*

Average Annual Cost (50 year program life): $251,706

* Costs are based on a similar system-wide program quantified for the UMR-IWW Study (see TABLE 8).

Condition Affecting Implementation
There are those river disciplines which strongly support licensing rec. craft operators and believe the majority of operators wanting safer waterways would also support such a program. Towing Industry personnel indicate existing safety seminars are well attended by an overall safety-conscious public even though the safety seminars are voluntary. These disciplines also believe licensing would reduce overall rec. craft insurance and cost. Some disciplines believe a licensing program would not be cost effective to implement and maintain. Also, some disciplines question the public and political reaction to such a program. Some disciplines also feel increased water patrol would be cost effective and could be incorporated into a licensing program. In association with this measure, the Navigation Study is currently evaluating the scheduling of times for rec craft lockages to improve lock efficiency.

Conclusion
The implementation of a licensing program for rec. craft operators is recommended for more in-depth analysis.

9. IMPROVE NAVIGATIONAL AIDS AND CHANNEL MARKINGS

NOTE:
This measure is currently being successfully implemented by various disciplines. The efforts of these disciplines are summarized below.

Measure Definition
Additional navigation aids, as well as the timely replacement and repair of missing aids, would greatly assist vessel operators by marking the river channel more clearly.

Description
Navigational aids and channel markings consist of many methods and implements designed to make commercial and recreational navigation on the UMR more efficient and safe.

Background and Present Conditions
The Coast Guard and UMR District all-purpose vessels, such as the St. Louis District's *Pathfinder*, do a fine job of maintaining effective navigational aids and channel markings on the UMR, especially considering the perpetual changes in the river channel, weather and the cumulative effects of tow traffic. The Corps and Coast Guard maintain buoys, channel markers, warning lights and other

Congestion Tolls and Lockage Time Charges

Jeff M. stated that this could be a licensing fee to operate on the Upper Miss System or a time charge. The licensing fee could serve as the toll, but with simpler administration. There would also be some set up costs. Recreational Craft Tolls, if they are included, could add somewhat to the coordination costs and research and analysis needs.

Cost estimates for congestion tolls, recreational scheduling, and scheduling programs are based primarily on labor. The following information was used to develop the costs in the following tables. When a range of GS levels is given for who could do the work, the average salary of the levels was used.

Salary Estimates, based on 1997 GS Salaries
(These estimates were used for estimating study costs for applicable measures).
GS 5 = $25/hr x 8 hrs = $200/day $1,000/wk
GS 9 = $40/hr x 8 hrs = $320/day $1,600/wk
GS 11 = $50/hr x 8 hrs = $400/day $2,000/wk
GS 12 = $60/hr x 8 hrs = $480/day $2,400/wk
GS 13 = $70/hr x 8 hrs = $560/day $2,800/wk

Salaries based on GS-97 rates * 1.41 (benefits) (1 + .26 District Overhead + .45 Tech Indirect) = 2.4
Used 2.4 * base salary for estimates.
GS 5/5 = $23,188 / 2080 hrs * 2.4 = $27
GS 9/5 = $35,133 / 2080 hrs * 2.4 = $41
GS 11/5 = $42,509 / 2080 hrs * 2.4 = $49
GS 12/5 = $50,948 / 2080 hrs * 2.4 = $59
GS 13/5 = $60,583 / 2080 hrs * 2.4 = $70

While a specific line item for Environmental efforts was not included, the allowance under several items of plan formulation allows for a team of 4 people, it is assumed that if necessary one of those team members would include a biologists.

Public Involvement Cost estimates 8/25/97 - Kevin Bluhm, CEMVP based on Overall Nav Study Costs
Nav Study currently costs $16,800 per issue for oversight, writing, printing, and mailing.
Public Meetings cost varies based on staff - $40,000 to 60,000 depending on staff levels

Develop and implement collection mechanism (likely some increase in demands on lock staff, billing costs)

TABLE 8

Table __: First Cost to Develop a Congestion Toll System	
Item	Cost
Study to identify Lock Sites, Toll Levels, Collection Mechanisms, and Public Coordination	
- Study Mgmt – Develop Study Plan, Coordination, Facilitation (6 wk 1 GS-12)	14,400
- Project Management Involvement (GS-13 for 4 wks at $4,200/wk & GS-11 2 wk at $3,000/wk, rates for PP-M 1.5 x PD rates)	22,800
- Literature Search (3 weeks for 1 GS-11 to 12)	6,600
- Identify Alternative Toll Approaches & Collection Mechanisms (2 weeks for 4 GS-11 to 13s)	19,200
- Revise GEM Model for use in Evaluation (3 weeks – GS-12 to 13)	7,500
- Run Model to Determine impacts of toll alternatives on traffic and optimal level of tolls to maximize NED (8 weeks – 1 GS-12 to 13 and 1 GS-5 student)	28,800
- Run Sensitivity on Selected Approach (2 weeks – GS-12 to 13)	5,200
- Evaluate Results and Select Toll Approach (2 weeks - 4 GS 11-13)	19,200
- Evaluate Options and Select Collection Mechanism (1wk – 4 GS 11-13)	9,600
- Report writing, editing, printing, & revising (5 weeks 4 – GS-11 to 12)	44,000
- Oversight, Support, Supplies, Mailing, and Travel	10,000
- ITR (3 days for 4 – GS-11 to 13's)	5,800
- Public Involvement - Coordination, Administration, & Oversight (4 weeks – GS-11) - Newsletter w/ comment form mailed to Nav Industry and public – at beginning and end of study – 2 * $17,000 each - Set of public meetings to collect comments 4 + meeting sites depending on # of locations effected by tolls $60,000	102,000
- Sub-Total	295,100
- Contingency 25%	73,775
- Total Study Cost	368,875
Establishing and Implementing Bookkeeping and Billing system	
- Identify options for implementing bookkeeping & billing (2 wks 1 GS 11-12)	4,400
- Establish mechanism to collect lockage information for billings (3 weeks 3 GS 11-13's)	21,600
- Develop a bookkeeping system to track billings and receipts (3 weeks – 2 GS-11-13s)	4,800
- Prepare mailing list of operators (2 week GS-11)	4,000
- Coordination between Districts and Information Sharing (1 week of 9 peoples time GS-11 to 13's)	21,600
- Notify Navigation Industry of Changes and Implement ($20,000)	20,000
- Sub-Total	76,400
- Contingency 25%	19,100
- Total Study Cost	95,500
Total First Costs (Study and Establishing and Implementing System)	464,375

Table __: Annual Cost to Implement a Congestion Toll System

Item	Cost
Collection and summary of data	$68,400
Billing and Collection	$120,800
Contingency of 25%	47,300
Total	$236,500

Based on following information and likelihood that 2-3 District coordination would be required:

TABLE 8

1 - GS-9 to 11 working 75% of a year to collect data. (38 weeks) = $1,800 * 38 = 68,400
2 - GS-11 working approximately 50% of time to oversee billings and collections (50 weeks total)
$2,000 * 50 = $100,000
1 – GS-13 Supervisor overseeing employees approximately 15% of time (8 weeks) = $2,600 * 8 = $20,800

navigational aids. The Coast Guard also sets buoys on the UMR.

The St. Paul District is the center of expertise for the updating and innovative design of various navigational aids. Their work includes critical safety signs designed to improve small boat safety as well as designing larger safety signs marking restricted zone areas around lock sites and within lock pools. They also design navigational aids involving international symbols and day markers on shorelines.

Environmental Effects
Improving navigational aids and channel markings received very favorable environmental parameter assessments and would reduce accidents and improve overall safety (see TABLE 5).

Conclusion
The current method of various disciplines working together to continuously improve navigational aids and channel markings is effective, efficient and innovative. Study research indicated additional reflectors are requested on UMR bridges to make them more visible and improve safety.

11. REAL-TIME CHANNEL DEPTH AND WEATHER MONITORING

Measure Definition
Tow pilots could make faster transits with better information on the conditions they will encounter throughout their trip.

Description
The implementation of real-time channel depth would give lock operations personnel real-time information on the location and number of tows awaiting lockage as well as giving tow pilots real-time information on the location of their tow in relation to river channel characteristics. This system would provide an overall view of the location of all tows, thus enabling more efficient tow lockages.

Background and Present Conditions
Any tow traversing the UMR system calls in to upcoming locks to request lockage and receive queue information. After a tow calls in from a designated call-in point to the first lock in its trip, that tow is entered into the lockage log program within the OMNI communications system and remains in the OMNI system until the tow reaches its destination. This enables lock operations personnel to know the location and activity (i.e., queue position while awaiting lockage, arrival at a lock, locking process, departure, or traveling to the next lock) of any tow within the OMNI system at all times. Thus, knowledge of tow positions and queue development at a particular lock is very advantageous to lock operations personnel making decisions to more efficient and safer lockages. Also, knowledge of tow positions and queue development is invaluable if, for instance, a particular lock needed to make any minor repairs and wanted to determine the most efficient / least costly time to make them.

The Corps is currently conducting hydrographic surveys and assembling the results into data sets. The data sets detail UMR river characteristics including river miles, shorelines, channel location, channel depth, navigation aids, buoy locations and other pertinent data. These data sets are then used to update UMR navigation chart books. Channel depth data could also be incorporated into the data sets as contour lines or another format, giving the navigation chart books a threedimensional reproduction of the surveyed river. Currently, the Corps primarily surveys potential navigation "trouble spots" on the rivers. Eventually the Corps would like to regularly survey the entire UMR navigation area to keep their data sets and navigation chart books updated every few years. The Corps is also working toward making these data sets readily available on the Internet for any disciplines requesting such information. This would provide navigation characteristics more efficiently and reduce the costs of repeatedly collecting and distributing the data.

The Towing Industry is very interested in obtaining electronic navigation charts for their tow pilots. Some companies within the Towing Industry have already hired contractors and outside vendors to produce electronic charts. The contractors have subsequently contacted the Corps for the use of their data sets and navigation chart books. The Corps data sets and navigation chart books could be used to produce accurate, detailed electronic charts. Only contractors and outside vendors can produce electronic charts for the Towing Industry since Corps officials have determined the Corps will not be involved in the conversion of data sets and navigation chart books into electronic charts.

Electronic charts would provide crucial navigation characteristics to tows and river vessels via onboard electronic equipment. Electronic charts could also be interfaced with a Differential Global Positioning System (DGPS). The DGPS could be linked with river depth data obtained from depth finders. The result could be a real-time interactive navigation system depicting a tow's location on electronic navigation charts which also detail navigation characteristics, including river channel depth.

Electronic navigation technology is currently being used in both the Dutch and German shipping industries to make navigation of hazardous waterways more efficient and safe. High-resolution radar images show a tow or ship's position relative to all structures and navigation characteristics. The images are computer processed, providing a high level of detail to vessel pilots. Several U.S. deep-water ports also currently employ an electronic navigation plan incorporating DGPS to safeguard the arrival and departure of ocean vessels.

The Coast Guard currently uses electronic charting to set buoys needed for safe, efficient navigation of the UMR. The Coast Guard in New Orleans is also involved in the development of a Vessel Traffic Management (VTM) / Automatic Identification System (ATS) which, via DGPS concepts, would identify the real-time location of commercial vessels on navigable rivers.

Regarding the weather monitoring aspect of this measure, several methods are currently to provide timely, accurate weather information to tows. Currently, tow companies contiguously call tows to inform them of changing weather conditions. The Corps website www.mvs.usace.army.mil provides current, detailed information on weather, river and queue conditions for all UMR locks, including channel depth, daily river gage readings and a three-day forecast of weather conditions. The River Industry Bulletin Board (RIBB) website www.ribb.com provides current, detailed information on river stages, river conditions and lock queues for the Mississippi, Illinois and Ohio Rivers. Also, the Corps website www.mvr.usace.army.mil/navdata/icemiss provides current, detailed information on ice conditions for all UMR locks.

Environmental Effects

Real-time channel depth and weather monitoring received very favorable environmental parameter assessments and would reduce accidents and improve overall safety (see TABLE 5).

Benefits
Real-time knowledge of navigation characteristics, including channel depth and tow location, would be very beneficial to tow pilots and the navigation conditions they encounter. These consist of river conditions, wind conditions, weather, outdraft, nighttime navigation and oncoming traffic. Safer and more efficient lockages would result, both beneficial to the environment.

Cost Estimates and Implementation
Implementation of a real-time navigation system including tow location, channel depth and weather monitoring by the Corps would be in the multi-millions of dollars. Implementation of an electronic charting system by outside vendors including channel depth, yet not including tow location, would provide updated channel depth and navigation characteristics, but not real-time channel depth data. However, electronic navigation charts would satisfy the Towing Industry's requests and the cost to the Corps would be considerably less.

Conditions Affecting Implementation
Members of the Towing Industry have expressed concern about maintaining secrecy of the location of their tows and barges in a competitive market in the possible implementation of a real-time navigation system including tow location.

Conclusion
As mentioned above, the Corps is currently surveying and assembling data for their navigation chart books. The Corps' work, in conjunction with the Towing Industry's requests for electronic navigation charts from contractors and outside vendors, could contribute substantially toward the Towing Industry's requests for updated navigation characteristics. The current weather information available to tows is efficient and effective. It is not recommended for the Corps to develop and implement a real-time navigation system incorporating tow location, channel depth and weather monitoring due to its multi-million dollar cost. The Coast Guard's application of a VTM / AIS would provide real-time tow location and identification. In conjunction with electronic navigation charts providing updated channel depth, safer and more efficient lockages would be realized.

Study research indicated each Corps District on the UMR performs river channel surveys every spring at the beginning of the navigation season to locate and document potential troublesome navigation areas as well as where dredging needs are anticipated for the upcoming year. The Towing Industry has indicated they would very much like the Corps work with them and contiguously share their spring channel survey findings of these critical navigation areas at the beginning of the navigation season. This would reduce accidents and improve safety.

Study research also indicated the Corps and Towing Industry used to have quarterly meetings to discuss the anticipatory effects of conditions such as snowpack melt, weather forecasts and flood forecasts for the next three or four months (i.e., the upcoming quarter). The Towing Industry would like to re-institute these valuable and beneficial meetings. All disciplines benefit from improved communication. This would also reduce accidents and improve safety.

12. ALLOCATION OF OPERATIONS AND MAINTENANCE (O&M) COSTS TO USERS

Measure Definition
Operations and maintenance costs at the lock could be offset by the allocation of the costs to the

users. This measure would better allocate the lock operation and maintenance costs to all river traffic using the lock system.

Description

This measure involves the charging of fees to all users of a UMR lock and / or the navigation pool created by the dam. This action would neither increase nor decrease O&M costs for the Corps, but would change the sources of the funding. As a result, O&M budgets would be comprised of fees collected from users of the navigable waters and regular congressional appropriations. There would be an added cost to develop and maintain a program to assess, collect, record and transfer fees to the Treasury Department. For this analysis, it is also assumed that the user fees would not significantly impact the demand for lockage or pool use such that O&M costs would be lessened. In reality, significant fees for use of the river or locks would drive a percentage of recreational craft users off the river. Boaters would choose less costly places to recreate, such as lakes. If fees were assessed for only usage of the lock, the cost would be the same as reported below.

Background and Present Conditions

Congress appropriates funds into select General Revenue accounts. One of the accounts is the (Operations and Maintenance (O&M) account. These funds comprise 50 percent of a District's O&M budget. The other 50 percent of a District's O&M budget is comprised of tax income generated from a per gallon tax on diesel fuel. All commercial vessels pay taxes on diesel fuel. This tax money is earmarked for placement into the Inland Navigation Trust Fund (INTF). The INTF is the source for the District's O&M budget not appropriated by Congress. Currently, each District's O&M budget is allocated amongst navigation system capacity expansion projects and major rehabilitation at its lock sites and lakes.

Environmental Effects

Allocation of O&M costs to users received neutral environmental parameter assessments (see TABLE 5).

Benefits

There are no quantifiable benefits. District O&M funds (not appropriated by Congress) would be more evenly generated by lock system and navigation system users.

Cost Estimates and Implementation

The cost includes developing and maintaining a program for changing the sources of the funding for a District's O&M budget.

First costs: $464,375 per system*
Annual cost: $236,500 per system*

Average Annual Cost (50 year program life): $251,706

* Costs are based on a similar system-wide program quantified for the UMR-IWW Study.

Conditions Affecting Implementation

Only the sources of the funding would change. Additional funding would not be generated. Also, recreational craft users can vary considerably from lock to lock. Some lock sites may have a tow / recreational craft lockage ratio of 70 percent / 30 percent, whereas other lock sites may have a tow

/ recreational craft lockage ratio of 20 percent / 80 percent. This could affect the acceptance of a standard fee by recreational craft users in select locales.

Conclusion

It is not recommended to change the sources of the funding for a District's O&M budget by charging fees to users. High development and maintenance costs in conjunction with no quantifiable benefits does not warrant implementing this measure. Recent study research indicated some disciplines have recommended implementing a fuel tax at marinas to generate additional funds. However, currently there is no authority to implement such a tax. If deemed credible, additional research would need to be conducted to determine the legal authority, benefits, cost and user acceptance of a marina fuel tax.

ADDENDUM

The Navigation Study team is currently evaluating a tow scheduling program which could reduce tow waiting times and thus effect environmental benefits. A restatement of the Navigation Study team's evaluation is provided below.

SCHEDULING PROGRAM

Description of Measure

The use of a scheduling program could achieve time savings by optimizing the sequence of the particular vessels present at a lock or series of locks. It would use a personal computer-based scheduling program that would develop a scheduling sequence for tows in a queue based on mathematical modeling of various types and configurations of queues. The potential delay reduction varies considerably based on the type of queue present, configuration of tows, weather, currents, etc. Scheduling primarily assists in maximizing lock efficiency, which can be achieved in a number of ways depending on the goals of the program. Two general approaches can be taken.

Under the first approach, the primary benefit of scheduling would be minimizing approach and reconfiguration times. For example, scheduling could result in a higher percentage of turnback lockages that generally take significantly less time than exchange lockages. Additional time savings could be achieved by locking recreational craft together and placing tows requiring only a single cut at the beginning and end of an N-up/N-down series. This type of program would provide flexible and responsive scheduling that would assist in maximizing throughput and reducing delays. A second approach would be to schedule tows to reduce delay per tow, delay per barge, or delay per loaded barge. Under this approach, the throughput remains relatively unchanged, but delay as defined by the criteria can be reduced.

The existing regulations for the navigation system, 33 CFR 207.300, state that the normal procedure for the system will be that vessels arriving first shall be locked first. However, the lockmaster may depart from this procedure when warranted. The regulations also state that recreational craft will not be required to wait for more than three commercial lockages before being locked through. In many cases, recreational craft are locked between every commercial lockage, and they can use the chamber when it is being turned back for the second cut of double lockages or the next tow. While these recreational craft lockages typically take a relatively short amount of time, approximately 15 minutes, they do impact the overall scheduling.

The proposed scheduling system would likely be housed and maintained in one location (i.e., a District office) and the locks would have on-line access to run the program as needed. This program would be used to assist in best managing variations in traffic levels at a lock. The computer program would be operated on a semi-real-time basis to produce a form of interactive scheduling. For example, during periods of low usage, the program would not be needed and a simple first come, first served policy could be used. As traffic increases and queues develop, a 3-up/3-down scheduling rule might be implemented. If queues persist or grow even longer, the scheduling program could be used to recommend and determine if other procedures would better maximize the locking facility and reduce delays. Depending on the level of detail in the scheduling algorithm, the program could provide detailed information in the specific lockage order of the particular tows.

While a program could be developed to schedule a specific lockage time for each tow at each lock as a form of system trip planning, this approach is not desired due to the variability in traveling the river and potential for unforeseen events that would result in the need to continually modify the schedule for all tows on the system. However, the program could optimize a group of locks systemically. This type of scheduling would allow for closer coordination between locks so that tows are processed through the system and not just from one queue to the next.

A potential benefit of a detailed system model would be that it could be designed to maximize net benefits to the nation (NED). A sophisticated scheduling algorithm could be developed to reduce total delay time (per tow, per barge, etc.), reduce delay costs, maximize lock throughput, etc.; however, its use would require increased amounts of information on the type of barge, commodities carried, and operating costs of a particular tow.

<u>Delay Reductions Methodology</u>
The expected benefits of a scheduling program include the potential to improve on the current N-up/N-down policy in minimizing approach and exit times and to better optimize the system based on a particular scheduling approach (e.g., reduce average delay per tow, reduce per barge delay, etc.) available for implementing a scheduling program. These sources, discussed in detail in this section, included: the 1981 Lewis Berger & Associated, Inc., report entitled, *Inventory of Potential Structural and Non-Structural Alternatives for Increasing Navigation Capacity – Upper Mississippi River System Master Plan*; the 1974 Daggett, *et al.* report entitled, *Use of Tow Sequencing Procedures to Increase the Capacity of Existing Lock Facilities*; the 1994 Ting and Schoneld draft report entitled, *Effects of Tow Sequencing on Capacity and Delay at a Two-Chamber Lock* and the 1990 LPMS data. This section summarizes the findings and results of these sources.

Lewis Berger & Associates, Inc. (1981) summarized a 1960s test on the Welland Canal, connecting Lake Erie and Lake Ontario, which sought to minimize delay times by giving priority to tows and vessels with the shortest lockage times. While it did not involve the use of a computer program, it used alternative scheduling to maximize the lockage rate. The result of this test was that a greater tonnage could be transported in a given time using this method compared to a standard first come, first served basis. These results are related to the fact that a slow locking tow can significantly delay an entire queue of tows. However, if slower tows are required to wait a relatively short period of time to allow other vessels to lock, the additional delay does not significantly affect their overall transit times.

In 1974, WES developed a real-time scheduling system for use by lock personnel to determine the optimal order in which to schedule tows waiting for a lock. The system that allowed direct data entry into a terminal for analysis was used for Lock 51 on the Ohio River. The program was developed to schedule tows from a queue based on various scheduling criteria (e.g., minimize total waiting time, minimize wait in barges per minute, minimize total waiting costs, etc.). The program allowed the lockmaster to analyze the scheduling using the various criteria and provided the second and third options. This information increased the lockmaster's flexibility (especially in meeting unanticipated or uncontrollable situations such as outdraft, adverse weather, etc.) while still utilizing the program's capabilities. The study concluded that a computer-based program could significantly reduce transit times (total waiting time plus lockage time) at locks based on its ability to evaluated and make determinations of a large amount of data in a short time period. While only expanding system throughput by approximately 2 percent, the report estimated that better scheduling of tows could produce an average transit time savings of approximately 16 minutes per tow.

A 1994 University of Maryland draft report on the *Effects of Tow Sequencing on Capacity and Delay at a Two-Chamber Lock* summarized the benefits of using a scheduling program to maximize lockage efficiency. The program assessed the benefits of scheduling following two separated barges per unit time. The results of this study indicate that delay time savings of over 70 percent are possible using these scheduling approaches over a first come, first served policy at a two-chambered lock. However, these savings are significantly overstated in terms of the UMR-IWW System, since some efficiency measures such 3-up/3-down are currently implemented in delay situations and very few locations have two chambers.

Time Savings Estimates

In evaluating the benefits of a scheduling program, Lewis Berger and Associates, Inc. (1981) were not able to identify significant changes in capacity. They estimated that implementing the measure might only increase lock capacity by approximately 3 percent. However, the use of scheduling can reduce various delays (e.g., delay per tow, minimize delay time per barge, reducing total delay cost, etc.). They also found diminishing returns as progressively more detailed scheduling is undertaken. In a separate assessment of the incremental benefits of various N-up/N-down policies, they found that the greatest benefits are associated with changing from 1-u/1-down to a 2-up/2-down, 3-up/3-down, or 4-up/4-down policy. These measures provide approximately 50 percent, 66 percent, and 75 percent of the potential benefits, respectively. While additional efficiencies are possible, they are incrementally smaller than the initial benefits of implementing a scheduling measure.

The use of a scheduling program does provide the opportunity to reduce delays in more ways than simply trying to lock the most tows through in the least amount of time. It can be used to minimize delays per tow, minimize delay per barge, maximize the lockage rates in tons of commodities, minimize total delay costs, etc. While many of these different approaches would produce similar results, they do vary to some extent and may provide different types of benefits to the nation and incentives for industry (e.g., to reduce empty backhauls, reconfigure tows to maximize lock usage, etc.).

Currently, scheduling in the form of an N-up/N-down policy is employed most frequently at the lower locks on the system when queues warrant its use. These times typically occur following an accident, during lock downtime for repair, or during periods of high traffic movements. Many of the lockmasters reported that its use already exceeds 10 percent of the year at their sites, with some of the highest usage reported for Peoria and LaGrange Locks.

TABLE 9 provides estimated potential time savings associated with better scheduling by evaluating approach and exit times using 1990 LPMS data. The time savings of replacing exchange lockages with turnbacks is approximately 8 minutes on single lockages and 16 minutes on doubles for the UMR Locks 11-25 (excluding Lock 19). IWW time savings are a little larger with potential savings of 10 minutes fo rsingles lockages and 19 miinutes on doubles. However, this does not account for the extra time associated with turning back the chamber of 8 minutes for the UMR and 14 minutes for the IWW, which reduces the time savings. In addition, not all tows realize this lockage time savings because scheduling only increases the percentage of turnback lockages. Some exchange lockages still must occur. Moreover, some of the time savings is already accounted for by existing turnbacks and the periodic use of an N-up/N-down policy. Due to the number of variables involved in determining the actual time savings, the study's systems models would be required to fully evaluate what these types of time savings mean in terms of reducing delays at locks.

TABLE 9

TIME SAVINGS ASSOCIATED WITH REPLACING EXCHANGE WITH TURNBACK APPROACHES AND EXITS

(In Minutes)

	Single Approach			Single Exit			Single	Double Approach			Double Exit			Double	Chamber
Lock Site	Exch	Turn-back	Sav-ings	Exch	Turn-back	Sav-ings	Total Sav-ings	Exch	Turn-back	Sav-ings	Exch	Turn-back	Sav-ings	Total Sav-ings	Turn-back
11	8.2	4.4	3.8	6.5	6.2	0.3	4.1	13.7	8.4	5.3	21.3	20.4	0.9	6.2	9.2
12	9.5	5.3	4.2	8.0	5.1	2.9	7.1	16.7	10.7	6.0	25.0	20.2	4.8	10.8	8.0
13	8.8	2.6	6.2	5.9	5.1	0.8	7.0	14.3	5.5	8.8	23.4	20.6	2.8	11.6	8.2
14	8.6	2.6	6.0	8.6	5.6	3.0	9.0	17.2	6.5	10.7	31.3	23.8	7.5	18.2	8.5
15	16.0	4.0	12.0	9.4	6.9	2.5	14.5	31.2	5.6	25.6	28.2	24.1	4.1	29.7	9.7
16	7.2	3.2	4.0	5.8	5.2	0.6	4.6	18.5	7.4	11.1	23.1	20.8	2.3	13.4	7.9
17	10.2	4.0	6.2	10.0	5.9	4.1	10.3	24.7	11.8	12.9	27.6	21.5	6.1	19.0	7.0
18	10.3	3.4	6.9	8.1	5.5	0.6	7.5	20.3	9.0	11.3	23.6	21.8	1.8	13.1	7.5
19	26.5	13.9	12.6	13.7	9.1	4.6	17.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16.2
20	10.9	4.8	6.1	8.0	4.6	3.4	9.5	20.2	9.2	11.0	27.7	22.2	5.5	16.5	7.8
21	9.9	3.9	6.0	6.0	3.7	2.3	8.3	22.6	9.9	12.7	25.3	22.5	2.8	15.5	6.2
22	9.7	4.5	5.2	10.0	5.4	4.6	9.8	25.8	11.5	14.3	30.6	22.7	7.9	22.2	6.9
24	8.0	3.2	4.8	8.5	5.4	3.1	7.9	19.4	7.3	12.1	26.5	21.9	4.6	16.7	9.7
25	8.4	3.0	5.4	4.3	4.0	0.3	5.7	18.2	6.3	11.9	24.2	21.6	2.6	14.5	9.0
Mel Price	14.3	4.7	9.6	11.1	7.7	3.4	13.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.4
27	15.9	4.1	11.8	11.6	7.8	3.8	15.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11.6
Lockport	9.7	4.4	5.3	8.0	5.6	2.4	7.7	20.3	9.4	10.9	37.8	26.6	11.2	22.1	21.3
Brandon	10.2	5.8	4.4	9.8	6.3	3.5	7.9	21.1	12.2	8.9	33.3	25.4	7.9	16.8	19.4
Dresden	9.4	5.5	3.9	8.2	5.3	2.9	6.8	15.1	8.5	6.6	30.4	25.6	4.8	11.4	13.5
Marseilles	11.4	4.8	6.6	11.0	5.7	5.3	11.9	18.3	7.3	11.0	34.6	32.8	1.8	12.8	17.9
Starved Rock	11.4	2.7	8.7	8.6	5.0	3.6	12.3	18.8	4.1	14.7	29.8	23.5	6.3	21.0	13.7
Peoria	10.6	3.6	7.0	9.1	6.0	3.1	10.1	20.7	5.6	15.1	31.9	25.5	6.4	21.5	7.9
La Grange	12.9	4.2	8.7	10.2	6.1	4.1	12.8	22.4	6.5	15.9	35.1	25.0	10.1	26.0	6.7
Avg. UMR 11-25*	9.7	3.8	5.9	7.5	5.3	2.2	8.1	20.2	8.4	11.8	26.0	21.9	4.1	16.0	8.1
Avg. Illinois	10.8	4.4	6.4	9.3	5.7	3.6	9.9	19.5	7.7	11.9	33.3	26.3	6.9	18.8	14.3

Note: * Avg. UMR 11-25 excludes Lock 19.

Cost Estimates

The costs of implementing a scheduling program are relatively low and are primarily related to designing, testing, and running the program. These costs would be influenced by how the actual program would be implemented and maintained. Potentially reducing the costs is that some similar types of scheduling programs have been developed (WES and University of Maryland) and could serve as a starting point. However, even if a developed model were used, it would still require additional efforts to adapt it for use on the UMR-IWW Navigation System. TABLE 10 summarizes the estimated first costs to develop a scheduling program for the system based in part on available information and models. In addition, an annual maintenance cost of $35,000 per year is anticipated to upgrade the model and provide some additional training to lock personnel.

TABLE 10

FIRST COSTS OF COMPUTERIZED SCHEDULING PROGRAM

Cost Item	Cost
Study	$253,000
Construct Model, Test, Refine, and Develop Manual	130,000
Training of Lock Staff	57,000

Subtotal	440,000
Contingency 25%	110,000

Total First Costs (not including site acquisition)	$550,000

Conditions Affecting Implementation

Frequently, the lockmasters vary scheduling from first come, first served to various N-up/N-down procedures. While a 3-up/3-down scheduling system is often used during congested periods, a great deal of flexibility actually exists depending on the requirements of the situation. In many instances, this procedure is modified in coordination with the River Industry Action Committee (RIAC) to implement a more suitable procedure, such as 6-up/1-down or 4-up/4-down, when conditions and queue dictate. In situations where these alterations are already made, it greatly reduces the potential incremental benefits associated with the use of a scheduling program. The requirements of locking recreational craft after every third commercial lockage also impact the effectiveness of scheduling programs since each commercial cut is considered a separated lockage. Changing the requirement to, recreational craft shall be provided a lockage after every third lockage or two double lockages, would provide lockmasters more flexibility on when to work in recreational craft lockages.

The use of a computer-based scheduling program has some potential disadvantages. It would likely require additional timely and accurate data and coordination. Depending on how the system is implemented, it could result in a reduction in the flexibility of lockmasters while not being able to fully account for site conditions or crew capabilities. Conversely, a model designed to address site-specific optimization may be too narrow in scope to adequately address system issues. In addition, the use of a scheduling program could impact the equity of service by requiring significant deviation from a first come, first served policy. For example, it may focus on increasing the probability that a single or knockout single lockage would be scheduled as the last tow in an N-up/N-down sequence to minimize recoupling and exchange times.

Relationship to Other Measures

The use of a scheduling program would be compatible with virtually all other measures, and in some cases additional time reductions could be obtained through joint implementation. For example, the use of extended guidewalls and helper boats, which can eliminate the need to remake tows before exiting the chamber, would greatly benefit from joint implementation with scheduling which maximizes the number of turnback lockages. The scheduling of recreational craft or other measures to reduce their use of the locks could also assist in increasing the efficiency of moving commercial vessels through the locks.

Conclusion

Most of the benefits of a scheduling program are already being obtained by the use of a flexible N-up/N-down policy. However, scheduling does provide benefits to the system and should continue in some form.

ADDENDUM II

The Navigation Study is currently evaluating the installation of adjacent mooring facilities, namely mooring buoys and anchors. Effective placement of mooring buoys and anchors would contribute to quicker lockages by allowing tows to wait closer to the lock, minimizing lock idle time. Buoys and anchors would also reduce environmental damage by enabling tows to await lockage near the channel, thus reducing propeller wash against river banks, reducing bank erosion and instability, and the reducing the re-suspension of sediments into the water column. Usage of buoys and anchors would also reduce the frequency of waiting tows tieing-off to frail riparian timber. Finally, tows awaiting lockage near the channel via buoys and anchors would reduce environmental damage to benthic organisms, fish larvae, fish spawning, and aquatic and terrestrial habitat crucial to traditional and endangered species.

Concurrent with the Navigation Study's efforts, the Corps and the Towing Industry together designed and developed an innovative mooring buoy more suitable for waiting tows. The prototype buoy has proven successful since its implementation below Lock 24 in spring 1998. Numerous additional requests have been made for this new, innovative buoy at locations throughout the UMR. A lockmaster survey in 1997 detailed lock approach tow waiting areas as well as existing and desired locations of mooring buoys and anchors. The survey results have been incorporated into the A&M program.

The economic efficiency of this new buoy regarding improved lockage times, less tow waiting time and reduced fuel usage, all significantly beneficial to the environment, will be evaluated as additional new buoys are installed and lockage data incorporating the new buoys is recorded.

APPENDIX E

1). Pallid Sturgeon Study--one page synopsis of report. To obtain copies of complete report contact Dr. Bob Sheehan, SIU-C, or T. Miller, St. Louis District.

PALLID STURGEON STUDY

The present study is funded by the U.S. Fish and Wildlife Service (USFWS) and U.S. Army Corps of Engineers (USACE) and recommended with high priority by the Central States Pallid Sturgeon Work Group. The study is being conducted by the Fisheries Research Laboratory and Department of Zoology, Southern Illinois University at Carbondale. The study was principally designed to address the Recovery Plan's Primary Task 3.2.1, Conduct field investigations to describe the micro- and macro-habitat components of spawning, feeding, staging and rearing areas. The study also addresses several Recovery Plan Secondary Tasks: 1) 1.1, Reduce or eliminate potential and documented threats from past, present and proposed developments initially within recovery priority areas; 2) 3.1, Obtain information on life history of the pallid sturgeon; 3) 3.3, Obtain information on genetic makeup of hatchery-reared and wild Scaphirhynchus stocks; and 4) 3.4, Obtain information on population status and trends. Sonic telemetry techniques were used to determine the movements, locations and habitat use of pallid sturgeon in the middle Mississippi River (MMR); i.e., the River between the mouths of the Missouri and Ohio Rivers.

The primary objective during year three of the study was to continue studying habitat use and movement of wild pallid sturgeon in the MMR and whether variable such as temperature, availability and discharge affect such use. Efforts were also continued in year three to locate ten hatchery-reared pallid sturgeon that had been implanted with transmitters and released in year two.

Points of Interest

- A character index calculator for identification of pallid sturgeon has been developed in two versions of Windows.
- Pallid Sturgeon were found in water with maximum depths from 6 to 12 meters in 87.7 percent of all relocations. These depths occur most frequently in main channel and main channel border habitats.
- The study area was approximately 64.85% main channel border, 11.05% main channel border, between 3.04% and 8.73% other macrohabitat types and 0.67% island tip downstream.
- Average home ranges for the study sturgeon was21.2 miles. This was lower than has been previously reported.
- Main channel border, island tip downstream, between wing dams and wing dam tip are important areas of habitat selection and may represent important pallid sturgeon habitat
- Pallid sturgeon are commonly found in the main channel, yet this may not be a preferred habitat.
- Study fish appeared to move slowly downstream winter months, and upstream during the late summer and fall. Movement over the remainder of the year was variable.
- There is evidence that Middle Mississippi River pallid sturgeon are not affected by severe winter temperature.

The current study is in the final year. Upon completion of this final year, decisions must be made for future study initiatives for pallid sturgeon in the Middle Mississippi River.

APPENDIX F

1). Prospectus for Monitoring Biological Response to Water Level Management in Pools 24, 25 and 26, by Robert Gates, SIU-C.

2). Progress Report: October-December 1998--Plant, Invertebrate, Fish, Waterfowl, and Water Quality Responses to Non-Persistent Wetland Vegetation Produced Vis Water-Level Management in Pool 25 of the Upper Mississippi River--by Robert Sheehan, et.al.

3). Fish Response to Water-Level Management: Mississippi River Pool 25--by Robert Sheehan and Brooks Burr.

Prospectus for Monitoring Biological Response to Water Level Management in Pools 24-26

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I. Scope

An experimentally controlled study to measure absolute effects of water level manipulation in Pools 24-26 is not logistically nor probably financially feasible. However, a sound monitoring program can be designed to document effects and improve understanding of biological response if it addresses specific planning assumptions that are inherent in water level management. Three primary assumptions are as follows:

1. Drawdowns at low pool levels during late spring and summer will expose substrate and stimulate growth of aquatic macrophytes, particularly moist soil emergent plants.

2. Increased abundance of aquatic macrophytes will be associated with increased biomass of aquatic macroinvertebrates.

3. Enhanced macrophyte communities will increase overall habitat diversity for waterbirds and fish.

The primary goal of managing water levels in Pools 24-26 is to enhance aquatic macrophyte and invertebrate communities in near-shore areas of the lower and middle reaches of these Pools. Consequently, the emphasis in evaluating water level manipulations is appropriately placed on measuring vegetation and invertebrate responses. However, the primary assumption of water level management is that enhanced macrophyte and invertebrate communities will benefit fish and wildlife by enhancing food, and cover. If the Corps is to continue in this or similar ventures, they will need to demonstrate benefits to fish and wildlife resources that exceed real and potential costs to the navigation industry and other user groups. Therefore, it is imperative to directly link vegetation and invertebrate response to effects on waterbirds and fish.

For example, the most crucial link between vegetation response and benefits to waterfowl is that increased food biomass (plant seeds, tubers, invertebrates, etc.) is available to and utilized by waterfowl during fall and spring migration. This means that water levels and flow velocities cannot increase after summer such that near-shore areas become unvailable or unattractive to waterfowl. Similarly, residual vegetation must be present after winter to support invertebrate communities that waterfowl need during spring migration, and water levels cannot be so deep as to prevent their utilization. A similar case can be made for fish response that others may wish to address with separate proposals.

II. Approach:

The limitation of this assessment is that it is semi-controlled and lacks baseline data for most components. The river will certainly not provide constant field conditions, but instead can be relied on to provide sufficient variation for correlative analyses of biological response to water level changes. Thus, it should be possible to measure response from comparisons within and among pools, and years, however, it may prove difficult to separate responses associated with intentional manipulation of water levels from uncontrolled events.

Monitoring should be designed to measure areas of exposed substrate and colonization of these areas by wetland vegetation. Satellite imagery and/or aerial photography could be used to identify such areas if acquired during low pool levels. There is no need to measure surface features other than exposed sediment and moist soil vegetation in near-shore areas. This should minimize the time and expense associated with more detailed habitat classifications. Areas of exposed substrate and wetland vegetation would be compared among pools, segments within pools (upper, middle, lower), and between years. Differences would be related to variation in water levels within and among pools.

Three sites would be selected in each segment of each pool for intensive investigations of plant, invertebrate, and fish/wildlife response. A transect would be established at each site, beginning inland at the high water mark and extending perpendicularly to where open water is first encountered. Sampling points would be distributed randomly along these transects to measure vegetation, invertebrates, and physical variables (water level, sediment characteristics, time exposed, etc.).

Observations and sampling of fish and water bird use would be conducted along or adjacent to vegetation/invertebrate transects during

III. Objectives:

1. Measure and compare areas of emergent wetland plant communities in near-shore areas of upper middle, and lower segments of Pools 24, 25, and 26.

2. Measure relative abundance (percent canopy coverage and/or frequency of occurrence) of individual plant taxa across the physical gradient of the land-water interface.

3. Quantify standing crop biomasses of moist soil plant seeds and root stocks that are potential food for waterfowl.

4. Quantify invertebrate invertebrate biomass during seasons and with gear that are consistent with anticipated utilization by fish and waterfowl (e.g. zooplankton when utilized by larval fish, nektonic and benthic invertebrates during fall and spring waterfowl migration periods).

5. Assess vertebrate (larval and Y-O-Y fish, waterbirds) response with focus on habitat and food utilization (food habits, feeding activity, distribution) that are necessary to establish the link between vegetation/invertebrate production and higher trophic levels.

IV. Implementation:

This monitoring program should be a cooperative venture among participants in the Pool 25 Integrated Resources Management planning effort. Cooperating agencies have the resources needed to conduct biological response monitoring of water level management. LTRMP/EMTC has the capacity to conduct GIS and other analyses of water level changes and wetland vegetation. SIUC can conduct vegetation, invertebrate, and fish sampling, as can LTRMP. Logistical and other support would be required from MDOC, IDOC, and USACOE.

Tentative General Study Design:

Sampling Layout:

1. Permanent transects established perpendicular to shoreline, extending across drawdown area between terrestrial and permanently inundated zones.

Logistical questions:

Fixed vs. variable length transect corresponding to width of the drawdown zone.

Average width of drawdown zones in past years, likely to vary annually and between pools and pool locations.

2. Plots randomly located along transects for sampling of vegetation and invertebrate abundance.

Logistical question:

Number of plots/samples per transect--may vary according to widths of drawdown zones.

3. Minimum of 3 transects established in upper, middle and lower pools.

Logistical question:

Tradeoff between intensive sampling along each transect vs. sampling more sites or trnasects, each less intensively.

4. Three pools sampled, for a total of at least 27 transects:

(3 sites/pool segment X 3 pool segments X 3 pools = 27).

Logistical question:

Drawdown schedules for each pool.

Sampling Schedule:

1. June-July (ca. maximum drawdown):

<u>Measurements</u>: frequency of occurrence, canopy cover, and/or, height of aquatic vegetation in 0.5 - 1.0 m^2 quadrats randomly placed across the drawdown zone. Width of drawdown zone and % of zone in which germination of aquatic plants is evident.

2. August-September (after seed maturation and return to "normal" pool levels):

<u>Measurements</u>: Standing moist soil seed biomass density (g/m^2), and below-ground tuber standing crop (g/m^{3}). Biomass of nektonic and possibly benthic macroinvertebrates (g/m^{3}). Macroinvertebrate sampling methods; activity traps and/or sweep nets for nektonic, petite ponar dredge for benthic invertebrates and possibly below-ground tubers. Water depths along transects.

3. October-December (once per month during autumn waterfowl migration):

<u>Measurements</u>: Presence/absence (% of drawdown zone) with aquatic vegetation above and below water surface. Water depths along transects. Distribution, abundance, and feeding activity of waterfowl within and beyond drawdown zone as observed from transect origin.

4. February-April (once per month during vernal waterfowl migration):

Presence/absence (% of drawdown zone) with aquatic vegetation above and below water surface. Water depths along transects. Distribution, abundance, and feeding activity of waterfowl within and beyond drawdown zone as observed from transect origin. Standing crops of nektonic and benthic invertebrates as described for August-September.

Other Considerations:

1. Incorporate GIS coverages of drawdown zones with measurements of vegetation and invertebrates to produce crude estimates of biomass production attributable to drawdown.

2. Incoporporate INHS aerial waterfowl surveys to evaluate pool-level waterfowl response.

Addendum: Monitoring waterfowl response to pool manipulations

The general approach to measuring biological response to environmental pool level manipulations remains essentially unchanged from that outlined in the attached prospectus. The following are suggestions for modifications to the monitoring plan for waterbird response:

1. A more intensive sampling regime can (and should) be implemented now that the monitoring program will be limited to Pool 25. More study sites can be distributed among the upper, middle, and lower pools of Pool 25, and they should be identical to those used to monitor fisheries response. There will need to be agreement between waterbird and fisheries investigators regarding the number, distribution and placement of transects/plots.

2. Herbicide-cleared plots may be a useful baseline for comparison of vegetation and invertebrate communities/biomass in vegetated vs. unvegetated areas, but do not really represent true "control" for pool level manipulation. There is some utility in sampling macroinvertebrates within cleared and uncleared plots because an important assumption of pool level manipulations is that macroinvertebrate abundance will increase with greater macrophyte abundance. Sampling vegetation within cleared plots will only measure effectiveness of the removal treatment used to create the "control", not the actual effect of pool level manipulation. Thus, vegetation sampling of cleared plots has more limited value.

3. General vegetation response to pool level manipulation has already been adequately documented through photo-points and growth measurements taken by Ken Dalrymple (MDOC). The focus can now shift more toward quantitative measurements of species composition along flooding and other physical gradients such as pool reach, substrate, etc during the growing season. Multivariate ordination techniques can be used to determine how vegetation responds to variation in the river hydrograph in different portions of Pool 25. Vegetation sampling should be conducted after the drawdown has stimulated germination and growth of aquatic macrophytes, preferably before reflooding.

4. Sampling of benthic, nektonic, and periphytic macroinvertebrate communities should be conducted during peaks of fall (Oct-Nov) and spring (Mar-Apr) migrations of waterfowl through the area. Sampling should correspond, if possible with sampling of zooplankton by CFRL.

5. Seed and root stock biomass of moist soil plants should be sampled at the end of the growing season, just before fall migration. Less intensive, or semi-quantitative sampling to determine presence of residual vegetation and availability of seed and root stocks of moist soil plants should be conducted during fall and spring migration, concurrent with sampling of macroinvertebrates during fall and spring waterfowl migrations.

6. Waterbird use of vegetated and non-vegetated areas (if feasible) can be recorded concurrently with measurements of vegetation composition (June-July), seed and root stock biomass (Sep-Oct), macroinvertebrate abundance (Oct-Nov and Mar-Apr.).

Progress Report: October-December 1998

Project: Plant, invertebrate, fish, waterfowl, and water quality responses to non-persistent wetland vegetation produced via water-level management in Pool 25 of the Upper Mississippi River.

Objectives:

1. Characterize the plant community associated with water level management and quantify production of seed biomass.
2. Quantify the aquatic invertebrate community response to increased non-persistent wetland vegetation production.
3. Determine the responses of fish to water level management and vegetation production.
4. Characterize waterbird/waterfowl use of food resources produced by water level management.
5. Monitor the effects of vegetation produced via water-level management on water quality.

Funding Source: St. Louis District, U.S. Army Corps of Engineers

Principal Investigators: Robert J. Sheehan, Brooks M. Burr, and Bruce D. Dugger

Graduate Research Assistants: Reid Adams and Jamie Feddersen

Introduction

Construction of levees, dikes, bank revetments, and locks and dams has changed the Mississippi River from a free-flowing river-floodplain ecosystem into a series of reservoirs with constricted flow and controlled flooding (Chen and Simons 1986). In an effort to reverse the trend in habitat loss, the U. S. Army Corps of Engineers (USACE) conducted early summer water-level drawdowns in 1994 on Pools 24-26. Investigations of the mudflats exposed after the drawdown showed lush production of non-persistent wetland vegetation (Dalrymple et al. 1996).

An increase in wetland vegetation can provide direct benefits to wildlife by producing foods like seeds and tubers (Bellrose 1941). It can also provide spawning and nursery-area habitat and cover for fish. In addition, aquatic macrophytes may provide indirect benefits by increasing invertebrates on which fish and wildlife feed (Kadlec 1962, Harris and Marshall 1963, Westlake 1975, Voigts 1976, Weller 1978, Murkin et al. 1982, Ward 1984, Murkin and Kadlec 1986).

While it is commonly accepted that populations of aquatic macroinvertebrates are influenced by the amount of vegetation in a wetland, very little is reported on invertebrate-vegetation dynamics in riverine systems with regulated flow. This study was undertaken to quantify the plant and animal food resources, the changes in water quality, and to evaluate avian and fish use of resources derived from the production of vegetation via water-level management in Pool 25 of the Mississippi River.

Activities

The study plan called for comparing organismic and water quality responses in *vegetated areas* to areas that are in other ways similar but in which vegetation production is eliminated via applications of a low-persistence contact herbicide (*devegetated areas*) during the drawdown phase of the water-level management regime. Responses solely attributable to the vegetation could thus be isolated and identified.

The project was initiated during fall 1998, too late in the annual water-level management cycle to create devegetated areas. Thus, results of sampling during the first year of the study will be used to determine the variability in responses across the sampling locations; this will aid comparisons and interpretations of responses in vegetated and devegetated areas in the following year of the project. In essence, the first year of study will be used to determine if biotic and abiotic responses are indeed similar in areas destined to be vegetated and devegetated in the following year.

Our personnel met with Ken Dalrymple, Missouri Department of Conservation, Neil Booth, Illinois Department of Natural Resources, and Dr. Joseph Wlosinski, U.S. Geological Survey-Biological Resource Division, to discuss the vegetation response to water-level management in previous years and to identify suitable sampling locations for the study. Three field reconnaissance trips were made to Mississippi River Pool 25 during fall 1998. Paired sampling plots, one to represent a vegetated site and the other a devegetated site, were then established on Jim Crowe Island, Turner Island, and in two locations within the Batchtown State

Wildlife Management Area. Each plot was 20 x 20 m and placed not closer than 10 m from the corresponding paired plot. Nine sampling points were then randomly selected within each plot.

Two project constraints were identified during fall 1998. First, heavy rains during early October resulted in Pool 25 being put "on tilt", causing a drawdown in the lower end of the pool. This resulted in dewatering of the sampling sites and the cancellation of a planned sampling trip during the period October 9-12. Responses by aquatic organisms to flooding of the vegetation during fall were thus interrupted and most probably diminished by the dewatering event. This indicates that interpretations of responses to the planned water-level management regime and drawdown-induced vegetation production will require considerations of the effects of such unplanned water-level changes. Second, it became apparent that sampling subsequent to the beginning and during the waterfowl hunting season will not be possible, due to the need to maintain good public relations with hunters using Pool 25. In the next sampling year, it will be possible to begin sampling during late summer, soon after flooding of the vegetation—a sampling schedule that was not possible this year, since funding for the project was not received until the fall.

Secchi disc depth (cm) and water depth (cm) were measured at each of the 72 sampling points (4 locations, two plots per location, 9 sampling points per plot) prior to invertebrate collection. We collected 72 invertebrate samples during 3-4 October 1998. Nektonic samples were collected at each sampling point by placing a 40-cm diameter stovepipe sampler in the water column with the lower 5 cm of the stovepipe forced into the substrate to contain all invertebrates within a known volume of water. Water volume was calculated by multiplying the measured water depth (cm) by the cross-sectional area (1,297 cm^2) of the stovepipe sampler. A D-frame sweep net was passed through the contained water column 5 times. After each sweep, the net was rinsed with water into a U.S. Standard 30 mesh bucket sieve. Samples were stored in plastic zipper-lock freezer bags and preserved with 80% ethyl alcohol. Benthic samples were collected at each sampling point using a 5 (diameter) x 10 cm (height) core sampler similar to that described by Swanson (1983). Benthic samples were rinsed and stored by the same methods previously discussed.

Heavy rains in the northern reaches of the Upper Mississippi River forced the USACE to drawdown Pool 25 to minimum channel maintenance depth. The drawdown dewatered the study plots and prevented invertebrate sampling planned for 9-12 October 1998. After vegetated areas were reflooded, we collected 24 additional samples on 14 October 1998 to investigate how short-term drawdowns may affect recently established invertebrate populations. Onset of the annual waterfowl hunting season precluded further invertebrate sampling.

Fish sampling was conducted via 10 seine hauls and 6 popnet samples at each of the 4 study locations during October. This sampling effort was equally divided into each of the two sampling plots (one to be vegetated and the other to be devegetated in the following year) at each location. Recently hatched emerald shiners and sunfish dominated the popnet samples. We currently are modifying the popnets to make them more efficient for capturing fish of such small size. In addition to seining and popnet samples, light-trap samples will be collected in the spring to determine use of the vegetation by fish for spawning and nursery areas. Spring and fall fish-sampling effort, both in terms of number of sampling trips and sampling effort per trip, will be substantially increased during the rest of the project.

The study plan called for electrofishing samples collected along 4 horizontal transects located along the length of the pool. It was envisioned that trends in the fish community associated with the increasing amount of vegetation that was thought to occur from the upper to lower end of the pool could thus be elucidated. However, it was determined during the fall reconnaissance that the vegetation produced during the drawdown was restricted to the lower end of the pool. Thus, the objectives of the electrofishing sampling were modified to compare fish using areas along vegetated areas to those using areas in other habitats in the lower end of the pool. Fish community and populaiton structures and dietary habits will be compared in these habitats. Electrofishing samples collected in fall 1998 were from along the vegetated areas and from the downstream side of wing dikes.

Plant, invertebrate, and fish samples have been preserved and returned to the laboratory. We are currently identifying and quantifying taxa in the collections.

We are also conducting a review of the literature pertinent to the project.

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Fish Response to Water-level Manipulation: Mississippi River Pool 25

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Background: Historically, Mississippi River (MR) pool levels have been allowed to fluctuate 2 to 3 feet during the growing season. This resulted in shallow mud flats devoid of vegetation. MR navigation dams are now being used to manipulate water levels in navigation pools to produce non-persistent wetland vegetation (Dalrymple et al. 1996). Pools are lowered in summer up to one to two feet to dry near-shore areas and allow vegetation (mostly wild millet and smartweed) to grow. The pool is then slowly brought back to normal stage in late summer as the vegetation is growing.

Pool-level manipulation is similar to standard moist-soil management techniques for waterfowl production with one important difference for fish; most moist soil units are isolated from the river by levees as well as drained during the summer, making them (at best) marginal fish habitats. River fishes have access to areas in which moist-soil vegetation is produced in pool-level management during all times with the exception of the 1.5-2 month period of the dewatering phase. They then, therefore, can utilize any benefits that may be provided by the vegetation. We have examined fish utilization of the vegetation produced via pool-level management in MR Pools 24, 25, and 26, and this approach appears promising, based on abundance and diversity estimates (Heidinger et al. 1998).

The goal of this study is to determine whether pool-level management provides benefits to fish. Specific objectives include an exploration of the nature of any realized fish benefits and a determination of how pool-level management practices may be refined to maximize fish benefits. Benthic macroinvertebrate and vegetation response data, that will be obtained in a concomitant waterfowl-response study (conducted by our institution's Cooperative Wildlife Research Laboratory), will also be used to interpret our findings.

Approach: We anticipate this study will be conducted over four years. All work will be done in MR Pool 25 (funding available for the study in years 2 to 4 is earmarked for use in this pool only). The current pool-level management regime will be utilized during the first two years. Information obtained in the first two years will then be used to determine whether modifications of the pool management scheme (timing and duration of the drawdown phase) should be attempted. The effects of the vegetation on fish forage-item abundance, fish diversity and abundance, and fish growth will be examined. Some of the effects of the vegetation on physicochemical conditions will also be explored.

Fish: Two approaches will be used to determine effects of pool management and vegetation on fish abundance and diversity. The first will involve fish sampling via electrofishing at six sites spread across the length of Pool 25. This approach is warranted, because the magnitude of the drawdown (as well as the amount of vegetation produced) diminishes with distance upstream of the dam (there is very little effect on water level above the hinge point). Electrofishing samples (50-100 m of shoreline) will be collected from all six sites in triplicate twice in the spring-summer period prior to the drawdown and twice in the fall after reflooding. Major sportfish and commercial species, collected in sufficient numbers, will be used for food habits analyses. The data will be examined for longitudinal trends in fish community structure, abundance and diversity.

A second approach examining the fish response is required, because lotic conditions in the upper reaches of navigation pools shift toward more lentic conditions downstream. Thus, biotic and abiotic factors vary in response to longitudinal effects on physicochemical characteristics. To aid in interpretation of the longitudinal trend data (i.e., to help determine whether trends in the data are due to pool management and the vegetation as opposed to the longitudinal differences within pools), a second more empirical approach examining the fish response will be utilized. A low-persistence, contact herbicide will be applied during the drawdown phase at four sites to prevent plant growth. A 30 to 50-m strip from the drawdown water line to the normal pool water line will be treated with herbicide. Fish will be sampled in zones denuded of vegetation (vegetation-free zones) and in an equivalent number of comparable vegetated zones using pop-up fish traps in the spring prior to drawdown and in the fall after reflooding. Fish community structure, abundance, and diversity will be compared between vegetation-free and vegetated zones. The food habits of sport and commercial species collected by the pop-up traps in sufficient numbers will also be examined. Pop-up trap fish sampling will be conducted every two weeks from the time of reflooding through September and every two weeks in spring from the beginning of May until the drawdown begins. Light traps will be used to collect larval fish in the vegetation-free and vegetated zones every two weeks during the spring, pop-up trap sampling trips. Larval fish will be identified to the lowest taxon possible. Pop-up traps and light traps will be used, because these capture techniques should be less biased by the presence or absence of vegetation than other sampling methods.

Invertebrates: Zooplankton samples will be collected in triplicate using an integrated sampler from vegetation-free and vegetated zones during the spring and fall sampling trips. Zooplankton community structure, abundance, and standing crop biomass will be compared between vegetation-free and vegetated zones. The invertebrate data collected by us and the CWRL plus the fish prey species data will be used to determine whether forage items utilized by sport and commercial fishes in the pool can be linked to the vegetation.

Other Monitoring: Water velocity, dissolved oxygen, and secchi-disc light penetration will be measured at three distances from the shore and at two locations at each vegetation-free and vegetated zone. Soil compaction will be measured at three distances between the drawdown shoreline and the normal pool shoreline at three locations at each vegetation-free and vegetated zone during the drawdown, just prior to reflooding.

Project Outputs: Annual reports will be completed subsequent to project years 1 and 3. Cumulative reports will be completed at the ends of years 2 and 4.

APPENDIX G

Biological Monitoring

1). Hydroacoustic Fact Sheet--by Brian Johnson.

2). Hydroacoustic Update, A&M Meeting, 11 March 1998--By T. Miller and Brian Johnson.

3). A&M Program--Fish Use of Thalweg Holes, Plan of Study--By Brian Johnson.

4). A&M Trip Report, Sample Thalweg Holes for Fish, 18/8/98--By Brian Johnson.

5). A&M Trip Report, Sample Thalweg Holes for Fish, 19/11/98--By Brian Johnson.

6). A&M Trip Report, Sample Thalweg Holes for Fish, 5/1/99--By Brian Johnson.

U.S. Army Corps of Engineers - St. Louis District

Hydroacoustic FAQs

Bottom Typing

How does the bottom typing work? St. Louis District uses a BioSonics DT5000 dual beam hydroacoustic system. The system emits acoustic "pings" into the water and receives the return echoes. Simply stated, the strength and shape of the return echo is compared to that of known substrates to determine unknown substrates.

A set of predetermined transects is run during field sampling. These transects are usually somewhere between 25-75 ft apart, with a goal of covering between 5-10% of the bottom. Pings are usually sent down at a rate of 5-10 per second. This equates to about 1 ping every .5-1 meter at a boat speed of 4-5 knots. We plot one data point for every 10 pings (between every 5-10 meters). That data point is the substrate type of the majority of those 10 pings. For example, if we have 7 sands pings and 3 gravel pings, that data point would be sand.

How do we determine the different bottom types? We have six different bottom types; soft mud, fine sand, medium sand, coarse sand/gravel, clay (hard) mud, and hard substrate. Samples were taken using a petite ponar to differentiate substrate types. Hydroacoustic data was collected at the same time and location. These collections served as the calibration samples. Using each set of calibration samples, we were able to create a range of values for each substrate type. Each of the six substrate types has a differing echo shape, strength, and defined range. On sampling transects each ping (10 ping groupings) is compared to these six substrate types, hopefully falling into the range of one of these groupings. This methodology is known as First Echo Division.

How do the substrate echoes differ? Harder substrates send back a stronger signal. Softer substrates send back a somewhat weaker signal, as more of the energy is absorbed into the substrate. Visually, the energy echo of harder substrates has an early sharp peak, while soft substrates tend to have a softer more bell shaped form.

What kinds of output are created? The completed data file contains a latitude and longitude reading (and/or state plane coordinates), water depth, and substrate type at 5-10 meter intervals along the sampling transect.

If you only get 10% coverage, how are the maps created? Ten acoustic pings are grouped to create one data point at about every five meters along each transect. After all the transects have been analyzed a computer program creates a series of lines between a data point and the other data points closest to it. The program then interpolates a point in the middle of each line where the substrate changes from the substrate at point A to the substrate at point B. The program then creates and shades polygons of like substrate types to create the complete coverage seen on the maps. Only substrate types that were encountered are shown on the map. Each substrate type is designated by a standard number (1 through 6) and color.

Fish Location/Counting

How does the BioSonics equipment locate fish? In essence, the BioSonics equipment is like a fancy fish finder. It sends an acoustic energy wave down through the water column. Anything that causes that signal to bounce back, like a fish or the bottom, is recorded. The BioSonics equipment records the strength of the return echo. By knowing the strength of the initial wave and the strength of the returning echo, we can determine the size of the fish using predetermined equations. Unlike a fish finder, the BioSonics system is calibrated and voltages are calculated, not just displayed as an echogram which can not be interpreted.

What are the limitations of the system? St. Louis District, in our section of the river, can usually get our resolution such that we can see a 3-inch fish, 8 inches off the bottom. We collect at a resolution that would allow use to see a 1-inch fish, but background noise caused by things like boat movement, suspended sediments, and air bubbles make a 3-inch fish the lower limit of the equipment on the Mississippi River. The minimum distance between the bottom and a fish can be as low as 2-3 inches (we use 8 inches), however, the pulse width necessary to measure fish this close to the bottom cannot accurately measure the size of fish greater than approximately 18 inches. The system can not tell the species of a fish.

How do you know what you are seeing are really fish? Everything that falls below the noise threshold is eliminated. Everything above that threshold is considered a fish. Items like submerged logs are usually neutrally buoyant and do not create an echo similar to fish or are attached to the bottom and look like logs on the readout. The echo from a log is usually deformed in comparison to the square pulse echo of a fish.

How do you determine the size of a fish? St. Louis District uses a dual beam hydroacoustic system. The distance away from the center of the beam is measured with the dual beam transducer allowing us to determine the expected size of the fish if it were on axis (below the boat), therefore, accurately measuring fish size.

What kinds of output are created? The completed data file contains a latitude and longitude reading (and/or state plane coordinates), depth, and length for each fish, as well as an overall water depth along the sampling transect.

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St. Louis District
Hydroacoustic Fact Sheet
September 1998

St. Louis District Capabilities

The MV Boyer is the main survey boat for the District and is one of three vessels equipped to operate the BioSonics DT hydroacoustic system. Of the three vessels, the MV Boyer has the greatest capabilities. In addition to its ability to collect the BioSonics fishing counting/location and bottom typing data, the MV Boyer can also simultaneously collect velocity profiles using an Acoustic Doppler Current Profiler. Together these technologies allow us to determine a fishes size and location (X,Y,Z), and the velocity of the water at that location. The Boyer can also collect multi-beam bathymetric data. This multi-beam system gives 100% coverage of the bottom. This information is then turned into both bathymetric and shaded relief maps onto which fish locations can be overlaid. All information (BioSonics, ADCP, and multi-beam bathymetry) is collected using DGPS.

Uses of the BioSonics DT system

Present

June 1998 - Rock Island District. Upper Mississippi River Dredge Site Survey. Fish, bottom typing and bathymetric surveys were collected at 25 sites, including proposed and past thalweg dredge sites, thalweg disposal sites, and dredge rehandle sites. The primary objective was to determine the location of substrates suitable for mussels. The information was used to focus efforts of mussel divers hired by the RI District to determine the presence of mussels. The work also included a fish survey of the Cottonwood Chute HREP and a bottom type and bathymetric survey of the Savanna Bay backchannel.

Ongoing - Mississippi Valley Division. Lower Mississippi River Habitat Monitoring Study. Fish, bottom typing, velocity and bathymetric surveys of selected side-channels in the middle Mississippi River below the confluence of the Ohio River to look at changes in available habitat.

Ongoing - St. Louis District. Avoid and Minimize Program. Fish use of thalweg holes. Fish, bottom typing, velocity, and bathymetric surveys on selected thalweg holes in Pools 24, 25, and 26 to determine seasonal fish use of thalweg holes and the potential impacts to fish caused by thalweg disposal. This work builds upon work already completed on thalweg holes in Pools 24 and 26.

Upcoming

Upper Mississippi River Navigation Study - St. Louis District. Winter Fish Study. In tandem with the ADCP velocity profiler, the BioSonics DT system will be used to look at changes in velocity and fish movement behind wingdams, in the winter, caused by tow passage.

Avoid & Minimize Program - St. Louis District. Fish Passage Through Dam Gates. Again, in tandem with the ADCP velocity profiler, the BioSonics DT system will be used to look at fish passage through the dam gates during spring flows. This work will likely occur in the spring of 1999 at Lock and Dam 25, in cooperation with EMTC.

Other Potential Uses

Can provide a method to explore fish use of deepwater over-wintering sites like sidechannels and training structures.

Can provide a method to determine and map the presence, size, and location of necessary habitat types for rare fishes like the pallid sturgeon, the sicklefin chub, and the sturgeon chub.

Can provide a method for determining the location of substrate suitable as mussel habitat.

Can provide a method to determine the success of EMP/HREP projects like Pharrs Island or Stag Island.

May provide a method to look at fish avoidance of tows, using the system in a side-scanning capacity.

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Gravel

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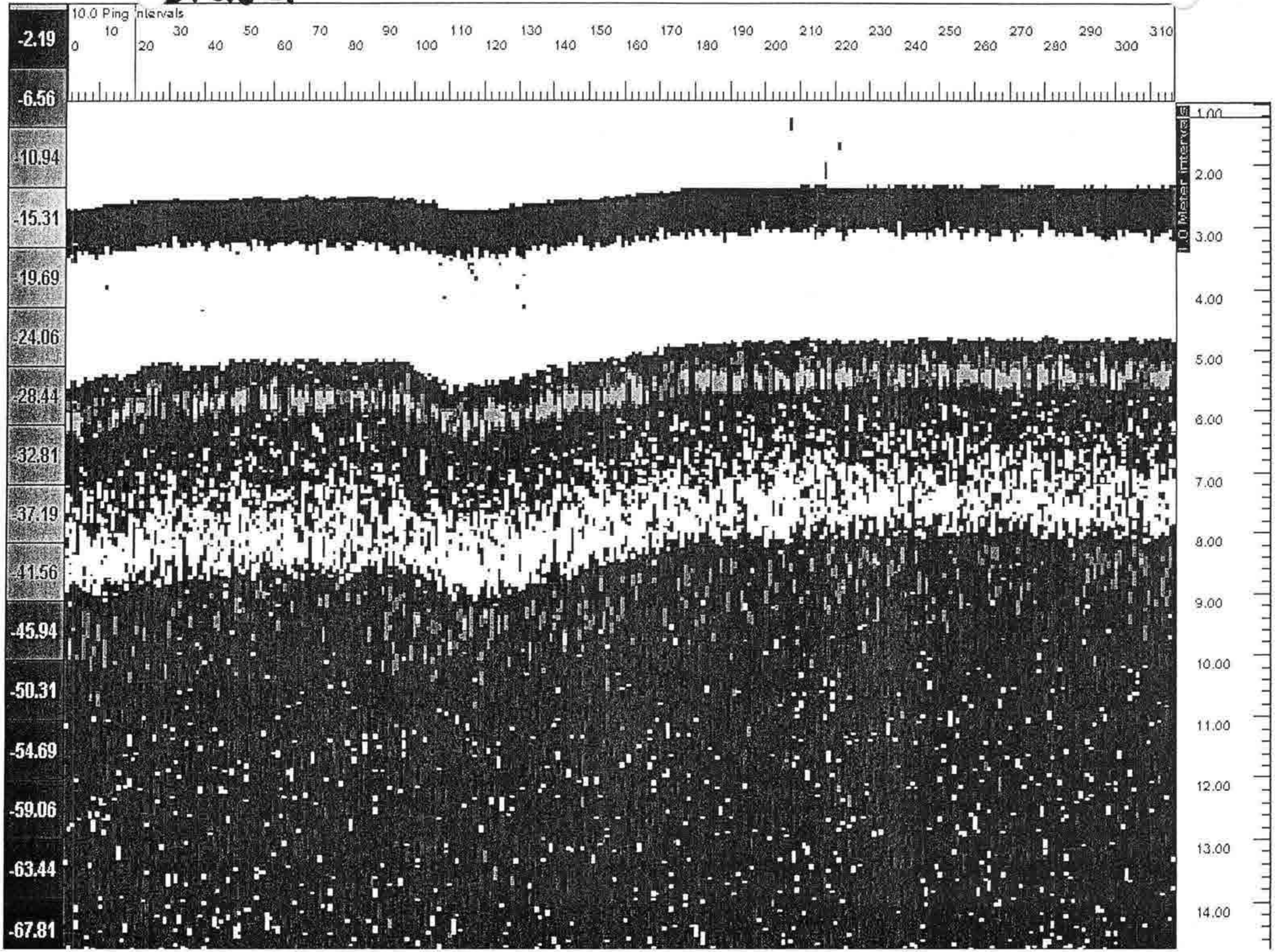

mud

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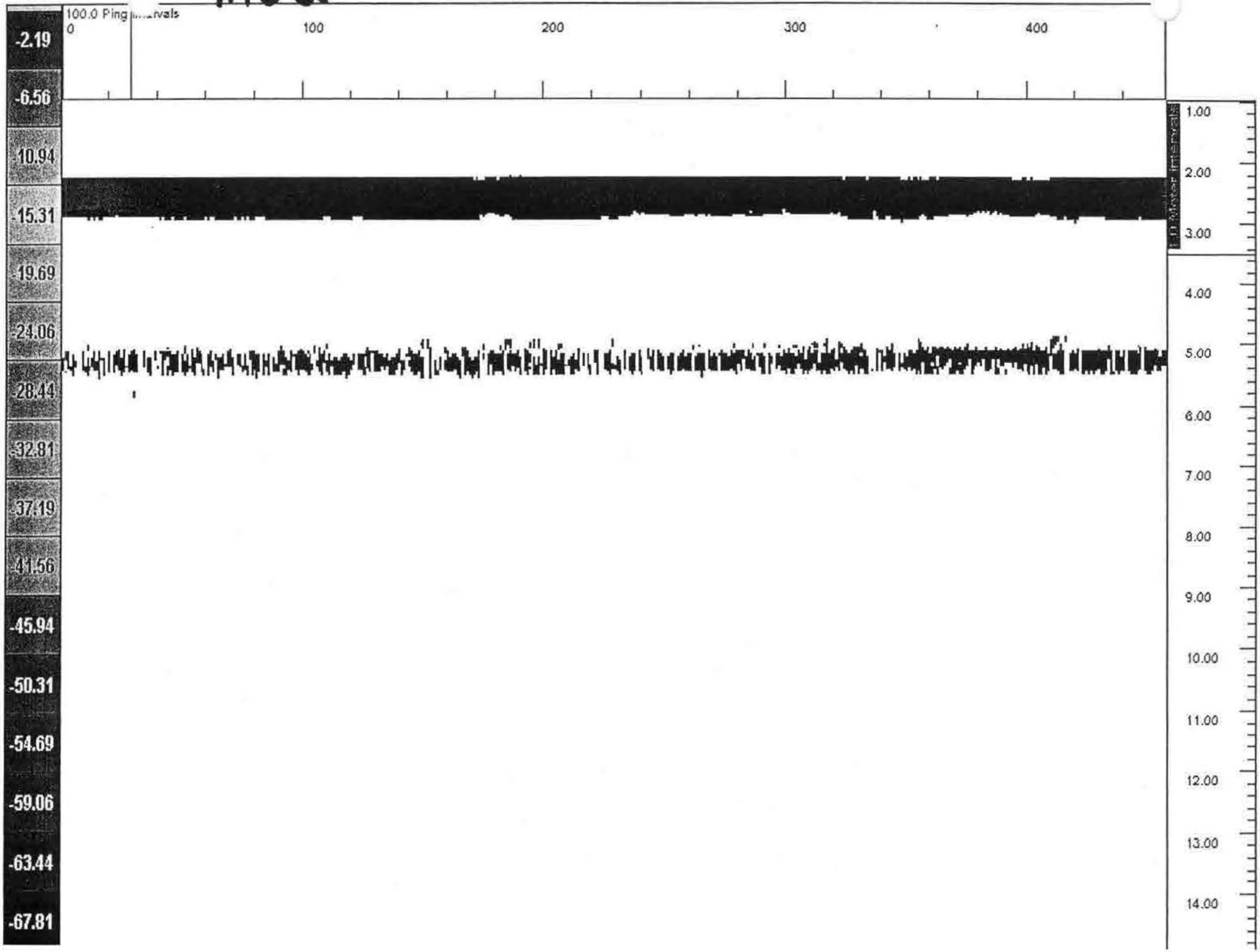

1998 Survey Sites
Rock Island District

Site Name	Pool	Lower River Mile	Upper River Mile	Study Location Type	Fish Survey	Substrate Survey	Bathymetric Survey	Mussel Study Site #
Island 241	12	562.5	563	Near Shore	done	done	done	
River Mile 563	12	561.9	562.4	Near Shore	done	done	done	
Island 241	12	561	561.6	Thalweg	done	done	done	
Savanna Bay	13	538.7	539.5	Back Channel	yes	done	done	
Savanna Bay	13	537.85	538.7	Thalweg	yes	done	done	2, 15
Sabula Lower	13	533.7	534.8	Wing Dams	yes	done	done	
Sabula Lower	13	532.9	523.5	Dredge Cut	no	done	done	16
Johnson Island	18	421.2	421.9	Dredge Cut	no	done	done	17
Jacoby Island	18	418.9	419.4	Near Shore	yes	done	done	7
Benton Island	18	419.85	420.2	Dredge Cut	no	done	done	8
Benton Island	18	418.2	418.5	Thalweg	yes	done	done	
Oquawka	18	415.1	415.3	Rehandle Site	no	done	done	
Howard's Crossing	21	338.2	338.4	Near Shore	yes	done	done	
Howard's Crossing	21	338.1	338.2	Placement Site	yes	done	done	20
Willow Island Upper	21	332.65	333.05	Dredge Cut	no	done	done	
Willow Island Lower	21	332.1	332.4	Dredge Cut	no	done	done	21
Hogback	21	330.1	330.9	Thalweg	yes	done	done	
Cottonwood Chute	21	328.6	329.4	Back Channel	done	no	done	
Northeast Power	22	319.4	319.8	Rehandle Site	yes	done	done	
Bebee Island	22	317.2	317.5	Rehandle Site	no	done	done	
Bebee Island	22	315.9	316.4	Dredge Cut	no	done	done	11
Whitney Light II	22	312.5	312.9	Thalweg	yes	done	done	24
Whitney Light I	22	311.6	312	Thalweg	yes	done	done	12
Lock & Dam 22 Lower *	24	300.3	300.9	Dredge Cut	no	done	done	
Lock & Dam 22 Lower *	24	300.3	300.9	Wing Dams	yes	done	done	

* indicates surveyed together

U.S. Army Corps of Engineers
St. Louis District

N 1988000
N 1986000
E 2296000
E 2298000
E 2300000
TYPE 6 HARD SUBSTRATE
TYPE 5 CLAY MUD
TYPE 4 COARSE SAND/GRAVEL
TYPE 3 MEDIUM SAND
TYPE 2 FINE SAND
TYPE 1 SOFT MUD
US Army Corps of Engineers St. Louis District
SAVANNAH BACK CHANNEL
BOTTOM TYPING ANALYSIS

A&M meeting 31 March 1998
Hydroacoustic Update

The district will have three boats equipped to use the hydroacoustic equipment by this summer.

1) ED-HQ boat, DGPS, medium-shallow draft, covered, open/shallow water
2) PD-A boat, DGPS (lat/long only), shallow draft, uncovered
3) Boyer - velocity, depth, substrate, temperature, DGPS, 4-5 ft. draft, covered, open water

Brian is developing a hydroacoustic utilization plan, long range look at how the District should and can be using the equipment

FY98-99

1) **Bendway weir work -** Take a comprehensive look at fish use of a bendway weir with hydroacoustics, blast, collect fish, analyze fish stomachs, attempt to compare hydroacoustic results with blast collection, possibly collect macroinvertebrates off the bendway rocks. Incorporate into one report.

2) **Thalweg holes** - Identify 2-4 thalweg holes for dredge disposal next year, start monitoring this fall with seasonal sampling, place material, continue to monitor for fish use after placement.

3) **Equipment testing/truthing** - Get in behind some wings dams, blast, look at species composition, and attempt to relate to hydroacoustic results.

4) **Side channel work** - Monitor completed side channel work in Sante Fe chute, Marquette chute, look at fish use of side channels proposed for rehabilitation.

5) **Overwintering work** - Determine where fish are overwintering, looking at:
- existing side channels
- rehabilitated side channels
- chevron dikes in pool 24
- behind the bullnose dikes
- connected blue holes
- behind wing dams

Other Uses

Training structures - Evaluate different training structures and their value to fishes.
- comparing seasonal fish use behind notched and unnotched dikes
- chevron dikes
- off bank revetments
- round points
- etc..
- fish use of training structures as habitat during different levels of flow
    - overwintering,

-refuge from high flows

Main channel work - Look at fish activity in the main channel
- fish use of the main channel in the winter, behind sand waves
- how fish in the main channel react to approaching tows and tow passage

Project Evaluation - Use as a tool to evaluate other completed and proposed Corps projects (HREP, EMP) like Pharrs Island

Fish Passage - Look at inducing fish passage through the locks in the spring

1. Fish sampling on a bendway weir. (2 days?)

a. fish stomachs
- contract for analysis and report
  - FY98 or 99 depending on timing of sampling

b. macroinvertebrates
- what is the value of added information vs. added cost?
  - costs:
    - Pathfinder (~5,000 pr day) (1 day, if on patrol)
    - analysis & report (~30,000), but would include fish stomachs
  - community likely different from 2 years ago?
- contract for analysis and report
  - likely FY99

c. hydroacoustic fisheries work
- contract for analysis?
  - at present cost unknown (~2000?)
- incorporate into a complete report, 1 author

d. other issues
- When?
  - late summer/early fall? Is season important?
  - navigation concerns/closing river and timing
    - get necessary permissions (CG), bulletin
- Estimate costs for project
  - Greg Hempen, blasting supplies
  - report cost
  - Pathfinder?
  - Boyer
  - hydroacoustic analysis
  - travel & per diem
  - hired labor
- Outside help
  - would need assistance from MDC, IDNR, USFWS, LTRMP
- Where?
  - Price's Bend, collected inverts. there in 1996
  - Carl Baer Bend, collected inverts. there in 1996

Plan of Study
Fish use of Thalweg Holes
Avoid and Minimize Program

Issue/Concern: Thalweg disposal has been used as a proven and effective means of disposing of dredge material. Little is known however, about fish use of these thalweg holes. St. Louis District has done some sampling work in thalweg holes at R.M. 224 & 289 but this work has been mostly pre-disposal. Our partner agencies in the A&M program have expressed concern about the potential for decreased use of these holes by fish as over-wintering habitat, post-disposal. In response, the St. Louis District has set forth a plan to look at seasonal fish use of potential thalweg disposal sites.

Action: With the help of the St. Louis District dredge coordinator seven thalweg holes have been selected as potential sample sites. Selected thalweg holes had to be at least 20 ft. below normal pool and be near areas which have been routinely dredged in the last ten years. River miles for those selected sites are:

Pool 26
222.5 - 222.3 Island 521
225 - 224.9 Bolters Bar - Iowa Island
227.1 - 226.4 Bolters Bar - Bolter Island
229 - 228.6 Golden Eagle Ferry

Pool 25
243 LDB near Batchtown
252.8 - 252.4 Sterling Island

Pool 24
297.8 - 297.2 Gilbert Island

Sampling Methodology: We intend to conduct sampling 3-4 times a year (fall, winter, spring, summer) using the M.V. Boyer. During each sampling trip, we will collect water temperature, velocity, fish location and size, bathymetry, stage data and pool conditions. In addition, some bottom type information may be collected. Fish and bottom type information will be collected using a BioSonics DT dual beam hydroacoustic system. Velocity profiles will be collected using an Acoustic Doppler Current Profiler unit. Simultaneous running of these two systems will allow us to collect both a fish's location and the velocity in that location. Sampling transects will be run perpendicular to the river current. DGPS technology will allow us to re-run the same transects lines during each sampling trip.

Expected Output:
1) Detailed bathymetric maps, with the ability to overlay velocity and fish results
2) Fish locations (X,Y), depth, size, numbers (maps and files)
3) Velocity profile maps and data

Decision Point: With this information we will have a clearer picture of the seasonal fish use of thalweg holes and the potential impact of disposing in the thalweg. If thalweg disposal is recommended in any of these areas it is likely that post-disposal seasonal monitoring will continue to assess the short- and long-term impact of disposal on fish usage.

Progress to Date: Sampling was conducted at RM 229 on July 22, 1998. Problems with the boat precluded sampling of other sites. That data is presently being analyzed. Given the amount of time necessary to sample each site it is likely that not all seven sites will be included in the study. Sampling will continue this fall and winter.

POC:
Brian Johnson
U.S. Army Corps of Engineers
St. Louis District
314-331-8146

25 Aug 1998

A&M Trip Report

Date: 18 August 1998

Purpose: Identify and sample thalweg holes for the presence of fish using the BioSonics hydroacoustic system, as part of an A&M program effort to determine the effects of open water dredge disposal in thalweg holes.

Participants: Sampling was conducted on the M.V. Boyer. Present from the Corps were Brian Johnson, John Naeger, and Joe Burnett.

Summary: On 22 July 1998 we collected multibeam bathymetry, velocity, and hydroacoustic fisheries and bottom typing data between R.M. 229 and 228 of the Upper Mississippi River. This site is just upstream of the Golden Eagle ferry. The site was one of 6 sites proposed for sampling. Equipment problems kept us from sampling the other sites. Sampling at those sites will begin in the fall. Depths in the thalweg hole exceeded 70 feet in spots. To collect hydroacoustic and velocity data, fifty transects were run cross-current over the hole, each approximately 50 ft apart. Velocity data were collected prior to collection of the hydroacoustic data. Hydroacoustic data were collected using a dual beam 123 kHz transducer, with a lower threshold of -70.0 dB, a pulse width of 0.3 ms, and at a rate of 5 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were between 3-4 knots. The water temperature was 83°F. Water level was 1 foot over flat pool. River conditions were excellent with few waves. Transects were numbered from downstream to upstream. Data sheets (5) were completed on-site. The fisheries data are being analyzed by Aquacoustics, Inc. Bottom typing data were collected and a decision has not yet been made as to whether it will be analyzed. Bathymetric and velocity maps will be created by ED-S.

This particular effort is part of a larger A&M effort to look at the feasibility of using thalweg holes as potential dredge placement sites. In 1996, the St. Louis District conducted thalweg disposal at river mile 224. Prior to placement, the area was surveyed for bathymetry, fish and mussels. There has been no post-disposal environmental monitoring.

Brian Johnson

BRIAN JOHNSON
Fishery Biologist
Environmental Planning Branch

A&M Trip Report

Date: 19 November 1998

Purpose: Identify and sample thalweg holes for the presence of fish using the BioSonics hydroacoustic system, as part of an A&M program effort to determine the effects of open water dredge disposal in thalweg holes. This report is on the second of a series of sampling trips designed to look at seasonal fish use of the thalweg holes. The first sampling trip, sampling one hole, was conducted on 22 July 1998.

Participants: Sampling was conducted on the M.V. Boyer. Present from the Corps were Brian Johnson, John Naeger, and Joe Burnett.

Summary: On 19, 20, and 21 October 1998 we collected multibeam bathymetry, velocity, and hydroacoustic fisheries data at four sites in Pool 26 of the Upper Mississippi River. These sites were:

1) Site 1. river mile 229 to 228.6 (Right descending bank (RDB), Apple Island, upstream of the Golden Eagle ferry),
2) Site 2. river mile 227.1 to 226.4 (RDB, upper end of Bolter Island),
3) Site 3. river mile 225 to 224.9 (RDB, upper end of Iowa Island),
4) Site 4. river mile 222.5 to 222.3 (RDB, Island 521).

<u>Site 1. River mile 229 to 228.6 (RDB, Apple Island, upstream of the Golden Eagle ferry)</u>
Sampling was conducted at Site 1 on 19 October 1998. This site was also sampled on 22 July 1998. Depths in the thalweg hole exceeded 55 feet in spots. To collect hydroacoustic and velocity data, fifty transects were run crosscurrent over the hole, each approximately 55 ft apart. Transect lines from the 22 July collection were used. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data were collected using a dual beam 123 kHz transducer, with a lower threshold of -60.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transects. Boat speeds were between 3.5-4.5 knots. The water temperature was 60°F. Pool 26 was at open river. River conditions included some floating debris and suspended sediments. Transects were numbered from downstream to upstream. Data sheets (5) were completed on-site.

<u>Site 2. River mile 227.1 to 226.4 (RDB, upper end of Bolter Island)</u>
Sampling was conducted at Site 2 on 21 October 1998. This was the first time this site had been sampled. Depths in the thalweg hole exceeded 30 feet in spots. To collect hydroacoustic and velocity data, sixteen transects were run downstream over the hole, each approximately 40 ft apart. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data was collected with a lower threshold of -60.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were about 7 knots. The water temperature was 59°F. Pool 26 was at open river. River conditions included some suspended

sediments. Transects were numbered from RDB to LDB. Data sheets (2) were completed on-site.

Site 3. River mile 225 to 224.9 (RDB, upper end of Iowa Island)
Sampling was conducted at Site 3 on 21 October 1998. This was the first time this site had been sampled during this study. This site was sampled for fish and mussels prior to open water thalweg disposal in 1996. The thalweg hole was not as deep as anticipated with very little area exceeding 30 feet deep. To collect hydroacoustic and velocity data, ten transects were run downstream over the hole. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data was collected with a lower threshold of -60.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were about 7 knots. The water temperature was 59°F. Pool 26 was at open river. River conditions included some suspended sediments. Transects were numbered from RDB to LDB. One data sheet was completed on-site.

Site 4. River mile 222.5 to 222.3 (RDB, Island 521)
Sampling was conducted at Site 4 on 20 October 1998. This was the first time this site had been sampled. Depths in the thalweg hole exceeded 35 feet. To collect hydroacoustic and velocity data, eleven transects were run downstream over the hole, each approximately 30 ft apart. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data was collected with a lower threshold of -55.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were about 7-7.5 knots. The water temperature was 60°F. Pool 26 was at open river. River conditions included a fair amount of floating debris and suspended sediments. Transects were numbered from RDB to LDB. Data sheets (2) were completed on-site.

The fisheries data for this project are being analyzed by Aquacoustics, Inc. Bathymetric and velocity maps will be created by ED-S. Data analysis and maps from the 22 July sampling trip have been completed, with the exception of the velocity map.

The next sampling trip is scheduled for middle December, when water temperatures have fallen below 40°F. Sampling during that trip should give us some insight into fish use of thalweg holes during the winter.

Brian Johnson

BRIAN JOHNSON
Fishery Biologist
Planning, Programs, and Project
Management Division
Environmental and Economics Branch
Environmental Section

A&M Trip Report

Date: 5 January 1999

Purpose: Identify and sample thalweg holes for the presence of fish using the BioSonics hydroacoustic system, as part of an A&M program effort to determine the effects of open water dredge disposal in thalweg holes. This report is on the third of a series of sampling trips designed to look at seasonal fish use of the thalweg holes. The first sampling trip, sampling one hole, was conducted on 22 July 1998. The second sampling trip, sampling four holes was conducted on 19-21 October 1998.

Participants: Sampling was conducted on the M.V. Boyer. Present from the Corps were Brian Johnson, John Naeger, and Joe Burnett.

Summary: On 15 and 16 December 1998 we collected single beam bathymetry, velocity, and hydroacoustic fisheries data at four sites in Pool 26 of the Upper Mississippi River. These sites were:

1) Site 1. river mile 229 to 228.6 (Right descending bank (RDB), Apple Island, upstream of the Golden Eagle ferry),
2) Site 2. river mile 227.1 to 226.4 (RDB, upper end of Bolter Island),
3) Site 3. river mile 225 to 224.9 (RDB, upper end of Iowa Island),
4) Site 4. river mile 222.5 to 222.3 (RDB, Island 521).

<u>Site 1. River mile 229 to 228.6 (RDB, Apple Island, upstream of the Golden Eagle ferry)</u>

Sampling was conducted at Site 1 on 15 December 1998. This site was also sampled on 22 July and 19 October 1998. Depths in the thalweg hole exceeded 60 feet in spots. To collect hydroacoustic and velocity data, fifty transects were run crosscurrent over the hole, each approximately 50 ft apart. The same transect lines were run during the earlier sampling trips. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data were collected using a dual beam 123 kHz transducer, with a lower threshold of -60.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were between 4.5-5 knots. The water temperature was 42°F. Sampling conditions were excellent. Transects were numbered from downstream to upstream. Data sheets (5) were completed on-site. The data have not been analyzed to date, but field observations indicated that a large number of fish were using a large slack-water area located downstream of a wing dike on the left descending bank. Fish aggregations of this magnitude were not noted during earlier sampling trips. A copy of one of the transects over this area is attached.

<u>Site 2. River mile 227.1 to 226.4 (RDB, upper end of Bolter Island)</u>

Sampling was conducted at Site 2 on 15 December 1998. This site was also sampled on 21 October 1998. Depths in the thalweg hole exceeded 33 feet in spots. To collect hydroacoustic and velocity data, sixteen transects were run downstream over the hole, each approximately 40 ft apart. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data were collected with a lower threshold of -70.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were about 6.5 knots. The water temperature was 42°F. Sampling conditions were good though a higher than expected level of acoustic "noise" was noted. Transects were numbered from RDB to LDB. Data sheets (2) were completed on-site. A hydroacoustic bottom type analysis will also be completed for this site using the data collected during this field visit. Results of that analysis will be used in completion of a micro model examining ways to decrease dredging in this stretch of the river.

Site 3. River mile 225 to 224.9 (RDB, upper end of Iowa Island)
Sampling was conducted at Site 3 on 16 December 1998. This site was also sampled on 21 October 1998. This site was sampled for fish and mussels prior to open water thalweg disposal in 1996. The thalweg hole was not as deep as anticipated with very little area exceeding 25 feet deep. To collect hydroacoustic and velocity data, eleven transects were run downstream over the hole. Transects were approximately 40 ft. apart. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data were collected with a lower threshold of -60.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were about 6.5 knots. The water temperature was 42°F. River conditions were excellent for sampling. Transects were numbered from RDB to LDB. One data sheet was completed on-site. Very few fish were noted during fieldwork.

Site 4. River mile 222.5 to 222.3 (RDB, Island 521)
Sampling was conducted at Site 4 on 16 December 1998. This site was also sampled on 20 October 1998. Depths in the thalweg hole exceeded 46 feet. To collect hydroacoustic and velocity data, eleven transects were run downstream over the hole, each approximately 30 ft apart. Velocity and hydroacoustic data were collected at the same time. Hydroacoustic data were collected with a lower threshold of -60.0 dB, a pulse width of 0.3 ms, and at a rate of 7 pings per second. Differential Global Positioning System (DGPS) coordinate readings and depth readings were taken continually along each transect. Boat speeds were about 7 knots. The water temperature was 42°F. River sampling conditions were excellent. Transects were numbered from RDB to LDB. One data sheet was completed on-site.

The fisheries data for this project are being analyzed by Aquacoustics, Inc. Bathymetric and velocity maps will be created by ED-S. Data analysis and maps from the July and October sampling trips have been completed, with the exception of the velocity maps. This information is being compiled and will be presented in a yet uncompleted interim report.

The next sampling trip is scheduled for sometime in late winter (early 1999), weather permitting.

Brian Johnson

BRIAN JOHNSON
Fishery Biologist
Planning, Programs, and Project
Management Division
Environmental and Economics Branch
Environmental Section

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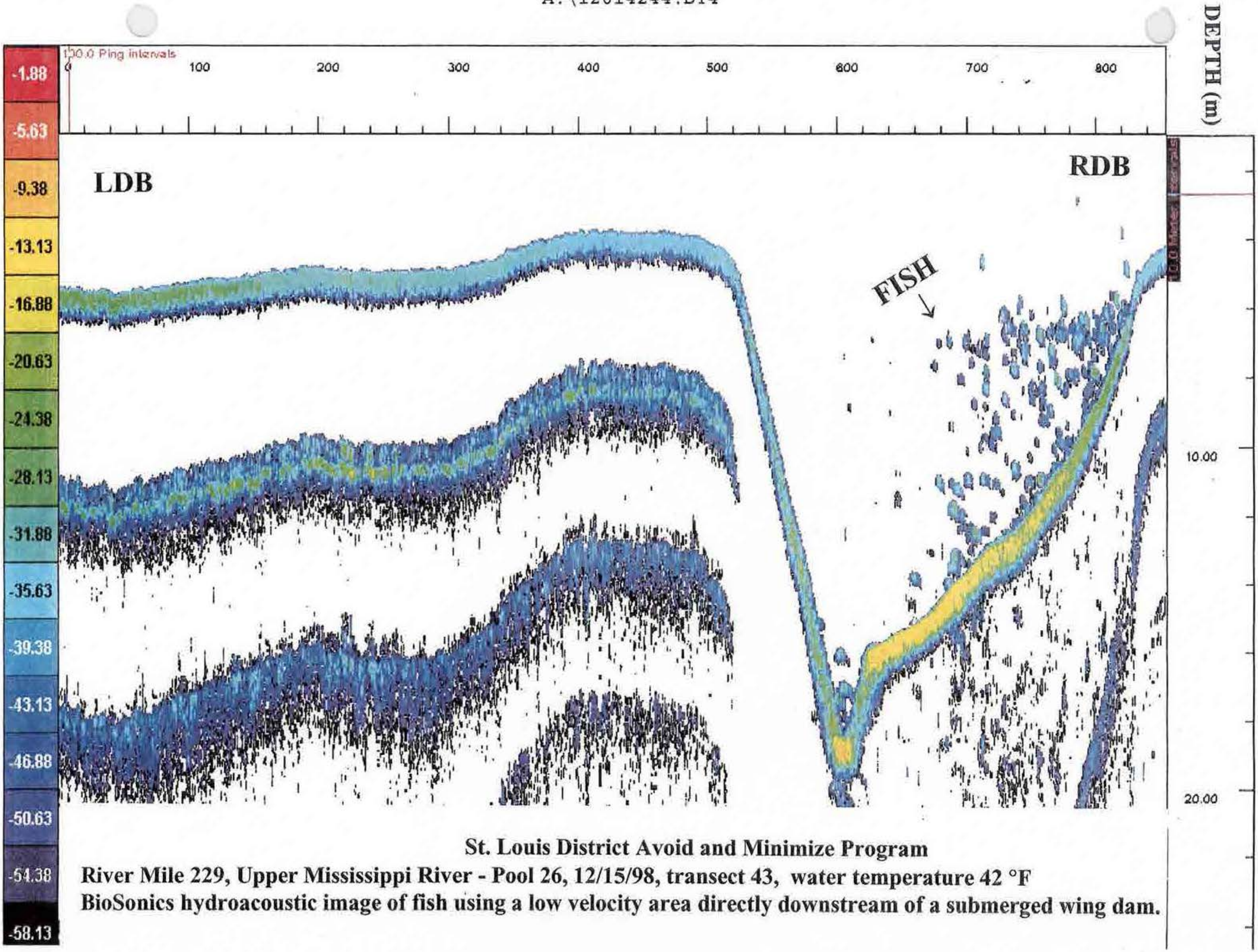

St. Louis District Avoid and Minimize Program
River Mile 229, Upper Mississippi River - Pool 26, 12/15/98, transect 43, water temperature 42 °F
BioSonics hydroacoustic image of fish using a low velocity area directly downstream of a submerged wing dam.

END OF DOCUMENT