US Army Corps
of Engineers
St. Paul District

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM

DEFINITE PROJECT REPORT/ENVIRONMENTAL
ASSESSMENT (SP-8)

INDIAN SLOUGH

HABITAT REHABILITATION AND ENHANCEMENT PROJECT

POOL 4
UPPER MISSISSIPPI RIVER
BUFFALO COUNTY, WISCONSIN

SEPTEMBER 1990

SUPPLEMENTAL REPORT FOR THE INDIAN SLOUGH HABITAT REHABILITATION AND ENHANCEMENT PROJECT BUFFALO COUNTY, WISCONSIN

REFERENCES

a. CENCD-PE-PD-PL memorandum, dtd. 5 November 1990, subject: Upper Mississippi River System Environmental Management Program (UMRS-EMP); Indian Slough, Buffalo County, Wisconsin.

b. CECW-PC memorandum, dtd. 10 September 1991 (1st End), subject: Upper Mississippi River System Environmental Management Program (UMRS-EMP); Indian Slough, Buffalo County, Wisconsin.

c. CENCD-PE-PD-PL memorandum, dtd. 26 September 1991 (2nd End), subject: Upper Mississippi River System Environmental Management Program (UMRS-EMP); Indian Slough, Buffalo County, Wisconsin.

d. DAEN-CWO-M memorandum, dtd. 10 June 1974, subject: Back Channel Dredging - Upper Mississippi River, signed by the Director of Civil Works.

e. CENCS-CO-M-NAV memorandum, dtd. 25 May 1990, subject: Indian Slough, UMRS-EMP Project.

f. CENCD-CO-O memorandum, dtd. 9 July 1990 (1st End), subject: Indian Slough, UMRS-EMP Project.

The references are attached to this supplemental report.

BACKGROUND

The Indian Slough Habitat Rehabilitation and Enhancement Project (HREP) is proposed for construction under the Upper Mississippi River System Environmental Management Program. On 5 November 1990, the Definite Project Report (DPR) was forwarded to HQUSACE for construction approval (reference a.). On 26 September 1991, the DPR was returned to CENCS (references b. and c.) unapproved by the Assistant Secretary of the Army (Civil Works) (ASA(CW)) citing:

"a. insufficient incremental justification of all measures employed in the project; and,

"b. incomplete justification for using O&M funding for a portion of the project."

The purpose of this supplemental report is to provide the information necessary to respond to ASA(CW) concerns stated above.

JUSTIFICATION FOR USING OPERATION AND MAINTENANCE FUNDING

Operation and maintenance (O&M) funding is proposed for the partial closure structure in Indian Slough. Authority to take action to prevent further habitat degradation associated with dredging operations for the 9-Foot Navigation Channel Project on the Upper Mississippi River is provided in reference d. Indian Slough is located immediately above the Crats Island dredged material containment area (DMCA). A review of past records, aerial photographs, surveys, sedimentation patterns, and other data indicates that historic dredged material placement practices at the Crats Island DMCA have increased flows in Indian Slough, causing erosion of historic dredged material deposits. This has increased sedimentation in the backwater complex known collectively as Big Lake. To prevent further dredging related habitat degradation, the District requested and received CENCD concurrence in O&M participation (references e. and f).

The partial closure structure is designed to alleviate the problems caused by historic dredged material placement practices by reducing the flows through Indian Slough and associated sedimentation in the Big Lake area. In addition, erosion of the dredged material deposits on the right descending bank of Indian Slough adjacent to the Crats Island DMCA should be reduced.

As part of the planning for the Indian Slough HREP, the habitat benefits associated with construction of the partial closure structure were evaluated. It was determined that the construction of a partial closure structure would prevent the conversion of an additional 120 acres of deepwater wetlands to fastland over the 50-year planning life of the project. This type of habitat conversion is occurring in a large proportion of Upper Mississippi River backwaters and needs to be reduced wherever possible to maintain the unique habitat values that these deepwater wetlands provide.

For cost allocation purposes, it was determined that the estimated cost of the most economical design for the partial closure structure required to accomplish O&M purposes should be funded under O&M authority. The UMRS-EMP program would fund any additional features of the partial closure structure designed to provide additional habitat benefits, provided they were incrementally justified.

INCREMENTAL COST AND HABITAT UNIT ANALYSIS

The incremental analysis and justification for the Indian Slough project can be broken down into three separate analyses: the partial closure structure, the Big Lake Bay dredging, and the riffle-pool complex. Each of these features is separate and whole. However, the partial closure structure must be considered first in place to achieve the benefits of the Big Lake Bay dredging and the riffle-pool complex.

Partial Closure Structure

Original Alternatives Analysis - During the planning process, there were a number of iterations of alternative partial closure structures designed to eliminate infeasible or low return alternatives. Five locations were initially investigated for the partial closure structure (pp. 30-33 of DPR), with two locations (A & D) eliminated due to engineering considerations. For each of the three remaining locations, two potential sources of fill material were investigated (p. 41 of DPR), backwater dredging or using material from the Crats Island DMCA. In the incremental analysis for this feature, the "1" options (such as E1) denote use of material from backwater dredging, while the "2" options (such as B2) denote use of material from the Crats Island DMCA.

The incremental analysis for the partial closure structure based on the cost estimates presented in the DPR is summarized in table A. The no action alternative is considered to be construction of the partial closure structure for operation and maintenance purposes only (i.e., the lowest cost alternative). Under the no action alternative, the structure would be constructed at the E location (p. 32 of the DPR), using material from the Crats Island DMCA (the E2 alternative). From the incremental analysis, the other alternatives that warranted further consideration were the B1 and E1 alternatives. The additional benefits to be achieved by these two alternatives have incremental costs in the $2,000-2,100/AAHU range.

An incremental analysis between alternatives B1 and E1 was conducted. This analysis indicated that the cost of achieving an additional 0.2 AAHU with the E1 alternative would be $3,556/AAHU, which is not considered acceptable.

Design Modification - Since submission of the DPR, a design modification has been made to the "B" options. By shifting the location of this structure 600 feet upstream (figure 1), the amount of rock necessary for the structure can be reduced from 9,200 cubic yards to 6,200 cubic yards, and the need for bank stabilization adjacent to the structure can be eliminated. This reduces the cost of the "B" options by approximately $140,400. This modification was identified during the early stages of plans and specifications when detailed surveys became available, and is being presented at this time because it offers a substantial cost savings over the design recommended in the DPR.

A similar savings cannot be achieved at the "C" and "E" locations because those locations are already at narrow points in the Indian Slough channel (see plates 7c and 7e of the DPR), and they did not have the bank stabilization required at the "B" location.

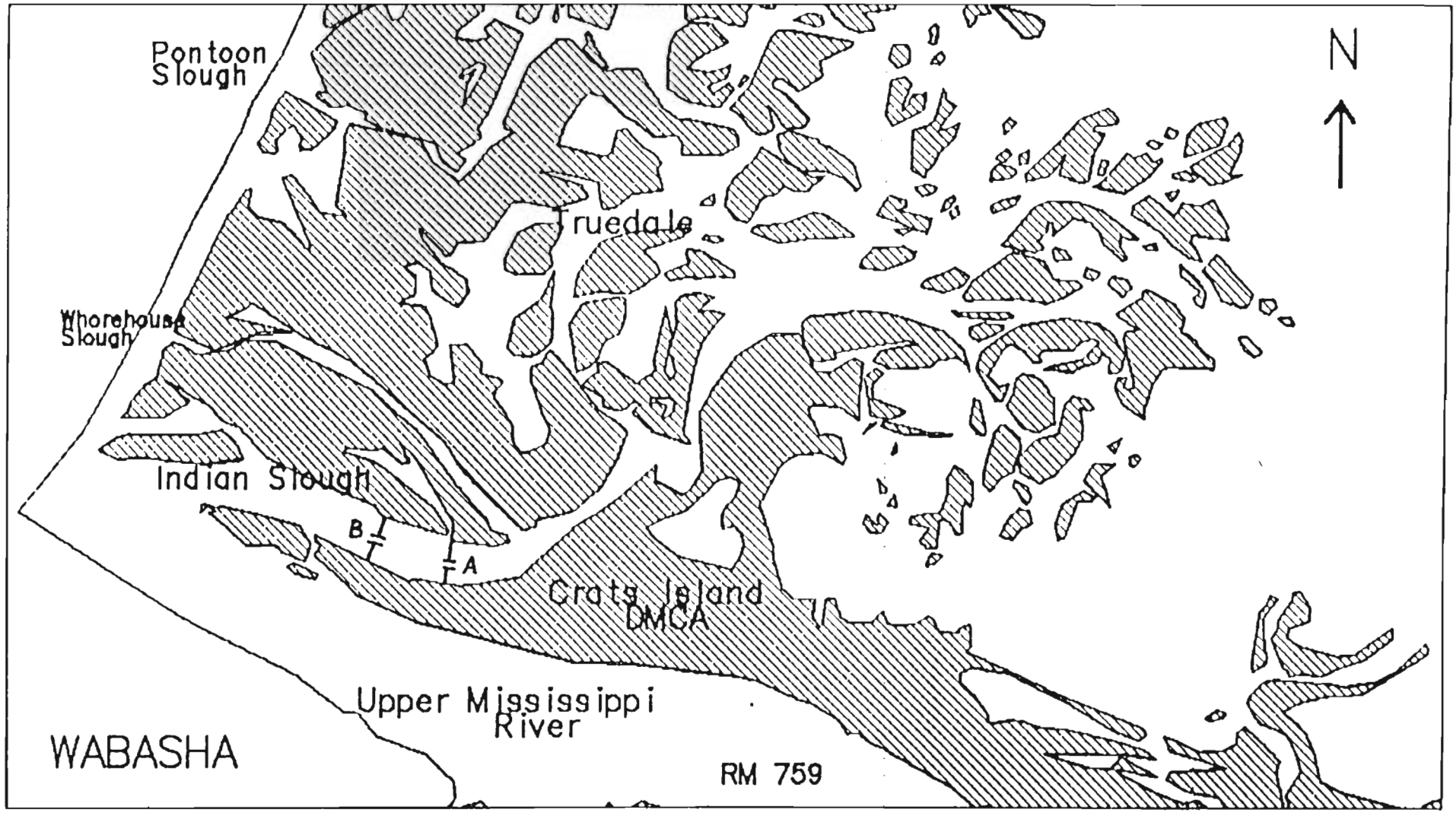
Table A. INDIAN SLOUGH – Partial Closing Structure Alternatives (DPR costs)

Partial Closure Alternatives	Est. Cost	Est. Annual Cost	Wetland Habitat Preserved/enhanced		Bank Habitat Enhanced		Flowing Channel Habitat Enhanced		Total AAHU	Annual Cost per AAHU Gain	Comparison of each alternative versus E2 - the low cost alternative. Incremental Cost	Incremental AAHU	Increm Cost per AAHU
			ACRES	AAHU	ACRES	AAHU	ACRES	AAHU					
E2* (no action)	$518,300	$46,046	240	45	1.9	0.5	0	0.0	45.5	$1,012			N/A
B1**	$664,900	$59,070	240	45	4	1.8	10	5.0	51.8	$1,140	$13,024	6.3	$2,067
E1	$672,800	$59,772	240	45	1.9	0.5	25	6.5	52.0	$1,149	$13,726	6.5	$2,112
C1	$784,300	$69,677	240	45	2.8	1.1	10	5.0	51.1	$1,364	$23,631	5.6	$4,220
B2	$615,000	$54,637	240	45	4	1.8	0	0.0	46.8	$1,167	$8,591	1.3	$6,608
C2	$646,500	$57,435	240	45	2.8	1.1	0	0.0	46.1	$1,246	$11,389	0.6	$18,982

* O&M recommended plan

** Initial recommended plan in DPR

Note for wetlands and flowing channel habitat the bluegill HSI model was used and for bank habitat the smallmouth bass HSI model was used.



A - Location of structure B1 as proposed in the DPR (Sept. 1990)
B - Location of structure B1 as currently proposed (Nov. 1991)

Figure 1

Table B contains the incremental analysis based on the design modification costs. Alternative E2 is no longer the most cost effective alternative, and it was eliminated from the incremental analysis because it provides less benefits at a greater cost. The incremental analysis is based on alternative B2 being the low cost alternative. Alternative B1 is the only alternative that provides an incremental gain in habitat benefits at a reasonable cost; i.e., 5 AAHU of gain at a cost $887/AAHU. The additional benefits that would be realized from alternative B1 are in the form of enhanced flowing backwater channel habitat which was identified as a project objective. This would result from dredging the material for the closing structure core from backwater channels in the project area. The fishery benefits to be gained support the additional cost.

Big Lake Bay Dredging

The type of backwater habitat that would be provided by this dredging feature is becoming increasingly scarce in lower pool 4 and the other Upper Mississippi River pools due to sedimentation. An incremental analysis of the Big Lake Bay dredging feature was presented in the DPR (pp. 42 and 44). This analysis, expanded in table C, considered dredging 10, 15, and 20 percent of Big Lake Bay.

Dredging in Big Lake Bay results in improved summer cover by reducing overabundant aquatic plant growth (V3), improved summer dissolved oxygen and water temperature conditions (V8, V10), improved water depths for winter cover (Va), and improved winter dissolved oxygen conditions (Vb). The gains in improved winter dissolved oxygen conditions account for the greatest portion of the overall improvement in habitat conditions. Under present conditions, and even with dredging 10 percent of the bay, winter dissolved oxygen is a limiting factor on habitat suitability for fish. Dredging 15 percent of the bay or greater eliminates winter dissolved oxygen as a limiting factor. The overall habitat suitability index would improve by approximately 100 percent with dredging 10 percent of the bay, approximately 170 percent with dredging 15 percent, and 190 percent with dredging 20 percent of the bay.

Incremental analysis indicates that it is more cost effective to dredge 15 percent of the bay ($970/AAHU) than 10 percent of the bay ($1,352/AAHU). It should be noted that the cost figures shown on page 42 and table 5b in the DPR are incorrect due to the use of an incorrect conversion factor in the calculation of average annual costs. Dredging 20 percent of Big Lake Bay would provide additional habitat benefits that would still be incrementally justified. However, dredging this greater amount was not recommended because of disposal site limitations; e.g., further expansion would result in unacceptable environmental impacts at the disposal site.

Table B. INDIAN SLOUGH – Partial Closing Structure Alternatives (With Design Modifications costs)

Partial Closure Alternatives	Est. Cost	Est. Annual Cost	Wetland Habitat Preserved/enhanced		Bank Habitat Enhanced		Flowing Channel Habitat Enhanced		Total AAHU	Annual Cost per AAHU Gain	Comparison of each alternative versus B2 – the low cost alternative.		
			ACRES	AAHU	ACRES	AAHU	ACRES	AAHU			Incremental Cost	Incremental AAHU	Increm Cost per AAHU
B2*	$474,600	$42,164	240	45	3.6	1.6	0	0.0	46.6	$905			N/A
B1**	$524,500	$46,597	240	45	3.6	1.6	10	5.0	51.6	$903	$4,433	5.0	$887
E1	$672,800	$59,772	240	45	1.9	0.5	25	6.5	52.0	$1,149	$17,608	5.4	$3,261
C1	$784,300	$69,677	240	45	2.8	1.1	10	5.0	51.1	$1,364	$27,514	4.5	$6,114
E2***	$518,300	$46,046	240	45	1.9	0.5	0	0.0	45.5	$1,012			
C2***	$646,500	$57,435	240	45	2.8	1.1	0	0.0	46.1	$1,246			

* O&M recommended plan

** Recommended plan for implementation

*** Average annual habitat unit gains for these alternatives are less than the lowest cost alternative.

Note for wetlands and flowing channel habitat the bluegill HSI model was used and for bank habitat the smallmouth bass HSI model was used.

Table B1. INDIAN SLOUGH – Partial Closing Structure Preservation of Wetlands
Habitat Suitability Index Model for Bluegills

EXISTING HSI BLUEGILL MODEL (non-winter)		Future without – No action Total of 240 acres – 120 land & 120 acres shallow wetlands		Future With Structure Total of 240 acres – 120 shallow wetlands & 120 deep wetlands	
Variable	Description	DATA	HSI	DATA	HSI
V1	% Pool Area	5%	0.10	30%	0.40
V2	% Cover (Logs & Brush)	5%	0.20	15%	0.60
V3	% Cover (Vegetation)	90%	0.10	55%	0.50
V4	% Littoral Area	NF	1.00	NF	1.00
V5	Ave. TDS	NF	1.00	NF	1.00
V6	Ave. Turbidity	20	1.00	20	1.00
V7	pH Range	Class A	1.00	Class A	1.00
V8	Min. D.O. Summer	Class D	0.10	Class B–C	0.55
V9	Salinity		N/A		N/A
V10	Max. Midsummer Temp.(Adult)	28–30	0.80	27–29	1.00
V11	Ave. Water Temp. (Spawning)	22–25	1.00	22–25	1.00
V12	Max. Early Summer Temp.(Fry)	22–25	1.00	22–25	1.00
V13	Max. Midsummer Temp.(Juvenile)	28–30	0.90	27–30	0.90
V14	Ave. Current	0	1.00	0–5	1.00
V15	Ave. Current (Spawning)	0	1.00	0–5	1.00
V16	Ave. Current (Fry)	0	1.00	0–5	1.00
V17	Ave. Current (Juvenile)	0	1.00	0–5	1.00
V18	Stream Gradient	NF	1.00	NF	1.00
V19	Reservoir Drawdown	NF	1.00	NF	1.00
V20	Substrate Composition	Class A	1.00	Class A	1.00
	Food (Cf)		0.13		0.49
	Cover (Cc)		0.15		0.55
	Water Quality (Cwq)		0.10		0.84
	Reproduction (Cr)		1.00		1.00
	Other (Cot)		1.00		1.00
	HSI		0.10		0.76
WITH WINTER HSI MODIFICATIONS		No action		With Structure	
Variable	Description				
Va	Water Depth	0%	0.40	20%	0.55
Vb	Dissolved Oxygen	Class D	0.10	Class B–C	0.55
Vc	Water Temperature	0–2	0.50	3–4	0.90
Vd	Current Velocity	0	1.00	0–5	0.30
	Winter Cover (Cw–q)		0.40		0.55
	Winter Water Quality(Cw–wq)		0.23		0.67
	Corrected Cw–wq(see note 1)		0.10		0.67
	Winter Other (Cw–ot)		1.00		0.30
	Winter HSI		0.38		0.52
	Corrected Winter HSI(see note 2)		0.10		0.30
	Composite HSI with winter mods.		0.10		0.48
	Average Annual HU increase(Note 3)		N/A		45.25

Note 1: If Vb or Vc is < or = 0.4 Cw–wq equals the lowest of these variables

Note 2: If Vb, Vc, or Vd is < or = 0.4 use the lowest variable as the Winter HSI

Note 3: Straight line loss in habitat projected over 50 years, with AAHU adjusted accordingly.

NF – NOT A FACTOR either because in the case of % littoral area is not used in the riverine model or because it is considered optimum with/without project

Table B2. INDIAN SLOUGH - Flowing Channel Habitat
abitat Suitability Index Model for Bluegills

EXISTING HSI BLUEGILL MODEL (non-winter)		Whorehouse Slough – 10 acres				Poontoon Slough – 15 acres			
		No Action – existing		With Dredging		No Action –existing		With Dredging	
Variable	Description	DATA	HSI	DATA	HSI	DATA	HSI	DATA	HSI
V1	% Pool Area	30%	0.50	40%	0.60	30%	0.50	40%	0.60
V2	% Cover (Logs & Brush)	15%	0.60	15%	0.60	15%	0.60	15%	0.60
V3	% Cover (Vegetation)	50%	0.70	45%	0.80	50%	0.70	45%	0.80
V4	% Littoral Area	NF	1.00	NF	1.00	NF	1.00	NF	1.00
V5	Ave. TDS	NF	1.00	NF	1.00	NF	1.00	NF	1.00
V6	Ave. Turbidity	20	1.00	20	1.00	20	1.00	20	1.00
V7	pH Range	Class A	1.00	Class A	1.00	Class A	1.00	Class A	1.00
V8	Min. D.O. Summer	Class C-D	0.25	Class B	0.80	Class C-D	0.25	Class B	0.80
V9	Salinity		N/A		N/A		N/A		N/A
V10	Max. Midsummer Temp.(Adult)	28-29	0.80	27-29	1.00	28-29	0.80	27-29	0.80
V11	Ave. Water Temp. (Spawning)	22-25	1.00	22-25	1.00	22-25	1.00	22-25	1.00
V12	Max. Early Summer Temp.(Fry)	22-25	1.00	22-25	1.00	22-25	1.00	22-25	1.00
V13	Max. Midsummer Temp.(Juvenile)	29	0.90	29	0.90	29	0.90	29	0.90
V14	Ave. Current	0	1.00	0-1	1.00	0	1.00	0-1	1.00
V15	Ave. Current (Spawning)	0	1.00	0-1	1.00	0	1.00	0-1	1.00
V16	Ave. Current (Fry)	0	1.00	0-1	1.00	0	1.00	0-1	1.00
V17	Ave. Current (Juvenile)	0	1.00	0-1	1.00	0	1.00	0-1	1.00
V18	Stream Gradient	NF	1.00	NF	1.00	NF	1.00	NF	1.00
V19	Reservoir Drawdown	NF	1.00	NF	1.00	NF	1.00	NF	1.00
V20	Substrate Composition	Class A	1.00	Class A	1.00	Class A	1.00	Class A	1.00
	Food (Cf)		0.59		0.66		0.59		0.66
	Cover (Cc)		0.65		0.70		0.65		0.70
	Water Quality (Cwq)		0.25		0.92		0.10		0.90
	Reproduction (Cr)		1.00		1.00		1.00		1.00
	Other (Cot)		1.00		1.00		1.00		1.00
	HSI		0.25		0.86		0.25		0.85

WITH WINTER HSI MODIFICATIONS		No action Whorehouse		Dredging Whorehouse		No action Poontoon		Dredging Poontoon	
Variable	Description								
Va	Water Depth	10%	0.40	15%	0.50	10%	0.40	15%	0.50
Vb	Dissolved Oxygen	Class C-D	0.25	Class B-C	0.55	Class C-D	0.25	Class B-C	0.55
Vc	Water Temperature	3-4	0.90	2-3	0.70	3-4	0.90	2-3	0.70
Vd	Current Velocity	0	1.00	0-1	1.00	0	1.00	0-1	1.00
	Winter Cover (Cw-q)		0.40		0.50		0.40		0.50
	Winter Water Quality(Cw-wq)		0.47		0.60		0.47		0.60
	Corrected Cw-wq(see note 1)		0.10		0.60		0.10		0.60
	Winter Other (Cw-ot)		1.00		1.00		1.00		1.00
	Winter HSI		0.54		0.65		0.54		0.65
	Corrected Winter HSI(see note 2)		0.25		0.65		0.25		0.65
	Composite HSI with winter mods.		0.25		0.75		0.25		0.74
	Average Annual HU increase(see note 3)		N/A		4.97		N/A		1.48

Note 1: If Vb or Vc is < or = 0.4 Cw-wq equals the lowest of these variables

Note 2: If Vb, Vc, or Vd is < or = 0.4 use the lowest variable as the Winter HSI

Note 3: The life expectency for Poontoon Slough is only estimated at 10 years. However, the Habitat Unit increase for that 10 years is spread out over the 50-year project life.

NF – NOT A FACTOR either because in the case of littoral area is not used in the riverine model or because it is considered optmium with/without project.

Table B3. INDIAN SLOUGH – Bank habitat – Smallmouth Bass benefits with closing structure

HABITAT SUITABILITY INDEX FOR SMALLMOUTH BASS

EXISTING HSI MODEL Variable	Description	No Action(note 1)		Alternative B – DPR (4 acres)		Alternative B – with mods (3.6 acres)		Alternative C (2.8 acres)		Alternative D (1.9 acres)	
		DATA	HSI	DATA	HSI	DATA	HSI	DATA	HSI	DATA	HSI
V1	Substrate Type – Incubation	Sand	0.20	Sand/cobble	0.80	Sand/cobble	0.80	Sand/cobble	0.80	Sand/cobble	0.60
	Substrate Type – Spawning	Sand	0.10	Sand/cobble	0.60	Sand/cobble	0.60	Sand/cobble	0.60	Sand/cobble	0.50
	Substrate Type – Juvenile	Sand	0.10	Sand/cobble	0.50	Sand/cobble	0.50	Sand/cobble	0.50	Sand/cobble	0.40
	Substrate Type – Adult	Sand	0.10	Sand/cobble	0.60	Sand/cobble	0.60	Sand/cobble	0.60	Sand/cobble	0.50
V2	% Pools	100%	0.20	50%	1.00	50%	1.00	50%	1.00	50%	1.00
V4	Pool Depth	1–4	1.00	1–4	1.00	1–4	1.00	1–4	1.00	1–4	1.00
V5	% cover	10%	0.10	50%	1.00	50%	1.00	50%	1.00	50%	1.00
V6	pH	Class A	1.00	Class A	1.00	Class A	1.00	Class A	1.00	Class A	1.00
V8	Dissolved oxygen	>5	1.00	>5	1.00	>5	1.00	>5	1.00	>5	1.00
V9	Turbidity	25–50	0.80	25–40	1.00	25–40	1.00	25–40	1.00	25–40	1.00
V10	Temperature – adult (C)	20–29	1.00	20–29	1.00	20–29	1.00	20–29	1.00	20–29	1.00
V11	Temperature – embryo (C)	20–29	0.90	20–29	0.90	20–29	0.90	20–29	0.90	20–29	0.90
V12	Temperature – fry (C)	20–30+	0.90	20–30+	0.90	20–30+	0.90	20–30+	0.90	20–30+	0.90
V13	Temperature – juvenile (C)	20–30+	0.90	20–30+	0.90	20–30+	0.90	20–30+	0.90	20–30+	0.90
V14	Water level fluctuations	Class A	0.30	Class A–C	0.50	Class A–C	0.50	Class A–C	0.50	Class A–C	0.50
V15	Gradient	NF	0.80	NF	0.80	NF	0.80	NF	0.80	NF	0.80
V16	Ave. Current Vel. (spawning)(Note 2)	1–2+	0.30	0 – 2	0.90	0 – 2	0.90	0 – 2+	0.70	1–2+	0.30
V17	Ave. Current (Fry)	1–2+	0.30	0 – 2	0.80	0 – 2	0.80	0 – 2+	0.60	1–2+	0.20
V18	Ave. Current (Juvenile)	1–2+	0.20	0 – 2	0.70	0 – 2	0.70	0 – 2+	0.50	1–2+	0.15
V19	Ave. Current Vel. (Adult)	1–2+	0.10	0 – 2	0.60	0 – 2	0.60	0 – 2+	0.40	1–2+	0.10
	Food (Cf)= ((average of v1 values)*v5*v7)1/3		0.14		0.85		0.85		0.85		0.79
	Cover (Cc) = ((average v1 values)+v5+v6+v7)/4		0.23		0.69		0.69		0.69		0.63
	Water Quality (Cwq)		0.93		0.97		0.97		0.97		0.97
	Reproduction (Cr)		0.49		0.85		0.85		0.83		0.73
	Other (Cot)(v15+v16+v17+v18+v19)/5		0.34		0.76		0.76		0.60		0.31
	HSI		0.41		0.84		0.84		0.81		0.69
	Average Annual HU Increase		N/A		1.75		1.58		1.12		0.54

Note 1: Even though with the no action alternative the specific area changes with each alternative location for the partial closing structure, the HSI value remains essentially the same and only one no action analysis summary is provided above.

Note 2: Model was modified to include current velocity as a variable with the use of the Instream Flow Methods curves contained in the smallmouth bass HEP model.

Table C. INDIAN SLOUGH - Dredging in Big Lake Bay.

Habitat Suitability Index Model for Bluegills

EXISTING HSI BLUEGILL MODEL (non-winter)			Dredging (10%)	Dredging (15%)	Dredging (20%)
Variable	Description	No Action	75 ac.*	75 ac.	75 ac.
V1	% Pool Area	1.00	1.00	1.00	1.00
V2	% Cover (Logs & Brush)	1.00	1.00	1.00	1.00
V3	% Cover (Vegetation)	0.40	0.45	0.50	0.60
V4	% Littoral Area	1.00	1.00	1.00	1.00
V5	Ave. TDS	1.00	1.00	1.00	1.00
V6	Ave. Turbidity	1.00	1.00	1.00	1.00
V7	pH Range	1.00	1.00	1.00	1.00
V8	Min. D.O. Summer	0.40	0.50	0.70	0.70
V9	Salinity	N/A	N/A	N/A	N/A
V10	Max. Midsummer Temp.(Adult)	0.80	1.00	1.00	1.00
V11	Ave. Water Temp. (Spawning)	1.00	1.00	1.00	1.00
V12	Max. Early Summer Temp.(Fry)	1.00	1.00	1.00	1.00
V13	Max. Midsummer Temp.(Juvenile)	1.00	1.00	1.00	1.00
V14	Ave. Current	1.00	1.00	1.00	1.00
V15	Ave. Current (Spawning)	1.00	1.00	1.00	1.00
V16	Ave. Current (Fry)	1.00	1.00	1.00	1.00
V17	Ave. Current (Juvenile)	1.00	1.00	1.00	1.00
V18	Stream Gradient	1.00	1.00	1.00	1.00
V19	Reservoir Drawdown	1.00	1.00	1.00	1.00
V20	Substrate Composition	1.00	1.00	1.00	1.00
	Food (Cf)	0.74	0.79	0.79	0.84
	Cover (Cc)	0.70	0.73	0.75	0.80
	Water Quality (Cwq)	0.67	0.71	0.77	0.77
	Reproduction (Cr)	1.00	1.00	1.00	1.00
	Other (Cot)	1.00	1.00	1.00	1.00
	HSI	0.78	0.81	0.84	0.86
WITH WINTER HSI MODIFICATIONS			Dredging	Dredging	Dredging
Variable	Description	No action	(10%)	(15%)	(20%)
Va	Water Depth	0.40	0.40	0.50	0.60
Vb	Dissolved Oxygen	0.10	0.40	0.50	0.70
Vc	Water Temperature	1.00	1.00	1.00	1.00
Vd	Current Velocity	1.00	1.00	1.00	1.00
	Winter Cover (Cw-q)	0.40	0.40	0.50	0.60
	Winter Water Quality(Cw-wq)	0.40	0.60	0.67	0.80
	Corrected Cw-wq(see note 1)	0.10	0.40	0.67	0.80
	Winter Other (Cw-ot)	1.00	1.00	1.00	1.00
	Winter HSI	0.50	0.62	0.69	0.79
	Corrected Winter HSI(see note 2)	0.10	0.40	0.69	0.79
	Composite HSI with winter mods.	0.28	0.57	0.76	0.82
	Average Annual HU increase	N/A	21.84	36.17	40.81
Estimated cost using winter modifications					
	Estimated cost	N/A	$332,400	$394,900	$450,900
	Estimated average annual cost	N/A	$29,530	$35,083	$40,058
	Est. cost/HU/year	N/A	$1,352	$970	$982
	Incremental Analysis of Dredging Alter.	N/A	$1,352	$388	$1,072

Note 1: If Vb or Vc is < or = 0.4 Cw-wq equals the lowest of these variables

Note 2: If Vb, Vc, or Vd is < or = 0.4 use the lowest variable as the Winter HSI

* Acres are those expected to benefit from dredging.

The information presented in the last six lines of tables C and D is comparable to the information presented in tables A and B. Because of a lesser number of increments being analyzed, additional backup information can be presented in tables C and D.

An average annual cost per habitat unit of $970 is considered highly acceptable for the benefits to be achieved from the Big Lake dredging. The habitat value for centrarchids and other fish species using this 75-acre backwater would be increased by approximately 170 percent. As noted earlier, this would help offset the effects of sedimentation that are resulting from the increased scarcity of this type of habitat in this area of the Upper Mississippi River.

Riffle-Pool Complex

Prior to inundation by lock and dam 4, the river in this area had natural gravel bars, which formed a series of riffles and pools. Since inundation by lock and dam 4, wing dams and closure structures have provided the only rock fishery habitat in lower pool 4. However, because of the tremendous sand bedload coming into the system from the Chippewa River, many of these rock structures in lower pool 4 are now buried by sand. Therefore, this type of habitat is very scarce in lower pool 4. The riffle-pool complex would restore some of the type of rock related fishery habitat that has been lost in lower pool 4. Because this feature would restore an extremely scarce habitat in lower pool 4, it was the judgment of the project planning team that this enhancement to the fishery resources of the area merited the inclusion of this feature.

An incremental analysis for the riffle-pool complex is summarized in table D. It was determined that to meet the minimum habitat requirements of the target fish species (smallmouth bass) at least two riffle-pool sequences would be needed. This would provide one pool with a riffle above and below it, and one riffle with a pool above and below it. This base plan would provide 7.6 AAHU of benefits at a cost of $2,955/AAHU.

As is readily evident from table D, installation of two riffle-pool complexes would result in substantial improvement to a number of habitat variables, most notably substrate type (V1-V4), percent pools (V5), water level fluctuations (V16), and current velocity (V18-V21). The result is a 140-percent improvement in the habitat suitability index for smallmouth bass.

An additional increment of two more riffle-pools was evaluated. As can be seen in table D, the addition of two more riffle-pools would not result in substantial improvements to the habitat variables and the overall habitat suitability index. This additional increment would have an incremental cost of $16,837/AAHU and result in a feature with an overall cost/AAHU of $4,645.

The incremental analysis indicates that it is most cost effective to limit this feature to two riffle-pools. The additional two riffle-pools would have an incremental cost over five times that of the initial increment and are not considered cost-effective. Additional increments were not pursued as it was obvious that additional habitat gains would not accrue proportionate to the added costs.

Table D. INDIAN SLOUGH – Fish Structures in Indian Slough

HABITAT SUITABILITY INDEX FOR SMALLMOUTH BASS

EXISTING HSI MODEL Variable	Description	No Action	Riffle/pools Two	Riffle/pools Four
V1	Substrate Type – Incubation	0.10	0.80	0.90
V2	Substrate Type – Spawning	0.10	0.80	0.90
V3	Substrate Type – Juvenile	0.10	0.50	0.75
V4	Substrate Type – Adult	0.10	0.60	0.70
V5	% Pools	0.20	0.60	0.70
V6	Pool Depth	0.80	1.00	1.00
V7	% cover	0.10	0.75	0.90
V8	pH	1.00	1.00	1.00
V9	Total dissolved solids	1.00	1.00	1.00
V10	Dissolved oxygen	1.00	1.00	1.00
V11	Turbidity	0.80	1.00	1.00
V12	Temperature – adult (C)	1.00	1.00	0.90
V13	Temperature – embryo (C)	0.90	1.00	1.00
V14	Temperature – fry (C)	0.90	1.00	1.00
V15	Temperature – juvenile (C)	1.00	1.00	1.00
V16	Water level fluctuations	0.30	1.00	1.00
V17	Gradient	0.80	0.80	0.80
V18	Ave. Current Vel. (spawning)	0.30	1.00	1.00
V19	Ave. Current (Fry)	0.20	1.00	1.00
V20	Ave. Current (Juvenile)	0.10	0.90	1.00
V21	Ave. Current Vel. (Adult)	0.10	0.90	0.90
	Food (Cf)= ((average of v1–v4)*v5*V7)1/3	0.13	0.67	0.80
	Cover (Cc) = ((average v1–v4)+v5+v6+v7)/4	0.19	0.63	0.85
	Water Quality (Cwq)	0.95	1.00	0.99
	Reproduction (Cr)	0.46	0.95	0.98
	Other (Cot)	0.18	0.95	0.95
	HSI	0.35	0.85	0.92
	Average Annual HU increase	N/A	7.60	8.65
Average annual cost per habitat unit				
	Estimated cost	N/A	$252,700	$452,300
	Estimated average annual cost	N/A	$22,450	$40,182
	Est. cost/HU/year	N/A	$2,955	$4,645
	Incremental Analysis of fish structures	N/A	$2,955	$16,837

The cost of two riffle-pools is considered acceptable given the acute scarcity (see previous discussion) of this type of habitat in this area of the Upper Mississippi River. In addition, this type of habitat is important for a number of State threatened and endangered fish species known to occur in this reach of the Upper Mississippi River such as the crystal darter (Ammocrypta asprella), blue sucker (Cycleptus elongatus), pallid shiner (Notropis amnis), black buffalo (Ictiobus niger), river redhorse (Moxostoma carinatum), paddlefish (Polyodon spathula), and shovelnose sturgeon (Scaphirhynchus platorynchus), a host fish for the Wisconsin endangered mussel Lampsilis teres.

SUMMARY OF PROJECT FEATURES

Table E contains a summary of the recommended project features. The construction of the least cost partial closure structure (B2) under the District's operation and maintenance program is defined as the no action alternative for the UMRS-EMP project. This feature would be constructed with or without UMRS-EMP involvement.

The UMRS-EMP funded features are displayed in order of cost effectiveness from left to right. The B1 partial closure structure is the most cost effective increment and would provide an additional 5 AAHU of benefits at a cost of $887/AAHU.

The dredging of Big Lake Bay is the next most cost effective feature, providing 36.2 AAHU of benefits at a cost of $959 per AAHU. The final increment is the construction of the riffle-pool complex providing 7.6 AAHU of benefits at a cost $2,954 per AAHU.

Table E. INDIAN SLOUGH – Incremental Analysis of Project Features

	No Action (with B2 Structure)	INCREASE OVER NO ACTION WITH PROJECT FEATURES B1 structure – Increase over use of B2	Dredging Big Lake Bay	Riffle/Pool complex
Estimated Cost	$474,600	$49,900	$394,900	$252,700
Estimated Annual Cost(1)	$42,164	$4,433	$35,083	$22,450
Maintain and enhance Wetlands(2)				
ACRES	240	0	0	0
AAHU	45	0	0	0
Bank Habitat Enhanced(3)				
ACRES	3.6	0	0	0
AAHU	1.6	0	0	0
Flowing Channel Habitat Enhanced(2)				
ACRES	0	10	0	0
AAHU	N/A	5	0	0
Dredging Big Lake Bay(2)				
ACRES	0	0	75	0
AAHU	N/A	0	36.2	0
Riffle/Pool Habitat(3)				
ACRES	0	0	0	15
AAHU	N/A	0	0	7.6
Annual Gain Per Feature (2&3)				
ACRES	243.6	10	75	15
AAHU	46.6	5	36.2	7.6
Annual Incremental Cost / AAHU	$905	$887	$969	$2,954
Cumulative – HREP only (2&3)				
Total AAHU	N/A	5	41.2	48.8
Total Cost	N/A	$49,900	$444,800	$697,500
Annual Cost Per AAHU	N/A	$887	$959	$1,270

1 – 50 year project life, 8 3/4% interest; includes future O&M costs

2 – Bluegill HSI Model Used.

3 – Smallmouth Bass HSI Model Used

COST SUMMARY AND ALLOCATION

The basic premise behind the cost allocation for the partial closure structure has been that O&M funds would pay for the least cost structure that would achieve the O&M objectives; i.e., reducing flow in Indian Slough and reducing erosion of historic dredged material deposits. UMRS-EMP funds would be used to fund any justified incremental increase in costs. Based on the cost estimate contained in the DPR, the E2 alternative was the least costly to construct at $518,300. The recommended UMRS-EMP plan in the DPR was alternative B1 at a cost of $664,900 with a cost allocation as shown in table F.

Table F. INDIAN SLOUGH - Cost Allocation as shown in the DPR (table 11, p.66)

Feature	O&M Cost	UMRS-EMP Cost	Total Cost
Partial Closure Structure (B1)	$518,300	$146,600	$664,900
Dredging of Big Lake Bay	0	394,900	394,900
Riffle-Pool Complex	0	252,700	252,700
Total	$518,300	$794,200	$1,312,500

Because of the design modification, alternative B2 is now the least costly to construct and it becomes the O&M plan; i.e., the least cost alternative that meets the goals of the O&M action. The recommended UMRS-EMP plan remains alternative B1. Therefore, the new recommended cost allocation is shown in table G.

Table G. INDIAN SLOUGH - Recommended Cost Allocation based on Design Modifications

Feature	O&M Cost	UMRS-EMP Cost	Total Cost
Partial Closure Structure (B1)	$474,600	$ 49,900	$524,500
Dredging of Big Lake Bay	0	394,900	394,900
Riffle-Pool Complex	0	252,700	252,700
Total	$474,600	$697,500	$1,172,100

CONCLUSIONS

1. The authority for operation and maintenance participation in the funding of the partial closure structure is provided by the Director of Civil Works memorandum of 10 June 1974 (reference d).

2. Construction of a partial closure structure is justified because the structure will prevent further environmental degradation from the channel maintenance activities of the 9-Foot Navigation Channel Project at an acceptable cost.

3. Construction of a partial closure structure across Indian Slough under operation and maintenance authority is an independent action that would proceed with or without UMRS-EMP involvement.

4. The modifications to the partial closure structure for UMRS-EMP purposes are incrementally justified and should be funded by the UMRS-EMP program.

5. A design modification has resulted in a lower cost estimate for the partial closure structure, which will result in cost savings for both the O&M and UMRS-EMP programs.

6. The DPR recommended plans for the dredging of Big Lake Bay and the riffle-pool complex are incrementally justified and the most cost effective to implement.

REFERENCES

DEPARTMENT OF THE ARMY
NORTH CENTRAL DIVISION, CORPS OF ENGINEERS
536 SOUTH CLARK STREET
CHICAGO, ILLINOIS 60605-1592

REPLY TO
ATTENTION OF

CENCD-PE-PD-PL (1105)

5 November 1990

MEMORANDUM FOR HQUSACE (CECW-P), WASH DC 20314-1000

SUBJECT: Upper Mississippi River System Environmental Management Program (UMRS-EMP); Indian Slough, Buffalo County, Wisconsin

1. This transmits the Indian Slough, Wisconsin, Definite Project Report (DPR) for your action. Recommend approval of the habitat project at an estimated construction cost of $794,200, including $111,000 for plans and specifications. Funds in the amount of $110,000 have been previously allocated for general design. Additional funds in the amount of $518,300 will be requested separately under the navigation project operation and maintenance authority. Also request approval and funding for plans and specifications at the earliest possible date.

2. The Indian Slough project area is located in Pool 4 of the Mississippi River and consists of several minor sloughs which enter the backwater area known as Big Lake. The movement of sediments from the main channel into the backwater areas has resulted in the degradation of habitat for a variety of fish and wildlife.

3. The proposed project consists of dredging over 40,000 cubic yards of material in Big Lake Bay to provide a 3,000-foot long channel of deeper fisheries habitat. A riffle pool complex in lower Indian Slough will enhance fish and mussel habitat. A partial closure structure at the Indian Slough inlet (constructed under operation and maintenance (O&M) authority) will reduce the quantity of sediment entering the backwater area.

4. The Indian Slough project is located on lands managed as a National wildlife refuge by the U.S. Fish and Wildlife Service (USFWS). Under Section 906(e) of the 1986 Water Resources Development Act, implementation funding would be 100-percent Federal. The U.S. Fish and Wildlife Service and the Wisconsin Department of Natural Resources will assure that O&M will be accomplished in accordance with Section 906(e) (see DPR, Attachment 6). Annual O&M costs for the habitat project are

estimated at $500. The annual O&M of the partial closure structure will be provided by the Corps of Engineers.

6. The HQ, NCD, POC is Ms. Joan Havrilla, CENCD-PE-PD-PL, (312) 353-3140.

JUDE W. P. PATIN
Brigadier General, USA
Commanding

3 Encls
1. Report (12 cys)
2. Fact Sheet and Map
3. PB-2a

10 SEP 1991

CECW-PC (CENCD-PE-PD-PL /5 Nov 90) (1105) 1stEnd/Kennedy/set/202-272-8529)
SUBJECT: Upper Mississippi River System Environmental Management Program (UMRS-EMP); Indian Slough, Buffalo County, Wisconsin

U. S. Army Corps of Engineers, Washington, DC 20314-1000

For Commander, North Central Division, ATTN: CENCD-PE-PD-PL

1. The Assistant Secretary of the Army (Civil Works) has returned our construction approval request, citing:

a. insufficient incremental justification of all measures employed in the project; and,

b. incomplete justification for using O&M funding for a portion of the project.

2. Accordingly, the report is returned for your action.

Hugh E. Wright/for

Encl
wd

JIMMY F. BATES
Chief, Policy and Planning Division
Directorate of Civil Works

13

Reference b

S: 1 November 1991

CENCD-PE-PD-PL (CENCD-PE-PD-PL/5 Nov 90) (1105) 2d End
Ms. Havrilla/(312) 353-1279
SUBJECT: Upper Mississippi River System Environmental Management Program (UMRS-EMP); Indian Slough, Buffalo County, Wisconsin

Cdr, North Central Division, U.S. Army Corps of Engineers,
111 North Canal Street, Chicago, IL 60606-7205 26 SEP 1991

FOR Cdr, St. Paul District, ATTN: CENCS-PD

1. References:

a. Memorandum, CENCS-PD-FS, 13 September 1990, subject: UMRS-EMP; Indian Slough Habitat Project.

b. EMP Coordinating Committee (EMP-CC) meetings on 10-11 September 1991.

2. The Indian Slough, Wisconsin, Definite Project Report (DPR), submitted with reference 1a, is returned for your action.

3. The NCS is requested to provide a complete and concise supplemental report by 1 November 1991. The supplemental report must include an incremental analysis of each separable project feature and clearly explain the rationale for proposing to fund a portion of the project with O&M (channel maintenance) funding. The work to be completed with O&M funding must be considered part of the without-project condition for the evaluation of alternatives. These issues were discussed at our meetings during the September 1991 EMP-CC. Following NCD review, the supplemental report will be submitted to HQUSACE.

4. The HQ, NCD, POC is Ms. Joan Havrilla, CENCD-PE-PD-PL, (312) 353-1279.

FOR THE COMMANDER:

JOHN P. D'ANIELLO, P.E.
Director, Engineering and
Planning Directorate

CF:
CENCR-PD
CELMV-PD
CELMS-PD
CECW-PC

WASHINGTON, D.C. 20314

REPLY TO ATTENTION OF:

DAEN-CWO-M

10 June 1974

SUBJECT: Back Channel Dredging - Upper Mississippi River

Division Engineer, North Central

1. Reference is made to the briefing 10 May 1974 by Rod Cox and Walt Johnson concerning dredging in the Upper Mississippi River.

2. During the briefing and subsequent discussion, DOI representatives claimed the Corps is responsible for blocking entrances to a number of sloughs by our maintenance dredging operations. It was understood that Civil Works would seek means to assist DOI where legal and proper.

3. While the Corps does not have the authority to perform work, without reimbursement, when based solely on a request from another agency, there are situations where work at Corps expense can be justified. In locations where it can be determined that our maintenance dredging operations have in fact contributed to back channel clogging or other unacceptable environmental damage, it is appropriate that Corps authority permit the provision of suitable remedial measures. The District Engineers may make a determination that Corps dredging operations caused the adverse conditions in the back channels, where:

a. A review of past records of dredging and disposal operations indicates that a reasonable appraisal of the data supports such a conclusion.

b. A review of photographs, charts, and surveys provides sufficient data from which a reasonable deduction could be made establishing Corps responsibility.

c. An evaluation of pertinent data assembled by the A/E in connection with the preparation of the EIS is considered sufficient and of such relevancy to support a determination as to Corps responsibility.

Reference d

d. An evaluation of the hydraulic flow characteristics in the channel and a comparison of grain sizes of the materials dredged with those in the disposal areas and back channel areas support the conclusion of Corps responsibility.

e. Judgments by the District Engineer should be tempered by application of sound engineering principles to the available data.

4. On the basis of the above and other appropriate factors, the District Engineer should review back channel clogging to determine specific areas where maintenance dredging operations are a factor and for which the Corps has the authority to perform remedial work. A preliminary scope of work and cost estimate should be developed for relieving the situation at each location. A list of these locations should be furnished BSF&WL outlining the FY 75 O&M funds which could be made available for this purpose. BSF&WL should be requested to coordinate with appropriate State agencies to provide the District Engineer a listing of priority locations which can be accomplished within available funds, and to designate disposal areas for each location within the capabilities of our dredging equipment. BSF&WL should be advised that the Corps will make efforts to budget for funds for FY 76 to continue the program, if necessary. Further, the Corps will provide assistance to the Department of Interior in efforts to budget fun for dredging of other back channel locations where maintenance dredging operations were not considered to be a contributing factor and for which the Corps has no authority to dredge.

5. This office should be advised of the scope of the program, the funds requirements and the results of the coordination actions with the BSF&WL as outlined above.

FOR THE CHIEF OF ENGINEERS:

J. W. MORRIS
Major General, USA
Director of Civil Works

CF:
St. Paul District
Rock Island District

Department of the Army
St. Paul District, Corps of Engineers
1421 USPO & Custom House
St. Paul, MN 55101-1479

CENCS-CO-M-NAV (11-2-240a) 25 May 1990

MEMORANDUM FOR Commander, North Central Division, ATTN: CO-MO, 536 S. Clark St., Chicago, IL 60605-1592

SUBJECT: Indian Slough, UMRS-EMP Project

1. References:

a. DPR for the subject project dated April, 1990.

b. Letter from DAEN-CWO-M, dated 10 June 1974, subject: Back Channel Dredging - Upper Mississippi River.

2. Reference 1.a. indicates that problems with excessive flows and sedimentation at Indian Slough and Big Lake can be partially attributed to past channel maintenance activities. The report recommends that O&M funds be used to elevate an existing wing dam (partial closing structure). This action is intended to stop problems resulting from previous dredged material disposal. EMP funds would be used to restore certain backwater areas that were indirectly affected by the past disposal.

3. Dredging records from 1957 through 1972, and aerial photography, show that dredged material has been extensively placed along the Wisconsin side of the main channel and has enlarged and connected a series of small islands to the larger complex of islands that once formed the main channel shoreline. This has created above-average flows into Indian Slough, which over time has eroded the natural banks along Indian Slough and also increased its size and sediment carrying capacity. The Fish and Wildlife Service surfaced this problem in the early 1980's and the local public has periodically complained about it, most recently at the 18 April 1990 public meeting for the proposed project.

4. Previous guidance contained in reference 1.b. indicates that in locations where it can be determined that our maintenance dredging operations have in fact contributed to back channel clogging or other unacceptable environmental damage, it is appropriate that Corps authority permit suitable remedial measures. In accordance with that guidance, we are proposing to participate with O&M funds in this project as described in the report, to the extent that existing funding capabilities and priorities allow. Your concurrence with this proposal is requested. Our point of contact is Dan Krumholz at (608) 687-3011.

FOR THE COMMANDER:

Encl

WM. L. GOETZ
Chief, Construction-
Operations Division

CF: NAV SECTION

Reference e

CENCD-CO-O (CENCS-CO-M-NAV/25 May 90) (11-2-240a) 1st End
Deda/nmj/(312)353-6373
SUBJECT: Indian Slough, UMRS-EMP Project

Commander, North Central Division, Corps of Engineers, 536 S. Clark St., Chicago, IL 60605-1592 JUL 0 9 1990

FOR Commander, U.S. Army Corps of Engineers, ATTN: CENCS-CO

1. Concur with your proposal to participate with O&M funds in the subject project, to the extent that funding capabilities and priorities allow. This is consistent with the guidance contained in DAEN-CWO-M letter dated 10 June 1974, that where it can be determined that our maintenance dredging operations have in fact contributed to back channel clogging or other unacceptable environmental damage, it is appropriate that Corps authority permit the provision of suitable remedial measures.

2. HQ, NCD, POC is Mr. Roy Deda, CENCD-CO-O, 312-353-6373.

FOR THE COMMANDER:

CARL C. CABLE, P.E.
Director, Directorate of
Construction and Operations

Reference f

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

APPENDIXES

INDIAN SLOUGH/BIG LAKE BACKWATER REHABILITATION
POOL 4, UPPER MISSISSIPPI RIVER, WISCONSIN
DEFINITE PROJECT REPORT/ENVIRONMENTAL ASSESSMENT (SP-8)

INTRODUCTION

GENERAL

The study effort documented assesses the problems associated with the Indian Slough/Big Lake backwaters and seeks possible solutions. From the onset, historic information available on the area indicated that any recommended project would, in all likelihood, ultimately require joint funding from two separate Corps functions - the Corps Operation and Maintenance activities and the Environmental Management Program. Although this document is written from the aspect of the environmental program in order to present final recommendations for funding under this authority, it addresses the overall study area, presents a plan of action for this entire area, and discusses apportionment of the selected solution between the two Corps program areas.

AUTHORITY

The authority for this report is provided by Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662). The proposed project which is discussed in detail in the main body of this report would be funded and constructed under this authorization in conjunction with features which would be constructed through Corps operation and maintenance activities (under the Rivers and Harbors Acts of January 21, 1927 and July 3, 1930). This report includes an integrated environmental assessment, preliminary Section 404(b)(1) evaluation and draft Finding of No Significant Impact.

Section 1103 of the Water Resources Development Act of 1986 is summarized as follows:

Section 1103. UPPER MISSISSIPPI RIVER PLAN

(a)(1) This section may be cited as the Upper Mississippi River Management Act of 1986.

(2) To ensure the coordinated development and enhancement of the Upper Mississippi River system, it is hereby declared to be the intent of the Congress to recognize that system as a nationally significant ecosystem and a nationally significant commercial navigation system....The system shall be administered and regulated in recognition of its several purposes.

(e)(1) The Secretary, in consultation with the Secretary of the Interior and the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, is authorized to undertake, as identified in the Master Plan -

(A) a program for the planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement....

A design memorandum (or implementation document) did not exist at the time of the enactment of Section 1103. Therefore, the North Central Division, U.S. Army Corps of Engineers, completed a "General Plan" for implementation of the Upper Mississippi River System Environmental Management Program (UMRS-EMP) in January 1986. The U.S. Fish and Wildlife Service (USFWS), Region 3, and the five affected States (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) participated through the Upper Mississippi River Basin Association. Programmatic updates of the General Plan for budget planning and policy development are accomplished through Annual Addendums.

Coordination with the States and the USFWS during the preparation of the General Plan and Annual Addendums led to an examination of the Comprehensive Master Plan for the Management of the Upper Mississippi River System. The Master Plan, completed by the Upper Mississippi River Basin Commission in 1981, was the basis of the recommendations enacted into law in Section 1103. The Master Plan report and the General Plan identified examples of potential habitat rehabilitation and enhancement techniques. Consideration of the Federal interest and Federal policies has resulted in the conclusions below.

a. (First Annual Addendum). The Master Plan report...and the authorizing legislation do not pose explicit constraints on the kinds of projects to be implemented under the UMRS-EMP. For habitat projects, the

main eligibility criterion should be that a direct relationship should exist between the project and the central problem as defined by the Master Plan; i.e., the sedimentation of backwaters and side channels of the UMRS. Other criteria include geographic proximity to the river (for erosion control), other agency missions, and whether the condition is the result of deferred maintenance....

b. (Second Annual Addendum).

(1) The types of projects that are definitely within the realm of Corps of Engineers implementation authorities include the following:

- backwater dredging
- dike and levee construction
- island construction
- bank stabilization
- side channel openings/closures
- wing and closing dam modifications
- aeration and water control systems
- waterfowl nesting cover (as a complement to one of the other project types)
- acquisition of wildlife lands (for wetland restoration and protection) Note: By letter of 5 February 1988, the Office of the Chief of Engineers directed that such projects not be pursued.

(2) A number of innovative structural and nonstructural solutions that address human-induced impacts, particularly those related to navigation traffic and operation and maintenance of the navigation system, could result in significant long-term protection of UMRS habitat. Therefore, proposed projects which include such measures will not be categorically excluded from consideration, but the policy and technical feasibility of each of these measures will be investigated on a case-by-case basis and recommended only after consideration of system-wide effects.

PROJECT SELECTION PROCESS

Under the EMP authority, the following procedures were followed in selecting this project for inclusion and eventual study.

Projects are nominated for inclusion in the District's habitat program by the respective State natural resource agency or the U.S. Fish and Wildlife Service (USFWS) based on agency management objectives. To assist the District in the selection process, the States and USFWS agreed to utilize the expertise of the Fish and Wildlife Work Group (FWWG) of the Channel Maintenance Forum (CMF) to consider critical habitat needs along the Mississippi River and prioritize nominated projects on a biological basis. The FWWG consists of biologists responsible for managing the river for their respective agency. Meetings were held on a regular basis to evaluate and rank the nominated projects according to the biological benefits that they could provide in relation to the habitat needs of the river system.

The FWWG followed a two-phase process. The first phase involved a prioritization of projects on a pool-by-pool basis. This step ensured that regional resource needs and deficiencies were being met and that the best expertise available was being used to optimize the habitat benefits created at the most suitable locations.

In phase 1, the individual projects proposed by the various Federal and State agencies were ranked according to the prioritized resource problems they were addressing and other ranking factors. The resource problems identified and prioritized in a pool included backwater sedimentation, water quality, erosion, lack of important habitat, and lack of habitat protection. The other ranking factors included anticipated fisheries benefits, wildlife benefits, habitat diversity, ease of implementation, potential for innovative or experimental techniques to be used, project longevity, maintenance, and socioeconomic benefits. The second phase of the evaluation involved the development of a prioritized list of the top 20 projects within the St. Paul District, from the individual pool lists, based on the numerical ranking from phase 1 and other factors.

The ranking was forwarded to the CMF for consideration of the broader policy perspectives of the agencies involved. The CMF submitted the coordinated ranking to the District and each agency officially notified the District of its views on the ranking. The District then formulated and submitted a program which is consistent with the overall program guidance as described in the UMRS-EMP General Plan and Annual Addendums and supplemental management guidance provided by the North Central Division.

Projects consequently have been screened by biologists closely acquainted with the river, using the process described above. Through this process, the Indian Slough project was recommended and supported as capable of providing substantial habitat benefits. In the FWWG ranking process, the Indian Slough project ranked the highest of projects in pool 4. In the overall ranking, only one other project scored higher than the Indian Slough project.

PARTICIPANTS AND COORDINATION

Participants in project planning included the Upper Mississippi River Wildlife and Fish Refuge and Region 3 Office of the U.S. Fish and Wildlife Service, the Wisconsin and Minnesota Departments of Natural Resources, and the St. Paul District, Corps of Engineers. The U.S. Fish and Wildlife Service was a cooperating agency throughout the process as allowed by the National Environmental Policy Act (40 CFR 1500-1508). Meetings of the study participants were held at the project site and other locations to discuss project objectives and designs. During various stages of project development, coordination was supplemented by correspondence between the agencies. This draft Definite Project Report/Environmental Assessment is being sent to the agencies and interests listed in attachment 4.

PROJECT LOCATION

Big Lake and Indian Slough are backwater areas in lower pool 4 between river miles (R.M.) 760 and 757 on the Upper Mississippi River. The immediate study area encompasses the backwater areas on the left (eastern) side of the main navigation channel. The project area is part of the National Upper Mississippi River Wildlife and Fish Refuge, administered by the U.S. Fish and Wildlife Service. It is located in northern Buffalo

County, Wisconsin, between the villages of Nelson and Alma, Wisconsin. The closest major city is La Crosse, Wisconsin, which is about 60 miles to the southeast. (See plates 1 and 2 for a location map and study area map, respectively.)

PROJECT SCOPE

The primary purpose of this project is twofold: 1.) To rectify conditions created by the activities associated with the Crats Island dredged material placement site; and 2.) To rehabilitate, enhance, and maintain the diverse riverine habitat for fish and wildlife in the study area.

Following inundation after construction of the lock and dam system in the 1930's, the Indian Slough/Big Lake backwater areas have been gradually filling with sediment. This process, which is occurring throughout much of the Upper Mississippi River system, has been compounded in the study area by the presence of the Crats Island dredged material placement site at the upstream entrance to this backwaters area at Indian Slough. Originally, the main channel of the Mississippi River flowed past the Indian Slough entrance. Wing dams were constructed along this reach during the early 1900's as river training structures for navigation improvement. Crats Island was formed from sedimentation and placement of dredged material riverward of the slough entrance. With the continued use of this disposal site, Crats Island became connected to the land immediately downstream of the slough entrance, and a spit was formed pointing upstream. These actions altered the path of water flowing past the entrance to Indian Slough, creating physical conditions by which additional sediment could enter the Indian Slough/Big Lake system. Sediment input into the project area has produced shallower water depths and increased aquatic plant growth which, in turn, have changed circulation patterns within the system. At the mouth of Indian Slough where it enters Big Lake, a sandy delta has formed which continues to increase in size. With the sand delta formation in the upper end of Big Lake, shallow wetlands are being converted to land and adjacent deep wetlands are being converted to shallow wetlands. The delta formation is predicted to fill in much of a bay area in the lake known as Big Lake Bay and eventually isolate it from the remainder of Big Lake.

The Big Lake Bay area has historically provided good winter centrarchid habitat, but it has diminished in value in recent times, mainly from a loss of deepwater habitat, and is threatened by continued expansion of the delta. Recent data collected for the Indian Slough/Big Lake backwater complex indicate that habitat conditions are generally good. Continued sedimentation, however, would degrade the habitat conditions. Project features have been developed to decrease the amount of sediment-laden waters entering the backwater area, rehabilitate selected reaches within the slough, and maintain existing quality habitat areas.

FISH AND WILDLIFE MANAGEMENT OBJECTIVES IN THE PROJECT AREA

The project area is within the Upper Mississippi River Wildlife and Fish Refuge. Fish and wildlife management goals and objectives, together with additional input from State and Federal agency natural resource managers, were used to guide the development of specific project objectives (presented in a subsequent section of this report). The refuge management objectives fall under those more broadly defined for the Upper Mississippi River Wildlife and Fish Refuge as a whole (USFWS 1988). These broader management objectives that most directly apply to the project area include:

Migratory Birds

+ Maintain or improve habitat of migrating waterfowl using the Upper Mississippi River.

+ Contribute to achievement of national population and distribution objectives identified in the North American Waterfowl Management Plan and flyway management plans by rehabilitating closed areas.

Fisheries and Aquatic Resources

+ Maintain and enhance, in cooperation with the States, the habitat of fish and other aquatic life on the Upper Mississippi River.

Other Wildlife

+ Maintain or increase species diversity and abundance.

EXISTING CONDITIONS

PHYSICAL SETTING

The Indian Slough/Big Lake area is found in the lower part of pool 4. The downstream end of Big Lake is approximately 4 river miles upstream of lock and dam 4. Pool 4 is part of the Upper Mississippi River system which was created by the construction of lock and dam 4 in the 1930's. The entire pool is 44.2 river miles in length, extending from R.M. 752.7 to 796.9 (Indian Slough/Big Lake lies between R.M. 757 and 760). The immediate study area is bounded on the north by Highway 25, which crosses from Nelson, Wisconsin, to Wabasha, Minnesota; on the east by the Burlington Northern Railroad which runs along the eastern (Wisconsin) shore of the river; and on the west and south by the main channel of the Mississippi River. The entire area covers approximately 3,500 acres of floodplain.

Prior to inundation by the lock and dam system, this section of the river was characterized by islands intertwined with sloughs, ponds, and marshes. Scattered areas of meadowland and timberland could also be found. The major sloughs such as Indian Slough, Catfish Slough, Pontoon Slough, and Beef Slough, that were present before construction of the lock and dam system, are still in evidence today. Pontoon Slough and Beef Slough run through the backwater areas upstream of Highway 25 (known as Nelson-Trevino Bottoms) before eventually entering Big Lake. The Nelson-Trevino Bottoms extend from Big Lake upstream approximately 3.5 miles to the mouth of the Chippewa River. Indian Slough and Catfish Slough presently flow in from the main channel of the Mississippi River approximately 1,000 feet and 6,500 feet downstream of Highway 25, respectively. The only other slough of note is a small side channel known as Whorehouse Slough that starts from a point on the Mississippi River immediately downstream of Highway 25 and

enters Indian Slough near the Crats Island dredged material placement site. The Indian Slough/Big Lake backwater area is separated from the main channel by a series of islands. The northern and western portions of the study area are primarily a marsh/slough/island complex. The majority of the remaining area is occupied by a large open body of water called Big Lake.

Several physical features within the immediate area which were part of the study effort are worthy of note. Crats Island, a Corps designated dredged material placement site, occupies an area just to the southwest of the original Indian Slough entrance into the backwaters. As previously discussed, dredged material placement blocked channel flow past this entrance when Crats Island was extended to the land on the downstream side of the original entrance to Indian Slough. With the formation of the spit upstream from this disposal site, the Indian Slough entrance moved from R.M. 759.5 upstream to R.M. 760. Within Indian Slough itself, approximately 1 mile downstream from the current entrance, there is a major loop (hereafter referred to as Truedale Slough) to the north into what is known as Truedale Lake. Pontoon Slough enters the Indian Slough system toward the downstream end of this loop. As stated previously in the "Project Scope" section, sediment deposition at the point where Indian Slough flows into Big Lake has created a large delta area which extended primarily to the east and south, with the downstream end of the delta protruding across the mouth of Big Lake Bay. Typical of delta areas of this nature, Indian Slough branches into a number of braided channels as it enters the lake. Another bay within Big Lake, known as Rice Lake, lies in the southwestern portion of the lake. See plate 2 for the location of the features discussed above.

WATER RESOURCES

Like the rest of the Upper Mississippi River, the project area experiences annual high water which occurs most frequently in March and April. The primary source of floodwaters is spring snowmelt combined with the increased precipitation which can occur during these months. The only major tributary of particular note in pool 4 is the Chippewa River, which enters the Mississippi River from the Wisconsin side about 3 miles upstream of Indian Slough at R.M. 763.5. The Chippewa River has a high sediment

load (primarily bedload) which supplies the Mississippi River in the project area.

Pool 4 is controlled by lock and dam 4 located near Alma, Wisconsin. The primary control point is at Wabasha, Minnesota (RM. 760.22), where project pool, elevation 667.00, is maintained by the operation of dam 4 until the discharge at the dam exceeds 19,000 cubic feet per second (cfs). The mouth of Indian Slough is located near the primary control point at Wabasha. At the 19,000 cfs discharge, the maximum allowable drawdown of the pool at the dam, 0.5 foot to elevation 666.5, is reached and the regulation of the pool is shifted to secondary control at the dam. As the discharge increases above 19,000 cfs, the pool level at the dam is held at elevation 666.5 and the stage at all other points in the pool is allowed to rise. When discharges reach 89,000 cfs, open river conditions exist and the dam is out of control.

In the upstream end of Indian Slough, the existing banks are overtopped at the 2-year flood event (elevation 671 feet msl) at which point river discharge is 78,000 cfs. The peak discharges for the 5-year and 10-year annual hydrographs were calculated to be 117,000 and 143,000 cfs, respectively. At these peak discharges, the river stages at the Wabasha control point would be at elevations 673.5 and 674.5, or 6.5 and 7.5 feet above normal pool. For these discharges, most of the floodplain forest within the study area would be inundated, except for areas that have been elevated by past dredged material disposal. During the 1965 flood, which was the most recent major flood event, the river crested 13 feet above normal pool at Wabasha.

There are four bridges along Highway 25 over sloughs draining the Nelson-Trevino Bottoms. These allow for some water exchange to occur at the upper end of the Indian Slough/Big Lake study area. Flow through these sloughs from the main channel and/or the Chippewa River occurs during periods of higher river discharges. However, during normal flows, these sloughs become partially or totally cut off in the upstream areas. Observations of the flow through the highway bridges during low river discharge indicated that very low flow was occurring both in an upstream and downstream direction, depending on the individual slough. It appears that flow patterns in these sloughs are complex and vary greatly with river

discharge. Generally, under low river discharges, flow through these sloughs does not greatly affect flow patterns in Big Lake. Flow into Big Lake from the main channel comes primarily from two side channels: Indian Slough, which enters the area near the upper end of Big Lake and provides most of the flow to Big Lake, and Catfish Slough, which enters near the lower end of the Big Lake area. Deer Creek, a small tributary, enters from the Wisconsin bluffs on the east.

Water depths in Indian Slough, Catfish Slough, and some of the smaller sloughs vary greatly at normal pool conditions. Portions of Indian Slough have water depths in excess of 15 feet. In Truedale Slough and in the braided channels within the Indian Slough delta, water depths of 1 foot or less occur, which impedes flow. Whorehouse and Pontoon Sloughs generally have water depths of 3 feet or greater; however, there are small shoal areas where the channels branch that have water depths of 1 foot or less.

Most of Big Lake contains water depths, at normal pool, of less than 6 feet. There is a small area near the downstream end of Big Lake that contains water depths of 8 to 12 feet. A rough estimate of the number of acres in various depth ranges for Big Lake is presented in table 1.

Table 1 - Big Lake Water Depths

Water Depth Range	Number of Acres in Depth Ranges
<2 feet	330
2-<4 feet	220
4-<6 feet	540
> 6 feet	80

The water quality in the Big Lake area has not been studied extensively, but is probably characteristic of other backwater areas, being highly eutrophic. Cursory water quality examination during the winter indicates that the two large bays, Big Lake Bay and Rice Lake, along the southwestern edge of Big Lake, which historically have been good winter centrarchid fish habitat, are beginning to experience winter dissolved

oxygen problems, and large areas are now freezing to the bottom. This is predominantly a result of changed water circulation patterns caused by the Indian Slough delta formation.

GEOLOGY/SOILS/SEDIMENT

Geology and Soils - The geologic events most significant to the present topography and soils within the Mississippi River valley near Indian Slough occurred near the end of the Pleistocene glaciation approximately 10,000 years ago. During the retreat of the glaciers, tremendous flows of glacial meltwaters, primarily glacial Lake Agassiz within the Red River Valley, deepened the preglacial Minnesota and Mississippi River valleys. As meltwaters diminished, the river valleys aggraded to about the present levels, and a braided stream environment developed. A vast deltaic deposit also developed at the mouth of the Chippewa River, partially blocking the Mississippi River and creating Lake Pepin upstream. Indian Slough is located on the downstream edge of this delta, which is a broad, low floodplain including many marshy depressions, sloughs, natural levees, islands, and shallow lakes. The near-surface sediments in this area are expected to be highly variable recent alluvium ranging from organic silts and clays to clean sands. The sediment survey results shown on plate 3 reflect the presence of sands within the "higher" flow velocity areas, such as Indian Slough, and organic silts and clays within the low velocity areas, such as Truedale Lake. Variably silty and clayey sands are expected to predominate near the surface within the areas of "intermediate" flow velocities. The soils at depth are expected to be primarily alluvial sands deposited by glacial meltwaters and the Chippewa River. The depth to bedrock in this area of the Mississippi River is commonly in excess of 200 feet.

Sediment - The Chippewa River, which enters the Mississippi River about 3 river miles upstream from the mouth of Indian Slough, contributes greatly to the sediment load in lower pool 4, mainly in the form of bedload. Simons et al. (1979) calculated the bedload from the Chippewa River to be 7.43 and 20.73 million cubic yards for the 2-year annual and 10-year annual hydrographs, respectively. The outflow to pool 5 through lock and dam 4 was calculated to be 4.28 and 8.73 million cubic yards for the same river discharge conditions. This would indicate that an extensive

amount of bedload sediment is trapped in pool 4, especially for the higher river discharges, and explains why this particular reach of river requires an extensive amount of dredging to maintain navigation. Simons and Chen (1976) had indicated that "if the pools are operated in the present-day manner for the next 10 years and if the sediment load to the study reach remains essentially unchanged, the riverbed in pool 4 would have aggraded approximately 0.7 feet overall, the natural levees along the riverbanks and on the islands would grow on the average approximately 0.5 feet, and on the average 0.1 feet of silts and clays would be deposited on the unprotected floodplains." McHenry and Ritchie (1975) reported sedimentation rates of fine material deposition in backwaters in lower pool 4 to be around 0.1 foot per year. This was the lowest reported value for the five pools for which they calculated values and reflects the fairly low suspended load being input from the Chippewa River and the presence of Lake Pepin, which acts as a settling basin for the sediment load on the Mississippi River.

The U.S. Fish and Wildlife Service conducted a survey of sediment types, based on visual characterization, in Indian Slough and surrounding areas in June 1980. The results of this survey are shown on plate 3. Fine sediments were found in the small bays, lakes, and quiescent sloughs adjoining Indian Slough. The substrate was found to be sand throughout most of Indian Slough, including the reach across the delta area in Big Lake. Large sandy flats extend far out into Big Lake and reflect the extensive amount of bedload deposition that has occurred in this delta area of Indian Slough. Beyond these sandy flats, the substrate changes to fine sediment, which is expected to be characteristic of the rest of the Big Lake area.

Sediment Analysis - The fine material that would be dredged to create deepwater habitat in Big Lake Bay was sampled and tested for contaminants. (Data from this sampling is contained in Attachment 3, Table 404(b)-1.) The material was sampled at three sites in Big Lake Bay, with 2-inch-diameter corers down to a foot below the proposed dredging depth. The material had between 50 and 90 percent silts and clays and was rich in organic material. The chlorinated hyrdocarbons and herbicides tested were below the limits of detection in all the samples. Metals were found at levels typical of fine backwater sediments. Ammonia nitrogen was detected at relatively low levels, with the highest level being recorded for the

sample that had the highest amount of organic material. At two of the three sites sampled in Big Lake Bay, the core was split vertically, top and bottom, to assess any potential heterogeneity with depth. No major difference was observed with sampling depth, other than it appeared that the surficial layer was slightly more enriched with metals.

The material in Indian Slough is predominantly sand, with only traces of silt (see Appendix A for particle size distribution). The material from selected areas in the backwaters (such as Truedale Slough and Whorehouse Slough) that might be dredged and used as fill for the closing structure in Indian Slough was visually inspected to determine the general particle size, but was not tested for contaminants. Most of the material that might be dredged in these sloughs would be a combination of sand and silty sand. This was not sampled for contaminants because it was felt that the analysis of the fine material from Big Lake Bay would reveal if contaminants were present at levels of concern in the general area. In addition, there is an abundance of information on the quality of the coarser sediments from the main channel in this area, including the inlet of Indian Slough. The data in the table indicates that coarse material in the area has very low levels of metals. All the chlorinated hydrocarbons were below the limits of detection. The combination of data bases, including the information collected from the fine material and the existing information for the main channel sediments, should bracket the sediment quality in the project area. Table 404(b)-2 in attachment 3 summarizes the existing sediment quality in the area, including some additional fine material samples collected by the U.S. Fish and Wildlife Service in the lower pool 4 area. It indicates that the bottom material in this area is relatively uncontaminated.

NATURAL RESOURCES

Vegetation - The study area covers 3,500 acres of floodplain habitat. The bottomland forest which covers about 1,000 acres within the study area is dominated by American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), cottonwood (*Populus deltoides*), and river birch (*Betula nigra*). Scattered stands of dense willows (*Salix spp.*) occur throughout the study area, near the water's edge. The understory is dominated by poison ivy (*Rhus radicans*) and wood nettle (*Laportea canadensis*).

According to Meyers (1976), in 1973 emergent and marsh vegetation covered about 1,000 acres of study area. Extensive, dense stands of arrowheads (*Sagittaria spp.*) and river bulrush (*Scirpus fluviatilis*) occur throughout the study area. Cattails (*Typha latifolia*), softstem bulrush (*Scirpus validus*), and burreed (*Sparganium eurycarpum*) occur in scattered stands throughout the study area. Lotus (*Nelumbo lutea*) occur in beds in the deeper areas of the Big Lake area.

Open water, consisting of river lakes, ponds, and oxbow channels, covers 1,500 acres of the study area. In the shallower water zones, interspersed in these open water areas, are extensive beds of submerged species. The abundant submerged species include several species of pondweeds (*Potamogeton crispus*, *P. zosteriformus*, *P. foliosus*, and *P. americanus*), coontail (*Ceratophyllum demersum*), wild celery (*Vallisneria americana*), water star grass (*Heteranthra dubia*), and waterweed (*Elodea canadensis*). Water lily (*Nymphaea spp.*) is frequently found along with some of the submerged species.

Fish and Wildlife - The Indian Slough/Big Lake complex contains a diversity of aquatic habitat types and supports a variety of fish species. Big Lake and the smaller ponds, lakes, and quiescent sloughs within the study area support excellent centrarchid based fisheries, including bluegill (*Lepomis macrochirus*), black crappie (*Promoxis nigromaculatus*), largemouth bass (*Micropterus salmoides*), and northern pike (*Esox lucius*). Indian Slough, Catfish Slough, and other running sloughs within the study area support centrarchids and riverine species, such as walleye (*Stizostedion vitreum*) and smallmouth bass (*Micropterus dolomieui*).

Benjamin and Talbot (1985) conducted creel surveys for the Big Lake area from 1984 to 1985 and found the area to be very productive, both in terms of numbers and size, for gamefish and panfish. Table 2 summarizes the catch results for some of the important sport fish found in the surveys. The average annual projected use by anglers was found to be 31.93 hours per acre, with about half of this use occurring on the ice.

Table 2 - Wisconsin Department of Natural Resources Big Lake Creel Survey

Species	Projected Harvest Numbers/acre	Projected Harvest Pounds/acre	Mean Length (inches)	Mean Weight (pounds)
Largemouth bass	0.54	0.909	13.5	1.685
Northern pike			25.2	4.092
Black crappie	4.08	2.33	9.13	0.57
Walleye	0.20	0.30		1.43
Bluegill	15.65	5.56	7.17	0.355

The diversity and quality of habitat types in the project area make it a productive area for a variety of wildlife species. The Indian Slough delta area in Big Lake has an abundance of sand islands containing herbaceous vegetation, lying only 1 to 3 feet above normal pool, which provides excellent shorebird habitat. Within the project area, especially valuable areas to puddleducks are Truedale Lake and the western and southern margins of Big Lake, which contain large areas of marsh, shallow water, and deepwater wetlands. Aquatic mammals, such as the muskrat (*Ondatra zibethicus*), are also abundant in these marsh areas. During migrations, diving ducks occur in great numbers in the more open water areas of Big Lake, containing submerged vegetation. Tundra swans (*Cignus columbianus*) extensively use the lower pool 4 area during fall migration, especially the marsh area at the mouth of the Buffalo River, which is located immediately downstream of the project area.

Although the study area is still very productive for fish and wildlife, there are certain problem areas. Habitat conditions in the upper end of Big Lake are changing rapidly, mainly as a result of the sediment load from Indian Slough. Aquatic areas are being converted to land, and the wetlands adjoining the Indian Slough delta are becoming shallower. In addition, over time, the formation of the Indian Slough delta has significantly modified water circulation patterns, causing dissolved oxygen problems in Big Lake Bay. This has diminished the value of this 75-acre bay as winter centrarchid habitat.

Threatened and Endangered Species - Three endangered (E) and threatened (T) species have been known to occur in the general vicinity of pool 4 of the Upper Mississippi River:

Common Name	Scientific Name
Peregrine falcon (E)	*Falco peregrinus*
Bald eagle (T)	*Haliaeetus leucocephalus*
Higgins' eye pearly mussel (E)	*Lampsilis higginsi*

There is no designated critical habitat for these species within the project area at this time.

The peregrine falcon was once a summer resident of Minnesota, breeding in the Lake Superior area and along the bluffs of the Upper Mississippi and St. Croix Rivers (Roberts, 1932). The last recorded native nesting in Minnesota was in 1962; by the early 1960's, DDT poisoning led to the demise of the entire eastern population (Tordoff, 1984). Peregrine falcons were always a relatively uncommon bird; the original breeding population in Minnesota was only 30 to 35 pairs. While there are presently no active native breeding sites for the species in Minnesota and Wisconsin, historic falcon eyries and potential nesting sites occur along the steep bluffs of the Upper Mississippi River and adjacent tributaries. Because of the potential sites, there is an interagency effort, the Peregrine Falcon Reintroduction Project, that is attempting to reestablish a breeding population of peregrine falcons in the Mississippi River Valley. One of the major release sites, with releases having occurred since 1982, had been located near Kellogg, Minnesota, at Weaver Dunes, a large tract of land owned by The Nature Conservancy. However, releases have not occurred at this site since 1986 because of problems with high mortality of the young peregrines, mainly from predation by owls. This area is located 10 miles downriver from the Big Lake area. In addition to the reintroductory efforts, a few transient birds, although their numbers are unknown, continue to use the river valley during spring and fall migrations.

The bald eagle is a summer resident of Minnesota and Wisconsin, generally breeding in more northern areas of the States. There is one active breeding site for bald eagles in pool 4, located around 1/4 mile downstream of the project area. Other active nests have been located in pools 5A, 8, and 9. Of primary value to bald eagles is their use of the river as a migration corridor and wintering area. Bald eagles winter in numbers on the Upper Mississippi River, concentrating below locks and dams

and at the mouths of tributaries where ice free conditions provide important feeding areas. One of the important wintering areas is the mouth of the Chippewa River, where flow from the Chippewa River maintains ice free conditions for much of the winter and numbers of bald eagles can be seen throughout much of the winter. In order to minimize any potential impacts on bald eagle use of the area, none of the large trees bordering the main channel, which are used by the eagles for perches, should be removed as part of the project.

Historically, the range of the Higgins' eye pearly mussel extended from St. Louis, Missouri, to the Twin Cities metropolitan area in Minnesota, with occurrences noted in the major tributaries including the Minnesota and St. Croix Rivers. While the literature suggests that this species was never abundant, data indicates a 53-percent reduction in its range from 1965 to 1980 (Havlik, 1981). Although the Higgins' eye pearly mussel is characterized as a large-river species restricted entirely to the Upper Mississippi River system, little is known about its ecology or what impacts have resulted to the species from natural or man-induced changes to the river ecosystem that have occurred over several decades. While the Higgins' eye pearly mussel has been found in several of the navigation pools within the St. Paul District, there has been no recent documented occurrence of the species in pool 4 or adjacent pools. Extensive mussel surveys by the Academy of Natural Sciences of Philadelphia (Fuller, 1978 and Fuller, 1980) and the Wisconsin Department of Natural Resources (WDNR) (Thiel, 1981) failed to collect the species in pool 4 or any of the adjacent pools. The WDNR survey included survey runs in Indian Slough and the Big Lake area. Both surveys found the abundance and diversity of mussels in lower pool 4 to be quite limited. However, a survey completed as part of the Highway 25 bridge replacement did locate a relatively diverse and abundant mussel bed in the main channel border near Wabasha. For this reason, an additional survey was completed in 1989 in Indian Slough in the areas that have been considered for the partial closing structures. Only one species (pocketbook) of mussels was collected in this survey.

CULTURAL RESOURCES

According to Section 106 of the National Historic Preservation Act, as amended, the National Register of Historic Places has been consulted. As of 1 October 1989, there are no sites on or determined eligible for the Register in the immediate project area. However, pool 4 is rich in archaeological and historic sites. Over 30 properties in the pool have been listed on the National Register of Historic Places. Five of these are historic districts: the Wabasha Commercial District; the Old Frontenac Historic District; the Red Wing Historic Mall District; and the Alma Multiple Resource District. In addition, there are over 100 individual standing structures noted for their historical or architectural significance. Over 100 archaeological sites are also located in the vicinity of pool 4. Forty-two of these are mound groups. The rest are habitation sites ranging in age from the Early Archaic to the Historic period.

Seven historical sites and six archaeological sites are within a 2-mile radius of the project area. The St. Paul District contracted with the Institute for Minnesota Archaeology in 1989 to do a survey of the pool 4 environs. Only an additional five archaeological sites were located by this survey.

SOCIOECONOMIC RESOURCES

The project area is located in Buffalo County, Wisconsin, between the towns of Alma and Nelson. Alma and Nelson both have populations of less than 1,000 people, and Buffalo County is one of the least populated counties in the State of Wisconsin. Leading occupational categories in this rural area include operators and laborers, technical related support jobs, and service occupations. Unemployment in the area is higher than the Wisconsin State average and greater than in Wabasha County and Wabasha City which border the project area on the Minnesota side of the river.

RECREATIONAL RESOURCES

Within pool 4, there are 35 boat accesses with a total of 48 launching lanes (32 in Minnesota, 16 in Wisconsin) and 1,530 parking spaces. Pool 4

also has 1,332 marina slips (1,210 in Minnesota, 122 in Wisconsin), 356 camping units, and 328 picnicking units, plus 17 dredged material placement islands used as undeveloped recreation areas. The dredged material islands/beaches/camps below the Chippewa River are the third-most heavily-used areas between St. Paul, Minnesota, and Guttenberg, Iowa. The study area is heavily used for both fishing and hunting. Along Highway 25, there are three boat accesses to the sloughs that lead into Indian Slough and Big Lake.

FUTURE WITHOUT PROJECT CONDITIONS

HISTORICALLY DOCUMENTED CHANGES IN HABITAT

Habitat changes as a result of sedimentation frequently have been defined as the number one resource problem on the Upper Mississippi River. Big Lake and parts of Indian Slough are suffering from excessive sedimentation and subsequent secondary problems that have developed as a result of sediment deposition. To assess the habitat (land/water) changes that have occurred, the 1932 Brown Survey, corrected for postinundation conditions (1940); the 1974 U.S. Geological Survey 7.5-minute quadrangle; and the U.S. Fish and Wildlife Service's 1984 aerial photographs (scale 1:24,000) were digitized and analyzed with a Geographic Information System (plates 4, 5, and 6). Comparing this digitized data, it appears that three general areas have shown the most changes in land/water areas. Each of these areas is discussed in detail in the following paragraphs.

The main channel border of the Mississippi River has shown a substantial increase in land area, due to historical channel maintenance activities and accretion of sediment. These changes are important from a number of perspectives. As was indicated previously, the historical channel maintenance activities near the mouth of Indian Slough have contributed greatly to the sediment problems in Indian Slough and Big Lake. The placement of the dredged material in areas adjacent to the main channel has also left sparsely vegetated sand habitat here, having limited wildlife value. In addition to this, since inundation by the 9-Foot Channel Navigation Project, the availability of rock substrate has become limited

to the rock channel training structures that were built as part of the 3- and 6-foot navigation projects. These structures are important because they provide good habitat for a variety of lithophilic fish species. The accumulation of sediment in these areas of the river has buried much of this rock substrate, further changing the main channel border habitat.

Another area of major change within the project boundaries has been in the upper portions of the study area downstream of the Highway 25 dike/bridges. Here, there has been a substantial increase in landmass along, and downstream of, the existing sloughs. Highway 25 modifications done in the 1950's included the placement of bridges in new areas. Instead of dredging channels to accommodate the changed flow conditions, the sloughs were forced to naturally cut new channels under the bridges. The substantial changes in land and water areas below Highway 25 may be at least partially explained by the erosion and deposition that occurred as a result of this highway upgrade.

The third area that has shown dramatic changes in land/water is the land adjacent to Indian Slough, including the upper end of Big Lake. Here, approximately 240 acres of aquatic area present in 1940 has been converted to land. It is difficult to determine the precise amount of adjacent aquatic areas that have become shallower as a result of the sediment load from Indian Slough, because detailed bathymetric surveys of the adjacent areas were not conducted. However, it is estimated that about an equal amount (240 acres) of adjacent aquatic area has become substantially shallower. One of the specific areas that has shown major changes is Truedale Lake. In 1940, Truedale Lake had about 160 acres of open water, which had been reduced to approximately 80 acres in 1984. An island had also formed across the mouth of Truedale Lake, effectively isolating it from Truedale Slough. This "lake," which now consists of predominantly isolated shallow wetlands, is considered very productive for a variety of aquatic wildlife species, but its fisheries value has substantially decreased. Big Lake Bay is following a similar trend, as the Indian Slough delta continues to encroach on this area.

The increased flows and meandering channel configuration through Indian Slough have also caused bank erosion along the slough, further adding to the sedimentation problem in Big Lake. From 1940 to 1984, Indian

Slough, from its original inlet to immediately downstream of where Truedale Slough branches from Indian Slough, has increased in surface area by 40 percent. One area where this erosion has been substantial is just downstream from where Truedale Slough branches from Indian Slough. Here, the channel (measured on 1949 and 1984 aerial photographs) has increased to almost twice its original width during this time frame.

In addition to the gradual changes in habitat, the creation of the sand delta at the mouth of Indian Slough has significantly modified water circulation patterns within Big Lake. Previously, water from Indian Slough flowed through several small channels within the delta area, providing flow to various portions of Big Lake, including Big Lake Bay. Presently, most of the flow is concentrated in only one channel which flows in an east/northeasterly direction in the delta, restricting water exchange in a portion of Big Lake, especially Big Lake Bay. Although not necessarily attributed to the same causal sources, sedimentation has also restricted flow in portions of Whorehouse Slough, Truedale Slough, and Pontoon Slough.

Big Lake Bay, according to resource managers, is presently experiencing occasional low winter dissolved oxygen conditions and high summer thermal conditions. Efforts to document these potential dissolved oxygen problems have largely been ineffective because of the last two consecutive mild winters, with limited snow cover.

FACTORS INFLUENCING HABITAT CHANGE

The factors potentially influencing habitat quality in the Indian Slough/Big Lake area are numerous, complex, and interrelated; but, as has been pointed out throughout this report, one of the dominant influences is sediment inflow from the Mississippi River. Two types of sediment can be carried into the backwaters: Bed material which is material found on the stream bed (composed primarily of gravel and fine sands) and wash load (consisting primarily of silts and clays). The former sediment type appears to be a substantial source of material found in the delta at the mouth of Indian Slough.

The excessive flows and sedimentation can be partially attributed to past channel maintenance activities. Dredged material has been placed on

and between a series of wing dams on the Wisconsin side of the main navigation channel across from Wabasha, Minnesota, and adjacent to Indian Slough. This has created above average flows into Indian Slough. Over time, the higher flows have eroded the natural banks along Indian Slough, thereby significantly increasing the size (and sediment load carrying capacity) of this slough. For this reason, the project is being developed as a joint EMP Habitat Rehabilitation and Enhancement Project and 9-foot Navigation Channel, Operation and Maintenance (O&M) Project. O&M would have the responsibilities for reducing flow and sediment input from the main channel. This would primarily center around construction of a partial closure structure. EMP would concentrate on enhancement and restoration of habitat quality either through modifications in partial closure structure design and placement or by implementation of additional construction features within Indian Slough and Big Lake.

ESTIMATED FUTURE HABITAT TYPES AND DISTRIBUTION

The future, without a project, would mean that sedimentation would proceed at its current rate, continuing the rapid loss and degradation of aquatic habitat within Big Lake. Based on the past changes in habitat conditions adjacent to Indian Slough, it is estimated that in the next 50 years an additional 240 acres of shallow wetlands would be converted to land and 240 acres of adjacent deep wetlands would be converted to shallow wetlands. Truedale Lake would continue to become more shallow, albeit at a slower rate than the area has historically shown because it has become more isolated. Many of the shallow wetlands present in Truedale Lake would be lost due to the sediment accretion. This would diminish the lake's value to waterfowl and other aquatic birds and mammals. Big Lake Bay would probably follow the patterns observed for Truedale Lake by becoming more shallow and eventually isolated from Big Lake. This would significantly diminish its fisheries value, especially as winter centrarchid habitat; but would, at least temporarily, improve its value for waterfowl. The apparent dissolved oxygen and high summer thermal problems in Big Lake Bay would continue and expand both in severity and spatially as the habitat conditions changed in the future. The Big Lake fisheries are being stressed because of the degraded aquatic habitat, which will continue without the project and will eventually result in an undesirable shift in the Big Lake fisheries.

PROBLEM IDENTIFICATION

EXISTING AND FUTURE HABITAT DEFICIENCIES

The shallower water depths and increased aquatic plants, in combination with changes in water circulation patterns by the sandy delta creation, have caused portions of Big Lake to experience winter dissolved oxygen problems and high summer thermal conditions. The loss of aquatic habitat and degradation of water quality, especially dissolved oxygen, are stressing the Big Lake fishery. Truedale and Whorehouse Sloughs and selected areas downstream of Highway 25 are also diminishing in fisheries value due to reduced flows during late summer and winter, making the areas become stagnant.

Much of the deeper water habitat in the upper part of Big Lake has been lost due to sedimentation from Indian Slough. A large, shallow sand flat extends out from the Indian Slough delta. Most of the deeper water habitat present in the Big Lake/Indian Slough complex is confined to sloughs and to the main body of Big Lake. The sloughs do not offer good winter habitat for the centrarchid based fisheries of Big Lake because of the high current velocities and lack of large vegetated areas. Current velocity and temperature measurements taken along transects in the main body of Big Lake indicate that current velocities are in excess of 0.1 foot/second and temperature is near 0^{o} C during the winter. These conditions make the deeper water habitat present in the main body of Big Lake generally undesirable for wintering bluegills. Although the current is projected to be decreased in this area because of the efforts to reduce discharge through Indian Slough, it will not be reduced enough to make these deeper water areas within Big Lake suitable for centrarchid winter habitat. Historically, the major wintering areas for centrarchids have been Big Lake Bay, Rice Lake, and some smaller bays near the Highway 25 dike and bridges. Rice Lake has maximum water depths of 3 to 4 feet and, as such, lacks deepwater habitat. However, Rice Lake has a high quality habitat value for wintering centrarchids until it diminishes in value during late winter because of the lack of deep water. Because of its location substantially distant from the Indian Slough delta area, Rice Lake habitat conditions are not likely to be altered significantly in the foreseeable

future. Big Lake Bay covers around 75 acres of aquatic habitat, with a maximum depth of 3 feet. During late winter, when ice is 2 feet thick, most of this area is unavailable for centrarchid use. Resource managers have indicated that during severe winters Big Lake Bay experiences winter dissolved oxygen problems. In addition to the winter problems, most shallow backwaters like Big Lake Bay experience significant diurnal dissolved oxygen and temperature swings during the summer, which can severely limit the quality of the habitat for fish.

Without the project, the delta will continue to expand at a rapid rate. Eventually, most of the Big Lake Bay area would be filled in, and the remaining aquatic area would become isolated from the rest of Big Lake. The winter dissolved oxygen problems and high summer thermal conditions would be exacerbated and eventually make this area of limited value to the fisheries of Big Lake.

DESIRED FUTURE HABITAT TYPES AND DISTRIBUTION

The Mississippi River is home to numerous fish and wildlife species, because of the diversity and productivity of the habitat present. Any habitat changes that have occurred and will continue to occur in the area, with or without efforts to reduce future sediment loading from Indian Slough, will benefit one group of fish and wildlife species over another. The most reasonable overall goal for this area, therefore, is to provide a balance between the needs of the various species of fish and wildlife. To this end, it would be desirable to create and/or maintain the following habitat conditions:

- to maintain the 160-acre Truedale Lake as a valuable complex of shallow wetlands, by reducing future sediment accretion.

- to restore Truedale Slough and Whorehouse Slough to flowing channel habitat, thereby improving the use of the areas by both lentic and lotic fish species.

- to reduce by half the conversion of shallow and deepwater wetlands in the upper end of Big Lake to habitat consisting of low islands and braided channels.

o to intensively manage Indian Slough for lithophilic fish species, to offset the loss of this type of habitat in the main channel border and the loss of deep water in the upper end of Big Lake.

o to restore and maintain the 75-acre Big Lake Bay as centrarchid habitat by reducing future sediment accretion and restoring deepwater habitat.

o to convert around 10 acres of the sparsely vegetated sand habitat, created by historical maintenance dredged material disposal, to habitat having a greater and more diverse vegetative cover and, subsequently, improved wildlife value.

PLANNING OPPORTUNITIES

In evaluating planning opportunities, two primary areas were investigated: other potentially compatible projects being planned in the general area by the various Federal, State, and local agencies; and other environmental enhancement or restoration opportunities identified in the general area but not yet programmed for implementation.

As stated previously, the total project has taken advantage of a combination of programs within the Corps. An existing Operation and Maintenance project was being planned in the vicinity of Crats Island in response to the effects of a dredged material placement site on the adjacent backwaters of Indian Slough/Big Lake. As part of the Environmental Management Program which contained a mechanism for implementing Habitat Rehabilitation and Enhancement Projects, the need for assessment and improvement of habitat in this same backwater area had been identified. Because of the similarity in both efforts in at least one of the major objectives (which is to reduce the continuing loss and degradation of aquatic habitat within Big Lake because of excessive sedimentation), this study has proceeded as a joint venture.

Another opportunity evaluated was the use of the dredged fine material as topsoil on sparsely vegetated floodplain forest in the study area where dredged material had been placed in previous years.

PLANNING CRITERIA AND CONSTRAINTS

The proposed project does not conflict with the goals of the Refuge Master Plan. The Upper Mississippi River Land Use Allocation Plan prepared by the St. Paul District, Corps of Engineers shows that the study area is owned either by the Corps or the U.S. Fish and Wildlife Service. The entire area is managed by the U.S. Fish and Wildlife Service.

There are several hydrologic constraints for this project. Any restoration or enhancement solution for this area should include consideration of the following:

1. No substantial increase in sediment input in Catfish Slough and Robinson Lake along the Minnesota shoreline should occur with the project.

2. The project should not significantly raise flood stages.

3. Water levels in the upper end of Big Lake should not be significantly altered for low river discharge conditions, as a result of reducing flows in Indian Slough.

Another constraint on project design was to not affect recreational navigation. In particular, this constraint should be considered when evaluating any partial closure structure placed at the entrance of Indian Slough and in any newly excavated channels within Indian Slough. Original criteria indicated that water depths in dredged channels should be greater than 4 feet and current velocities less than 3 feet per second.

Because of the wide variety of future habitat types desired for the area, more specific concerns and criteria for use with planning and design are included with the description of the project alternatives that were evaluated.

PROJECT OBJECTIVES

From the standpoint of both the Operation and Maintenance program and the Habitat Rehabilitation and Enhancement Program, the common concern in the study area was to reduce sedimentation into the Indian Slough/Big Lake backwaters. Therefore, the major purpose of the project is to reduce the continuing loss and degradation of aquatic habitat within Big Lake and adjacent sloughs, resulting from the sediment load introduced via Indian Slough. With some control of sediment input, additional project purposes included implementation of features to restore and offset some of the habitat changes that have occurred, and to rehabilitate/enhance winter centrarchid habitat in Big Lake Bay. These general purposes, combined with the consideration of desired future habitat types which were discussed in a previous section, were incorporated into the following objectives:

1. To cut by at least 50 percent the rate of conversion of aquatic habitat to land in the Indian Slough delta area. Similarly, to halve the rate of conversion in the adjoining wetland areas of Big Lake where water depths currently ranging from 2 to 4 feet are decreasing to areas with 0 to 2 feet of water.

2. To provide conditions so that dissolved oxygen of 5 mg/l is maintained throughout most of the winter and during the high summer thermal conditions in at least 15 percent of the 75 acres of wetlands in Big Lake (Big Lake Bay) that have historically provided good centrarchid fish habitat.

3. To reestablish 10 acres of flowing slough habitat.

4. To enhance 11 acres of Indian Slough for lithophilic fish species, including the creation of 3 acres of riffle/pool habitat and placement of log snags along the existing cut banks to partially offset the approximately 240 acres of aquatic habitat, at the outlet of Indian Slough, that has been converted to land since inundation by lock and dam 4 in the 1930's.

PLAN FORMULATION

The principal purpose of plan formulation is to develop a plan that would provide the best use, or combination of uses, of water and land resources to meet the established project objectives. To accomplish this, causal factors associated with each of the stated objectives were identified. Alternative solutions to these problems were then assessed. Design efforts centered around achieving the desired project objectives with the lowest first costs considering habitat goals for the area.

ALTERNATIVES CONSIDERED

Several alternatives were considered to meet the identified project objectives. These included a no-action alternative, as well as several alternatives for each of the various developed objectives. Each of the proposed alternatives is described below. Because the stated objectives for this project are, for the most part, not interrelated, the discussion for each objective includes a further mini-discussion of factors that caused the problem, a proposed general solution, a list of the concerns and criteria that need to be addressed when trying to arrive at a more specific solution, and a description of alternative plans to alleviate the problem. Where applicable, a discussion of the ability of each alternative to meet the objective and an estimated cost for the proposed solution are included.

No Action. With this alternative, no project would be implemented using Federal funds. Specific details of future conditions with no action have been described in previous sections; therefore, they will not be reiterated in this section. (In particular, refer to the "Estimated Future Habitat Types and Distribution" section.)

Objective 1. To cut by at least 50 percent the rate of conversion of aquatic habitat to land in the Indian Slough delta area. Similarly, to halve the rate of conversion in the adjoining wetland areas of Big Lake where water depths currently ranging from 2 to 4 feet are decreasing to areas with 0 to 2 feet of water.

Causal Factor: The extensive flows through Indian Slough are causing large inputs of sediment laden main channel water and are causing bank erosion, which is adversely affecting Indian Slough, adjacent sloughs, and Big Lake.

Proposed General Solution: Reduce sediment inflow from the main channel and bank erosion in Indian Slough.

Specific Concerns and Criteria: The project should maximize the reduction of sediment input in Indian Slough (minimum of 50 percent), while providing sufficient flow, in combination with existing flows from Pontoon Slough, to maintain adequate circulation in Big Lake.

Discussion of Potential Alternatives/Measures:

Two options were evaluated for the reduction of sediment into the backwater areas. These were construction of a partial closure structure somewhere in the upstream end of Indian Slough and the need for the implementation of other measures to reduce erosion within Indian Slough itself.

Closing off the entrance of Indian Slough from sediment-laden waters as much as possible was the obvious method for reducing sedimentation in the backwater area. Complete cutoff of flows was rejected because it would severely hamper recreational use of the area and because dissolved oxygen problems could result with the loss of flow into the area. Therefore, a partial closure structure which would reduce flows as much as practicable by decreasing the size of the channel along a stretch of Indian Slough without affecting the boat traffic or dissolved oxygen needs was evaluated. A 2-dimensional computer model was developed and used to design a standard partial closure structure that could be used at various locations in the upper reaches of Indian Slough. In order to determine the most desirable location for this structure, a number of potential sites for the partial closure structure were assessed from the standpoint of cost and/or possible impacts. Two cost estimates were done for each viable alternative. The first used the assumption that fill material required for the closure structure would be obtained by mechanical means from the Crats Island disposal site. The second assumed that material would be hydraulically

dredged from suitable areas in the backwaters to improve habitat conditions. The five partial closure structure locations listed below were evaluated in detail. Plates 7a through 7e show the locations of each site that was considered.

Alternative A: Closure at the head of Crats Island spit. The existing first wing dam found at the present entrance to Indian Slough would be raised to elevation 671 feet msl, with a notch (of standard partial closure structure design) to allow reduced flow into the backwaters. The notched entrance would consist of two L-shaped riprapped embankments having sand-filled cores. (This design is shown on plate 7a.) The main channel side of the spit would need to be armored with riprap in order to prevent breakthrough of flows from the Mississippi River at any point downstream of the proposed closure. Further evaluation of this plan indicated that the position of this structure, immediately adjacent to the main channel of the Mississippi River, was a cause for concern. The turbulence of the river in this area could allow higher concentrations of suspended sand and silt to pass through the partial closure structure than would occur if the structure were located farther off the main channel. Given this situation and the additional costs associated with placing riprap along the spit, this option was dropped from further consideration.

Alternative B: Closure at the most downstream (fourth) wing dam. This alternative would consist of the construction of the L-shaped berm partial closure embankment across the fourth wing dam in Indian Slough. (See plate 7b for a plan view of this design.) The top elevation of this structure would be at 671 feet msl which ties into the existing bank elevation. Implementation of this option would require 7,200 cubic yards (cy) of fill and 10,800 cy of riprap. The estimated cost for this option was $615,000 if the Crats Island site was used and $664,900 if material was taken from the backwaters.

Alternative C: Closure in a narrow/deeper portion of Indian Slough immediately upstream of Whorehouse Slough. This alternative would place the partial closure structure across the narrow area immediately adjacent to the Crats Island disposal site. (See plate 7c for the location of this design.) Because the structure would be located in a narrower portion of Indian Slough, the closure would consist of a 300-foot-long narrowed

channel reach created by filling on both sides of the existing channel. Both the upstream and downstream ends of this fill, as well as the channel notch, would be protected with riprap. The top elevation of the structure would be at 673 feet msl. This higher elevation was used to ensure that flow during flood events would first overtop the surrounding land. Construction of this option would require the use of about 40,000 cy of fill and 7,800 cy of riprap. The estimated cost was $646,500 with fill from the Crats Island site and $784,300 using material dredged for habitat benefits.

Alternative D: Closure in the Crats Island spit, with the existing entrance to Indian Slough blocked off and a new entrance through the spit. A complete closure would be placed across the fourth wing dam in Indian Slough. (Plate 7d shows the elements of this design.) The elevation would be 671 feet msl which ties into the existing bank elevation. A channel would then be excavated through the spit to provide flow into Indian Slough below this elevation. The dimensions of the channel would be similar to those proposed for entrances through the other partial closure structures. Turbulent conditions at this location were perceived to be the same as those associated with alternative A; therefore, this option was also dropped from further consideration.

Alternative E: Closure in a narrow/deeper portion of Indian Slough, downstream of Whorehouse Slough. This partial closure structure would be constructed across the narrowest part of Indian Slough, immediately downstream of the Crats Island disposal site. (See plate 7e for the location of this site.) The design of this structure would be similar to that proposed for alternative C. Some concerns were voiced over this location because of potential environmental and recreational disadvantages. This reach of Indian Slough is considered to be a higher quality fishery area within the slough. Loss of this habitat through the placement of fill material in the channel would need to be considered. Also, placement of the closure structure downstream of Whorehouse Slough would need to be assessed for the possibility of reducing flow through this smaller slough. This could create a dead water area which could eventually silt in, again causing a loss in some aquatic habitat, as well as making an existing boat access from Highway 25 unusable. Construction of this option would use 33,700 cy of fill and 5,800 cy of riprap. The cost for this alternative

would be $518,300 for material borrowed from the Crats Island site and $672,800 with material taken from the backwaters.

All of the above partial closure structures would be constructed such that flow would continue to enter the backwater areas overland at approximately the 2-year flood event much as it does during existing (pre-project) conditions. The stage of this flood event is equivalent to the elevation of the existing top of bank. Some consideration was also given to trying to close off the entire upper part of the backwater area for higher flood events, which would produce a greater decrease in sedimentation in the backwater area. This proposal was assessed by looking at the effects of construction of a dike that would run from Highway 25 along the shore, across the first wing dam at the mouth of Indian Slough, along the spit ending at the Crats Island disposal site. Flow into Indian Slough below the dike elevation would again be through a partial closure structure. The height of the dike investigated was equivalent to a 10-year flood event (elevation 674 feet msl). Using an existing HEC-2 computer model from a Wabasha Flood Insurance Study, it was calculated that this dike height would raise flood stages for the 100-year event by 0.2 to 0.3 foot. This increase would be within Minnesota's floodplain regulations but not Wisconsin's. The ultimate effect of a dike on decreasing sediment entrance into the backwater areas is unknown and was determined to be beyond the scope of this study. It was felt, however, that although the dike would keep more flows from directly entering this portion of the backwater (overland and via Indian Slough), the increase in the water surface elevation caused by the dike would extend upstream, thereby allowing more flow (and sediment) to enter Big Lake via Nelson-Trevino Bottoms. Given the increase in flood stages which would not meet Wisconsin State floodplain regulations and the inability to determine how much, if any, sedimentation would be further reduced, this option was not pursued.

Historically, there has been significant erosion along the Indian Slough channel (primarily associated with the Crats Island disposal activities) which has also increased sediment input to Big Lake. Assuming that construction of a partial closure structure would be implemented, the potential for continued erosion within the backwaters with a partial closure structure in place needed to be evaluated. One area of primary concern for erosion within Indian Slough was more thoroughly investigated

in order to determine if erosion protection was required in the backwaters. This was at a bend located just upstream of the junction of Indian Slough and Truedale Slough where significant loss of the bank had occurred on both sides of the channel. See plate 8 for the location of this eroded section of the slough. The 2-dimensional model indicated that velocities in the vicinity of the two identified erosion prone areas (as well as along the entire channel) would be significantly reduced with the closure structure in place. Table 3 shows the existing and with project velocities at the left and right bank points in this eroding area.

Table 3 - With and Without Project Channel Velocities

Condition	Left Bank Velocity (ft/s)	Right Bank Velocity (ft/s)
Low flow without project	0.3	0.3
Low flow with project	0.1	0.1
Bank-full flow without project	4.4	4.2
Bank-full flow with project	1.7	1.4

Given the reduced velocities at these two points with a partial closure structure in place, erosion would be expected to be minimal. In addition to the reduction in velocities in the threatened reach, there is another consideration which argued against the placement of riprap protection. At present, the bend has eroded substantially and is not very far from achieving a relatively straight alignment. If additional erosion were to occur, it would likely be short lived. A fairly small area of land would be lost before stability was achieved. Given the above, it was determined that no riprap would need to be placed on either of these eroding banks, nor should it be required elsewhere along Indian Slough.

Objective 2. To provide conditions so that dissolved oxygen of 5 mg/l is maintained, throughout most of the winter and during high summer thermal

conditions, in at least 15 percent of the 75 acres of wetlands in Big Lake (Big Lake Bay) that have historically provided good centrarchid fish habitat.

Causal Factor: The decreasing depths in Big Lake and, in particular, the continued extension of the Indian Slough delta are causing portions of Big Lake to experience winter dissolved oxygen reductions and high summer thermal conditions.

Proposed General Solution: Direct and maintain flow from Indian Slough into the Big Lake backwater complex along specific channels to prevent dissolved oxygen in the winter from dropping below 5 mg/l. Another potential solution considered was to restore deeper water habitat in selected degraded areas within Big Lake to make them more suitable for use during the winter and summer by the centrarchid based Big Lake fisheries.

Specific Concerns and Criteria: Any channels dredged in the backwater areas should be continued into Big Lake until a minimum of 4 feet of water depth is encountered.

Discussion of Potential Measures:

Creation of channels in the Indian Slough delta to better direct flow into Big Lake Bay was evaluated as a possible means of improving flow to the backwater areas.

Because delta areas are typically very dynamic, the viability of dredging channels in this area of Big Lake was assessed. From the inspection of aerial photographs, it appears that historically there have been fluctuations in the locations of channels through the delta into Big Lake. Flow measurements taken in the summer of 1989 indicate that the majority of flow is currently directed east/northeastward, with very little water discharging directly south into the main portion of the lake. It was proposed that an existing channel that runs south into Big Lake Bay be expanded to a greater depth to increase circulation through the bay. It was determined that if this channel (or any other channel in the delta) were deepened, it is highly likely that it would fill back to its original depth in a fairly short time. This is so because Indian Slough and Pontoon

Slough will continue to transport some sediment into the delta area in spite of the presence of a partial closure structure. Dredging a channel in the delta would provide a sediment trap for this passing sediment.

Over the long term, it is not possible to assure that a dredged channel would remain because of the process by which channels are formed and change. The formation of channels in the delta and the amount of flow within these channels are generally dictated by the length of each distributary. As sediment is deposited, the primary distributaries increase in length. This increases flow distance and decreases the water surface slope within the distributary until either new channels are formed or older channels become better flow conductors because of their shorter lengths. As a result, the direction of flow and sediment transport shifts from time to time. Deepening a distributary such as proposed in the delta area would increase the efficiency of that channel and cause it to become one of the major channels. This increased discharge would carry with it a corresponding increase of sediment. As discussed above, over time, the length of the channel would grow and finally be abandoned. Given the above, it was apparent that the short life of the dredged channel (because of sedimentation) and the potential for eventual natural abandonment made this option not worthy of further consideration.

Much of the deeper water habitat in the upper part of Big Lake has been lost due to sedimentation from Indian Slough. Large, shallow sandy flats extend out from the Indian Slough delta. To restore some of the deepwater habitat that has been lost, it was proposed that some dredging be done in the Big Lake Bay area. Discussions indicated that creation of a 15 percent interspersion (11 acres) of deepwater habitat (5 feet) in Big Lake Bay, connected with the flowing deepwater habitat in the main body of Big Lake, would improve this area.

One of the primary reasons for creating open water areas in Big Lake Bay would be to create/enhance the winter centrarchid habitat present in Big Lake. Deeper water interspersed in this shallow water area, because of the increased volume and reduced dissolved oxygen demand, would reduce these diel swings in temperature and dissolved oxygen. In addition, connecting this deepwater habitat with the deepwater flowing habitat in the main body of Big Lake may increase the circulation slightly in the Big Lake

Bay area, which also would dampen the diurnal swings in temperature and dissolved oxygen. The deeper water would also allow for an escape route, if conditions in Big Lake Bay become undesirable. Creating an interspersion of deepwater habitat would allow centrarchids to use the shallow areas within Big Lake Bay when conditions are favorable and retreat to deepwater habitat when nocturnal dissolved oxygen and diel temperatures become unfavorable. An incremental analysis was performed on this proposal to ascertain the optimum amount of dredging in the bay. A discussion of this is contained in the Alternative Selection section of this report. The projected costs of dredging 10 and 15 percent of Big Lake Bay were estimated to be $337,800 and $400,300, respectively. Dredging of greater percentages of the bay was not analyzed because of a lack of additional spaces in the immediate vicinity of the selected disposal areas.

Although Rice Lake has some of the depth problems of Big Lake Bay, it was felt that, given its distance from Indian Slough, this area had less exposure to sedimentation problems. Therefore, no habitat rehabilitation or enhancement alternatives were evaluated for the Rice Lake area.

Objective 3. To reestablish 10 acres of flowing slough habitat.

Causal Factor: Sediment input has caused shoals (water depths of 1 foot or less) to develop in the channels north of Indian Slough, decreasing flows and diminishing the fisheries value of Indian Slough.

Proposed General Solution: Restore deeper water channels in selected areas in the backwaters.

Specific Concerns and Criteria: The channels should be designed so that deepening would restore flow characteristics (minimum cross sectional velocity of 0.1 foot per second) in the channels. Water depths should be greater than 4 feet.

Discussion of Potential Measures:

Restoration of flowing slough habitat concentrated on the feasibility of deepening Truedale Slough. Field investigations of that portion of Truedale Slough near where it enters Pontoon Slough indicated that

virtually no flow was present here and that water depths were as little as 1 foot. A 2-dimensional model was used to determine if it was possible to have flows around 0.1 foot per second through channel dredging in this area. With construction of the partial closure structure, flows would not only be lowered in Indian Slough, but would also be further reduced through Truedale Slough. Dredging a channel in Truedale Slough should increase flows so that existing discharges would be maintained; this, however, would not elevate flows to the desired goal of 0.1 foot per second. Because this level of flow could not be achieved, this option was dropped from further consideration.

Objective 4. To optimize 11 acres of Indian Slough for lithophilic fish species, including the creation of 3 acres of riffle/pool habitat and placement of log snags along the existing cut banks to partially offset the approximately 240 acres of aquatic habitat, connected with Indian Slough, that has been converted to land since inundation by lock and dam 4 in the 1930's.

Causal Factor: There has been a loss of aquatic habitat in the upper end of Big Lake caused primarily by sediment accretion at the outlet of Indian Slough. In addition, there has been a loss of rock substrate for lithophilic fish species in the main channel border because of sediment accretion and past channel maintenance activities.

Proposed General Solution: Partially offset the loss of aquatic habitat by enhancing the fisheries value of Indian Slough channels through the placement of fisheries structures to provide cover and substrate.

Specific Concerns and Criteria: To assist in the design of a riffle/pool complex, a target species of fish, smallmouth bass, was selected. This species was chosen for the following reasons: it is a characteristic species of riffle/pool habitat, an abundance of habitat requirements information is available, its habitat requirements are typical of other species associated with this type of habitat, and it is an important sport fish. The criteria to be used in the design of the riffle/pool complex described below were derived from the U.S. Fish and Wildlife Service's Habitat Suitability Information for Smallmouth Bass and a review of the literature.

1. General: A system with alternating pools and riffles supports the largest riverine populations of smallmouth bass. Optimally, pools should cover between 50 and 75 percent of the total surface area. Criteria for a system: alternating pools (75 percent of the areal extent) and riffles (25 percent). Each channel area would either start with a pool to act as a bedload trap or one larger pool area at the beginning of the entire complex.

2. Cover/substrate: The species requires a clean stone, rock, or gravel substrate for spawning. Bass use all forms of submerged cover, such as boulders, rocks, stumps, root masses, trees, and crevices, without an apparent preference for any one type. Between 25 and 50 percent cover is optimum. Criteria for pools: Total cover greater than 25 percent; Wisconsin log crib structures covering 2.5 percent of bottom (10 per acre) and shallow littoral area (0 to 5 feet), which should encourage aquatic plant growth, thereby providing additional cover, comprising 25 percent of channel area. Criteria for riffles: gravel to split rock (0.5 to 1.5 inches in diameter), with large boulders (2 to 4 feet) interspersed to cover 25 percent of total bottom area.

3. Water depths: The optimum average depth of pools ranges from 4 to 15 feet. The optimum water depths for various life stages and functions in a flowing environment are as follows:

Life stage/function	Optimum water depths (feet)
spawning	2-5
fry	>3-?
juvenile	>2.5-?
adult	>4-?

Criteria for riffles: Average depth of 4 feet, which will provide optimum depth for the various life stages, while not presenting a hazard to recreational navigation. Criteria for pools: Minimum depth of 8 feet, which will allow the top of the Wisconsin crib structures (4 feet tall) to remain within the desired depth range of 4 to 15 feet and not pose a hazard to recreational navigation.

4. Current velocity: Smallmouth bass generally prefer no or very slow current. Current velocity criteria for riffles: In turbid water, such as the Mississippi River, the velocity curve for incubation goes to zero utilization at zero velocity, as a function of siltation potential. At about 0.5 foot per second, silt sized material should remain in suspension, based on the Hjulstrom curve of erosion and deposition of uniform material. The results of swimming performance tests indicate that smallmouth fry are capable of maintaining position, without tiring, in velocities up to 0.5 foot per second. Therefore, a target velocity in the riffles, under normal river discharge, of around 0.5 foot per second appears to be most reasonable. The boulders and larger rocks should provide zones of no or little current, which should provide good habitat within the riffles for adults and juveniles. Current velocity criteria for pools: Current velocity preference curves developed for juveniles and adults would indicate that current velocity in the pools should be less than 0.5 foot per second and preferably near 0.1 foot per second.

Discussion of Potential Measures:

Several locations for the proposed riffle/pool complex were investigated. These included Truedale Slough, the delta area, and Indian Slough (between the inlet and outlet of Truedale Slough). Truedale Slough was dropped from consideration because velocities in this loop were too low to meet the current criteria. The delta area was also abandoned because of the instability of channels, as discussed in alternative selection under objective 2. From the standpoint of longevity and the potential to meet design criteria, it appeared that the only viable reach where this complex could be constructed was in Indian Slough between the entrance and exit of the Truedale Slough channel. Within this part of the slough, the best location for the riffle pool complex would be approximately 800 feet downstream of where Truedale Slough splits off. Here, excavation of the pool area and filling required in the riffle areas would be kept to a minimum. The proposed riffle pool complex would consist of two short stretches of faster moving water over a rock substrate (riffle) and one intermediate area of fairly still, deeper water (pool). In addition to this formal complex, Wisconsin crib structures would be placed in the pool and snags would be placed upstream of the complex to further enhance fish habitat. The estimated cost for construction of this complex is $224,600.

ALTERNATIVE SELECTION

The "no-action" alternative represented the condition of Indian Slough in 50 years if the existing trends continued. It was evident, from this futures outlook, that the major feature of this project that needed to be implemented was construction of a partial closure structure. Three technically feasible locations for this structure that would provide the maximum reduction of sedimentation were evaluated based on cost and habitat considerations. These were alternatives B, C, and E of objective 1. Cost comparisons for these three options are shown in table 4. It appears that strictly from a cost standpoint alternative E would be the cheapest plan. However, construction of a partial closure structure here with the placement of a 300-foot-long notched channel would not have the habitat benefits that could be gained elsewhere. The two L-shaped riprapped embankments constructed over the fourth wing dam would provide more rock substrate which is desirable fish habitat. The configuration of this structure, as well as the flow patterns that would be created by it, should also provide improved fish habitat. In addition, the downstream location (alternative E) is already considered to be excellent habitat for fish. Placement of the structure at that site would cause a loss of about 1 1/2 acres of good aquatic habitat in this reach. Given the loss in aquatic habitat at the alternative E location plus the gain in fisheries benefits with a partial closure structure design such as shown for alternative B, it was determined that this latter alternative would be the plan of choice. With the reduction of sedimentation in the backwater area through the construction of the partial closure structure, it was possible to look at methods of improving the Indian Slough/Big Lake area itself.

Table 4 - Cost Comparison of Partial Closure Structures

Alternative	Fill from Backwater Dredging	Fill from Crats Island Disposal Site
Alternative B	$664,900	$615,000
Alternative C	$784,300	$646,500
Alternative E	$672,800	$518,300

From the original remaining objectives which were proposed, two other objectives merited consideration: selective dredging in Big Lake Bay and construction of the riffle pool complex. One of the primary benefits of selective dredging in Big Lake Bay would be to create/enhance the winter centrarchid habitat present in Big Lake. This type of habitat is presently limited, and even though only 11 acres of deepwater habitat would be created, this would represent a significant addition to the amount of late winter centrarchid habitat. Because of the presence of this late winter habitat, the other 64 acres would be enhanced for early to mid-winter centrarchid habitat.

The creation of deepwater habitat would also increase the habitat suitability of Big Lake Bay as summer centrarchid habitat. Deeper water because of the increased volume and reduced dissolved oxygen demand tends to experience less severe diel swings in temperature and dissolved oxygen. In addition, connecting this deepwater habitat with the deepwater flowing habitat in the main body of Big Lake would increase the circulation in the Big Lake Bay area, which also would dampen the diurnal swings in temperature and dissolved oxygen. Creating an interspersion of deepwater habitat would allow centrarchids to use the shallow areas within Big Lake Bay when conditions are favorable and retreat to the newly created deepwater habitat when nocturnal dissolved oxygen and diel temperatures become unfavorable. Therefore, the entire 75-acre Big Lake Bay area would increase in value during the summer for centrarchids. Table 5 summarizes a quick and simple evaluation of the potential outputs, using the bluegill HSI model, including modifications made by Palesh and Anderson (1989). In this HEP evaluation, the entire 75-acre area of Big Lake Bay was used, for the reasons stated above. This analysis estimated the cost per annual habitat unit gained would be $457 and $350 for dredging 10 and 15 percent of the bay, respectively. Given this, the 15 percent option was selected.

Another benefit of the backwater dredging is that it offers an opportunity to provide better topsoil at some of the old channel maintenance dredged material disposal areas where wildlife values are very limited because of the sandy soil and sparse vegetation. These areas have been significantly elevated by past dredged material disposal and are not inundated by most flood events. By providing topsoil, these areas could be

managed for a vegetative community that is rather unique to the Upper Mississippi River Wildlife and Fish Refuge.

The primary benefit of the construction of the riffle/pool complex and other measures in Indian Slough is to enhance its use by lithophilic species, such as smallmouth bass. The actual fish structures that would be built cover a relatively small number of acres. However, they have been placed and designed to provide benefits to a much larger area, a minimum of 11 acres. Todd and Rabeni (1989) found that adult smallmouth bass "spent the majority of their time in less than 10% of the total area that was available to them." They also indicated that smallmouth bass showed a strong use preference for the types of structures being proposed. Rock and wood structures are very productive for macroinvertebrates, and production can exceed 10 times that of sand.

Table 5a. Indian Slough – Comparison of Alternatives for Dredging in Big Lake Bay.

Alternative	Annual Cost	Incremental Cost	Habitat Gain Unit	Habitat Gain Annual	Habitat Gain Incremental	Cost/Habitat Gain Annual	Cost/Habitat Gain Incremental
Dredging 10%	$6,648		HU	14.56		$457	
Dredging 15%	$7,898	$1,250	HU	22.53	7.97	$350	$157

Table 5b. Habitat Suitability Index for Bluegill.

EXISTING HSI MODEL (non-winter only) Variable	Description	No Action	Dredging (10%) 50 acres	Dredging (15%) 75 acres
V1	% Pool Area	1.00	1.00	1.00
V2	% Cover (Logs & Brush)	1.00	1.00	1.00
V3	% Cover (Vegetation)	0.40	0.45	0.50
V4	% Littoral Area	1.00	1.00	1.00
V5	Ave. TDS	1.00	1.00	1.00
V6	Ave. Turbidity	1.00	1.00	1.00
V7	pH Range	1.00	1.00	1.00
V8	Min. D.O. Summer	0.40	0.50	0.70
V9	Salinity	N/A	N/A	N/A
V10	Max. Midsummer Temp.(Adult)	0.80	1.00	1.00
V11	Ave. Water Temp. (Spawning)	1.00	1.00	1.00
V12	Max. Early Summer Temp.(Fry)	1.00	1.00	1.00
V13	Max. Midsummer Temp.(Juvenile)	1.00	1.00	1.00
V14	Ave. Current	1.00	1.00	1.00
V15	Ave. Current (Spawning)	1.00	1.00	1.00
V16	Ave. Current (Fry)	1.00	1.00	1.00
V17	Ave. Current (Juvenile)	1.00	1.00	1.00
V18	Stream Gradient	1.00	1.00	1.00
V19	Reservoir Drawdown	1.00	1.00	1.00
V20	Substrate Composition	1.00	1.00	1.00
	Food (Cf)	0.74	0.79	0.79
	Cover (Cc)	0.70	0.73	0.75
	Water Quality (Cwq)	0.67	0.71	0.77
	Reproduction (Cr)	1.00	1.00	1.00
	Other (Cot)	1.00	1.00	1.00
	HSI	0.78	0.81	0.84
WITH WINTER HSI MODIFICATIONS Variable	Description	No action	Dredging (10%)	Dredging (15%)
Va	Water Depth	0.40	0.40	0.50
Vb	Dissolved Oxygen	0.10	0.30	0.70
Vc	Water Temperature	1.00	1.00	1.00
Vd	Current Velocity	1.00	1.00	1.00
	Winter Cover (Cw–q)	0.40	0.40	0.50
	Winter Water Quality(Cw–wq)	0.40	0.53	0.80
	Corrected Cw–wq(see note 1)	0.10	0.40	0.40
	Winter Other (Cw–ot)	1.00	1.00	1.00
	Winter HSI	0.50	0.58	0.75
	Corrected Winter HSI(see note 2)	0.10	0.40	0.40
	Composite HSI with winter mods.	0.28	0.57	0.58
	Annual HU increase	N/A	14.56	22.53
Estimated cost using winter modifications				
	Estimated cost	N/A	$332,400	$394,900
	Estimated cost/50 years	N/A	$6,648	$7,898
	Est. cost/HU/year	N/A	$457	$350

Note 1: If Vb or Vc is < or = 0.4 Cw–wq equals the lowest of these variables

Note 2: If Vb, Vc, or Vd is < or = 0.4 use the lowest variable as the Winter HSI

SELECTED PLAN

PROJECT FEATURES

Plate 13 shows an overall view of the construction features recommended for this project.

1. PARTIAL CLOSURE STRUCTURE

The partial closure structure would be constructed over an existing wing dam located just upstream of the original inlet of Indian Slough. This wing dam would be used as a base for the proposed partial closure structure. A sand embankment would be placed on top of the wing dam and capped with 30 inches of rock fill. Every attempt would be made to take fill material from the backwaters to construct the core of this closure structure. A number of potential sites where suitable material appears to be available have been identified. These included a shoaled-in area in the upper third of Whorehouse Slough, the previously discussed Truedale Slough area, and shoaled areas in certain channels north of Truedale Slough which probably were occluded by construction of the Highway 25 bridges. The first site was determined to be the location of choice. In 1988, a dike was built across the upstream end of Whorehouse Slough with a connection to the main channel of the Mississippi River retained through construction of a 54-inch culvert in order to reduce flows and sediment into Whorehouse Slough. This was done as part of a Highway 25 bridge construction project which replaced the bridge across the main channel of the Mississippi River. Because of the presence of a shoal which was there prior to placement of the culvert, maximum flow capabilities through the slough are presently not being achieved. Therefore, dredging in this slough is desirable since it would reestablish the flowing channel conditions. With the construction of the dike across the upper end of Whorehouse Slough, the channel should remain open, once this shoal is removed. If additional material were needed for the closure structure or if the material at this site proved to be unsuitable once soil samples are taken during plans and specifications, the remaining sites would be explored for potential use.

The partial closure structure would consist of two L-shaped embankments, one extending from each bank. The top of this structure would

be at elevation 671 feet msl, which would tie into the existing banks. The top width of the closure would be 10 feet. Side slopes would be 1 foot vertical for each 3 feet horizontal throughout most of its length. The legs of these embankments would form an extended 300-foot-long, triangular notched structure having a water surface top width and depth of 65 and 13 feet, respectively, at a normal pool elevation of 667 feet msl (1912 datum). Here, side slopes in the 300-foot-long notch would change to 1 foot vertical for each 2.5 feet horizontal. The primary purpose of this structure would be to dissipate energy as flow passed into the backwater area. See plates 9 and 10 for a plan view and typical cross sections, respectively.

The opening through the closure structure was designed to maximize the reduction of sedimentation into Indian Slough/Big Lake while allowing at least a minimum flow into this backwater area. The following discussion relates how the optimum design was arrived at and what effects this design would have on sediment input into the backwaters.

Minimum Flow Criteria. Initial indications, through professional judgment of staff members of all agencies, were that a minimum flow between 200 and 400 cfs should provide adequate circulation and, therefore, dissolved oxygen (DO) into the backwaters. Continuing discussions led to a minimum design flow of 375 cfs during low flow events. This flow rate was half of the summer low flow rate measured on 12 July 1989. Selection of this particular flow was based on an attempt to balance the objective of maximizing the reduction of sedimentation with the desire to maintain Indian Slough as a flowing habitat and to maintain good circulation within Big Lake. Information gathered at a Corps project at Weaver Bottoms, Minnesota (where a backwater area has been essentially cut off from the main channel flows with only minimal entrance through partial closure structures) was also used to help make this determination. Applying the above criteria of sediment reduction versus adequate circulation, a 2-dimensional model was used to determine the flow reduction potential of a partial closure structure which would be placed somewhere in the upstream end of Indian Slough. The adopted dimensions for this structure were ultimately derived by balancing the need to reduce sediment, provide moderate velocities through the closure structure itself, and minimize scour at the downstream end of the structure with the need to keep costs

down. Maximum velocities anticipated through the structure and their corresponding Mississippi River discharges are as follows:

Mississippi River Discharge	Flood Event	Maximum Velocity	Indian Slough Discharge (cfs) Existing	With Project
15,700 cfs	------	0.9 ft/s	750	375
45,000 cfs	1 year	4.6 ft/s	5,100	2,150
76,000 cfs	2 year	8.1 ft/s	13,000	4,750

Sedimentation Reduction. The next step in this design phase was to determine the reduction in sediment inflow that may be possible with the proposed closure structure. (See Appendix A for a detailed account of the analysis.) Through this evaluation, it was calculated that a 55-percent reduction in bed-material load would be expected into the Big Lake area. Bed-material load refers to the transport of material that makes up the channel bed, which is primarily composed of gravels to fine sands. Suspended sediment would also be reduced by the closure structure. Suspended sediment includes silts and clays, as well as some fine and medium sands. Therefore, suspended sediment load and bed-material load overlap somewhat. Flow analysis predicted a 57-percent reduction in suspended sediment after the installation of the partial closure structure.

Hydraulic Impacts of Construction of This Structure on Other Areas. With the construction of a partial closure structure at Indian Slough, the effects of this action elsewhere in the immediate area needed to be assessed. These are discussed briefly here; however, a more detailed explanation can be found in Appendix A of this report. The first concern was potential breakthrough of a new channel into the backwater area once flow was restricted at the present site. A field inspection of the eastern bank upstream of the proposed partial closure structure revealed one significant low spot. Just above the fourth wing dam, a small channel runs into a wetland area that lies between Indian Slough and Whorehouse Slough. This channel would need to be filled in and the bank in this reach would then be riprapped. To plug this reach and provide additional minor repair along the bank, it is estimated that 500 cubic yards of fill and 250 cubic yards of riprap would be required. At this time, it appears that closure

of this channel would not affect the wetland itself since water from Indian Slough does not seem to be needed to adequately supply the wetland. However, if this were not the case during plans and specifications, a culvert would be installed to ensure that the wetland area would have sufficient water.

The flow which would no longer be passing down Indian Slough would be once again carried along the main channel of the Mississippi River. The effects of this flow on Catfish Slough and Robinson Lake, a backwater area on the Minnesota side of the river just downstream of Indian Slough, needed to be evaluated. Water enters Robinson Lake through two side channels which branch off from a larger backwater slough. According to local residents and Minnesota Department of Natural Resources personnel, this lake has been losing depth over time. Examination of aerial photography shows that, in the past 50 years, a delta has been forming at the outlet of the two channels entering Robinson Lake. With the construction of the partial closure structure, it was calculated that bedload material and suspended sediment entering the Robinson Lake area would increase by approximately 10 percent. The bedload material input would change from 109 tons per day to 120 tons per day (pre and post project conditions). Suspended sediment load would go from 73 to 81 tons per day for these same conditions. It should be noted that the change in sediment input to Robinson Lake is quite small when compared to the amount of bedload (239 tons per day) and suspended sediment (168 tons per day) that is being kept out of Indian Slough. However, in order to minimize the amount of additional sediment entering the lake, a 30-inch layer of rock will be placed along the openings of the two channels leading into Robinson Lake. It is estimated that a total of 600 cubic yards of rock will be required at these openings. The placement of this rock would not only stabilize the channel openings, but would also reduce the existing cross sectional area of these openings by approximately 50 percent. Following construction of the entire project, conditions in Robinson Lake will be monitored by taking flow measurements along the two entrance channels. Alterations in flow will be used as an indication of changes (if any) in sediment input into the lake. The effects of this addition to Robinson Lake will be discussed in the Environmental Effects Section.

The only other area of concern from the standpoint of bringing more water and sediment into Big Lake was Catfish Slough. The difference in water surface elevations between the main channel and Big Lake at this point in the river is not significant. Therefore, it is not anticipated that there will be a great likelihood of breakout into Big Lake. Although some riprap is present at the inlet of Catfish Slough, it is recommended that a small amount of additional riprap be placed on the banks here to further assure that this channel will not increase in size once the partial closure structure is in place. Approximately 200 cubic yards of rock should be sufficient in this area.

The other major concern raised at the onset of this study was the impacts of construction of a partial closure structure on water surface elevations. During floods, the greatest increase in elevation should occur at the 2-year flood event. For this event, it was determined that river stages would increase a maximum of 0.2 foot. This local increase was not considered to be significant. The other area of concern with regard to water surface elevations was Big Lake. Currently, the water profile between the upstream and downstream ends of Big Lake is very flat. The lake's water surface elevation is essentially the same as the elevation of the Mississippi River at the downstream end of Big Lake. Given these factors, it appears that the lack of flow through Indian Slough should not affect the water surface elevations in Big Lake.

2. BIG LAKE BAY

A channel would be dredged in approximately 15 percent of Big Lake Bay to create 11 acres of deeper habitat for the benefit of fish. This channel would be approximately 3,000 feet long, having a bottom width of 125 feet and a depth of 5 feet. No attempt would be made to dredge a stable side slope along the channel length. These slopes would be allowed to form naturally following removal of the material from the proposed channel. It is currently estimated that about 46,000 cubic yards of fine material would be dredged from the bay. See plate 11 for a plan view of this dredging plan.

In order to use the material dredged from Big Lake Bay in a manner that would have environmental benefits, it was determined that the best

disposal area would be old dredged material disposal areas with sparse understory and few trees. The new fine material disposal area would cover around 10 acres of land. In the immediate vicinity, two potential sites were identified: an area immediately upstream of the Teepeeota channel maintenance containment site and areas both upstream and downstream of the Crats Island channel maintenance containment site. The Teepeeota Point site was dropped from further consideration because of the greater distance from the dredge site (and, hence, the greater dredging costs) and the potential for conflicts with future channel maintenance requirements. Both sandy areas above and below the Crats Island channel maintenance containment site appeared viable and have, therefore, been incorporated into the final plan. See plate 11 for the location of these selected areas.

A small containment dike (5 to 6 feet) would be constructed around an area (maximum of 10 acres) upstream of the Crats Island containment area. This area was created entirely from past channel maintenance activities and has virtually no trees and very sparse herbaceous cover. A 6-acre area downstream of the Crats Island containment area would also be used. This latter area was floodplain forest that has been significantly elevated and disturbed by past channel maintenance activities. The area is sparsely covered by trees, with very limited understory. Here, dredged material would be spread in one of the following manners. A long, perforated pipe would be placed on the end of the dredge pipe. The dredged material and carriage water would be allowed to exit through these pipes in small streams. Another method under consideration is a system similar to that used for irrigation spraying. The dredged material would be sprayed out onto the surrounding land. The carriage water should seep through the existing sand soil at the site with little effluent generated. For either of these options, small berms would be placed across low areas to trap any carriage water that does not seep into the sandy soils. If during plans and specifications it appears that neither of these methods would be effective, a larger berm would be constructed around the area, with the removal of only those trees necessary to construct the berm. Material dredged from the bay would then be handled in a manner similar to what is being proposed for the area upstream of the Crats Island disposal site. The two areas upstream and downstream of the Crats Island disposal site would alternately be disposed in to maximize retention time and effluent

quality. Any effluent generated from the two disposal areas would be directed into the Crats Island channel maintenance containment area, allowing for additional settling time, before being discharged to the main channel, if necessary. Over 800,000 cubic yards of material was recently removed from the Crats Island containment area to restore capacity. Although some maintenance dredging has occurred since, the capacity of the site is still very large, and the likelihood of an unacceptable effluent occurring from the site is fairly small. Following dredging, some of the fine material collected in the two disposal areas would be dried and spread along the slopes of the existing channel maintenance containment area. Where required, or desirable, the rest of the material would be spread after drying and incorporated into the existing sand soil within the two small containment areas. Selective seeding of the two containment sites would be performed after the dredged material was redistributed.

3. RIFFLE/POOL COMPLEX

The riffle/pool complex would consist of two rock riffle areas (each 4 feet deep, 188 feet wide, and 70 feet long) alternating with two deep pool areas (each 8 feet deep, 302 feet wide, and 200 feet long). Rock fill used in the riffle areas would have a thickness of 30 inches. Approximately 15 Wisconsin log crib structures would be placed in the pools to provide wood cover in the pools. In addition, log snags would be placed along 400 feet of the eroded banks upstream of the riffle/pool complex to provide additional wood cover. These logs would be taken from the immediate vicinity; however, trees near the edge of the water (potential eagle perching trees) would not be used. About 3 acres of the slough would be directly enhanced by the construction of the riffle/pool complex. This would be extended by placement of additional structures along the banks of the slough. See plates 12a and 12b, respectively, for a plan view and cross sections of this complex. Plate 12c shows the Wisconsin log crib structure and snag design. (A detailed discussion on the criteria for this complex was contained in the previous discussion of objectives and alternatives.)

CONSTRUCTION METHODS

The partial closure structure would be constructed by hydraulically dredging fill material from the identified shoaled area in Whorehouse Slough. Due to the small size of this job and the relatively shallow depths in the backwater areas, it is anticipated that this work, as well as the dredging in Big Lake Bay, would be done by a "mudcat" dredge. Given the limited containment area for fine materials dredged from the bay, it is also felt that a larger dredge would have extreme difficulty meeting State water quality standards for the discharge water from the containment site. Rock would be brought in by barge and mechanically placed on the fill material to complete the partial closure structure. Access to this construction site would be via the Indian Slough channel. Surveys taken in the upstream end of the channel indicate that depths should be sufficient, with the exception of the wing dams. Here, at least part of the first wing dam would need to be removed temporarily during construction to allow entrance to the site.

The containment areas upstream and downstream of Crats Island for material taken from Big Lake Bay would consist of one cell, with the Crats Island disposal site acting as the secondary cell in order to help meet water quality standards. The dikes for these structures would be built by bulldozing up sand material that is on site. Following completion of the dredging, some of the fine material would be spread in additional areas where there was sparse vegetation. It is likely that the dredge will need to enter Big Lake Bay from the downstream end of Big Lake, since water depths in lower Indian Slough through the delta area are extremely shallow. Water depths in Big Lake should be sufficient for access of a small dredge from this southerly direction.

The shallow and deep areas of the riffle/pool complex would be created by moving existing material along the channel sides and bottom by means of a dragline. Rock would then be placed over the top of the riffle complex. Every effort would be made to enlist the help of interested sports clubs in the area to assist in construction of the Wisconsin log crib structures. This is an activity typically undertaken by these groups. Material for these structures, as well as their eventual on-site placement, would be provided under the construction contract.

REAL ESTATE REQUIREMENTS

The construction features of this project are all located in the Indian Slough/Big Lake Bay area. No land needs to be permanently acquired for the project since the proposed project area is located on land owned by the Corps of Engineers or the U.S. Fish and Wildlife Service and is managed for wildlife by the Upper Mississippi River Refuge. A special use permit would be required from the U.S. Fish and Wildlife Service to construct the project in the refuge.

FULFILLED GOALS WITH THE PROJECT

During the plan formulation phase of the study, a number of project objectives were identified. The projected measurable accomplishments of the proposed plan are presented in table 6.

Table 6 - Measurable Goals and Accomplishments of the Proposed Plan

Goal	Project Accomplishment	Potential Enhancement Feature	Unit of Measure	Enhancement Present	Potential Future
Reduce loss of aquatic habitat	1. Reduce conversion of aquatic habitat to land	Partial closure structure	Acres		120 Preserved
			cfs		50% Reduction in flow in Indian Slough
	2. Reduce loss of banks along Indian Slough		Acres		4
Create more fish habitat with adequate DO	1. Maintain adequate water depths	Lake dredging	Acres of water > 4 feet	0	11.0
	2. Maintain DO above 5 mg/l		Mg/l	< 5 mg/l	> 5 mg/l
Enhance fisheries	Create additional fish habitat	Riffle/ pool complex	Acres	0	11

ENVIRONMENTAL EFFECTS OF PROPOSED PROJECT

An environmental assessment has been conducted for the proposed action, and a discussion of the impacts on habitat conditions follows. As specified by Section 122 of the 1970 Rivers and Harbors Act, all impacts of the project are summarized by category in the environmental impacts matrix (table 7) and were considered in arriving at the final determination. In accordance with Corps of Engineers regulations (33 CFR 323.4(a)(2)), a

TABLE 7

IMPACT ASSESSMENT MATRIX	MAGNITUDE OF PROBABLE IMPACT						
	<----- INCREASING BENEFICIAL IMPACT			NO APPRECIABLE EFFECT	INCREASING ADVERSE IMPACT ---->		
NAME OF PARAMETER	SIGNIFICANT	SUBSTANTIAL	MINOR		MINOR	SUBSTANTIAL	SIGNIFICANT
A. SOCIAL EFFECTS							
1. Noise Levels				X			
2. Aesthetic Values				X			
3. Recreational Opportunities			X				
4. Transportation				X			
5. Public Health and Safety				X			
6. Community Cohesion (Sense of Unity)				X			
7. Community Growth & Development				X			
8. Business and Home Relocations				X			
9. Existing/Potential Land Use				X			
10. Controversy				X			
B. ECONOMIC EFFECTS							
1. Property Values				X			
2. Tax Revenues				X			
3. Public Facilities and Services				X			
4. Regional Growth				X			
5. Employment				X			
6. Business Activity				X			
7. Farmland/Food Supply				X			
8. Commercial Navigation				X			
9. Flooding Effects				X			
10. Energy Needs and Resources				X			
C. NATURAL RESOURCE EFFECTS							
1. Air Quality				X			
2. Terrestrial Habitat			X		X		
3. Wetlands		X					
4. Aquatic Habitat		X					
5. Habitat Diversity and Interspersion		X					
6. Biological Productivity			X				
7. Surface Water Quality		X			X		
8. Water Supply				X			
9. Groundwater				X			
10. Soils			X				
11. Threatened or Endangered Species				X			
D. CULTURAL EFFECTS							
1. Historic Architectural Values				X			
2. Pre-Hist & Historic Archeological Values				X			

section 404(b)(1) evaluation was prepared (see attachment 3). The Finding of No Significant Impact (attachment 2) will be signed after the public review period has elapsed, any issues have been resolved, and the water quality certification has been obtained.

FISH AND WILDLIFE

The project is being designed to benefit fish and wildlife habitat and the benefits associated with the project have been discussed previously in this document. Therefore, the ensuing discussion will only briefly summarize the anticipated benefits and discuss the unavoidable trade-offs.

Reducing the sediment load in Indian Slough, with the creation of the partial closing structure, would prevent the future loss of around 120 acres of shallow wetlands and the conversion of 120 acres of deepwater wetlands to shallow water wetlands. The reduction in sediment load should maintain Truedale Lake as a valuable shallow wetland area and reduce the future conversion of Big Lake Bay to an isolated, shallow area.

To restore some of the deepwater habitat that has been lost and will continue to be lost in the future, the creation of a 15-percent interspersion (11 acres) of deepwater habitat (5 feet) in Big Lake Bay, connected with the flowing deepwater habitat in the main body of Big Lake, was proposed. One of the primary benefits would be to create/enhance the winter centrarchid habitat present in Big Lake. This type of habitat is presently limited, and even though only 11 acres of deepwater habitat would be created, this would represent a significant addition to the amount of late winter centrarchid habitat. As discussed in the "Alternative Selection" section of this report, the deeper water in Big Lake Bay and the connection of this deepwater flowing habitat to the main body of Big Lake would dampen the diurnal swings in temperature and dissolved oxygen in these more open areas of the bay. This creation of an interspersion of deepwater habitat allows centrarchids to use the shallow areas within Big Lake Bay when conditions are favorable and retreat to the newly created deepwater habitat when nocturnal dissolved oxygen and diel temperatures become unfavorable.

Restoring flow in Whorehouse Slough would prevent the area from becoming stagnant in the summer and winter and subsequently improve the fisheries. The creation of the partial closing structure, the placement of snags along the eroded bank, and the creation of a riffle/pool complex in Indian Slough would significantly improve the value of lithophilic fish species, such as smallmouth bass. Rock substrate is at least 10 times as productive for macroinvertebrates, including crayfish, an important food source for smallmouth bass, as the sand substrate it would be replacing.

The disposal of the fine material in the small containment areas, upstream and downstream of the Crats Island channel maintenance containment area, would significantly disturb the existing sparse vegetation. However, by providing a better topsoil, these areas would quickly develop a vegetative community that would be more diverse and productive than presently exists. This should have a long-term positive benefit on wildlife use of the area.

The construction of the partial closing structure and other measures in Indian Slough would at least temporarily disturb fish use of the area.

Dredging in Big Lake Bay would convert 11 acres of shallow wetlands, that have predominantly submerged species of aquatic plants, to deepwater wetlands. This would have both positive and negative effects, depending on the species. As pointed out above, it would have a very positive benefit to the centrarchid-based fisheries of Big Lake. It would also benefit certain species of wildlife that use deepwater wetlands. However, it would have a slightly negative effect on certain wildlife species that use shallow water wetlands. This slight negative effect would be easily offset by other project features addressing future loss of shallow wetlands in the project area.

Most of the flow that is prevented from entering Indian Slough because of the partial closure would be maintained in the main channel. The anticipated slight increase in flow through Catfish Slough and the two channels into Robinson Lake and any associated adverse impacts on fish and wildlife are being minimized by rock stabilization of the mouths of each of these channels.

WATER QUALITY

The potential for water quality impacts with the construction of the project features is described in more detail in the 404(b)(1) evaluation (see attachment 3).

Potential construction related negative effects on water quality would be derived from the construction of the partial closing structure, including open-water placement of dredged material from Whorehouse Slough, and from the effluent from the fine-material containment area. The coarse dredged material to be used as a base for the closing structure and the rock fill would minimize impacts on water quality. Local turbidity plumes would be generated from the construction of the partial closing structure, but releases of contaminants should be minimal due to the relatively uncontaminated material.

The disposal area for the fine material was designed to achieve at least 24 hours of settling, in the initial settling ponds, with additional settling occurring in the Crats Island containment area. If an effluent was generated, these efforts should maximize effluent quality. The bulk chemical analyses of the sediments indicate that high levels of contaminants are not likely to be released in the effluent. Effluent generated from the containment area would be discharged into the main channel, where mixing and dilution would occur rapidly. Another potential concern is that the backwater dredging could re-expose sequestered contaminants. The limited sediment sampling with depth (table 404(b)-1) that was done indicates that the sediments are fairly homogeneous with depth and that dredging should not expose higher levels of contaminants that could produce long-term effects on water quality.

Dredging in Whorehouse Slough would remove the shoal that is presently impeding flows, causing the slough to become stagnant in late summer and during the winter. Restoring flows to these sloughs should improve water quality, especially dissolved oxygen.

Current velocities measured on transects across Big Lake in winter were above 0.1 foot per second. The maximum retention time in Big Lake for summer low river flow was conservatively estimated to be around 2.5 days,

assuming a uniform and complete water exchange for the entire water volume present in Big Lake. Even using this extremely conservative approach, this is a relatively high exchange rate compared to most lakes. This would be doubled with the reduction in discharge through Indian Slough. Another Corps of Engineers project, the Weaver Bottoms Rehabilitation project in pool 5, was built in 1987 and involved similar sediment and flow reduction measures. At this project, for an area three times the size of Big Lake, a similar amount of flow, as is being proposed for the Big Lake area, is being provided. Winter dissolved oxygen monitoring at Weaver Bottoms for the last 3 years has not indicated any problems with dissolved oxygen from the reduced circulation rates. A limited amount of diurnal dissolved oxygen monitoring in the summer for Weaver Bottoms has noted some changes in diurnal D.O. patterns. However, interpretation of this information has been confounded by the drought conditions that have been prevalent since the project was constructed. Additional monitoring of Weaver Bottoms will be necessary to provide a more definitive answer. However, this apparent problem is one of the reasons why the higher discharge of 375 cfs was selected over the range of discharges that was deemed acceptable to the resource agencies and should provide circulation rates 2 to 3 times higher than is occurring in Weaver Bottoms. In conclusion, even though flow would be cut in half in Indian Slough by the construction of the partial closing structure, there should be adequate flows to maintain existing water quality conditions in Big Lake.

Creation of deepwater habitat in Big Lake Bay should improve water quality in this area by allowing the 5 mg/l dissolved oxygen standard to be met more frequently.

THREATENED AND ENDANGERED SPECIES

The absence of Higgins' eye pearly mussels from any recent surveys in and adjacent to the project area would indicate that the project should not have any significant impact on this species. Bald eagles do use the area, mainly as a wintering area and during migrations. To ensure that no impacts to this use would occur from the project, none of the large trees bordering the main channel, which could be used as perches by the eagles, would be removed. The one active eagle nest located downstream of the project area is sufficiently removed from the project area that it should not be

affected. The U.S. Fish and Wildlife Service has concurred with this determination of no significant impacts (see Attachment 5, Correspondence).

AIR QUALITY

No significant impacts on air quality should occur.

CULTURAL RESOURCES

The affected land masses in the project area either have been formed by natural deposition in the last 10 years or have been created by the St. Paul District using dredged material. Historic and archaeological site maps do not show the presence of cultural resources in the proposed project area. Therefore, the project would not affect any significant cultural resources.

SOCIOECONOMIC RESOURCES

The proposed project was reviewed in accordance with Public Law 91-611, Section 122. The habitat improvement would likely have a minor positive effect on local fishing opportunities. The project would have no other appreciable effects on social parameters.

RECREATIONAL RESOURCES/AESTHETIC VALUES

As stated in the previous section, there would be minor recreation benefits due to the increase in depth in areas of Big Lake Bay, the construction of the partial closure structure and riffle/pool complex, and the proposed dredging in Whorehouse Slough. Short-term negative impacts to recreation activities would occur during project construction due to the restriction in access to the area through Indian Slough.

COMPLIANCE WITH ENVIRONMENTAL LAWS AND REGULATIONS

An environmental review of the proposed project indicates that the project would not result in a significant effect on the environment. Therefore, an environmental impact statement will not be prepared, as described in the attached Finding of No Significant Impact. For the

current stage of planning, the proposed action complies with all applicable Federal environmental laws, executive orders (E.O.) and policies, and State and local laws and policies. The pertinent ones include the Clean Air Act, as amended; the Endangered Species Act of 1973, as amended; the Land and Water Conservation Fund Act of 1965, as amended; the National Historic Preservation Act of 1966, as amended; the National Environmental Policy Act of 1969, as amended; the Fish and Wildlife Coordination Act of 1958, as amended; E.O. 11988-Floodplain Management; E.O. 11990-Protection of Wetlands; and the Farmland Protection Policy Act of 1981.

PROJECT REQUIREMENTS

OPERATION AND MAINTENANCE

Operation and maintenance (O&M) requirements would be limited to work associated with the partial closure structure in Indian Slough. This would be borne by operations and maintenance within the Corps since no additional maintenance costs would be required at the partial closure structure because of its selected location. For increased habitat benefits, however, the proposed location of this structure has required the placement of fill and riprap along the left bank of Indian Slough upstream of this structure in order to guard against breakout flows and establishment of another channel into the backwaters. This proposed riprap would have to be maintained as part of the HREP responsibilities. No future dredging within the proposed channels in Big Lake Bay is anticipated. With the construction of the partial closure structure, which would reduce sediment input into the backwater area, and channel depths of 5 feet, adequate depths should be maintained throughout the 50-year project life. Similarly, no maintenance is anticipated at the riffle pool complex. An O&M manual detailing HREP operation and maintenance requirements would be prepared by the Corps during the plans and specifications phase. The projected average annual estimated maintenance costs for the HREP portion of this project are shown in table 8.

Table 8 - Estimate of Average Annual Operation and Maintenance Costs

Inspection and reporting	$250
Replacement of riprap	250
Total annual cost	$500

Note: Costs for operation and maintenance would total $25,000 over a 50-year project life.

PERFORMANCE EVALUATION

Monitoring plans for project evaluation purposes were designed to directly measure the degree of attainment of the selected project objectives. Therefore, for each objective, an evaluation plan was developed. These are described below and presented in tables 9 and 10.

a. Project Objective: To cut by at least 50 percent the rate of conversion of aquatic habitat to land in the Indian Slough delta area. Similarly, to halve the rate of conversion in the adjoining wetland areas of Big Lake where water depths currently ranging from 2 to 4 feet are decreasing to areas with 0 to 2 feet of water.

Evaluation Objectives:

1. Determine the changes in the patterns and rate of Indian Slough delta formation, through aerial photography.

2. Determine the net percent reduction in discharge in Indian Slough for river discharges up to the 2-year average peak.

3. Determine changes in the Indian Slough bank and bed.

b. Project Objective: To provide conditions so that dissolved oxygen of 5 mg/l is maintained, throughout most of the winter and during the high summer thermal conditions, in at least 15 percent of the 75 acres of wetlands in Big Lake (Big Lake Bay) that have historically provided good centrarchid fish habitat.

Evaluation Objectives:

1. Determine circulation patterns in Big Lake Bay for selected ice conditions.

2. Determine dissolved oxygen and temperature conditions in Big Lake Bay for selected ice and snow conditions.

3. Determine summer diel temperature and dissolved oxygen patterns in Big Lake Bay.

c. Project Objective: To enhance 11 acres of Indian Slough for lithophilic fish species, including the creation of 3 acres of riffle/pool habitat and placement of log snags along the existing cut banks to partially offset the approximately 240 acres of aquatic habitat, at the outlet of Indian Slough, that has been converted to land since inundation by lock and dam 4 in the 1930's.

Evaluation Objectives:

1. Determine flow patterns in the channel under summer low river discharges.

2. Determine changes in the channel bed over time through periodic soundings.

Periodic on-site inspections, with personnel from the various agencies, would be done to ensure that the goals were being met. Monitoring activities would be closely coordinated with any similar efforts by the Long-Term Resource Monitoring program. Any data gathered by local resource agencies, such as test netting or creel census, flow measurements, and dissolved oxygen measurements, and information on angling success would also be used.

Table 9 – Summary of Project Evaluation for Recommended Plan for Indian Slough

Project Objective	Recommended Alternative	Unit of Measure	Enhancement Potential w/Project Target	Measurement	Monitoring Interval (Years)	Projected Cost per Effort	1/ Annual Field Observations
1. To cut by at least 50% the rate of conversion of aquatic habitat to land in the Indian Slough delta area. Similarly, to halve the rate of conversion in the adjoining wetland areas of Big Lake where depths currently ranging from 2 – 4' are decreasing to areas with 0 – 2' of water.	Partial Closure Structure	acres	Preserve 120 acres in 50 years	Aerial Photos (with GIS digitization)	5 years	$4,000	
		cfs	Preserve 120 acres in 50 years	Measure discharge in Indian Slough	Will only be done 1st & 3rd year after construction	$4,000	
		acres	4 acres	Measure bed & bank elev. along set transects in Indian Slough	5 years	$5,000	
		stage (feet)	Preserve 120 acres in 50 years	Use gage records to plot pre– & post project conditions	Annually	$250	
2. To provide conditions so that DO of 5 mg/l is maintained in at least 15 % of the 75 acres of wetlands in Big Lake Bay throughout most of the winter & during high summer thermal conditions.	Dredging in Big Lake Bay.	cfs	11 acres	Dye studies	5 years	$3,000	
		mg/l	11 acres	DO (also temp & vel.)	5 years	$6,000	
		mg/l	11 acres	diel DO measurements semi–weekly Dec. – Mar.	Will be done 1st & 5th year after construction only.	$6,000	
3. To optimize acres of Indian Slough for lithophilic fish species.	Riffle/pool complex	cfs	11 acres	Measure current vel.	5 years	$1,500	
		acres	11 acres	Measure bed & bank elev. along estab–lished transects in Indian Slough.	5 years	(1)	

(1) This work will be done in conjunction with bed and bank elevation measurements performed under objective 1.

Table 10 - Estimated Annual Performance Evaluation Monitoring Costs
(December 1989 Price Levels)

Monitoring type	Monitoring Activity	Average Annual Cost ($)
Pre-Project		(1)
Design		(1)
Construction		(1)
Post Construction		
a. Quantitative:		
OBJECTIVE 1		
To cut by at least 50% the rate of conversion of aquatic habitat to land in the Indian Slough delta area.	GIS Digitization	$670
	Discharge Measurements	$610
	Cross Sectional Survey	$840
	Plot Gage Information	$250
OBJECTIVE 2		
To provide conditions so that DO of 5 mg/l is maintained in at least 15% of the 75 acres of wetlands in Big Lake Bay.	Dye studies	$500
	DO (temp & vel)	$1,000
	diel DO	$850
OBJECTIVE 3		
To optimize acres of Indian Slough for lithophilic fish species.	Velocity measurements	$250
	Cross Sectional Survey	(3)
b. Qualitative (2)		0
Subtotal Monitoring		$4,970
Contingencies		$700
Total per year		$5,670

(1) These costs are incorporated in project planning, design, and construction costs.

(2) To be included in USFWS annual management report. No significant increase in cost is identified.

(3) This work will be done in conjunction with cross sectional surveys performed under objective 1.

COST ESTIMATE

A summary of project costs is shown in table 10. Quantities and unit costs will be verified during preparation of construction plans and specifications. As was discussed in the "Alternative Selection" section of this report, the partial closure structure has been placed in its present selected location with material from the backwaters used in the construction of the structure, because of the additional habitat benefits that can be gained by this action. Given this, the cost of this structure will be shared between the two funding authorities within the Corps. The cost for the least costly location (alternative E site) and construction method (mechanical placement of fill from Crats Island disposal site) would be assigned to operation and maintenance. Additional costs accrued because of habitat enhancement caused by the movement of this structure upstream (alternative B site) and/or the use of fill from the backwaters would be borne by HREP. The cost estimate shown in table 11 reflects the present determination on assignment of costs.

Table 11 - Construction Cost Allocation for Navigation (O&M) and Habitat Project (CG)

Item	Operation & Maintenance	HREP	Total Cost
Partial Closure Structure	$518,300	$146,600	$664,900
Dredging of Big Lake Bay	0	394,900	394,900
Riffle/Pool Complex	0	252,700	252,700
TOTAL	$518,300	$794,200	$1,312,500

Note: (1) This does not include prior allocations of $110,000 for general design (planning).

(2) A detailed cost estimate is contained in appendix B.

Annualized first costs, using first construction costs and general design expenditures (based upon a 50-year economic life and an 8-7/8 percent discount rate), would amount to $71,500 for the HREP portion of the above project.

With the addition of annual operation and maintenance cost, as indicated above, the total average annual costs are estimated to be $72,000.

PROJECT IMPLEMENTATION

DIVISION OF PLAN RESPONSIBILITIES

The responsibilities of plan implementation and construction would fall to the Corps of Engineers both for the operation and maintenance portion of this project (closure structure) and for the habitat rehabilitation portion of this project (additional costs associated with the partial closure structure and backwater dredging) in which the Corps is the lead Federal agency. After construction of the project, no annual operation and maintenance would be required for the backwater dredging. Maintenance duties would be required on a riprapped bank upstream of the partial closure structure. These would be the responsibility of the U.S. Fish and Wildlife Service. Operation and maintenance of the partial closure structure would be assumed by the Corps as part of their ongoing operation and maintenance program. Should rehabilitation of the Indian Slough project which exceeds the annual maintenance requirements be needed (as a result of a specific storm or flood event), the Federal share of mutually agreed upon rehabilitation would be the responsibility of the Corps. Performance evaluation, which includes monitoring of physical/chemical conditions, would be a Corps responsibility. General monitoring and performance evaluation responsibilities for the EMP projects are shown in table 12.

COST APPORTIONMENT

Construction - The placement of the partial closure structure and dredging activities conducted in the backwater areas would be conducted on the Upper Mississippi River National Wildlife and Fish Refuge. The costs for construction of the partial closure structure would be assumed 100 percent by the Corps of Engineers under both its operation and maintenance program and through HREP. It is currently estimated that the cost for this structure under each of these Corps authorities would be $518,300

Table 12

Monitoring and Performance Evaluation Matrix

Type of Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Remarks
Sedimentation Problem Analysis	System-wide problem definition. Evaluates planning assumptions.	USFWS	USFWS (EMTC)	LTRM	
Pre-project Monitoring	Identifies and defines problems at HREP site. Establish need of proposed project features.	Sponsor	Sponsor	Sponsor	
Baseline Monitoring	Establishes baselines for performance evaluation.	Corps	Field station or sponsor thru Cooperative Agreements or Corps.	LTRM	
Data Collection for Design.	Includes quantification of project objectives, design of project, and development of performance evaluation plan.	Corps	Corps	HREP	
Construction Monitoring	Assess construction impacts; assures permit conditions are met.	Corps	Corps	HREP	
Performance Evaluation Monitoring	Determines success of project as related to objectives.	Corps (quantitative) sponsor (Field Observations).	Field station or sponsor thru Cooperative Agreement, sponsor thru O&M, or Corps.	LTRM	
Analysis of Biological Responses to Pro[illegible]s	Evaluate predictions and assumptions of habitat unit analysis. Studies beyond scope of performance evaluation, or if projects do not have desired biological results.	USFWS	USFWS (EMTC)	LTRM	

(Operation and Maintenance) and $146,600 (HREP). The dredging portion of this project in Big Lake Bay and construction of the riffle/pool complex would be done for improvement of habitat within the backwater areas. The estimated cost for these two items is $647,600. To summarize, in accordance with Section 906(e)(3), first costs (estimated to be $794,200) for construction of the riffle/pool complex, dredging in Big Lake Bay, and the allocated portion of the partial closure structure would be 100-percent Federal and would be borne by the Corps of Engineers under the UMRS-EMP authority. The costs allocated to the least costly partial closure structure would also be a 100-percent Federal cost under the Corps navigation project operation and maintenance authority.

Operation and Maintenance - After construction of the project, O&M would need to be conducted by the Corps of Engineers on the partial closure structure. The maintenance of the riprapped bank upstream of this closure would be conducted by the U.S. Fish and Wildlife Service. The U.S. Fish and Wildlife Service would assure that non-Federal operation and maintenance responsibilities were in conformance with Section 906(e) of the Water Resources Development Act of 1986. The non-Federal sponsor is the Wisconsin Department of Natural Resources. Specific operation and maintenance features would be defined in a project O&M manual which would be prepared by the Corps and coordinated with the involved agencies during the plans and specifications phase.

STEPS PRIOR TO PROJECT CONSTRUCTION

Funds for plans and specifications for the HREP portion of this project can be provided by the Office of the Chief of Engineers (OCE), prior to approval of the project by the Assistant Secretary of the Army (Civil Works). As described in this report, this work would include additional soil borings in the backwater areas where it is anticipated that fill would be taken for the proposed partial closure structure. Plans and specifications are currently scheduled to be initiated in fiscal year 1991. It is anticipated that a construction contract for the partial closure structure and other HREP features of the Indian Slough project would be advertised by the competitive bid process and would likely be awarded in fiscal year 1991 and completed in fiscal year 1992. It should be noted, however, that improvement in the backwaters is dependent upon construction

of the partial closure structure (which is financed primarily under a separate Corps authority). Therefore, proceeding on the schedule outlined above will be regulated by the ability of the Corps to receive funding for the construction of this structure.

RECOMMENDATIONS

I have weighed the accomplishments to be obtained from this habitat project against its cost and have considered the alternatives, impacts, and scope of the proposed project. A partial closing structure will be constructed across Indian Slough under the navigation project operation and maintenance authority. In my judgment, the proposed increase in the cost of the partial closing structure to enhance fish and wildlife habitat, dredging in Big Lake Bay, and construction of a riffle pool complex is a justified expenditure of Federal funds. I recommend that higher authority approve construction of the habitat rehabilitation and enhancement features of the Indian Slough, Wisconsin, project at a total estimated construction cost of $794,200, which amount would be a 100-percent Federal cost according to Section 906(e)(3) of the 1986 WRDA.

Roger L. Baldwin
Colonel, Corps of Engineers
District Engineer

F. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem (40 CFR 230.10(d)) - The project was designed to minimize adverse effects, while reaching the stated goals and objectives. The containment areas are designed to achieve a relatively high quality effluent.

G. Compliance with the Guidelines for the Discharge of Dredged or Fill Material - Based on this evaluation, I have determined that the proposed action complies with the requirements of these guidelines, with the inclusion of appropriate and practicable conditions to minimize pollution or adverse effects to the aquatic ecosystem.

18 Sept 90
Date

Roger L. Baldwin
Colonel, Corps of Engineers
District Engineer

Attachments:

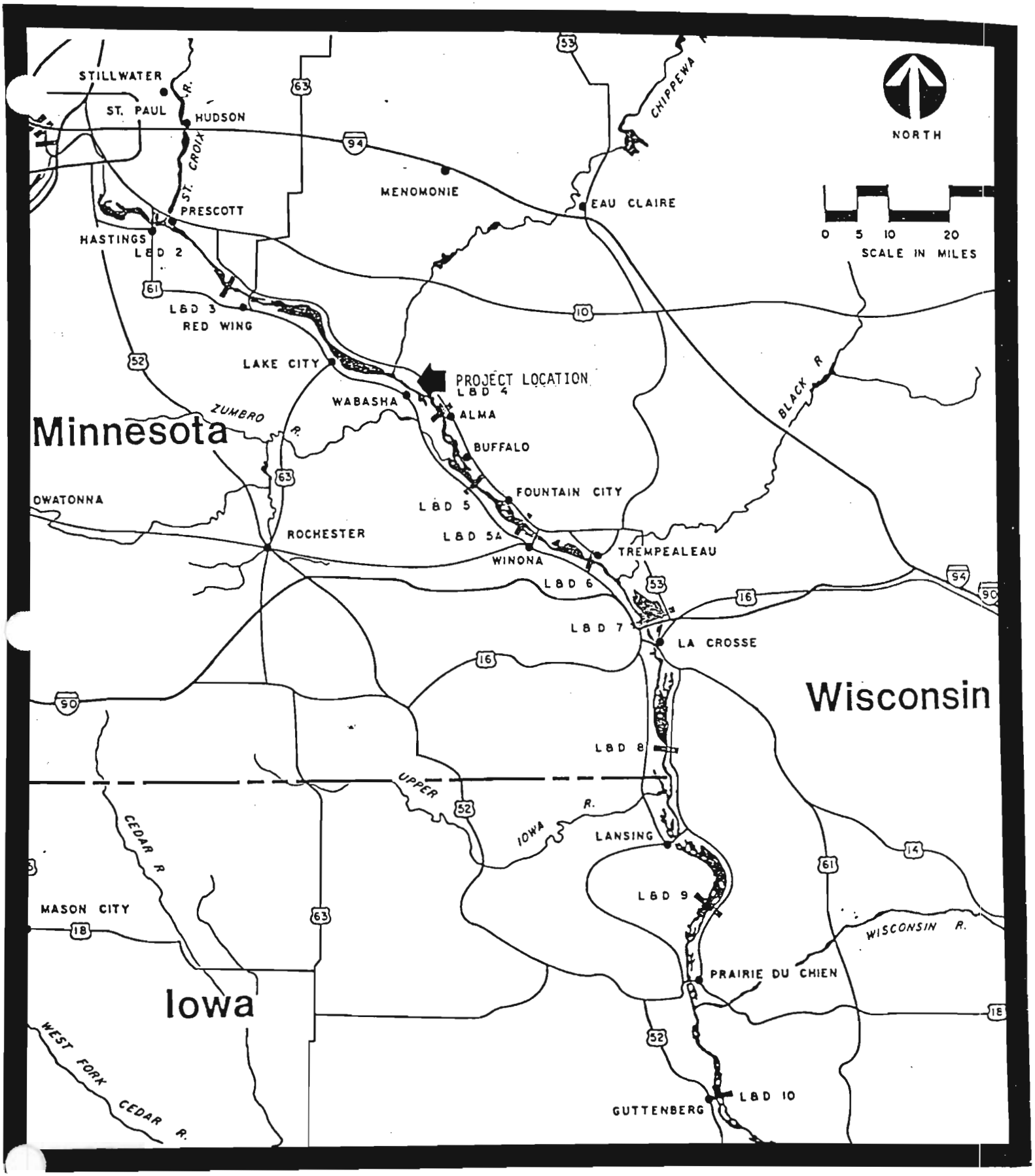
1. Plates

Plate 1.	Location Map
Plate 2.	Study Area Map
Plate 3.	Indian Slough Sand Deposition (FWS)
Plate 4.	GIS
Plate 5.	GIS
Plate 6.	GIS
Plate 7a-e.	Alternatives
Plate 8.	Erosion Site
Plate 9.	Selected Plan, Closure Structure, Plan View
Plate 10.	Selected Plan, Closure Structure, Cross Sections
Plate 11.	Selected Plan, Big Lake Bay Dredging, Plan View
Plate 12a.	Selected Plan, Riffle/Pool Complex, Plan View
Plate 12b.	Selected Plan, Riffle/Pool Complex, Cross Sections
Plate 12c.	Wisconsin log crib structure and snag design.
Plate 13.	Overall view of recommended construction features.

2. Finding of No Significant Impact
3. Sediment Quality Data and Section 404(b)(1) Evaluation
4. Distribution List
5. Correspondence
6. Memorandum of Agreement

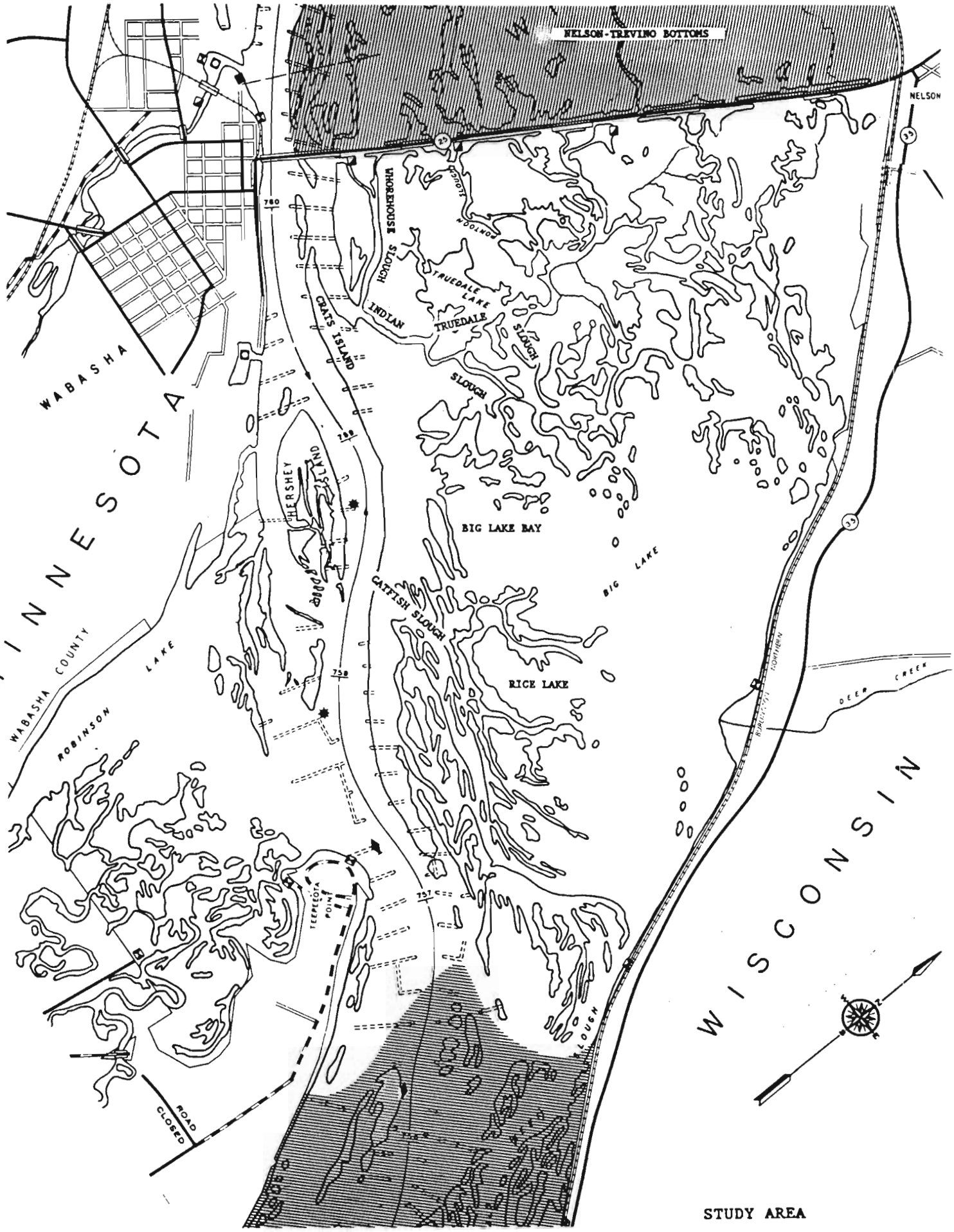
Attachment 1

Plates 1-13



LOCATION MAP

Plate 1



STUDY AREA

Plate 2

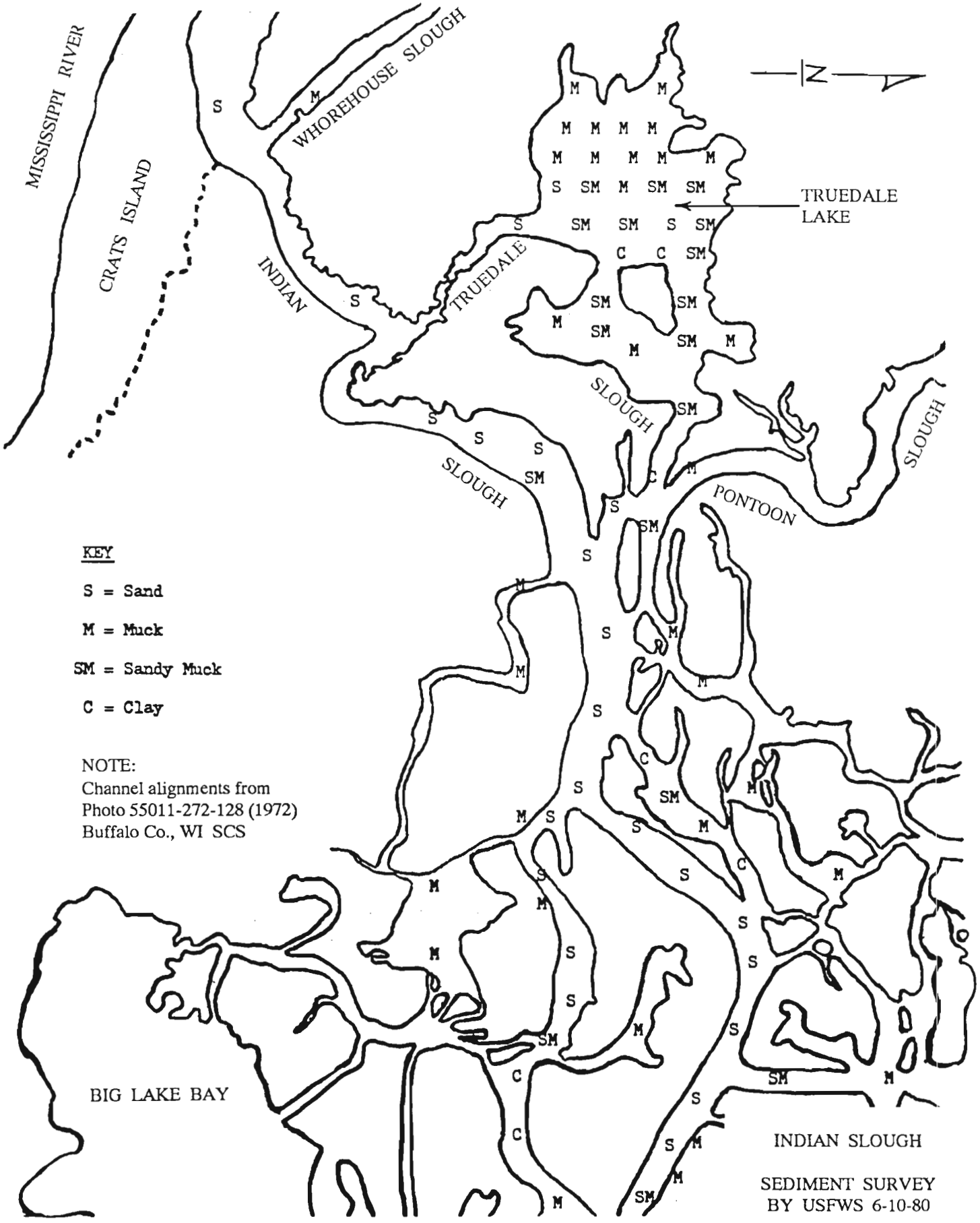

MISSISSIPPI RIVER
CRATS ISLAND
WHOREHOUSE SLOUGH
INDIAN
TRUEDALE
TRUEDALE LAKE
SLOUGH
SLOUGH
SLOUGH
PONTOON
BIG LAKE BAY
INDIAN SLOUGH
KEY
S = Sand
M = Muck
SM = Sandy Muck
C = Clay
NOTE:
Channel alignments from
Photo 55011-272-128 (1972)
Buffalo Co., WI SCS
SEDIMENT SURVEY
BY USFWS 6-10-80

PLATE 3

TITLE: Cross of 1940 and 1974
LOCATION: INDIAN SLOUGH / BIG LAKE

SCALE: 1 : 30671

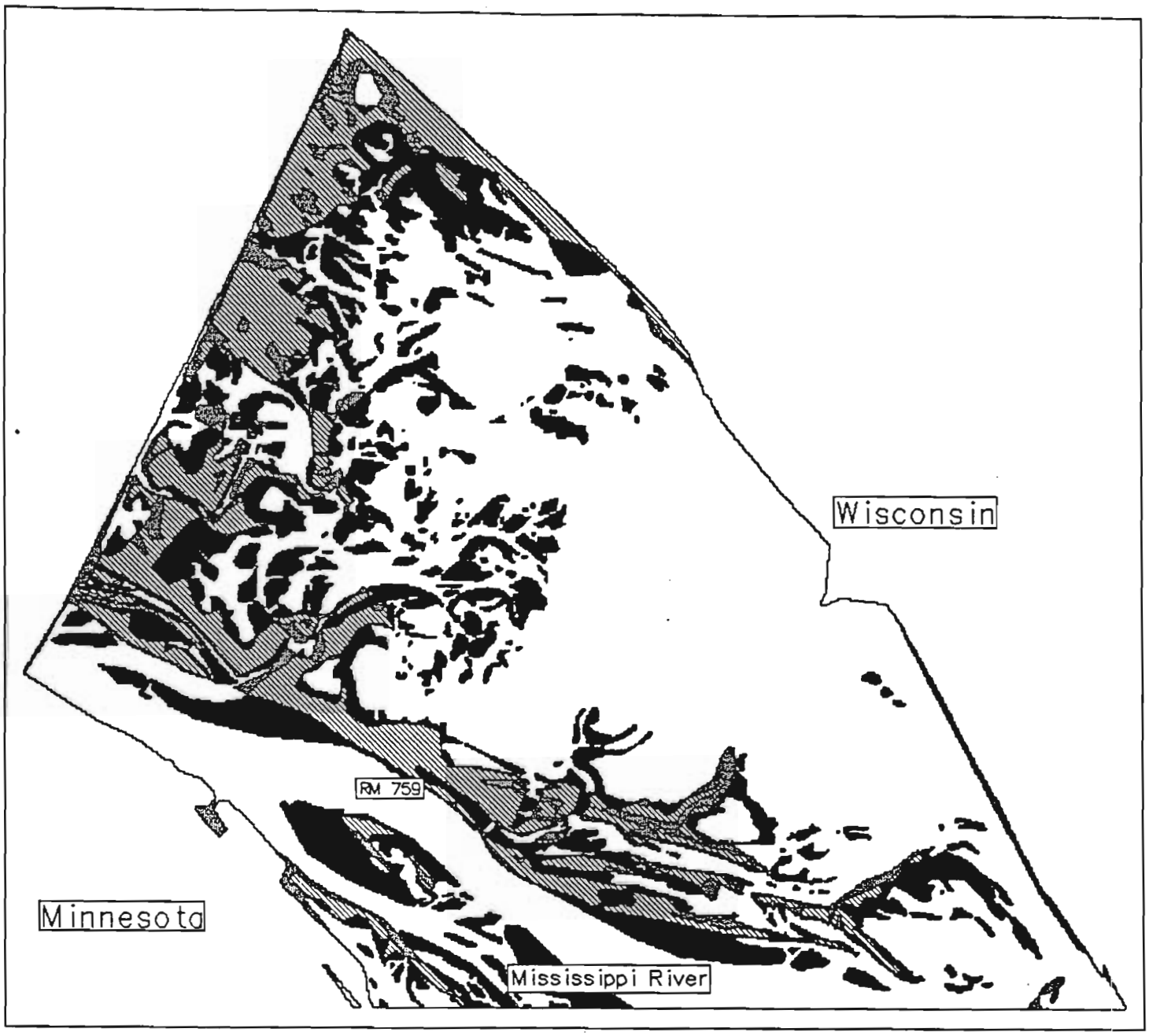
WINDOW: 576950.00 4918780.00 583530.00 4912880.00

1 Terrestrial/Floodplain Habitat
2 Increase in Open Water Due to Erosion
3 Open Water Loss Due to Sedimentation
4 Open Water

GIS - 1940 AND 1974

Plate 4

TITLE: Cross of 1940 and 1984
LOCATION: INDIAN SLOUGH / BIG LAKE



SCALE: 1 : 30671

WINDOW: 576950.00 4918780.00 583530.00 4912880.00

1 Terrestrial/Floodplain Habitat
2 Increase in Open Water Due to Erosion
3 Open Water Loss Due to Sedimentation
4 Open Water

GIS - 1940 AND 1984

Plate 5

TITLE: Cross of 1974 and 1984
LOCATION: INDIAN SLOUGH / BIG LAKE

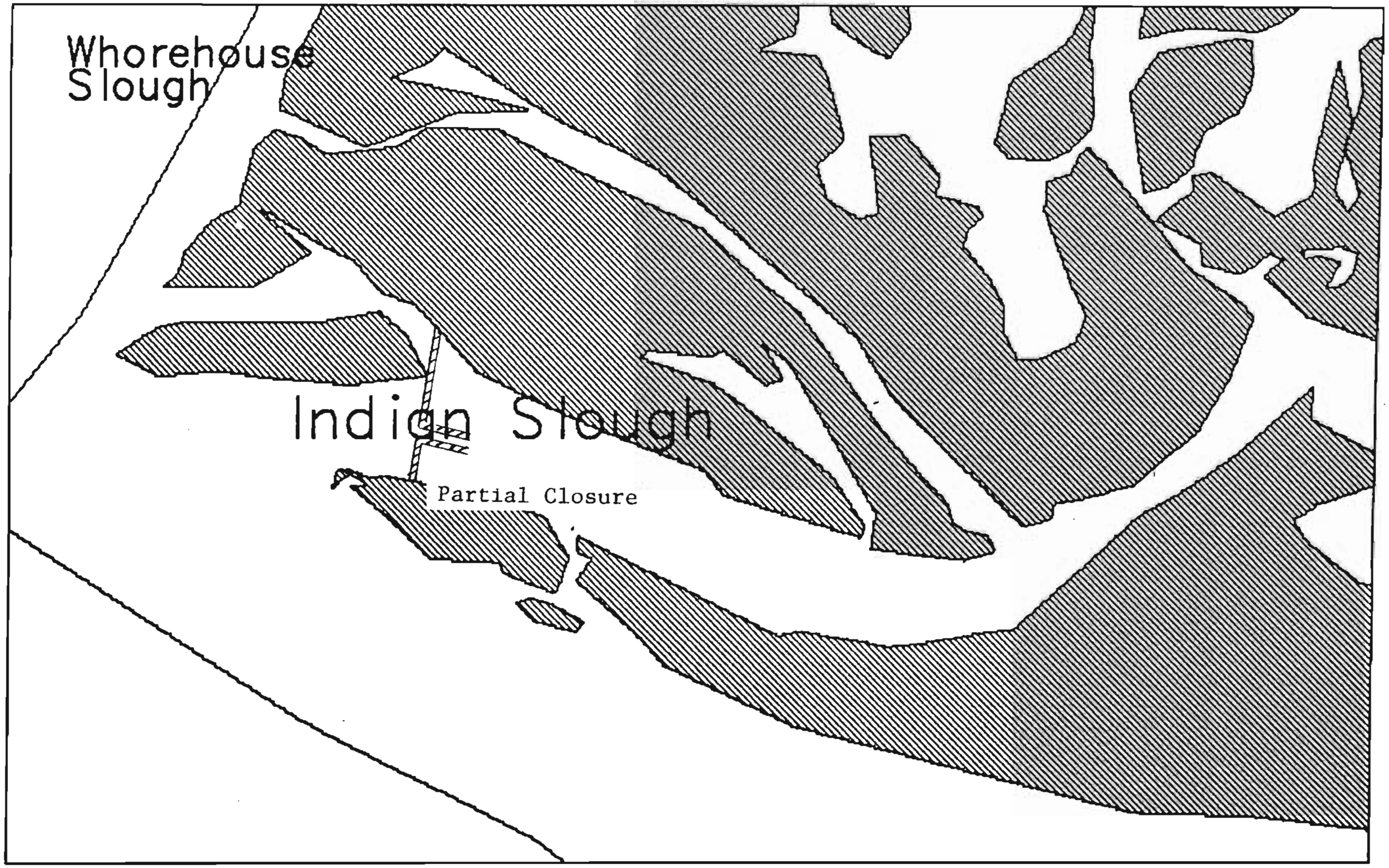
SCALE: 1 : 30671

WINDOW: 576950.00 4918780.00 583530.00 4912880.00

1 Terrestrial/Floodplain Habitat
2 Increase in Open Water Due to Erosion
3 Open Water Loss Due to Sedimentation
4 Open Water

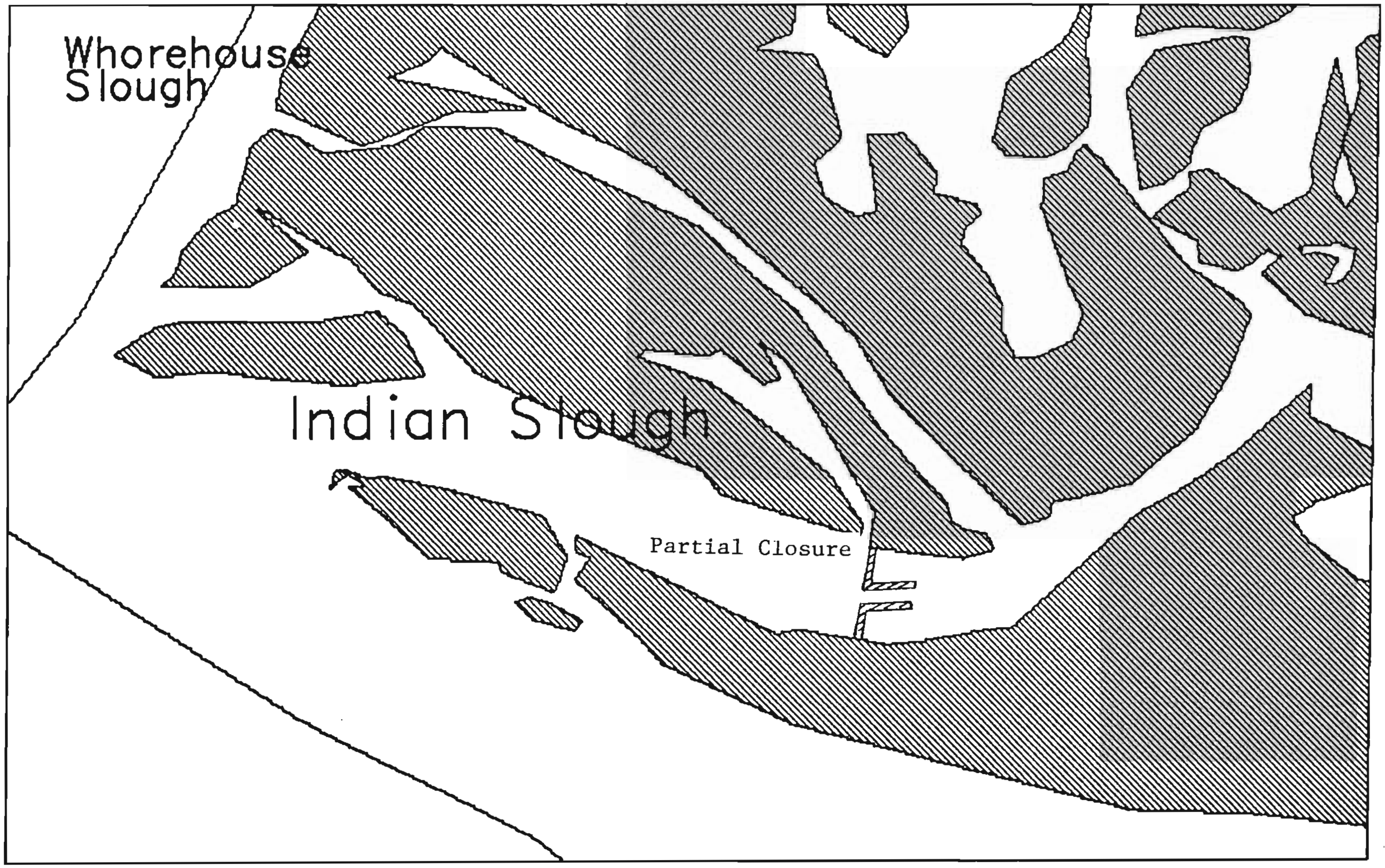
GIS - 1974 AND 1984

Plate 6



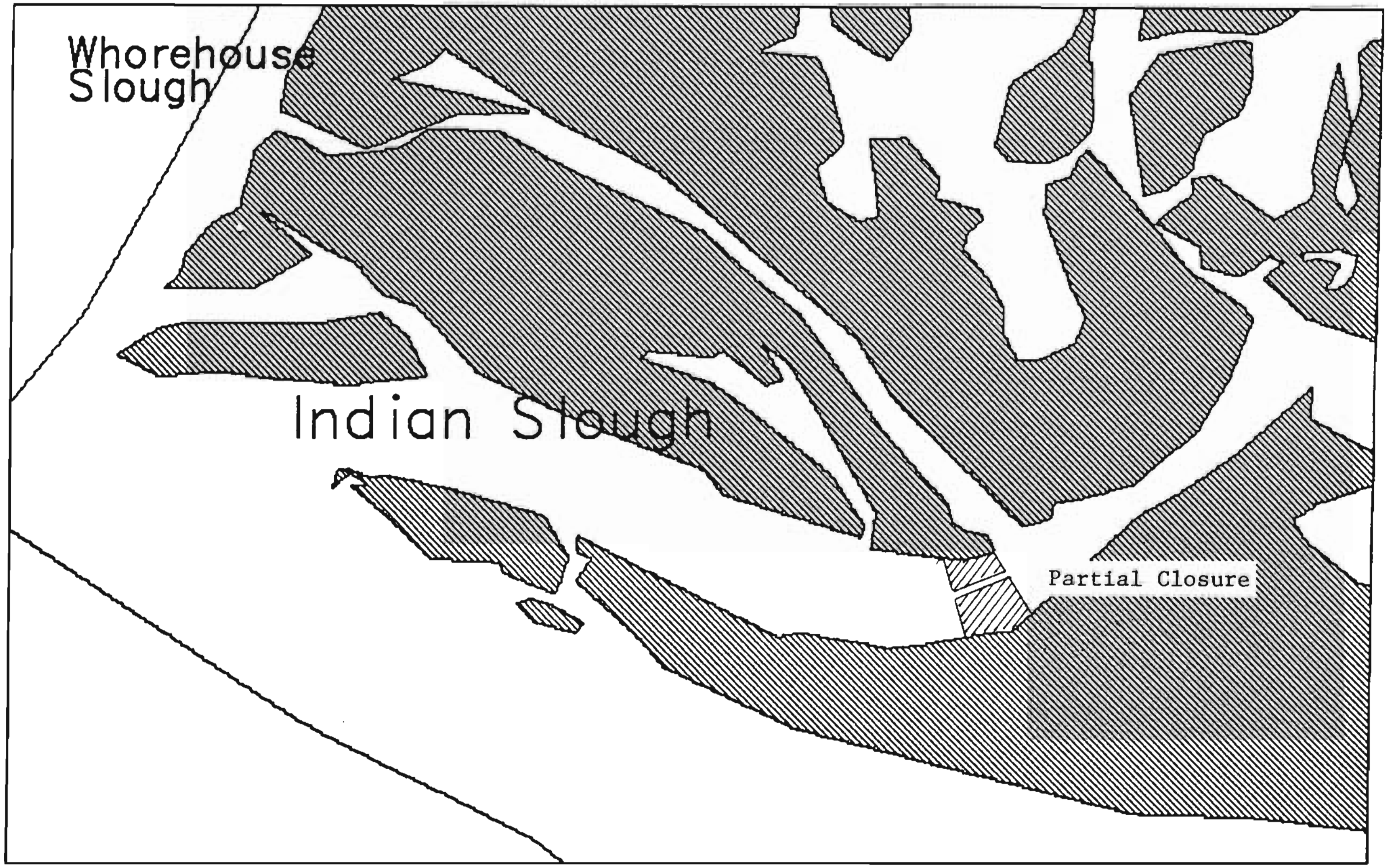
ALTERNATIVE A

Plate 7a



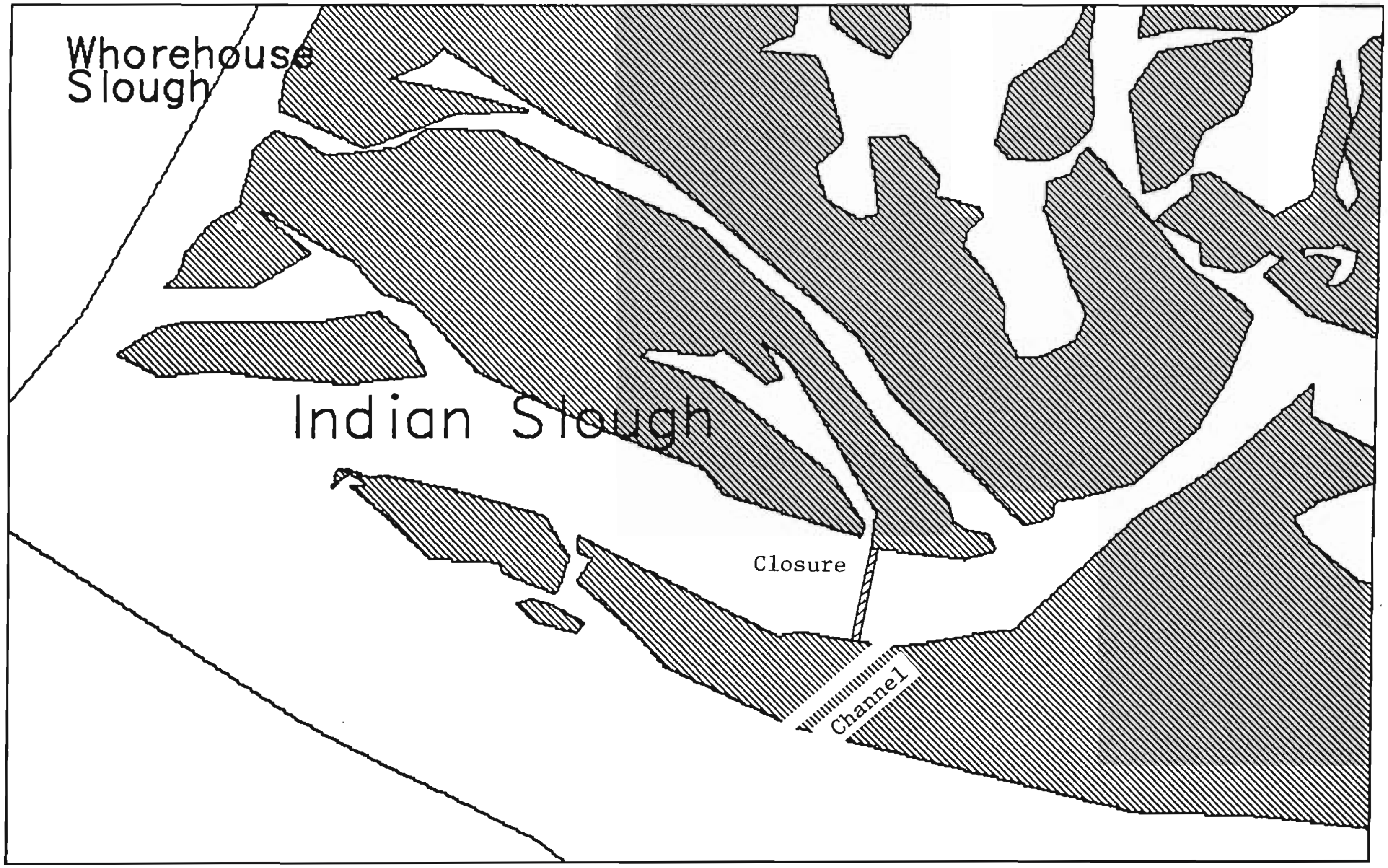
ALTERNATIVE B

Plate 7b



ALTERNATIVE C

Plate 7c



ALTERNATIVE D

Plate 7d

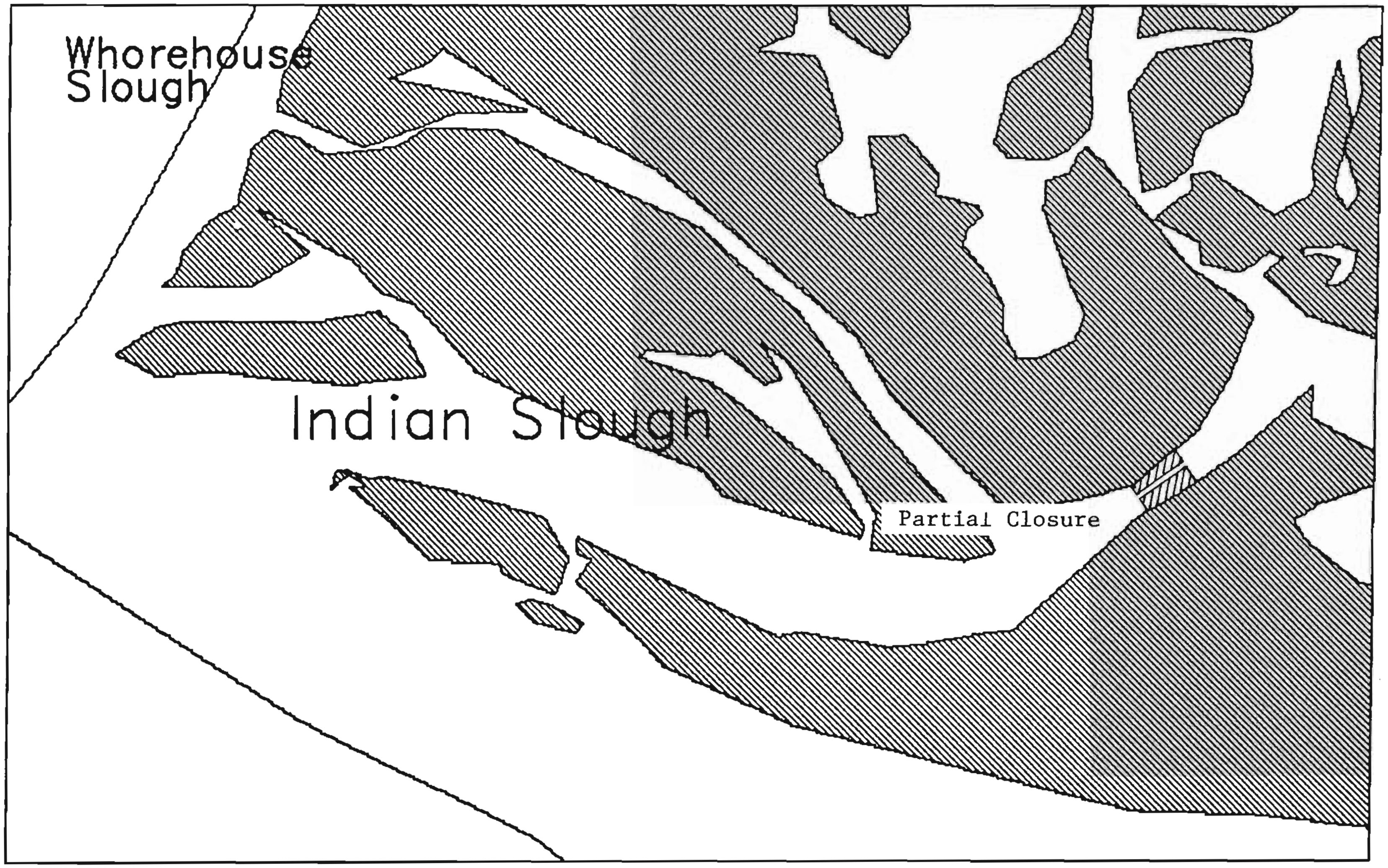
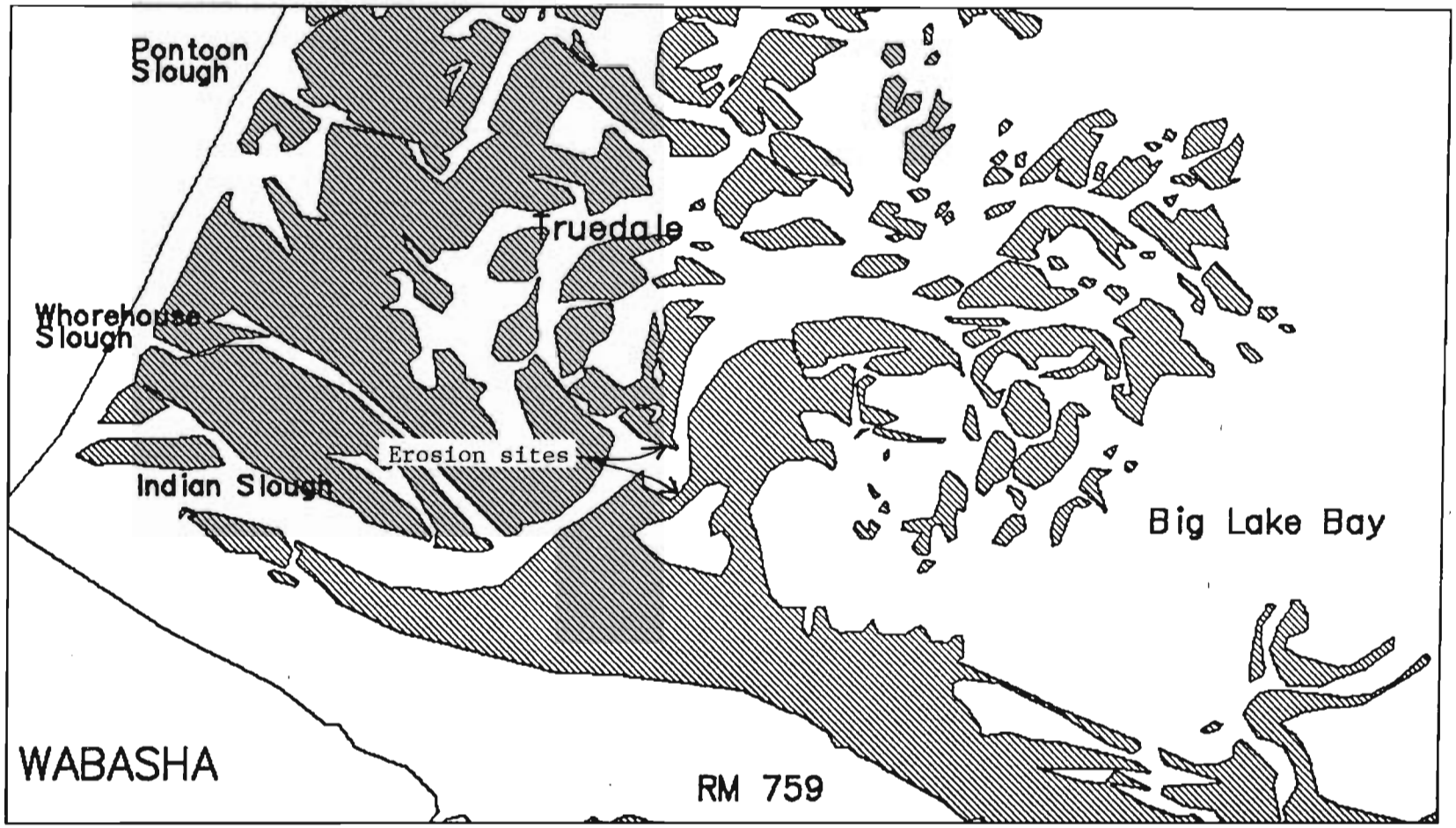


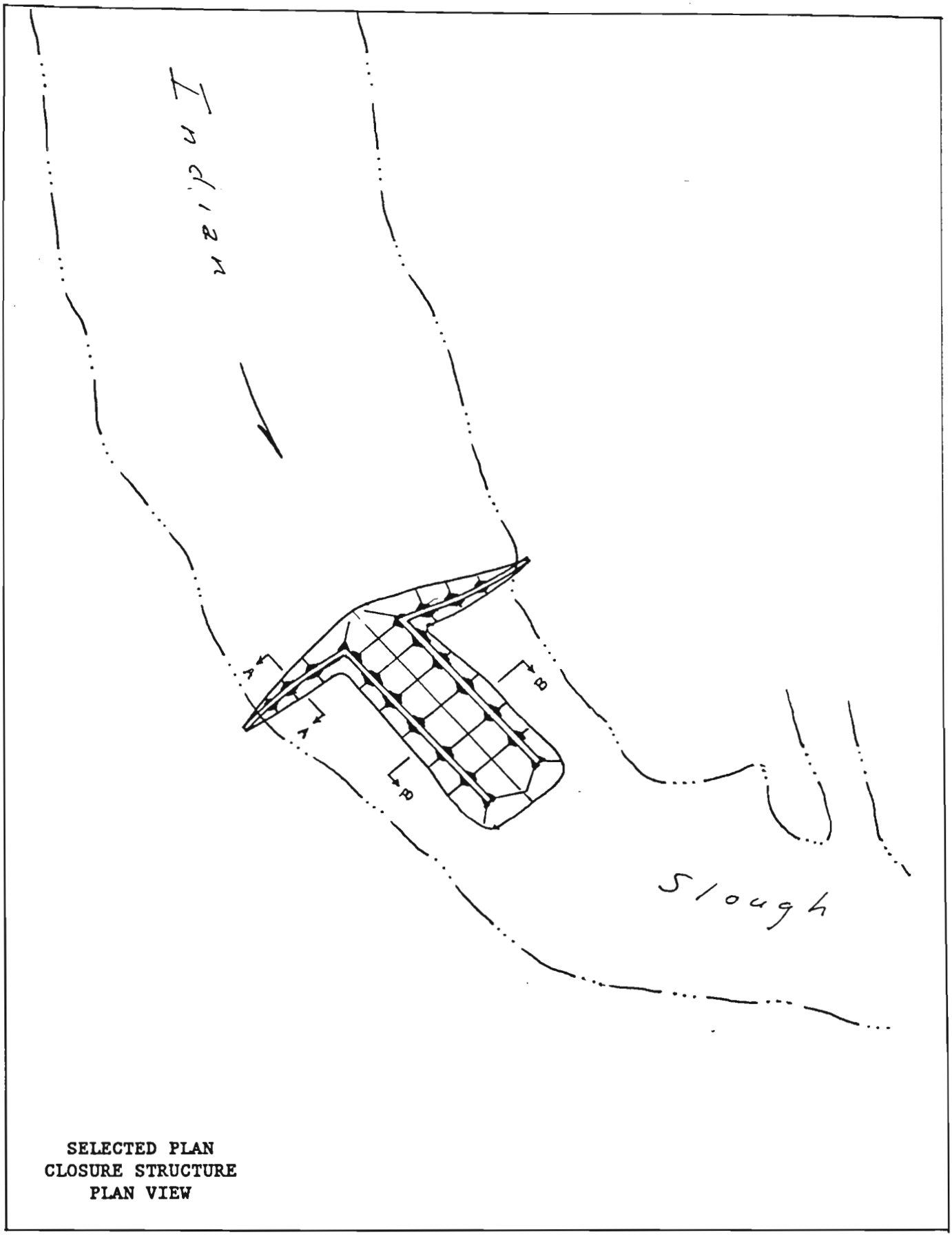
Plate 7e

ALTERNATIVE E

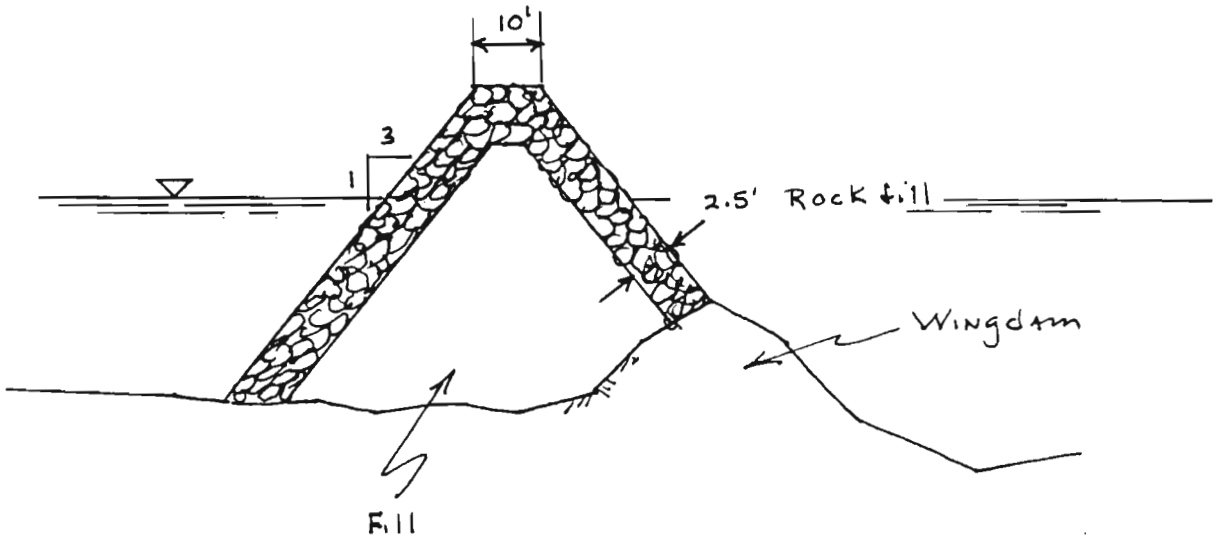


EROSION SITE

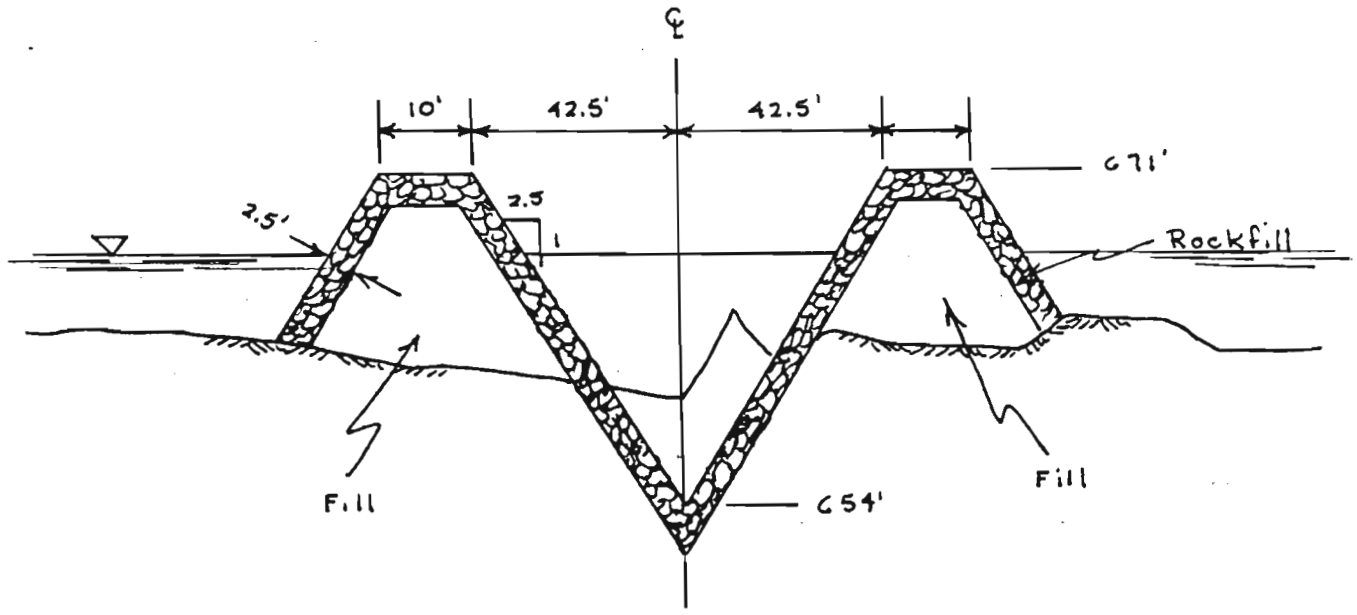
Plate 8



SELECTED PLAN
CLOSURE STRUCTURE
PLAN VIEW



X-Section A-A



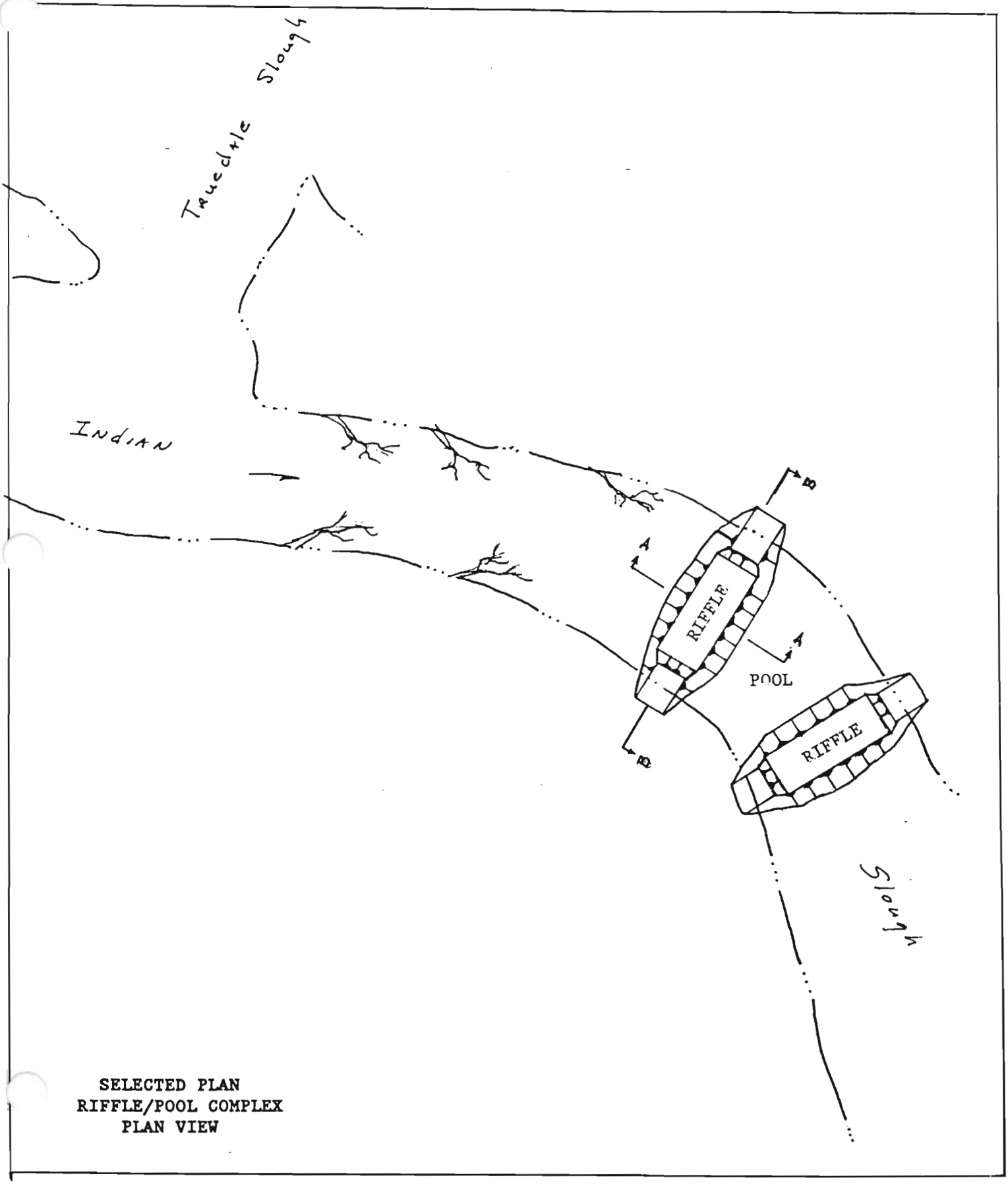
X-Section B-B

SELECTED PLAN
CLOSURE STRUCTURE
CROSS SECTIONS

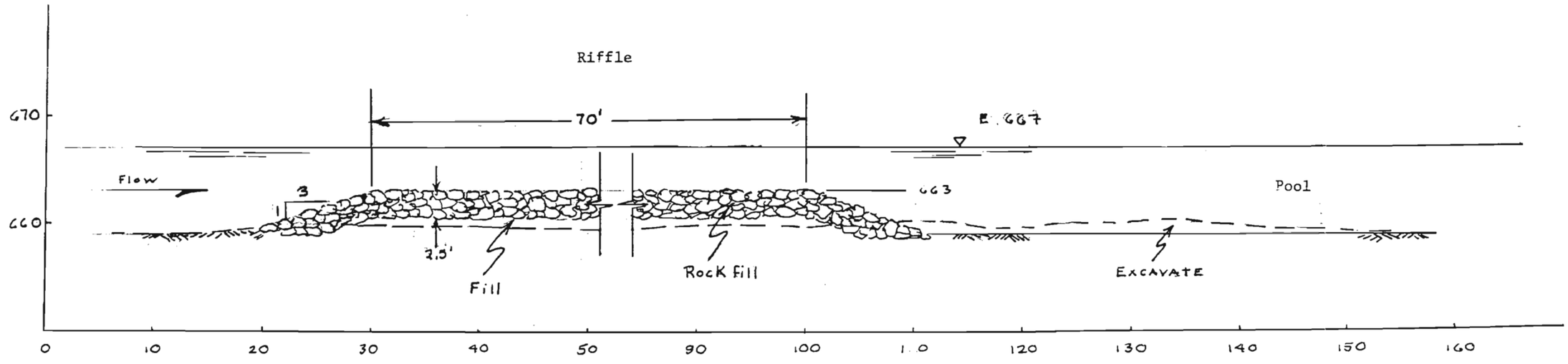
Plate 10

SELECTED PLAN
CLOSURE STRUCTURE
BIG LAKE BAY DREDGING

Plate 11



SELECTED PLAN
RIFFLE/POOL COMPLEX
PLAN VIEW



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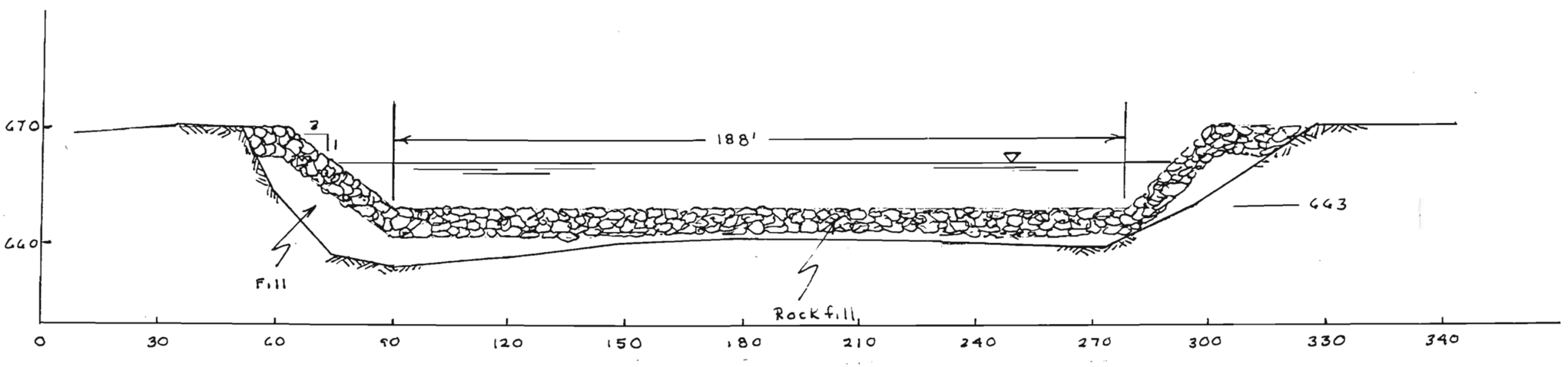

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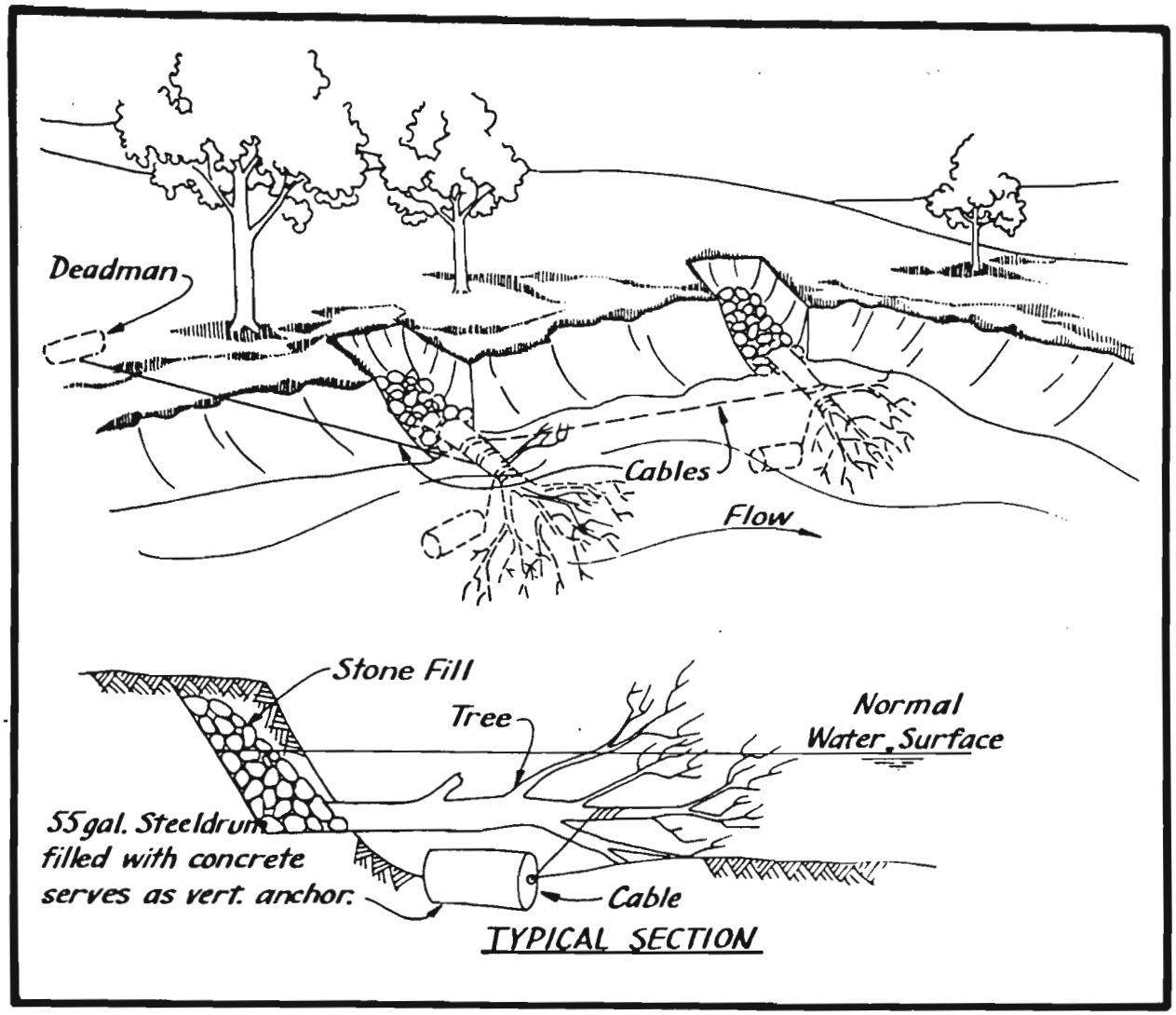
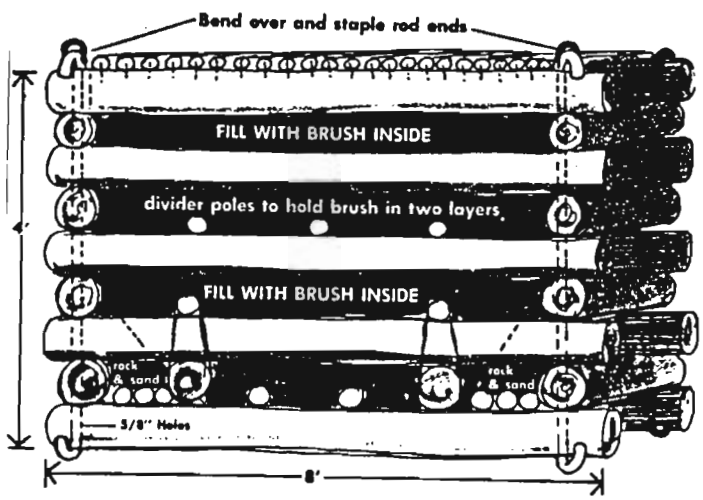
SELECTED PLAN
RIFFLE/POOL COMPLEX
CROSS SECTIONS

Plate 12b



SNAG DESIGN



WISCONSIN LOG CRIB STRUCTURE

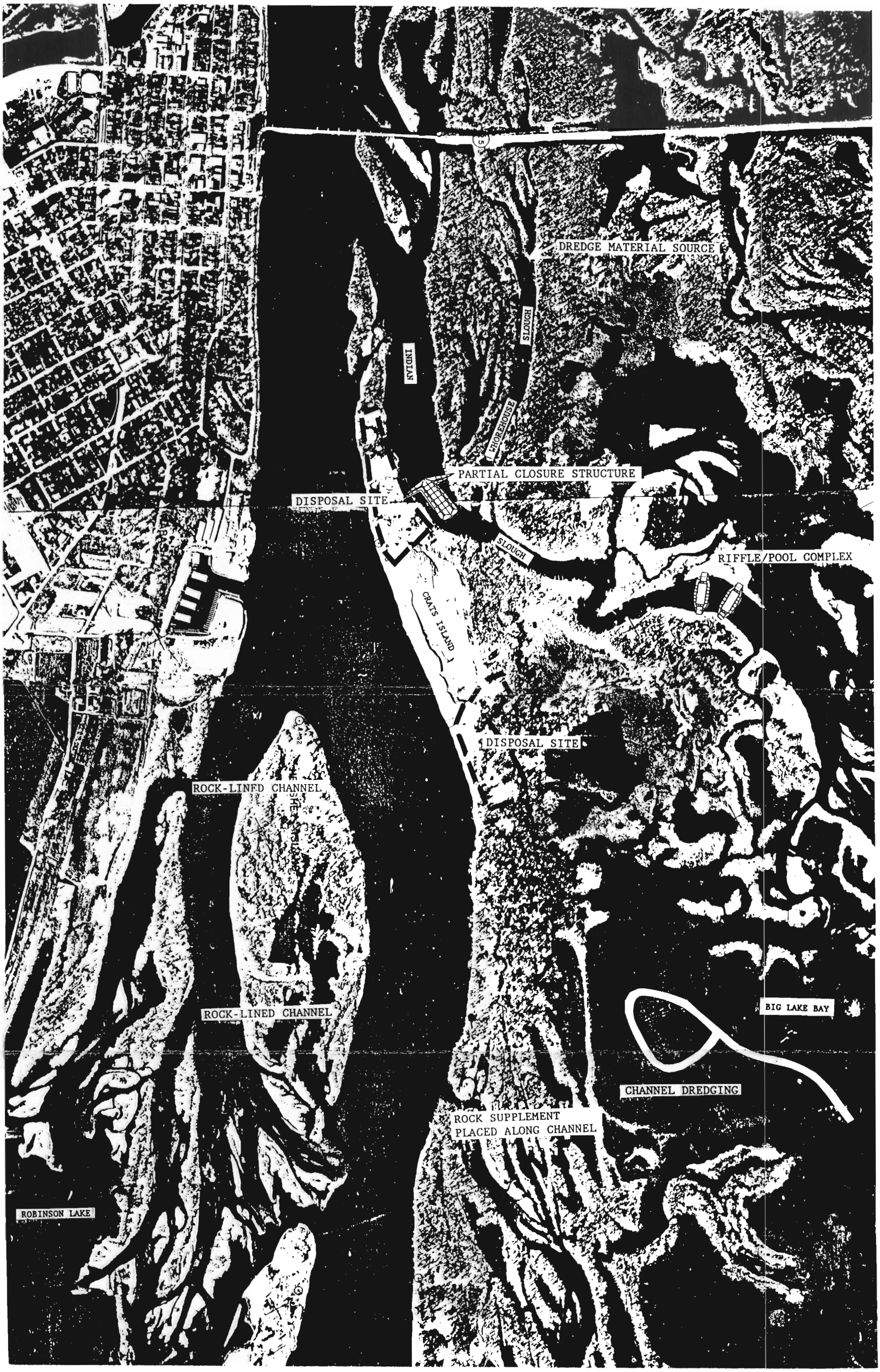

DREDGE MATERIAL SOURCE
INDIAN
SLOUGH
THORNHOUSE
PARTIAL CLOSURE STRUCTURE
DISPOSAL SITE
SLOUGH
RIFFLE/POOL COMPLEX
CRATS ISLAND
DISPOSAL SITE
ROCK-LINED CHANNEL
ROCK-LINED CHANNEL
BIG LAKE BAY
CHANNEL DREDGING
ROCK SUPPLEMENT
PLACED ALONG CHANNEL
ROBINSON LAKE

Plate 13

Attachment 2

Finding of No Significant Impact

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1421 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101-1479

REPLY TO
ATTENTION OF

Environmental Resources Branch
Planning Division

Finding of No Significant Impact

In accordance with the National Environmental Policy Act of 1969, the St. Paul District, Corps of Engineers, has assessed the environmental impacts of the following proposed project.

INDIAN SLOUGH/BIG LAKE HABITAT REHABILITATION AND ENHANCEMENT PROJECT
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 4, UPPER MISSISSIPPI RIVER
BUFFALO COUNTY, WISCONSIN

The proposed work involves the construction of a partial rock closing structure in Indian Slough, re-opening Whorehouse Slough by dredging 7,000 cubic yards of sand, construction of rock and wood fish structures in Indian Slough, and creation of deepwater habitat in Big Lake Bay by dredging 41,000 cubic yards of fine material. The sand dredged material from Whorehouse Slough would be hydraulically placed as a base for the partial rock closing structure in Indian Slough. The fine material dredged to create the deepwater habitat would be placed in a containment area constructed on old channel maintenance dredged material. The project has four purposes: 1). to reduce sediment load from Indian Slough by 50 percent to reduce the conversion of wetlands to land in Big Lake; 2). to restore flow in Whorehouse Slough; 3). to maintain dissolved oxygen levels above 5 mg/l in at least 15 percent of the Big Lake Bay area to enhance its value as centrarchid habitat; and 4). to create riffle/pool habitat in Indian Slough.

Based on the information presented in the environmental assessment, I have determined that the proposed action would not be a major Federal action significantly affecting the human environment. An environmental impact statement will therefore not be prepared.

Roger L. Baldwin
Colonel, Corps of Engineers
District Engineer

Attachment 3

Section 404(b)(1) Evaluation Report

SECTION 404(b)(1) EVALUATION
INDIAN SLOUGH/BIG LAKE HABITAT REHABILITATION AND ENHANCEMENT PROJECT
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 4, UPPER MISSISSIPPI RIVER
BUFFALO COUNTY, WISCONSIN

I. Project Description

A. Location - Big Lake and Indian Slough are backwater areas in lower pool 4 between river miles (R.M.) 760 and 757 on the Upper Mississippi River. The immediate study area encompasses the backwater areas on the right (east) side of the main navigation channel. The project area is part of the Upper Mississippi River National Wildlife and Fish Refuge, administered by the U.S. Fish and Wildlife Service. It is located in northern Buffalo County, Wisconsin, between the villages of Nelson and Alma, Wisconsin (see plates 1 and 2 of the main report for the locations of the various areas discussed in this 404).

B. General Description - The proposed work involves cutting and filling 3 acres of Indian Slough channel bottom and placement of rock and log crib structures to create a riffle/pool complex in Indian Slough. The project also involves the construction of a partial rock closing structure in Indian Slough. The project includes the disposal of fine dredged material obtained from Big Lake Bay to create deepwater habitat for use by centrarchid fish.

C. Authority and Purpose - The proposed project would be funded and constructed under authorization of Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) in conjunction with features which will be constructed through Corps operation and maintenance activities (under the Rivers and Harbors Acts of January 21, 1927 and July 3, 1930). The overall purpose of this project is twofold: (1) To rectify conditions created by the activities associated with the Crats Island dredged material placement site and (2) to rehabilitate, enhance, and maintain diverse riverine habitat for fish and wildlife.

D. General Description of Dredged and Fill Material

1. Physical Characteristics - The material that would be dredged from Big Lake Bay has between 50 and 90 percent silts and clays and is rich in organic material (Table 404(b)-1). The material that would be mechanically shaped for the construction of the riffle/pool habitat in Indian Slough is predominantly sand, with only traces of silt (see hydraulics attachment). The rock used in the partial closing structure and in the creation of the riffles would be quarry-run rock, ranging in size from 2 inches to 2 feet. Visual inspection of the material that might be dredged in Whorehouse Slough indicated that the material consists of sand to silty sand.

2. Chemical Characteristics - The fine material that would be dredged to create deepwater habitat in Big Lake Bay was sampled and tested for contaminants (Table 404(b)-1). Samples were collected from three sites in Big Lake Bay (figure 1) with 2-inch-diameter corers (PVC-corer for metals and a stainless steel corer for pesticides and herbicides). Samples were collected to 1 foot below the depth of dredging. The chlorinated hyrdocarbons and

herbicides tested were below the limits of detection in all the samples. Metals were found at levels typical of fine backwater sediments. Ammonia nitrogen was detected at relatively low levels, with the highest level being recorded for the sample that had the highest amount of organic material. At two of the three sites sampled, the core was split vertically, top and bottom, to assess any potential heterogeneity with depth. No major difference was observed with sampling depth, other than it appeared that the surficial layer was slightly more enriched with metals.

The 7,000 cubic yards of material that might be dredged in Whorehouse Slough and used as a base for the closing structure in Indian Slough would be sand to silty sand. This material was visually inspected to determine the general particle size. It was not tested for contaminants, because it was felt that the analysis of the fine material would reveal if contaminants were present at levels of concern in the general project area. There is also an abundance of information on the quality of the coarser sediments from the main channel in this area. Table 404(b)-2 summarizes the existing sediment quality in the area. It indicates that the coarse material in this area is relatively uncontaminated.

3. Quantity of Fill Material - Around 10,800 and 3,800 cubic yards of quarry run rock would be used to construct the partial closing structures and riffle areas, respectively. An additional 800 cubic yards of rock would be placed at the mouth of Catfish Slough and Robinson Lake to stabilize the area and ensure that these areas are not adversely affected by the construction of the partial closing structure at Indian Slough. Around 1,500 cubic yards of sand material would be cut and filled in Indian Slough to create the riffle/pool complex. Around 15 Wisconsin log crib structures would be placed in the pools. These structures consist of logs and brush. Around 7,000 cubic yards of sand fill would be required as a base for the rock closing structure. This material would be obtained from Whorehouse Slough, if it is determined to be suitable. Around 46,000 cubic yards of fine material from Big Lake Bay would be placed in the two containment areas.

E. Description of Proposed Dredged Material Disposal Sites - The disposal area for material dredged from Big Lake Bay would be old dredged material disposal areas, with sparse understory and few trees. Several potential sites were identified. These include an area immediately upstream of the Teepeeota Point channel maintenance containment area and areas both upstream and downstream of the Crats Island channel maintenance containment site. See plate 2 of the main report for the location of these areas. The Teepeeota Point site was dropped from further consideration because of the greater distance from the dredge site and, hence, the greater dredging costs and the potential for conflicts with future channel maintenance requirements. Two separate disposal areas would be used near the Crats Island containment area. One area would cover a maximum of around 10 acres located upstream of the Crats Island containment area. This area was created entirely from past channel maintenance activities and has virtually no trees and very sparse herbaceous cover. In addition, a 6-acre area downstream of the Crats Island containment area would be used. This area was floodplain forest that has been significantly elevated and disturbed by past channel maintenance activities. The area is sparsely covered by trees and has very limited understory.

F. Timing and Duration of Dredged Material Disposal and Fill Activities - The project is scheduled for construction in 1991. Various features associated with the project would be constructed throughout the construction season. The dredging equipment is being restricted to an 8- or 10-inch dredge to maximize effluent quality. However, this means that, because of the lower daily production rates, the disposal would take a few months to complete.

G. Description of Fill and Dredged Material Disposal Methods - The material from Big Lake Bay and from Whorehouse Slough would be dredged with a small hydraulic dredge (8 to 10 inches). Rock placement and the cutting and filling necessary for the construction of the riffle/pool complex would be done mechanically.

For the fine material disposal, a small berm (5 to 6 feet) would be constructed around the 10-acre area, upstream of the Crats Island containment area. In the 6-acre disposal area downstream from the Crats Island channel maintenance containment area, a long perforated pipe would be placed on the end of the dredge pipe. The dredged material and carriage water would be allowed to exit through these pipes in small streams. The carriage water should seep through the existing sand soil at the site, and no effluent should be generated. Small berms would be constructed across any low areas on the site to catch effluent that did not soak into the sandy soil. If this method proved to be not effective, a small berm would be constructed around the area, and would involve removal of only those trees necessary to construct the berm. Some of the material collected in the two disposal areas would be dried and spread along the slopes of the existing channel maintenance containment area. The two areas would alternately be disposed in to maximize retention time and effluent quality. Any effluent generated from the two disposal areas would be directed into the Crats Island channel maintenance containment area, allowing for additional settling time, before being discharged to the main channel, if necessary. Over 800,000 cubic yards of material was recently removed from the Crats Island containment area to restore capacity. Although some maintenance dredging has occurred since, the capacity of the site is still very large and the likelihood of an effluent being generated from the site is fairly small.

The material from Whorehouse Slough would be placed hydraulically as a base for the partial closing structure. If the material from Whorehouse Slough contained a higher amount of fine material than was anticipated, this material would also be placed in the fine material containment sites. Material for the base of the partial closing structure would then be obtained from either the coarse sediments present at the Crats Island disposal site or from Indian Slough next to the partial closing structure.

II. Factual Determinations

A. Physical Substrate Determinations

1. Substrate Elevation and Slope - The existing channel bed in the area proposed for the closing structure and riffle areas would be raised to 4 feet below normal water surfaces.

2. Substrate Changes - The project would modify around 4 acres of sand substrate to rock substrate in Indian Slough, with the construction of the partial closing structure and riffle habitat. The disposal of the fine

material on the old dredged material would modify the existing sandy topsoil to a more loamy-type topsoil.

3. Dredged/Fill Movement - The 30-inch layer of rock placed at the partial closing structure and riffle should minimize any potential secondary movement of material. The two disposal areas that would be used for the fine material dredged have been substantially elevated from past channel maintenance disposal, which would make it unlikely that floodwaters would have a chance to erode any of the material placed at the sites, prior to it being stabilized by vegetation.

B. Water Circulation and Fluctuations

1. General Water Chemistry - The general water chemistry of the project area would not be modified by the proposed disposal activities. Creating deep water in Big Lake Bay would dampen the diurnal swings in temperature and dissolved oxygen during the summer and maintain higher levels of dissolved oxygen in the winter.

2. Current Patterns and Circulation - The partial closing structure would reduce flow in Indian Slough by 50 percent up to the 2-year peak discharge. Current velocities measured on transects across Big Lake in winter were above 0.1 foot per second. The maximum retention time in Big Lake for summer low river flow was conservatively estimated to be around 2.5 days, assuming a uniform and complete water exchange for the entire water volume present in Big Lake. Even using this extremely conservative approach, this is a relatively high exchange rate compared to most lakes. This would be doubled with the reduction in discharge through Indian Slough. Another Corps of Engineers project, the Weaver Bottoms Rehabilitation project in pool 5, was built in 1987 and involved similar sediment and flow reduction measures. At that project, for an area three times the size of Big Lake, an amount of flow similar to that being proposed for the Big Lake area is being provided. Winter dissolved oxygen monitoring at Weaver Bottoms for the last 3 years has not indicated any problems with dissolved oxygen from the reduced circulation rates. A limited amount of diurnal dissolved oxygen (D.O.) monitoring in the summer for Weaver Bottoms has noted some changes in diurnal D.O. patterns. However, interpretation of this information has been confounded by the drought conditions that have been prevalent since the project was constructed. Additional monitoring of Weaver Bottoms will be necessary to provide a more definitive answer. However, this apparent problem is one of the reasons why the higher discharge of 375 cfs was selected over the range of discharges that was deemed acceptable to the resource agencies and should provide circulation rates two to three times higher than is occurring in Weaver Bottoms. In conclusion, even though flow would be cut in half in Indian Slough by the construction of the partial closing structure, there should be adequate flows to maintain existing water quality conditions in Big Lake.

3. Sedimentation Patterns - The partial closing structure is designed to reduce the future sediment load in Indian Slough by 50 percent. This is designed to prevent the future loss of 120 acres of shallow and deepwater wetlands.

C. Suspended Particulate/Turbidity Determinations

1. Suspended Particulates and Turbidity - Small, localized turbidity plumes would be generated by the construction of some of the project features. Turbidity plumes would be generated in Indian Slough from the hydraulic placement of material from Whorehouse Slough for a base for the partial closing structure and from the mechanical cutting and filling that would occur to construct the riffle/pool complex. The operation of the hydraulic cutterhead in Big Lake would also cause a turbidity plume, which because of the lack of circulation in the area could persist for some time. If an effluent were generated from the fine material containment sites, a small turbidity plume would be generated in the main channel border area.

2. Effects on Physical and Chemical Properties of the Water Column

a. Light Penetration - Light penetration could be slightly suppressed in Indian Slough because of the construction activities and in Big Lake because of the disturbance of the fine sediments by the hydraulic cutterhead.

b. Dissolved Oxygen - No adverse effects on dissolved oxygen should occur with the construction of the project features. The creation of deep water in Big Lake Bay should allow the 5 mg/l D.O. standard to be met more frequently in this area.

c. Toxic Metals and Organics - The relatively uncontaminated material and the efforts being made to minimize construction related impacts on water quality should minimize any potential problems with toxic metals or organics.

d. Pathogens - Pathogenic organisms are not likely to be found in the sediments, because of the lack any major sewage treatment discharge in the general area.

D. Contaminant Distribution Determinations - The relatively uncontaminated material should minimize any potential redistribution of contaminants. Vertical sampling stratification was done to assess the potential of reexposing sequestered contaminants in Big Lake Bay. The results indicate that the material is fairly homogeneous with depth.

E. Aquatic Ecosystem and Organism Determinations

1. Effects on Plankton - Planktonic activity in Indian Slough may be suppressed during the construction because of slightly elevated suspended solids levels during construction.

2. Effects on Benthos - The rock and wood substrate that would replace the existing sand substrate at the partial closing structure and riffle area would increase local production of macroinvertebrates.

3. Effects on Fish - Fish use of the Indian Slough area during construction may be reduced by all the activities. However, the project features were designed to provide long-term benefits to both lotic and lentic fish species. The rock and wood habitat being created in Indian Slough would

be very beneficial to species such as smallmouth bass. The creation of deepwater habitat in Big Lake should improve water quality in this area and enhance the area for centrarchids.

4. Effects on Wildlife - The disposal of the material from backwater dredging offers an opportunity to provide a better topsoil at some of the old channel maintenance dredged material disposal areas. These areas have very limited wildlife values because of the sandy soil and sparse vegetation. These areas have been significantly elevated by past dredged material disposal and are not inundated by most flood events. By providing a better topsoil, these areas could be managed for a vegetative community that is rather unique to the Upper Mississippi River Wildlife and Fish Refuge. One of the goals of the project is to prevent future loss of wetlands, which should have a very positive effect on a variety of wildlife species.

5. Effects on Aquatic Food Web - The dredged material disposal activities should not produce any effects on the aquatic food web. Because the project is intended to provide some better structure in Indian Slough and improve water quality in Big Lake Bay, it would have a positive effect on the aquatic food web in the Indian Slough/Big Lake area.

6. Effects on Special Aquatic Sites

a. Sanctuaries and Refuges - The project area is part of the Upper Mississippi River National Wildlife and Fish Refuge. The project is listed for implementation in the recently completed Refuge Master Plan and should be compatible with the goals and objectives established for the refuge.

b. Wetlands, Mud Flats, and Vegetated Shallows - The fill and dredged material disposal would not directly affect wetlands. Dredging in Big Lake Bay would convert 11 acres of shallow wetlands, water depths of 2 to 3 feet with predominantly submerged aquatic plant species, to deepwater wetlands, water depths of 5 feet. One of the project goals is to reduce sediment input from Indian Slough into Big Lake and subsequently prevent the future loss of 120 acres of shallow and deepwater wetlands.

7. Threatened and Endangered Species - The absence of Higgins' eye pearly mussels from any recent surveys in and adjacent to the project area indicates that the project should have no significant impact on this species. Bald eagles do use the area, mainly as a wintering area and during migrations. To ensure that no impacts to this use would occur from the project, none of the large trees bordering the main channel, which could be used as perches by the eagles, would be removed with the creation of the fine material disposal areas.

8. Actions Taken To Minimize Impacts - Efforts are being taken to maximize effluent quality. These efforts include restricting the hydraulic dredge size and having multiple containment areas. It is anticipated that an effluent return to the main channel from the fine material containment areas would not be necessary due to the size of the last settling pond.

F. Proposed Disposal Site Determinations

1. Mixing Zone - Because of the relatively uncontaminated dredged or fill material, no mixing zone should be required of any contaminants. Small, localized turbidity plumes may be generated by the construction of the project features. If an effluent is generated from the Crats Island containment area, it would be of very high quality. The high quality effluent in combination with the rapid mixing and dilution that would occur in the main channel would make the mixing zone very small. The coarse material that would be used in the construction of the project features in Indian Slough would minimize any mixing zone, although small, localized turbidity plumes would be generated.

2. Compliance with Applicable Water Quality Standards - The State of Wisconsin's water quality standards are contained in NR 102 and NR 103. Wisconsin (NR 103) indicates that "water quality shall meet the standards and requirements for recreational use and fish and aquatic life." Wisconsin's standard of "unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish and other aquatic organisms" is not likely to be violated by the proposed project. Wisconsin's 80 mg/l standard for suspended solids would be exceeded in the effluents and the turbidity plumes generated. The project would allow Wisconsin's 5 mg/l dissolved oxygen standard to be met more frequently in Big Lake Bay. The Wisconsin Department of Natural Resources (WDNR) has received legislative approval to enter into an agreement with the Corps for EMP projects and implementation of GREAT I recommended disposal sites that allows the WDNR to waive State permit and other requirements, including State water quality certification and the prohibition on disposal of dredged material below the ordinary high water mark. The existing Memorandum of Agreement between the WDNR and the Corps has been amended to cover this project, and water quality certification for the placement of rock has been obtained. Minnesota's water quality standards will not be violated by the placement of rock in the Robinson Lake area.

3. Potential Effects on Human Use Characteristics

a. Municipal and Private Water Supply - No private or municipal water supplies are located in the immediate project area.

b. Recreational and Commercial Fisheries - The project should have a very positive effect on fish and other wildlife habitat, which should result in better fishing and hunting experiences. Because the project is designed to enhance fisheries value, there could be a slight benefit to the commercial fisheries.

c. Water Related Recreation and Aesthetics - The aesthetic quality of the area would be reduced during construction, because of the presence and operation of the dredging and other construction equipment. All structures were designed to maintain water depths and current velocity within safe operating conditions for small recreational craft.

d. Cultural Resources - The major land groups in the project area have either been formed by natural deposition in the last 10 years or created by the St. Paul District using dredged material. Historic and archaeological site maps do not show the presence of cultural resources in the

proposed project area. Therefore, the project would not affect any significant cultural resources.

G. Cumulative and Secondary Effects on the Aquatic Ecosystem - No secondary effects are anticipated with the project, because of the measures being implemented to ensure stability of the project features. The project would have a cumulative effect of improving the overall fish and wildlife value of the project area.

III. Findings of Compliance or Noncompliance with Restrictions on Discharge

A. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge that Would Have Less Impact Upon the Aquatic Ecosystem (40 CFR 230.10(a)) - Several different partial closure alternatives and alternative enhancement measures were considered in arriving at the proposed project, which should maximize the enhancement goals, while minimizing any construction related adverse impacts. In addition, several disposal options were considered. A variety of specific project features were incorporated to maximize effluent quality, especially for the fine material disposal operation. A more detailed explanation of the alternatives considered is contained in the environmental assessment.

B. Compliance with Applicable State Water Quality Standards (40 CFR 230.10(b)(1)) - The project is in compliance with Wisconsin and Minnesota water quality standards. Water quality certification has been obtained from both States (see correspondence section).

C. Compliance with Section 307 of the Clean Water Act (40 CFR 230.10(b)(2)) - The proposed action would not violate any applicable effluent standard or prohibition under Section 307 of the Clean Water Act.

D. Compliance with the Endangered Species Act (40 CFR 230.10(b)(3)) - The project has been coordinated with the U.S. Fish and Wildlife Service, and they concur with the determination that there should be no significant impacts on endangered species or their critical habitat.

E. Evaluation of the Extent of Degradation of Waters of the United States (40 CFR 230.10(c))

1. The proposed project would not have any significant adverse effects on human health and welfare.

2. The proposed project would not have any significant adverse effects on life stages of aquatic life or any other wildlife dependent upon aquatic ecosystems.

3. The proposed project would not have any significant adverse effects on aquatic ecosystem diversity, productivity, or stability.

4. The proposed project would not have any significant adverse effects on recreational, aesthetic, cultural, or economic values.

Table 404(b)–1. Bulk chemical sediment results from Big Lake Bay in lower pool 4, Upper Mississippi River (dry weight).

Compound	LAB BLANK	Site 1 Top	Site 1 bot	Site 2 top	Site 2 bot	Site 3 comp.	Site 3–dup	Spike (1.42)	SPIKE (1.42)
PESTICIDES	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
ALPHA–BHC	< 0.24	< 2.3	< 2.1	< 3.7	< 3.4	< 3.4		< 6.8	< 6.8
BETA–BHC	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
DELTA–BHC	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
GAMMA–BHC (LINDANE)	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
HEPTACHLOR	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
ALDRIN	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
HEPTACHLOR EPOXIDE	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
ENDOSULFAN I	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
DIELDRIN	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
4,4'–DDE	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
ENDRIN	< 1.8	< 17	< 16	< 28	< 26	< 26		< 51	< 51
ENDOSULFAN II	< 0.60	< 5.8	< 5.3	< 9.3	< 8.5	< 8.5		< 17	< 17
4,4'–DDD	< 1.8	< 17	< 16	< 28	< 26	< 26		< 51	< 51
ENDRIN ALDEHYDE	< 1.8	< 17	< 16	< 28	< 26	< 26		< 51	< 51
ENDOSUL. SULFATE	< 1.8	< 17	< 16	< 28	< 26	< 26		< 51	< 51
4,4'–DDT	< 1.9	< 18	< 17	< 30	< 27	< 27		< 55	< 55
METHOXYCHLOR	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
ENDRIN KETONE	< 1.8	< 17	< 16	< 28	< 26	< 26		< 51	< 51
CHLORDANE	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
TOXAPHENE	< 9.6	< 92	< 84	< 150	< 140	< 140		< 270	< 270
AROCLOR–1016	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
AROCLOR–1221	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
AROCLOR–1232	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
AROCLOR–1242	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
AROCLOR–1248	< 4.8	< 46	< 42	< 74	< 68	< 68		< 140	< 140
AROCLOR–1254	< 9.6	< 92	< 84	< 150	< 140	< 140		< 270	< 270
AROCLOR–1260	< 9.6	< 92	< 84	< 150	< 140	< 140		< 270	< 270
HERBICIDES	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg		ug/Kg spike 28	ug/Kg spike 28
2,4–D	< 4.0	< 1.9	< 1.8	< 1.6	< 1.4	< 1.4		< 1.4	< 1.4
SILVEX (2,4,5–TP)	< 1.6	< 0.77	< 0.70	< 0.62	< 0.57	< 0.57		12	< 0.6
2,4,5–T	< 1.6	< 0.77	2.0	< 0.62	< 0.57	< 0.57		5.8	4.4
METALS & MISC.	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	% recovery	
Arsenic	< 0.84	2.7	2.1	1.3	2.3	1.7	1.7	147	
Cadmium	< 0.92	< 1.8	< 1.6	< 1.4	< 1.3	< 1.3	< 1.3	123	
Chromium	< 1.3	25	18.7	24.3	22.8	19.4	18	90.4	
Copper	< 1.2	22.7	14.7	17	10	9.8	17.6	98.6	
Mercury	< 0.1	< 0.19	< 0.18	< 0.16	< 0.14	< 0.14	< 0.14	97	
Managanese	< 0.3	397	242	521	1640	224	210	78	
Nickel	< 4.6	16.3	9.7	8.3	11.6	9	7.3	87.6	
Lead	< 0.68	13.2	7.5	7.3	6.6	7.4	6.5	69	
Selenium	< 0.66	1.5	1.5	< 1	1.5	1.2	1.1	84	
Zinc	< 0.48	77.1	43.1	45.2	46.5	41.8	37.6	87.5	
Cyanide	< 0.5	< 1.24	< 0.99	< 0.74	< 0.72	< 0.7	< 0.7	94.3	
Ammonia nitrogen	< 0.2	170	99	58	48	57	58	87.3	
T. organic carbon	< 1	76600	67300	24700	29500	15900	16400	94	
MISC.	Percent	Percent	Percent	Percent	Percent	Percent	Percent		
% Total solids	< 0.01	40.3	50.7	67.4	69.5	71.2	71		
% Volatile solids	< 0.01	9.6	8.5	4.6	3.2	2.5	2.3		
% Moisture	< 0.1	59.7	49.3	32.6	30.5	28.8	29		
Particle size (% finer) phi mm U.S. Sieve		Percent	Percent	Percent	Percent	Percent	Percent		
-2 4 5		100.0	100.0	100.0	100.0	100.0	99.5		
-1 2 10		100.0	99.9	99.9	99.9	99.7	99.5		
0 1 18		99.9	99.8	98.9	98.7	98.9	98.5		
1 0.5 35		99.1	98.6	87.3	85.9	90.2	87.7		
2 0.25 60		98.3	94.1	77.4	75.6	67.8	60.7		
3 0.125 130	Coarse fraction	95.4	76.3	68.0	65.7	53.5	44.6		
4 0.0625 230	Fine fraction	91.1	57.6	57.0	53.4	48.5	39.0		
5 0.0312		87.5	53.8	53.1	50.6	43.5	34.5		
6 0.0156		67.8	41.8	43.1	40.7	33.2	25.9		
7 0.0078		48.1	28.9	31.9	30.9	24.1	19.3		
8 0.0039		34.4	20.1	24.1	23.3	18.3	14.8		
9 0.0019		24.1	13.2	16.7	16.4	12.6	10.5		

Summary of Analytical Work – Analyses were performed by Keystone Environmental Resources, Inc., Houston, Texas.

– Arsenic (EPA 7060); cadmium (EPA 7131); copper, chromium, mercury, nickel, zinc, & managanese (EPA 6010); lead (EPA 7421); selenium (EPA 7740); cyanide (EPA 9010); pesticides (EPA 8080, with cleanup EPA 3640); herbicides (EPA 8150); particle size (sieve & pipette – Plumb 1981); total solids (EPA gravimetric 160.3); volatile solids (EPA ashing 160.4); total organic carbon (EPA 9060); percent moisture (EPA 160.3); ammonia nitrogen (Plumb 1981).

–Poor performance on spiked organic samples were due to matrix interference, which required diluting the samples.

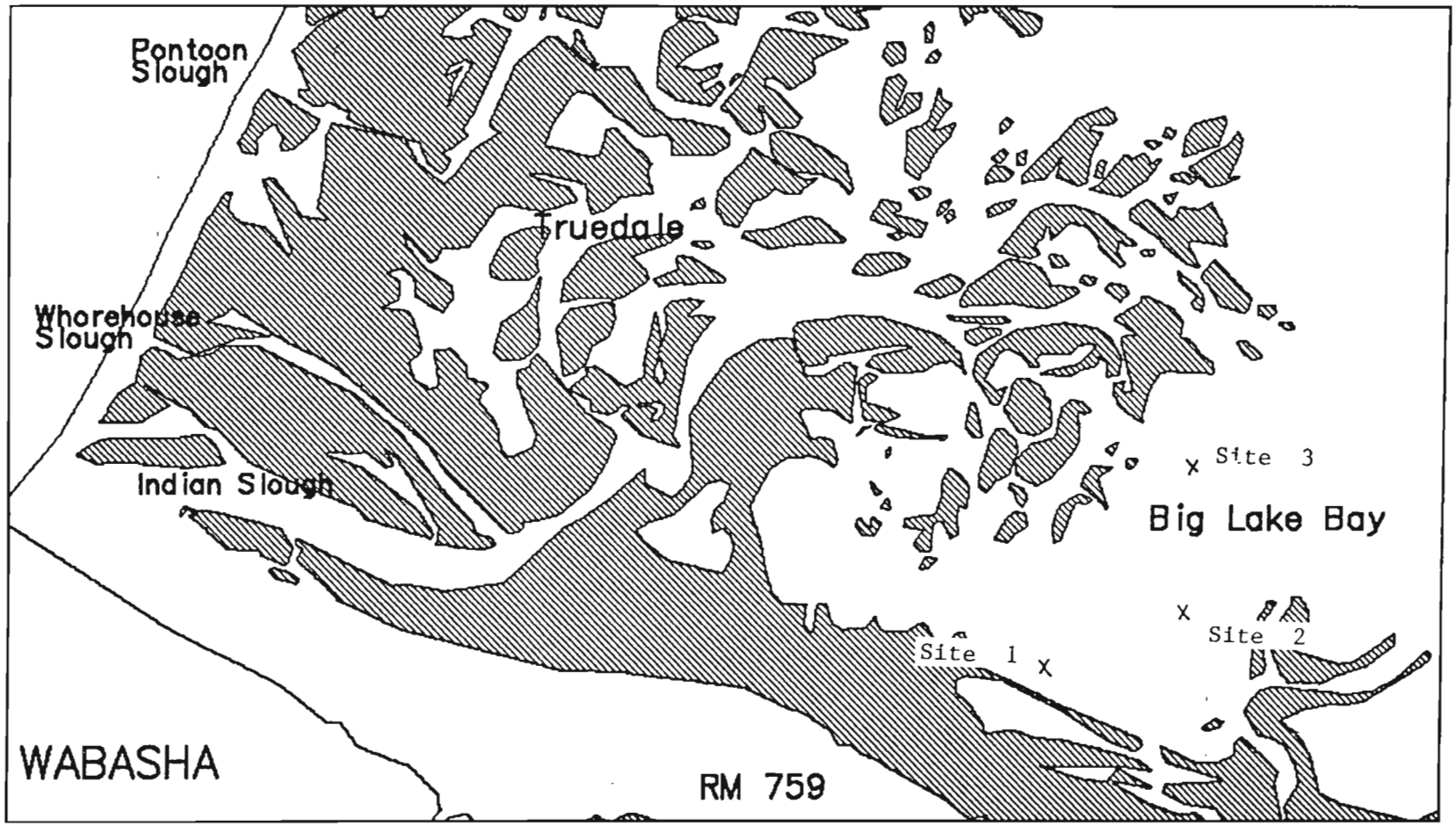
Summary of Sample collection efforts – July 19, 1989

–Samples were collected with 2 inch diameter cores, stainless steel for organics and PVC for metals.

–Samples were placed in glass containers, with teflon lined lids, and shipped on ice to the contractor's laboratory, where they were processed and stored at 4 degrees C until analyses were performed.

Location	Water Depth feet	Corer Depth feet	Extruded Core Length (feet)	Sub sample	Description
Site 3	3.2	5.5	1.2	Depth composited	Last 2 inches of core was silty sand.
Site 2	2	5	1.3	Split top and bottom	Organic material in top layer with mostly silty/clayey material below.
Site 1	3	5.5–6	1.5	Split top and bottom	Rich in organic matrerial, except bottom 2" of core

Record #	129	130	131	132	133	134	135	136	137	138	139	140	141	142	705	143	144	145	146	147	706	148	149	150	151	152	153	154	155	156
River Mile	763.5	763.5	763.0	763.0	762.5	762.3	761.9	760.0	759.1	759.1	759.0	759.0	759.0	759.0	758.6	757.5	757.5	757.5	757.5	757.5	757.3	756.8	756.3	755.8	754.6	754.4	754.2	754.2	754.0	754.0
Location	1	1	2	2	2	2	2	3	4	4	4	4	4	4	5	6	6	6	6	6	7	8	8	8	9	9	9	9	9	10
Year	1982	1982	1974	1974	1980	1980	1980	1981	1974	1974	1982	1982	1978	1978	1985	1982	1982	1978	1978	1974	1985	1980	1974	1980	1982	1982	1978	1978	1974	1979
Habitat Type	1	1	1	1	1	1	1	2	1	1	1	1	1	1	3	1	1	1	1	1	3	1	1	1	1	1	1	1	1	2
Pool	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Sampling Gear	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Sample depth (cm)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Collection citation	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	FWS	COE	COE	COE	COE	COE	FWS	COE	COE	COE	COE	COE	COE	COE	COE	COE
METALS (mg/kg)																														
Silver														<	0.4					<	0.4									
Aluminum															6520						11500									
Arsenic	1.30	< 1.10	< 0.90	1.00		0.00	0.00	< 1.00	< 0.90	1.00	3.00	1.70	0.00	0.00	< 7.0	1.40	1.80	0.00	0.00	0.90	< 7.0	0.00	< 0.80	0.00	2.00	1.50	0.00	0.00	< 0.70	0.00
Barium						20.0	< 10.0	80.0					30.0	30.0	203			30.0	30.0		141	20.0		20.0			10.0	10.0		70.0
Beryllium															0.44						0.65									
Cadmium	< 0.19	< 0.19	< 1.00	< 1.00	0.76	< 10.00	< 10.00	1.00	1.00	1.00	< 0.19	0.20	< 10.00	< 10.00	1.30	< 0.20	0.19	< 10.00	< 10.00	1.00	0.80	< 10.00	< 1.00	< 10.00	< 0.20	< 0.20	< 10.00	< 10.00	< 1.00	< 10.00
Chromium	4.8	3.8	8.0	5.0	14.6	< 10.0	< 10.0	10.0	7.0	7.0	15.0	4.0	< 10.0	20.0	25.0	4.0	3.9	< 10.0	< 10.0	6.0	34.0	< 10.0	7.0	< 10.0	5.9	4.0	< 10.0	< 10.0	23.0	10.0
Copper	3.9	2.8	10.0	7.0	1.6	< 10.0	< 10.0	10.0	7.0	7.0	5.7	4.0	< 10.0	< 10.0	19.0	3.0	3.5	< 10.0	< 10.0	6.0	26.0	< 10.0	10.0	< 10.0	3.9	3.0	< 10.0	< 10.0	8.0	10.0
Iron	5100	3800			10320	4200	4000	11000			10000	5200	2700	2400	20400	4000	4550	1900	2300		24500	3400		3400	6200	4400	2000	2200		12000
Mercury	< 0.010	< 0.010	0.300	0.400	< 0.010	0.000	0.000	< 0.010	1.400	0.600	0.017	0.015	0.000	0.000	0.060	0.027	0.010	0.000	0.000	0.400	0.060	0.000	0.400	0.000	< 0.010	0.010	0.000	0.000	0.400	0.000
Manganese						240	180	920					260	310	2340			250	250		866	220		180			180	130		550
Nickel	5	5	8	5	13	< 10	< 10	< 10	7	7	10	6	< 10	< 10	20.0	10	5	< 10	< 10	6	22.0	< 10	5	< 10	7	6	< 10	< 10	17	20
Lead	2.0	2.0	< 7.0	< 7.0	2.6	< 10.0	< 10.0	80.0	< 7.0	< 7.0	4.0	2.0	< 10.0	< 10.0	25.0	2.0	2.0	< 10.0	< 10.0	< 11.0	26.0	< 10.0	< 7.0	< 10.0	2.0	2.0	< 10.0	< 10.0	26.0	20.0
Antimony														<	4.0					<	4.0									
Selenium														<	10.0					<	10.0									
Thallium														<	20.0					<	20.0									
Zinc	14.0	13.0	19.0	13.0	48.0	20.0	40.0	72.0	17.0	17.0	26.0	15.0	10.0	10.0	74.9	26.0	14.0	10.0	10.0	16.0	96.8	14.0	15.0	12.0	16.0	14.0	12.0	10.0	17.0	40.0
PESTICIDES (ug/kg)																														
Alpha-BHC														<	10					<	10									
Beta-BHC														<	10					<	10									
Gamma-BHC (lindane)														<	10					<	10									
Chlordane	< 1.00	< 1.00	< 10.00	< 10.00	< 0.40	0.00	0.00	< 10.00	< 10.00	< 1.00	< 1.00	0.00	0.00	<	10	< 1.00	< 1.00	0.00	0.00	< 10.00	< 10	0.00	< 10.00	0.00	< 1.00	< 1.00	0.00	0.00	< 10.00	1.00
PP-DDD	2.2	< 0.1	< 10.00	< 10.00	< 0.2	0.0	0.0	< 10.00	< 10.00	< 0.1	< 0.1	0.0	0.0	<	10	< 0.1	< 0.1	0.0	0.0	< 10.00	< 10	0.0	< 10.00	0.0	< 0.1	< 0.1	0.0	0.0	< 10.00	0.3
PP-DDE	< 0.1	< 0.1	< 10.00	< 10.00	< 0.2	0.0	0.0	< 10.00	< 10.00	< 0.1	< 0.1	0.0	0.0	<	10	< 0.1	< 0.1	0.0	0.0	< 10.00	< 10	0.0	< 10.00	0.0	< 0.1	< 0.1	0.0	0.0	10.00	0.0
PP-DDT	16.7	< 0.1	< 10.00	< 10.00	< 0.40	0.0	0.0	< 10.00	< 10.00	< 0.1	< 0.1	0.0	0.0	<	10	< 0.1	< 0.1	0.0	0.0	< 10.00	10	0.0	< 10.00	0.0	< 0.1	27.0	0.0	0.0	< 10.00	0.0
Dieldrin	< 0.1	< 0.1	< 10.00	< 10.00	< 0.2	0.0	0.0	< 10.00	< 10.00	< 0.1	< 0.1	0.0	0.0	<	10	< 0.1	< 0.1	0.0	0.0	< 10.00	< 10	0.0	< 10.00	0.0	< 0.1	< 0.1	0.0	0.0	< 10.00	0.0
Endrin	< 0.1	< 0.1	< 10.00	< 10.00	< 0.2	0.0	0.0	< 10.00	< 10.00	< 0.1	< 0.1	0.0	0.0	<	10	< 0.1	< 0.1	0.0	0.0	< 10.00	< 10	0.0	< 10.00	0.0	< 0.1	< 0.1	0.0	0.0	< 10.00	0.0
Heptchlor														<	10					<	10									
Total PCB's	< 0.1	< 0.1		<	1	0	0			<	0.1	< 0.1	0	0	< 50	< 0.1	< 0.1	0	0	<	50	0		4	< 0.1	< 0.1	0	0		15
ORGANICS (ug/kg)																														
Anthracene														<	10						10									
Benzo(a)Fluoranthracene														<	10						10									
Benzo(b)Fluoranthene														<	10						30									
Benzo(k)Fluoranthene														<	10						10									
Benzo(a) Pyrene														<	10						20									
Benzo(e) Pyrene														<	10						50									
Benzo(g,h,i) Perylene														<	10						20									
Bis(2-ethythexyl) phthalate																														
Chrysene														<	10					<	10									
Dibenzo(a,h) Anthracene														<	10						20									
Di-n-Butyl phthalate																														
Fluoranthrene														<	10						20									
Fluorene														<	10					<	10									
Naphthalene														<	10					<	10									
Phenanthrene														<	10					<	10									
Pyrene														<	10						20									



SEDIMENT SAMPLING SITES

Record #		129	130	131	132	133	134	135	136	137	138	139	140	141	142	705	143	144	145	146	147	706	148	149	150	151	152	153	154	155	156
River Mile		763.5	763.5	763.0	763.0	762.5	762.3	761.9	760.0	759.1	759.1	759.0	759.0	759.0	759.0	758.6	757.5	757.5	757.5	757.5	757.5	757.3	756.8	756.3	755.8	754.6	754.4	754.2	754.2	754.0	754.0
Location		1	1	2	2	2	2	2	3	4	4	4	4	4	4	5	6	6	6	6	6	7	8	8	8	9	9	9	9	9	10
Year		1982	1982	1974	1974	1980	1980	1980	1981	1974	1974	1982	1982	1978	1978	1985	1982	1982	1978	1978	1974	1985	1980	1974	1980	1982	1982	1978	1978	1974	1979
Habitat Type		1	1	1	1	1	1	1	2	1	1	1	1	1	1	3	1	1	1	1	1	3	1	1	1	1	1	1	1	1	2
Pool		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Sampling Gear		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Sample depth (cm)		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Collection citation		COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	COE	FWS	COE	COE	COE	COE	COE	FWS	COE	COE	COE	COE	COE	COE	COE	COE	COE
Settleability Tests																															
Susp. solids--0 hours(mg/l)		112	0				324	904	34276			40	8	88	112		116	48	144	92			248		3720	72	304	276	596		41924
Susp. solids--4 hours(mg/l)		0	0				96	48				0	8	16	0		120	68	0	48			132		328	144	136	0	4		1044
Turbidity - 0 hours(NTU)		14	27				100	85	880			32	30	16	20		64	33	23	14			44		10500	56	160	32	140		3000
Turbidity - 4 hours(NTU)		7	15				22	90				19	15	10	20		30	27	12	10			21		160	42	80	20	31		830
Particle size - percent finer																															
mm	Classification																														
0.005	SILTS	0	0		0	1	0	0	5	0	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0	0	0	0	7
0.020	&	1.0	1.0		0.0	1.0	0.0	0.0	11.0	0.0	0.0	1.0	1.0	0.0	0.0		1.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	26.0
0.063	CLAYS	2	3						20			1	2				3	1								2	3				
0.074	SAND	2	3		0	1	0	0	21	0	0	1	2	1	1		4	1	1	0	0		0	0	1	3	3	0	1	0	56
9.500	GRAVEL	100	100		89	100	100	100	100	100	100	96	100	100	100		100	100	100	100	100		100	100	100	100	100	100	100	100	100
Miscellaneous																															
Percent moisture																															
Volatile solids (mg/kg)		3200	3080	6000	7000	3000	3900	3780	21200	4000	6000	3540	3000	1820	1450		3540	3080	1020	1190	5000		2870	7000	3710	3850	3710	870	2620	7000	44300
COD (mg/kg)		585	1686	772	980	527	1600	1300	16000	< 481	< 453	952	956	1500	1700		803	730	2200	2800	< 515		550	< 400	1700	959	1713	1800	2000	5867	48000
Ammonia nitrogen (mg/	<	0.2	< 0.2			< 0.5	6.7	5.9	40.0			< 0.2	< 0.2	0.5	0.5	<	0.2	0.6	0.7	0.7			3.5		6.4	< 0.2	< 0.2	0.4	1.2		40.0
Kjedahl nitrogen (mg/kg)		26	35	48	44		600	460	1280	117	42	68	44	130	250		177	44	260	200	66		160	13	220	29	82	220	170	273	6300
Total Phosphorus (mg/kg)		94	111	232	227	672				235	188	270	233	67	240		270	186	140	35	117			229		147	184	180	35	166	1300
Oil & Grease (mg/kg)	<	50	< 50	85	80	185	0	0		101	126	< 50	< 5	0	0	<	50	< 50	0	0	801		0	756	0	< 50	< 50	0	0	624	0

*Note other pesticides and organics have been analyzed by the various agencies. The parameters listed are only those that have been detected in a least one sample from the river.

KEY FOR DESCRIPTORS

Sampling site

MOUTH OF CHIP. RIVER	1
READS LANDING	2
WABASHA SM BOAT	3
ABOVE CRATS ISLAND	4
R-Bay Lower End of Islan	5
AB. TEEPEEOTA POINT	6
L-Bay Down. of Disposal	7
GRAND ENCAMPMENT	8
BEEF SLOUGH	9
ALMA SM BOAT	10

Habitat Type

Main channel	1
Boat Harbors	2
Backwaters	3

Sampling Gear

Large Ponar dredge	1
Petite Ponar or Eckman dredge	2

Data citation

Corps of Engineers	COE
Fish and Wildlife Service	FWS

Attachment 4

DISTRIBUTION LIST

The Draft Definite Project Report/Environmental Assessment will be sent to the following agencies and interests:

Congressional
Sen. Robert W. Kasten, Jr. (Madison)
Sen. Herbert Kohl (Madison)
Rep. Steve Gunderson (Black River Falls, WI)

Federal
Cmndr, Coast Guard (St. Louis)
Department of Transportation (Chicago)
Environmental Protection Agency (Chicago)
U.S. Fish and Wildlife Service
National Park Service (Omaha)
Soil Conservation Service (Madison, St. Paul)
Advisory Council on Historic Preservation (Wash D.C.)
Office of Environmental Compliance - DOE (Wash D.C.)
Office of Environmental Project Review - DOI (Wash D.C.)

State of Minnesota
Governor of Minnesota
Department of Administration (St. Paul)
Department of Natural Resources (Frontenac)
Department of Ener, Econ & Dev. (St. Paul)
Department of Health (Minneapolis)
Pollution Control Agency (St. Paul)
State Archaeologist (Cass Lake)
State Planning Agency (St. Paul)
Water and Soil Resources Bd. (St. Paul)

State of Wisconsin
Governor of Wisconsin
Department of Administration (Madison)
Department of Agricultural (Madison)
Department of Health & Soc. Serv. (Madison)
Department of Natural Resources (Madison; La Crosse; Alma)
Department of Transportation (La Crosse)
State Historic Preservation Officer (Madison)
State Archaeologist (Madison)
State Conservationist (Madison)
Bureau of Water Reg. and Zoning (Madison)

Other
Alma Rod and Gun, (Alma, WI)
Ducks Unlimited (Minneapolis)
Izaak Walton League (Minneapolis)
Upper Mississippi River Basin Assoc. (St. Paul)
MN/WI Boundary Area Commission (Hudson, WI)

Counties
Buffalo
Wabasha

Local interests too.

Attachment 5

CORRESPONDENCE

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny, Secretary
Box 7921
Madison, Wisconsin 53707
TELEFAX NO. 608-267-3579
TDD NO. 608-267-6897

September 26, 1990 IN REPLY REFER TO: 1490

Colonel Roger L. Baldwin
District Engineer
U. S. Army Corps of Engineers
1421 U.S. Post Office and Custom House
St. Paul, MN 55101-1479

Dear Colonel Baldwin:

I understand the Corps of Engineers requires a letter of support from state resource management agencies before you can proceed with construction of projects authorized by the Mississippi River Environmental Management Program.This is to inform you that the Department does indeed support construction of the Indian Slough Habitat Rehabilitation and Enhancement Project as described in the draft Indian Slough Definite Project Report.

Upon completion and final acceptance of the project by the Corps of Engineers and the Fish and Wildlife Service, the Department agrees to cooperate with the Fish and Wildlife Service and the Corps of Engineers to assure that operation, maintenance, and any mutually agreed upon rehabilitation, as described in the Definite Project report, will be accomplished in accordance with Section 906(e) of the Water Resources Development Act of 1986 and the 5th Annual addendum of the Upper Mississippi River Environmental Management Program.

I look forward to seeing the project completed and the benefits it will provide to the Mississippi River System.

Sincerely,

C. D. Besadny

C. D. Besadny
Secretary

EARTH YEAR
WISCONSIN
1970 1990

Minnesota Pollution Control Agency
520 Lafayette Road, Saint Paul, Minnesota 55155
Telephone (612) 296-6300

Celebrate MINNESOTA 1990

August 31, 1990

Colonel Roger L. Baldwin
District Engineer
St. Paul District
U.S. Army Corps of Engineers
1421 U.S. Post Office & Custom House
St. Paul, Minnesota 55101-9808

Dear Colonel Baldwin:

RE: Section 401 Certification Request
Environmental Management Program, Habitat Rehabilitation Enhancement Project
Robinson Lake, Wabasha County

This is in response to your letter to the Minnesota Pollution Control Agency (MPCA) dated August 8, 1990. That letter requested Section 401 Certification for the work related to the referenced project.

The referenced project involves a proposal to construct a 30-inch thick layer of rock to be placed along the openings of two channels leading into Robinson Lake. The work is intended to control suspended sediment and bedload that would go from the main channel into Robinson Lake backwater area. The rock would not only serve the purpose of stabilizing the channel openings but would also reduce the existing cross sectional area of these openings by approximately 50 percent. The Definite Project Report indicates that conditions in Robinson Lake would be monitored by taking flow measurements along the two channel entrances. Alterations in flow would be used as an indicator of changes of sediment input into the lake.

The MPCA will waive certification of the referenced project since, if properly conducted, the project impacts do not appear to be significant as defined by present water quality standards. The project should generally be conducted in a manner which would minimize the turbidity and habitat destruction associated with rock placement, to the maximum practicable extent.

The Robinson Lake project is a small portion of a larger project being conducted on the Wisconsin side of the Mississippi River. Work on the Wisconsin side is being conducted in areas known as Big Lake and Indian Slough.

The work on the Wisconsin side involves closure to the channels similar to closures proposed in Minnesota. Additional habitat modifications in Big Lake are also proposed. It is our understanding that a small hydraulic dredge would be used to place fine material in an upland disposal site, and place granular material as fill for the channel closures. Rock materials would be used to armor the granular fill. Sediment sampling was conducted by the Corps and the results of those samples were submitted by memo dated August 6, 1990. The results did not show any detectable levels of organic materials of concern. However, in response to the sampling information, the state of Wisconsin raised some concerns regarding the reporting and coordination procedures related to the sediment sampling. We support Wisconsin's position with regard to their concerns.

The state of Wisconsin will be taking a lead position with regard to Section 401 Certification and other requirements related to the project. However, the MPCA feels that we retain some rights with regard to Section 401 Certification since the project affects interstate waters. We request that once Wisconsin has developed the final position with regard to the project, we will be notified of their position and be given an opportunity to comment. We also request that you continue to coordinate with the MPCA in order to avoid delays and potential misunderstanding.

This letter does not approve activities beyond those specified above. It does not waive your responsibility to obtain any other permits or approvals which may be required by other state or federal laws nor does it grant any right to violate personal or property rights.

If you have any questions regarding our position on these projects, please feel free to contact Mr. Louis Flynn of my staff at (612) 297-3364.

Sincerely,

Gerald L. Willet

Gerald L. Willet
Commissioner

GLW:ach

cc: Mr. Ron Nargang, Minnesota Department of Natural Resources
Mr. Robert F. Welford, U.S. Fish and Wildlife Service
Mr. Bill Franz, U.S. Environmental Protection Agency, Chicago, IL
Mr. Steve Johnson, Mississippi River Coordinator, MDNR
Mr. John F. Sullivan, Wisconsin DNR, LaCrosse, Wisconsin

United States Department of the Interior

FISH AND WILDLIFE SERVICE
FEDERAL BUILDING, FORT SNELLING
TWIN CITIES, MINNESOTA 55111

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

FWS/ARW-SS

JUL 6 1990

Colonel Roger L. Baldwin
District Engineer
U. S. Army Engineering District, Saint Paul
1421 U. S. Post Office and Custom House
Saint Paul, Minnesota 55101-1479

Dear Colonel Baldwin:

The U.S. Fish and Wildlife Service (Service) has reviewed the Definite Project Report/Environmental Assessment (SP-8) dated June 1990 for the Indian Slough Habitat Rehabilitation and Enhancement Project. This project, located in Pool 4 of the Mississippi River, is proposed under the Water Resources Development Act of 1986 (Public Law 99-662) as part of the Upper Mississippi River System Environmental Management Program.

The Indian Slough project has been coordinated with the Service, and we approve and support the project as planned and described in the Definite Project Report. The Service agrees with the preferred alternative described in the Environmental Assessment. On April 6, 1990, the Refuge Manager, Upper Mississippi River National Wildlife and Fish Refuge, found the project compatible with the purposes for which the refuge was established.

The Service will assure that operation and maintenance requirements of the project will be accomplished in accordance with Section 906(e) of the Water Resources Development Act of 1986. The Service will perform the operation and maintenance requirements for this project, the riprapped bank upstream of the partial closure structure, in accordance with the policies stated in the Fourth Annual Addendum.

This project being in part located on Service lands, the Service will complete its finding of no significant impact upon learning from you that the public review period produced no substantive changes in the Definite Project Report/Environmental Assessment.

We look forward to our continued cooperative efforts in developing habitat rehabilitation and enhancement projects under the Environmental Management Program.

Sincerely,

Marvin E. Moriarty
Acting Regional Director

United States Department of the Interior

OFFICE OF THE SECRETARY
OFFICE OF ENVIRONMENTAL AFFAIRS
230 S. DEARBORN, SUITE 3422
CHICAGO, ILLINOIS 60604

TAKE PRIDE IN AMERICA

August 9, 1990

ER 90/596

Colonel Roger L. Baldwin
District Engineer
U.S. Army Engineer District
St. Paul
1421 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

Dear Colonel Baldwin:

The Department of the Interior (Department) has reviewed the Draft Report and Environmental Assessment for Indian Slough, Buffalo County, Wisconsin, and concurs with the recommended plan.

Thank you for the opportunity to provide comments.

Sincerely,

Sheila Minor Huff

Sheila Minor Huff
Regional Environmental Officer

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REPLY TO THE ATTENTION OF:

- 1 AUG 1990

Mr. Louis Kowalski
Department of the Army
St. Paul District, Corps of Engineers
1421 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Mr. Kowalski:

We have reviewed the Definite Project Report/Environmental Assessment for Indian Slough Habitat Rehabilitation and Enhancement Project. The purpose of the project is to rectify conditions created by the Crats Island dredging material placement site, and rehabilitate, enhance and maintain the diverse riverine habitat for fish and wildlife in the study area. The project would consist of one of five alternatives. The alternatives that were considered included no action, closure of fourth wing dam, narrow/deeper portion of Indian Slough above and below Whorehouse Slough, channel dredging in Big Lake Bay, and a riffle/pool complex. The objective of the project would be to reduce the amount of sedimentation by fifty percent in the backwater area, obtain a 5 mg/l dissolved oxygen level throughout winter and summer high thermal conditions for approximately 12 of the 75 acres of aquatic habitat. To enhance 11 acres of Indian Slough for lithophilic fish species. The selected plan would consist of partial closure structure in Indian Slough, channel dredging, and the riffle/pool complex. The material that will be removed from the channel will be used to dress the dredge material placement site.

Based on the information provided, our Agency has no objections to the proposed project. The use of routine measures to maintain water, air, and noise quality should be adequate to offset any short or medium term impacts. The project should reestablish valuable habitats that have long since been degraded. We would appreciate the opportunity to attend inspection trips, once the project has been completed.

Thank you for the opportunity to comment on the EA for Indian Slough. If you have any questions or comments, please contact Al Fenedick at 312/88-6872.

Sincerely yours,

William D. Franz

William D. Franz, Chief
Environmental Review Branch
Planning and Management Division

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Western District Headquarters
1300 W. Clairemont Avenue
Call Box 4001
Eau Claire, WI 54702-4001

Carroll D. Besadny
Secretary

August 14, 1990 File Ref: 3500

Mr. Louis Kowalski
Chief, Planning Division
Department of the Army
St. Paul District, Corps of Engineers
1421 U.S. Post Office & Custom House
St. Paul, MN 55101-1479

Dear Mr. Kowalski:

The Wisconsin Department of Natural Resources has examined the application of the Corps of Engineers for Water Quality Certification for the Pool 4 HREP project (Indian Slough), Mississippi River, Buffalo County, Wisconsin. This project involves the construction of a partial closing structure, dredging a portion of Big Lake Bay, and the construction of a riffle/pool complex. The overall goal of the project is to reduce sedimentation into Big Lake Bay and to provide additional in-water habitat.

The Department is granting Water Quality Certification because there is reasonable assurance that the activity will be conducted in a manner that will not violate the standards enumerated in NR 229.05(1), Wisconsin Administrative Code.

The certification is granted provided the following conditions are met:

1. The Wisconsin Department of Natural Resources should have an opportunity to review and approve the design of the confined disposal facility for fine materials. The facility should be constructed to ensure any carriage water (other than infiltration) be routed to the Crats Island Channel maintenance containment area.

2. The results of the follow-up bulk sediment analysis from Big Lake should be within the range normally encountered for backwater sediment as indicated in the St. Paul COE District's standard operating procedure for HREP projects.

3. Sediment borings should be collected from Whorehouse Slough to determine the suitability of bed materials for the closing structure. Only sand material (greater than 90 percent P200) should be used for the closing structure.

4. In order to minimize downstream loss of materials during hydraulic placement of sand for the closing structure, the current velocity (discharge) of Indian Slough should be reduced during the period of closure construction.

5. At least five working days prior to the beginning of the discharge, the applicant shall notify the Department of its intent to commence dredging. Please notify John Sullivan at La Crosse, Wisconsin, (608) 785-9995.

6. Within five days after the completion of the discharge, the applicant shall notify the Department of the completion of the project. Please notify John Sullivan at La Crosse, Wisconsin, (608) 785-9995.

7. The applicant shall allow the Department reasonable entry and access to the discharge site in order to inspect the discharge for compliance with the certification and applicable laws.

8. The project shall be completed as described.

Sincerely,

Edward J. Bourget
District Water Management Supervisor

c: Terry Moe - LAX
John Sullivan - LAX
Ron Benjamin - Alma
WZ/EB070.sz

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

Upper Mississippi River National Wildlife and Fish Refuge
51 East 4th Street
Winona, Minnesota 55987

May 4, 1990

Ms. Mary Schommer
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
180 E. Kellogg Blvd.
St. Paul, Minnesota 55101

Dear Ms. Schommer:

This provides U.S. Fish and Wildlife Service (Service) comments on the Definite Project Report and Environmental Documentation (SP-8) for the Indian Slough Habitat Rehabilitation and Enhancement Project. This project will benefit the fisheries resources of the refuge and is an excellent example of a cooperatively planned project between the U.S. Army Corps of Engineers and other participating agencies.

The project is being built on federal lands managed as part of the Upper Mississippi River National Wildlife and Fish Refuge (Refuge), therefore, a Refuge compatibility determination and Refuge approval is needed before the project can be constructed. Attached is a signed compatibility determination for the selected alternative discussed in this draft report. Approval of the project will be formally provided by the Regional Director after completion of the final project report.

The final draft definite project report must include a copy of the draft Memorandum of Agreement for operation, maintenance, and rehabilitation. In accordance with the Fourth Annual Addendum the Fish and Wildlife Service will cover operation and maintenance costs as discussed in this report. The Regional Director's letter on the final draft definite project report will include the certification of support for operation and maintenance.

The limits of detection provided for PCB aroclors were too high to provide worthwhile information relative to possible bioaccumulation of total PCBs by fish or other aquatic organisms inhabiting the Big Lake Bay dredged area. If the contract laboratory hasn't retained sample homogenate for Site 1 Bottom and Site 2 Bottom, additional sediment core samples should be collected from two sites within the proposed dredged area. Portions of each core corresponding to the finished dredged depth plus and minus one foot should be analyzed for PCBs with limits of detection of 50 ug/kg for estimated total PCBs.

It is our understanding that you are collecting additional information on the impacts of the partial closure structure on other areas i.e., Robinson Lake. We will be interested in reviewing this information as it becomes available.

We agree completely with your determination that the only suitable area for the dredged material from Big Lake Bay area is the sandy area above and below the Crats Island Channel Maintenance Containment area.

Based on information contained in the review documents and the nature of the proposed project, its location, and the habitat requirements of the federally threatened bald eagle (Haliaeetus leucocephalus), endangered Higgins' eye pearly mussel (Lampsilis higginsi) and peregrine falcon (Falco pereqrinus), we support your determination that the proposed project will not affect federally listed endangered or threatened species. This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended. Should this project be modified or new information indicates listed species may be affected, consultation with this office should be reinitiated.

These comments have been prepared under the authority of and in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; U.S.C. 661 et. seq.) and are consistent with the intent of the National Environmental Policy Act of 1969.

The report illustrates the cooperation evident between the U.S. Army Corps of Engineers and the Service. These efforts at working together on this project as well as the environmental management program as a whole help ensure the success of mutual concerns for improvements on the Upper Mississippi River System.

Sincerely,

Richard F. Berry

Richard F. Berry
Complex Manager

Enclosure

cc: SPFO
LTRM
Winona FAO
WIDNR-Alma, WI
Winona District

Upper Mississippi River National
Wildlife and Fish Refuge
Established 1924

Compatibility Study
Indian Slough Rehabilitation

Establishment Authority:

Public Law No. 268, 68th Congress, The Upper Mississippi River Wildlife and Fish Refuge Act.

Purpose for Which Established:

"The refuge shall be established and maintained (a) as a refuge and breeding place for migratory birds included in the terms of the convention between the United States and Great Britain for the protection of migratory birds, concluded August 16, 1916 and (b) to such extent as the Secretary of Agriculture may by regulations prescribe, as a refuge and breeding place for other wild birds, game animals, fur-bearing animals, and for the conservation of wild flowers and aquatic plants and (c) to such extent as the Secretary of Commerce may by regulations prescribe a refuge and breeding place for fish and other aquatic animal life."

Description of Proposed Use:

The proposal is a Habitat Rehabilitation and Enhancement project authorized by the Water Resource Development Act of 1986 (Pub. L. 99-662). The proposed project will be constructed in Indian Slough and the Big Lake backwater complex located in Pool 4 immediately downstream of Highway 25. The project will include the following features:

A. Build a partial closing structure in Indian Slough to reduce sediment load in Indian Slough and Big Lake backwater complex.

B. Dredge Whorehouse Slough to restore flow to prevent the area from becoming stagnant in the summer and winter and subsequently improve the fisheries.

C. Restore some of the deep water habitat (5 feet) by dredging up to 11 acres in Big Lake Bay area.

D. Dispose of the fine material dredged from Big Lake Bay in the Crats Island Channel Maintenance Containment area. This will provide a better topsoil for this area which is now very sparsely vegetated.

E. Create a riffle/pool complex in Indian Slough to improve the area for lithophillic fish species, such as smallmouth bass.

Complete details of the project, including maps and drawings, are contained in the draft report entitled, "Upper Mississippi River System Environmental Management Program Definite Project Report with Integrated Environmental Assessment (SP-8) Indian Slough Rehabilitation and Enhancement, Pool 4, Upper Mississippi River, Buffalo County, Wisconsin" prepared by the St. Paul District, Corps of Engineers.

Anticipated Impacts on Refuge Purposes:

As a result of the project the fish and wildlife populations should increase which will be a direct benefit toward maintaining and accomplishing refuge purposes. The above mentioned report contains detailed information on the project's impacts on fish and wildlife resources.

Justification:

The proposed project works toward the accomplishments of the stated objectives of the refuge.

Determination:

The proposed project is compatible with purposes for which the refuge was established.

Determined by: Berry 4/6/90 _____ Refuge Manager — 4/6/90 Date

Reviewed by: _____ Acting WAM-1 — 4/26/90 Date

Concurred by: _____ Acting Regional Director — 5/1/90 Date

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1421 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101-1479

REPLY TO
ATTENTION OF

June 25, 1990

Planning Division
Flood Plain Management
and Small Projects

Mr. Richard Berry
U.S. Fish and Wildlife Service
51 East 4th Street
Winona, Minnesota 55987

Dear Mr. Berry:

Thank you for your comments on the draft Definite Project Report/Environmental Assessment, Indian Slough Habitat Rehabilitation and Enhancement Project. In response to your most significant comment on PCB's, we do not believe (based on the data that was collected for this project and by others in the general area) that there is a problem with this substance or with other contaminants. However, we are presently resampling the sediments for PCB's. This information will be sent to your agency when it becomes available.

Enclosed are comments received from the Minnesota Department of Natural Resources during this preliminary review, as well as our response to these comments. None have been received to date from the Wisconsin Department of Natural Resources.

The draft report will be going out for public review concurrent with this letter. If you have any further comments you wish us to address or any questions about our enclosed responses please feel free to contact Mary Schommer, project manager (612-220-0282).

Sincerely,

Louis Kowalski

Louis Kowalski
Chief, Planning Division

Enclosures

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

Celebrate MINNESOTA 1990

PHONE NO.

FILE NO.

April 30, 1990

Mississippi River System Management Team
Route 2, Box 230
Lake City, Minnesota 55041
(612) 345-3331

Ms. Mary Schommer
Department of the Army
St. Paul District Corps of Engineers
1421 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Ms. Schommer:

The Department of Natural Resources has completed its review of the preliminary draft Definite Project Report for the Indian Slough Habitat Rehabilitation and Enhancement Project. The project should prove to be very beneficial to the Mississippi River and the DNR fully supports the proposed project. Listed below are comments and suggestions based on our review of the document and concerns raised during the April 18, 1990 public meeting. Many of our comments make note of areas in the document that need further explanation for those readers and government reviewers that do not have an extensive background in aquatic ecosystems and fisheries biology.

page 5. The term "fast land" is used extensively in the document but is never defined. While one can get a definition of the term from the context of the sentence in which it is used it may be beneficial to explicitly define the term.

page 9. Feet, inches and centimeters are used in two consecutive sentences to describe sedimentation rate. It may be helpful use all the same units to describe sedimentation.

page 16. Existing and Future Habitat Deficiencies. In the first paragraph it is stated that the increase in aquatic plants contributes to low winter dissolved oxygen and high summer thermal conditions. In the second paragraph the lack of large vegetated areas is one reason given for the poor winter habitat for centrarchids. These two statements seem to be contradictory. We suggests you drop the first reference to aquatic plants contributing to low winter dissolved oxygen and high summer thermal conditions or qualify the statement with more of an explanation.

page 16 and 17. The high current velocities and low winter temperatures in Big Lake are described as generally undesirable for wintering bluegills. On page 25 the discussion argues that the creation of deeper open water tied into the present Big Lake Bay deep water circulation will create/enhance centrarchid habitat. Perhaps the Corps could expand the discussion on what conditions are best for wintering centrarchids in relation to the project design and existing conditions in order to explain what appears to be a contradiction in the document. Also, it is our belief that the deeper habitat will provided a temperature and dissolved oxygen refuge because of thermal and dissolved oxygen gradients rather than an increase in circulation (advective or convective).

page 24. "...it was determined that no riprap would need to be placed on either side of these eroding banks; nor should it be required elsewhere along Indian Slough." This is inconsistent with page 31 under "Hydraulic Impacts..." which calls for riprap along a portion of Indian Slough.

page 27. It would be helpful if a picture or a diagram of a Wisconsin Crib was provided for review.

page 27. Current velocity. The first sentence states "Smallmouth bass generally prefer no or very slow current." The paragraph then goes on to talk about riffles without a transition statement explaining why riffles are a desired component of the HREP.

page 32. The DPR indicates that a reduction of flow down Indian Slough may increase flow volumes into Robinson Lake. An increase in flow may increase sedimentation rates which are already perceived as unacceptably high. The DNR suggests that the Corps further evaluate the possible impacts and consequences that the Indian Slough HREP may have on Robinson Lake. Based on this further evaluation, the Indian Slough HREP scope of work may need to be expanded or modified to address concerns regarding Robinson Lake.

page 33. Plate 11 is referenced as showing the location of the potential dredge disposal sites. Plate 11 does not show the locations in any detail. It would be helpful if an additional plate was added showing the relationships between the two identified dredge disposal areas, the berms to be constructed, the possible carriage return water route and the Crat's dredge disposal site.

page 34. Perhaps it should be stated that trees near the water's edge (potential eagle perching trees) will not be used to create the snags in the slough.

page 34. It is implied that the use of the small "mudcat" dredge and the dredge material disposal sites will allow the project to meet water quality standards. On page 7 of the 404(b) evaluation in Attachment 3 it is stated that the effluent and turbidity plumes would exceed the State of Wisconsin 80 mg/l standard for suspended solids. Perhaps the discussion on page 34 should be rewritten to explicitly state what is expected to happen during the project dredging operation with regard to water quality.

Attachment 3. Section 404(b)(1) Evaluation Report. The DNR has discussed the sediment quality data results for the three locations in Big Lake with appropriate personnel at the Pollution Control Agency. The DNR and PCA find the sediment quality data insufficient in a couple of areas. The results for the laboratory samples spiked with organic compounds for Quality Assurance/ Quality Control purposes do not provide a useful check as to how well the laboratory performed the sediment analyses. Also, the detection limits for some of the PCB compounds are not low enough to determine if PCBs could be of concern.

Assuming that additional Quality Assurance/Quality Control information would have been provided to verify the reported findings if it was available, the DNR and PCA suggest that at a minimum the Corps resample and reanalyze the sediments for the complete list of pesticides and herbicides at the proposed project depth. The DNR is satisfied with the plans outlined to handle the dredged material once it is removed from Big Lake. Resampling and analysis of the sediments at project depth is suggested in order to evaluate the quality of the sediment that will be left exposed once the project is completed.

The manganese concentration as site 2 is elevated (1640 mg/kg) in comparison to the values at the other sites and may be of potential concern.

This last minute kind of input from various participating agencies could probably be avoided if the sediment quality data could be distributed in a table much like the one provided in the Evaluation Report early on in the process, accompanied with a first cut Corps interpretation of the results. It is my understanding that the sediment information was distributed early on to the appropriate agencies in raw data form with no Corps interpretation which led to its position on the bottom of most peoples "in" basket.

The DNR and PCA believe that the DPR should; (1)reference the "Standard Operating Procedure for Sediment Evaluation of Habitat and Rehabilitation Projects within the St. Paul District, U.S. Army Corps of Engineers", (2)describe how this procedure is being followed and (3)provide a detailed description of the results. If the Corps decides not to proceed to the next tier of tests in the "Procedure", then the rationale for making such a decision should be detailed.

Thank you for the opportunity to comment on the preliminary draft of the Indian Slough Definite Project Report. Please let Scot Johnson of my staff know if we can be of any further assistance in your planning efforts.

Sincerely,

Steve Johnson
Mississippi Team Coordinator

cc. Larry Gates, Lake City Fisheries
Dan Helwig, Pollution Control Agency
Ron Benjamin, Wisconsin DNR
Dennis Anderson, Corps of Engineers

Response to MNDNR Comments on
Indian Slough
Habitat Rehabilitation and Enhancement Project
Definite Project Report

1. To avoid confusion, the term "fastland" has been replaced with "land".

2. Concur. One unit of measure is now being used.

3. The comments are referring to two different habitat areas in the project area. To maximize values for centrarchids, you need a combination of vegetated areas and open water areas. Therefore, either too little vegetation or too much vegetation can make particular areas less suitable for centrarchids.

4. We agree that the primary advantage of the creation of the deeper water areas will be because of the increased volume of water created which should create a dissolved oxygen and temperature refuge. Our discussion on page 25 concentrates on this being the primary benefit. The project should slightly increase circulation rates in Big Lake Bay, which will add to this benefit. The current velocity is projected to only slightly increase in Big Lake Bay and any increase would be substantially below what is presently occurring in Big Lake proper and should not adversely affect bluegill use. The primary purpose of connecting the deepwater habitat created in Big Lake Bay is to ensure that there is fish escape route should conditions in Big Lake Bay degrade under severe winter conditions.

5. Riprap referred to in the Hydraulic Impacts section is upstream of the proposed partial closure structure. It would be put in place to stabilize fill added to a low spot present in the existing bank. Its purpose is to prevent breakout flow which could establish another channel into the backwater area. The riprap on page 24 refers to erosion protection downstream of the partial closure structure which was determined to be unnecessary because of the lowered flows that would be present with this structure in place.

6. Concur.

7. The reasons stated for the rationale for the riffles are stated in previous sections including section 1.General on page 26. This particular section is designed to provide the rationale for the target current velocity in both the riffles and pools.

8. Concur. Following additional study of the Robinson Lake area, placement of rock along the two channels which enter the lake is being proposed to minimize impacts to the lake. The report has been revised to reflect these changes.

9. Concur.

10. Concur. The report has been changed to reflect comment.

11. The intent of the section on page 34 is to describe the proposed construction methods. It is not a discussion of the water quality effects. Based on our best estimate, we anticipate that no effluent would be generated. However, if an effluent is generated, because of the fine nature of the dredge material the Wisconsin Standard of 80 mg/l is likely to be exceeded.

12. The remaining comments concern the sediment analyses and are addressed as a whole. We have a Standard Operating Procedure for Sediment Analysis for HREP's, that has been adopted by all the appropriate regulatory agencies. The sampling, analysis, and coordination of the results followed these procedures. The results of the analyses were sent in November, 1989 to the designated sediment contaminants person in the appropriate agency, for their review and comment. A summary table of the sediment data; the contractor's report, including the QA/QC data and the laboratory sheets; a map depicting the sampling sites; and a general cover letter were sent out in this package in November. In the cover letter we concluded that based on the nature of the project and the sediment quality data that we would be preceding with the project, without any additional testing. In the letter we asked for your opinion on this information and if you would like to have a meeting. No responses were received. We are now confused by your comments on sediment quality at this stage. The whole concept of the development of the Standard Operating Procedure, which was followed in this project planning, was to avoid these last minute type of comments. We do not believe, based on the data that was collected for this project and the data collected by others in the general area, that there is a problem with PCB's or other contaminants. We will, however, resample the sediments for PCBs and provide this information to your agency.

THE STATE HISTORICAL SOCIETY OF WISCONSIN

H. Nicholas Muller III, Director

816 State Street
Madison, Wisconsin 53706
608/262-3266

Octobr 3, 1989

Mr. Gary Palesh
Chief, Environmental Resources Branch
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

SHSW: 89-1343
RE: Restore Aquatic Habitat in Pool 4, Mississippi

Dear Mr. Palesh:

We have reviewed the materials that you submitted concerning the proposed habitat improvement project in Pool 4 of the Mississippi River that were described in your letter of May 16, 1989.

As it appears that all work proposed will only affect newly created land/islands, we do not believe that the proposed undertakings would have any effect on properties that are listed in, or eligible for inclusion in, the National Register of Historic Places. Should other lands be affected, please let us know.

Sincerely,

Richard W. Dexter
Chief, Compliance and Archeology Section
DIVISION OF HISTORIC PRESERVATION

RWD:da
2096N

Attachment 6

MEMORANDUM OF AGREEMENT

MEMORANDUM OF AGREEMENT

BETWEEN

THE UNITED STATES FISH AND WILDLIFE SERVICE

AND

THE DEPARTMENT OF THE ARMY

FOR

ENHANCING FISH AND WILDLIFE RESOURCES

OF THE

UPPER MISSISSIPPI RIVER SYSTEM

AT THE

INDIAN SLOUGH

BUFFALO COUNTY, WISCONSIN

I. PURPOSE

The purpose of this Memorandum of Agreement (MOA) is to establish the relationships, arrangements, and general procedures under which the U.S. Fish and Wildlife Service (FWS) and the Department of the Army (DOA) will operate in constructing, operating, maintaining, repairing, and rehabilitating the Indian Slough separable element of the Upper Mississippi River System - Environmental Management Program (UMRS-EMP).

II. BACKGROUND

Section 1103 of the Water Resources Development Act of 1986, Public Law 99-662, authorizes construction of measures for the purpose of enhancing fish and wildlife resources in the Upper Mississippi River System. The project area is located on lands managed as a national wildlife refuge. Therefore, under conditions of Section 906(e) of the Water Resources Development Act of 1986, Public Law 99-662, all construction costs of those fish and wildlife features for the Indian Slough Project are 100% Federal, and all operation, maintenance, repair, and rehabilitation costs are to be cost shared 75% Federal and 25% non-Federal.

III. GENERAL SCOPE

The Indian Slough project would reduce sediment-laden flows into the Indian Slough/Big Lake backwater complex through the construction of a partial closure structure. This decrease in sedimentation allows the placement of a riffle/pool complex and dredging in Big Lake Bay, additional habitat improvement features in this area.

IV. RESPONSIBILITIES

A. DOA is responsible for:

1. Construction: Construction of the Project which consists of sharing in the building of a partial closure structure at the upper end of Indian Slough; building a riffle/pool complex with two riffles and two pools in the lower end of Indian Slough; and dredging a 3,000-foot-long open area in Big Lake Bay. The location of the partial closure structure was ultimately determined based on environmental considerations; therefore, the cost of this structure which is primarily being constructed with Corps operation and maintenance (O&M) funds will be shared under the Habitat Rehabilitation and Enhancement Program (HREP) authority. The division of costs will be apportioned in the following manner:

(least costly site/selected site) * 100 = percent paid under O&M
100 - percent paid under O&M = percent paid under HREP

2. Major Rehabilitation: Any mutually agreed upon rehabilitation of the project that exceeds the annual operation and maintenance requirements identified in the Definite Project Report and that is needed as a result of specific storm or flood events.

3. Construction Management: Subject to and using funds appropriated by the Congress of the United States, DOA will construct the Indian Slough project as described in the Definite Project Report, Indian Slough, Habitat Rehabilitation and Enhancement, dated September 1990, applying those procedures usually followed or applied in Federal projects, pursuant to Federal laws, regulations, and policies. The FWS will be afforded the opportunity to review and comment on all modifications and

change orders prior to the issuance to the contractor of a Notice to Proceed. If DOA encounters potential delays related to construction of the Project, DOA will promptly notify FWS of such delays.

4. Maintenance of Records: DOA will keep books, records, documents, and other evidence pertaining to costs and expenses incurred in connection with construction of the Project to the extent and in such detail as will properly reflect total costs. DOA shall maintain such books, records, documents, and other evidence for a minimum of three years after completion of construction of the Project and resolution of all relevant claims arising therefrom, and shall make available at its offices at reasonable times, such books, records, documents, and other evidence for inspection and audit by authorized representatives of the FWS.

B. FWS is responsible for:

1. Operation, Maintenance, and Repair: Upon completion of construction as determined by the District Engineer, St. Paul, the FWS shall accept the Project and shall operate, maintain, and repair the Project as defined in the Definite Project Report entitled "Indian Slough Habitat Rehabilitation and Enhancement," dated September 1990, in accordance with Section 906(e) of the Water Resources Development Act, Public Law 99-662.

2. Non-Federal Responsibilities: In accordance with Section 906(e) of the Water Resources Development Act, Public Law 99-662, the FWS shall obtain 25% of all costs associated with the operation, maintenance, and repair of the Project from the Wisconsin Department of Natural Resources.

V. MODIFICATION AND TERMINATION

This MOA may be modified or terminated at any time by mutual agreement of the parties. Any such modification or termination must be in writing. Unless otherwise modified or terminated, this MOA shall remain in effect for a period of no more than 50 years after initiation of construction of the Project.

VI. REPRESENTATIVES

The following individuals or their designated representatives shall have authority to act under this MOA for their respective parties:

FWS: Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

DOA: District Engineer
U.S. Army Engineer District, St. Paul
1421 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-9808

VII. EFFECTIVE DATE OF MOA

This MOA shall become effective when signed by the appropriate representatives of both parties.

THE DEPARTMENT OF THE ARMY

BY:
(signature)
ROGER L. BALDWIN
Colonel, Corps of Engineers
St. Paul District

Date

THE U.S. FISH AND WILDLIFE SERVICE

BY:
(signature)
JAMES C. GRITMAN
Regional Director
U.S. Fish and Wildlife Service

Date

APPENDIX A

INDIAN SLOUGH

ENVIRONMENTAL MANAGEMENT PROGRAM

ST. PAUL DISTRICT

HYDRAULICS AND SEDIMENT ANALYSIS SECTION

FEBRUARY 1990

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

GENERAL

Indian Slough is a backwater channel leaving the main channel of the Mississippi River across from Wabasha Minnesota. Sediment from the Mississippi River has been degrading the backwater habitat of Indian Slough and Big Lake. The purpose of this study is to reduce the sedimentation threat to this area.

The study area may be seen on Plate 1. The study area starts at the Mississippi River where Indian Slough begins (approximately at river mile 760.0). (This is at the tip of a sand spit, the origins of which will be discussed below.) The study area extends through Indian Slough and its delta distributaries, Truedale Lake and Truedale Slough, and Big Lake.

On or around 1938 a dredge disposal facility called Crats Island disposal site was started in the old river channel just downstream of the original entrance to Indian Slough at river mile 759.5. The facility began as an island within the channel and gradually increased in size. By 1965 the facility had become attached to the left bank of the river. Following this attachment, aerial photographs show a significant trend of widening in Indian Slough. A sand spit has grown from the disposal area in an upstream direction progressively moving the mouth of the slough in a north-westerly direction. The disposal facility created the obstruction in the river which has increased Mississippi River stages in the immediate vicinity and has caused increased flow down Indian Slough and a corresponding widening of the slough. The increased flow down the slough has brought with it greater volumes of sediment. At the downstream end of the slough, a delta has been growing into Big Lake and in particular has encroached on a bay in the lake called Big Lake Bay. Concern has been voiced over continued delta building into the bay.

The growing delta and the increasing sedimentation in the slough areas has hurt fisheries and waterfowl habitat in Indian Slough and in Big Lake and Big Lake Bay. The purpose of this project is to reduce the amount of sediment passing through Indian Slough, thereby decreasing the adverse impacts on the backwater fishery habitat. A partial closure structure has been proposed to restrict the amount of river flow and accompanying river sediment volumes entering the slough, its backwaters, and Big Lake. The location of the site for this structure has been chosen based on construction costs, environmental impacts, effectiveness, and anticipated longevity. A prediction of the percent reduction of sediment into the Indian Slough system will be established.

ALTERNATIVES

Partial closure structures have been proposed to reduce the flow and sediment transport into Indian Slough. Partial closure structures are considered to be the best way of reducing flow and sediment into the backwaters of Indian Slough. These structures encroach on the channel to restrict flow. The

cross section dimensions and length of this narrow channel affect its discharge capacity and velocity characteristics. Two general layouts for the partial closure structure may be considered. Closure type A will consist of riprapped earth fill extended from the existing river banks into the channel. This filling produces a narrow channel of a particular length. This type of closure has been used successfully at the Weaver Bottoms site at Murphy's Cut. When placed across a wide section, the channels may be constructed by extending embankments from both channel banks. The embankments will extend far enough into the channel to provide the required channel width. They would then be turned in a downstream direction to provide the required channel length. This partial closure layout will be referred to as type B. The expense of riprap protection is generally the primary reason for selecting one configuration over the other.

The partial closure structures will generally be built to the elevation of the surrounding high ground. In the case of the earth filled type of partial closure construction, (Type A) a few feet of additional elevation will be added to reduce the chances of erosion during high water.

The primary effect of the partial closure structure is the reduction of flow and velocities in the slough channel. This reduces the ability of the channel to move sediment. The structure itself, will most likely pass any sediment it receives on into the downstream slough complex. Plates 2 through 6 show the proposed partial closure alternatives. The hydraulic characteristics of the partial closure are not expected to vary significantly due to the location of the closure site. This is because most of the head loss through the slough will occur through the closure structure itself. The slough upstream and downstream of the structure will have fairly flat hydraulic grade lines.

Alternative A would be to locate a partial closure structure at the upstream end of the spit. This closure embankment would extend from the spit end in a northerly direction to tie into the Highway 25 Bridge. This embankment would be the longest of those proposed at approximately 600 feet and would be placed over a wing dam for most of its length. The large channel width at this location would dictate the use of partial closure type B.

Alternative B is located at Wing Dam #63. The type B closure structure would be constructed by adding material to elevate the existing wing dam. The distance across the channel is 450 feet. The length of channel within this closure structure would be 300 feet.

Alternative C would consist of a partial closure structure just upstream of Whorehouse Slough. The width of the channel at this location is approximately 330 feet.

Alternative D is similar to Alternative B in that it utilizes Wing Dam #63. In this case the wing dam would be built up to the bank elevation. The difference would be that the access channel would be constructed through the spit. This would eliminate the need for the construction of the 300 feet of riprapped channel embankment in the middle of the slough.

Alternative E is in the narrows area downstream of Truedale Slough. This alternative would be very similar to Alternative C. A closure at this location would require the least amount of riprap protection. The partial closure structure would be of the type A layout. The width at this location is the smallest of the proposed closure sites at 200 feet.

CONCERNS RELATED TO ALTERNATIVE LOCATIONS

The decision as to which alternative will be constructed will ultimately be made with regard to construction cost, environmental effects, expected effectiveness of the alternative, and the expected longevity of the project.

A major concern for Alternatives A is the stability of the spit. The spit has grown in an upstream direction between the late 1930's and the 1950's. The construction of a partial closure structure would alter the flow pattern in the navigation channel to some extent, and this could cause erosion of the spit. During overtopping flood conditions, the closure structure would cause a head loss across the spit. Overtopping flows could cut a new channel through the spit and thereby allow discharge to bypass the partial closure structure. The river side of the spit would have to be riprapped in addition to the structure itself.

Several of the alternatives are connected on the left bank to the edge of an island bounded by Indian Slough and Whorehouse Slough. The upstream end of Whorehouse slough is closed with an embankment and culvert. Within the island is a pond with a wide channel connection to Indian Slough. Alternatives B, C, and D are downstream of this channel. The channel would have to be closed to prevent Indian Slough from rerouting itself through the pond and into Whorehouse Slough.

As was stated previously, sediment transport is reduced by the reduction in discharge and velocities in the channel. The closure structure itself will pass most of the sediment that it receives. Alternatives A and D locate the partial closure adjacent to the channel of the Mississippi River. A very large concern over these alternatives is that the turbulence of the river may allow for higher concentrations of suspended sand and silt to pass through the partial closure channel.

TWO DIMENSIONAL MODELING

In order to evaluate flow conditions in the study area with and without a project or projects, a two dimensional computer model was used. The two dimensional modeling has been done with the FESWMS computer model developed for the U.S. Department of Transportation Federal Highway Administration by the U.S. Geological Survey. The program uses the finite element method to compute two dimensional flow in the horizontal plane.

The portion of the Indian Slough system modeled in this study consisted of Indian Slough from the upstream end of the spit to a point just downstream of

the entrance of Pontoon Slough. The model also includes Truedale Slough and the portion of Pontoon Slough from its union with Truedale Slough down to Indian Slough.

Network Construction

The finite element grid network for the two dimensional model was constructed from survey data obtained in February of 1989. The existing condition network consists of 262 elements and 949 nodes. Each element is defined by 8 node points. The main trace of Indian Slough from the tip of the spit to the exit of Truedale Slough is modeled with elements six across. Truedale Slough and the remainder of the modeled Indian Slough are modeled with elements three across. Plate 7 shows the finite element network.

Starting Water Surface Rating Curve

The downstream starting water surface elevations for the model were derived from information in the "Mississippi River Nine Foot Channel Navigation Project Reservoir Regulation Manual, Appendix 4, Lock and Dam No.4 Alma Wisconsin". The backwater curves for the Mississippi River were used to compute a rating curve at the mouth of Big Lake. Inspection of the backwater curves and the Wabasha gage operating curve indicated that the rating curve at Wabasha had changed since the backwater curves were formulated. The rating curve for the mouth of Big Lake was shifted the same amount as the Wabasha gage rating curve had shifted.

This adjusted rating curve has been taken to represent the water level over all of Big Lake. Indian Slough and Pontoon Slough are the only sources of inflow into Big Lake. The flow from these sloughs is not expected to create a significant slope on the lake surface. The conveyance of the lake would allow only low velocities and therefore small head loss through the lake.

The downstream end of the model is located a distance upstream of the downstream terminus of the delta. Additional head losses occur between the lake and the downstream end of the model. An estimate of this head loss is needed for addition to the Big Lake rating curve to produce a rating curve at the downstream end of the model. Manning's equation was used to predict a water surface slope which could be used for the delta area. Three cross sections on Indian Slough were used to compute slopes for the May 4 1988 calibration event flow rate (the largest of the calibration events). A slope of 0.00005 feet per foot was adopted. In a delta area with several distributaries, each with its own travel distance, it was necessary to choose a general travel distance. A value of 2000 feet was adopted. This produced a head loss of 0.05 feet between the lake and the model's starting point. Because of a lack of data in the delta area this amount of head loss was assumed for all flow rates. While this may not be absolutely true for all discharges, the effects on model results should be minimal. The rating curve used to start the model is the Big Lake rating curve plus this head loss.

The model was deemed calibrated when the calibration flow rates produced upstream stages compatible with those measured at the Wabasha gage.

Model Calibration

The model was calibrated using flow data obtained during two field measurements. The dates of these measurements were 4 May 1988 and 12 July 1989. Flows measured in Indian slough for these dates were 1940 cfs and 750 cfs respectively. These flows correspond to Mississippi River discharges of 23,200 cfs and 15,700 cfs respectively.

Manning's coefficients for the elements were used to calibrate the model. Calibration was achieved with the Manning Coefficients shown in Table 1.

Table 1 Manning's Coefficients

Location	Manning's Coefficient
Indian Slough	0.028
Truedale Slough	0.035
Truedale Lake	0.055
Pontoon Slough	0.028

Modeling Partial Closure Structure

Modifications were made to the model to portray the effects of the closure structure. The dimensions of the closure structure were first obtained from rough calculations using Manning's equation. The primary design criteria was the reduction of flow and therefore sediment transport into the backwater areas of Indian Slough. Other design criteria for the structure was to minimize the channel velocity through the structure for riprap stability and navigation purposes. The channel needed to have sufficient depth and top width to allow boat traffic during low flow conditions.

A V shaped channel was chosen. The V shaped channel is the most inefficient at transporting flow. This shape produces a minimum hydraulic radius. The side slopes of the channel have been taken to be 1 vertical to 2.5 horizontal to provide stability for the riprap. Closure dimensions were modeled in the FESWMS 2-dimensional model by changing node elevations and by subdividing some elements in the vicinity of the partial closure to provide model stability in

rapid velocity transition locations. A length of 300 feet has been shown to adequately reduce velocities to safe levels. The maximum draft of the channel at normal pool is 13 feet at the center of the channel.

The narrows location of Alternative E was used in the modeling. Time constraints did not allow for modeling the partial closure structure in each of the alternative locations. It is believed that these closure dimensions would act very similarly regardless of where the closure was located. The head loss across the structure would be almost identical at the various proposed locations.

Results

The prediction of sediment reduction due to the structure has been accomplished by comparing the transport capabilities of Indian Slough for existing conditions and with project conditions. Several Mississippi River flow conditions have been modeled to provide flow rates down Indian Slough . Four flow conditions were studied in the existing condition 2-dimensional model. The two calibration events provide information for the low flow conditions. Additional modeling has been done to show flow conditions in the slough when the water is at a level between the higher calibration event (4 May 1988) and bankfull, and at bankfull. The flow split from the Mississippi River for these two events were obtained in a similar fashion as was done with the calibration event. The downstream starting water surface elevations were obtained from the rating curve. A trial and error method was used to determine what flow rate in Indian Slough would produce an upstream water surface elevation compatible with those expected from the Wabasha gage operating curves. This approach was taken to determine the Indian Slough flows for project conditions as well as existing conditions.

The 2 dimensional model can only be used for slough stages up to the bankfull condition. For flows higher than bankfull, Manning's Equation was used to predict the amount of flow passing down the channel of Indian Slough. Plate 8 compares the flow in Indian Slough for existing and project conditions, with the total Mississippi River discharge. Plates 22 and 23 show existing and project condition velocity vector diagram for the bankfull condition modeling.

SEDIMENT TRANSPORT

The reduction of sediment into the Indian Slough backwater areas is the primary goal of this study. No measured sediment discharge was available for Indian Slough. The term "bed material transport" refers to the transport of the material that is found in the stream bed. This is primarily composed of gravel to fine sands. This type of sediment transport is believed to be the primary process responsible for delta formation. Many empirical formulas have been developed to predict bed material load. Several of these were examined with hopes that a trend would be established which would point to a particular

method to be used for further analysis. These are the Colby Method, Shields Method, Toffaleti's Method, and Einstein's Bed Load Function. The various methods require a variety of input data.

All of the methods with the exception of Shield's Method require either a distribution of sediment size or the mean sediment diameter d50. Eight surface samples of bed material have been obtained from various locations in the slough. Plate 9 shows the locations at which these samples were taken. Sediment gradation analyses were performed on each of the samples. A mean gradation was chosen to represent the character of bed sediment passing through the reach. This gradation had a d50 of 0.45mm. Plates 8 through 16 show gradation curves for the sediment samples as well as for the average gradation.

Other data needed by the methods include flow, velocity, cross sectional area, top width, hydraulic depth, hydraulic radius, energy slope, water temperature, kinematic viscosity, and fine material concentration. Table 2 illustrates the various input parameters required for each method.

Table 2 Input Parameters for Bed-Material Load Methods

	Colby	Shields	Toffaleti	Einstein
Flow		X		
Velocity	X	X	X	
Area				
Top Width	X		X	X
Hydraulic Depth	X		X	X
Hydraulic Radius		X		
Energy Slope		X	X	X
Water Temperature			X	
Kinematic Viscosity				X
Fine Material Concent.	X			
Sediment Gradation			X	X
d50	X			

Preliminary calculations were performed using each of the methods. Of the four methods, none agreed very closely. The methods become increasingly divergent as flows increase. Plate 19 shows the bed-material transport predicted by each of the methods. Lacking any consensus between any of the methods, the two moderate methods of Toffaleti's method and Colby's method were used in trying to predict a bed material yield.

A bed material yield analysis which combines the bed load relationships with the annual discharge duration relationship was done to provide a way to quantify the reduction in bed load transport. This type of analysis weights the transport rate of a given discharge by the annual duration of that discharge resulting in an average annual transport rate.

For instance, Toffaleti's method estimated 4213 tons per day of bed-material load were passing down Indian Slough under existing conditions. Assuming a general delta area of 1 square mile, this would mean about 1.1 feet rise in the delta per year. Similar results were obtained using Colby's method. This method predicted 2476 tons per day which would be about 0.6 feet over a square mile in one year. These large amounts of sediment do not appear to be reasonable. The supply of sediment in the Mississippi River could be the limiting factor. This could help explain the widening of the main Indian Slough channel over time. Both methods also resulted in unrealistically high reductions in bed load transport down Indian Slough. When with and without project conditions were compared, reductions using Toffaleti's and Colby's methods were 95.4 and 96.4 percent respectively.

Given the unreasonableness of the results obtained using either Toffaleti's method and Colby's method, another approach was sought. The Einstein's Bed Load Function predicts higher sediment transport than Toffaleti's or Colby's methods. The Shields method had shown lower bed material transport rates than Colby's Method. It's input parameters, however, do not use any characteristics of the type of sediment being studied. This method was not used to predict bed material yield because of it's crude nature.

As an alternative, equations for bed-material transport in the Mississippi River at Winona developed by Simons and Chen (1980) for GREAT1 study were used to predict bed-material transport in the Mississippi River near Indian Slough at Wabasha. The total bed-material load at each flow rate was ratioed between Indian Slough and the main channel based on the flow distribution between the two. The portion assigned to Indian Slough was directly proportional to the flow down Indian Slough versus the main channel of the Mississippi River. A bed load yield analysis predicted 442 tons per day passing into Indian Slough under existing conditions. This amounts to an annual deposition rate of 0.12 feet depth over a one square mile delta area. The with project condition would show a transport rate of 203 tons per day. Although its without project conditions were not comparable, the with project condition transport rate is very close to that predicted by the Toffaleti method. Using this methodology there was a 54 percent reduction in bed-material load down Indian Slough. This reduction seems to be the most reasonable. It is also the most conservative in regard to the percent reduction of bed-material load.

Wash load consisting primarily of silts and clays is also reduced by the closure structure. Wash load is computed by multiplying discharge by suspended sediment concentration. The fine material concentration varies with river discharge. Data obtained from the Winona gage has been used to predict concentrations for different river flow rates. A least square regression was used on daily data (1976-1985) to produce an equation for predicting concentrations. Plate 20 shows a plot of the data along with the normalized line given by the following equation:

$$C = 9.797 + Q\ (\ 0.00033\ )$$

C = concentration in mg/l
Q = discharge in cfs

Flow duration analysis predicts suspended sediment yields of 293 and 125 tons per day for existing and project conditions respectively. This is a 57 percent reduction in wash load after the installation of the partial closure structure.

PROTECTION OF EROSION PRONE AREAS WITHIN INDIAN SLOUGH

With the construction of the partial closure structure, flows within Indian Slough should be significantly reduced. Given the historic erosion problems in Indian Slough, it was necessary to ascertain what, if any, affect the construction of this structure would have on these problems. The area of primary concern for erosion is in the bend area across from the mouth of Truedale Slough. This bend is what remains of an eroded meander (See Plate 21). Two points of land at the entrance of the bend are the locations where erosion is currently taking place. On the right bank, the point is eroding as the flow is drawn to the right. The point on the left bank receives the head on momentum of the flow. The 2-dimensional model indicated that velocities in the vicinity of the two identified erosion prone areas were significantly reduced by the partial closure structure. Table 3 shows the existing and with project velocities at the left and right bank points.

Table 3 Channel Bank Velocities at Bend in Indian Slough

	Left Bank Velocity (ft/s)	Right Bank Velocity (ft/s)
low flow without project	0.3	0.3
low flow with project	0.1	0.1
bankfull flow without project	4.4	4.2
bankfull flow with project	1.7	1.4

Given the velocities at these two points, erosion should be minimal with the project in place. As flows rise much higher than the bankfull, backwater effects will make this area behave more like a lake. Significant portions of the flow will be overland flow, in which case the velocities should be small. At present the bend has eroded substantially and is not very far from achieving a relatively straight alignment. If additional erosion were to occur, it would likely be short lived. A fairly small area of land would be lost before stability is achieved. Therefore, no riprap will need to be placed on either of these banks.

RIPRAP DESIGN

Riprap is required on the partial closure structure. Riprap was designed using a recent draft of EM-1110-2-1601 "Hydraulic Design of Flood Control Channels". The two dimensional modeling predicted a maximum velocity of 8.8 feet per second within the closure structure could be expected for the two year event (bankfull). This is the maximum discharge that will occur. The following table shows riprap gradation dictated by the procedures in the EM.

Table 4 Riprap Gradation

	Weight Limits (lbs)	
	Maximum	Minimum
W100	86	35
W50	26	17
W15	13	5

A riprap layer thickness of 12 inches is required for this gradation. This thickness was increased by fifty percent to allow for underwater placement. Quarry run stone is expected to be used on this project.

It is common practice on this type of project to use rock fill for erosion protection. The EM recommends increasing the layer thickness by 1.5 to 2.0 times to accommodate quarry run stone. This would give a layer thickness of 27 to 36 inches. A final layer thickness of 30 inches has been adopted.

EFFECTS ON MISSISSIPPI RIVER STAGES

The project alternatives which employ only a partial closure structure across the channel will have little effect on flood stages. When the river rises above bankfull conditions, the partial closure structure will lose its impact on river stages due to the overland flow bypassing the structure. Any alternatives which incorporate a levee to tie into high ground would have a more significant impact on the river stages.

The HEC-2 model developed for the Wabasha FIS study was used to predict the likely stage increases due to a levee/closure structure with crest at the 10 year flood stage. The model was initially run to determine the amount of flow passing through the main span of the Highway 25 bridge which crosses the main channel. This portion of the total flow was used in all subsequent modeling.

X3 cards were used in the HEC-2 model to allow a four to one expansion of flow as it passed through the bridge into the Indian Slough area. The stages produced under this condition have been deemed the appropriate stages for the existing condition.

To model the levee/closure alternative, the encroachments were modified to prevent the four to one expansion for water below the 10 year flood elevation. Downstream of the Crats Island disposal facility a four to one expansion was employed.

The results of this modeling indicated that maximum increased in river stages for the 10, 50, and 100 year flood events would be 0.4, 0.3, and 0.2 feet respectively. This increase in river stage would also have an impact in increasing the amount of flow and sediment entering Big Lake via Pontoon Slough and other sloughs which leave the main river channel upstream of Indian Slough.

EFFECTS ON WHOREHOUSE SLOUGH

Whorehouse Slough begins on the main channel of the Mississippi River just downstream of the Highway 25 bridge. It parallels Indian Sough for about two thirds of a mile before merging with it. The upstream end of the slough is closed off with an embankment near the rivers edge. A 42 foot long 54 inch diameter culvert connects the slough to the river. Very little flow passes down Whorehouse slough during low flow conditions. An increase in flow would be expected down Whorehouse Slough during low flow conditions if the closure structure is located upstream of the junction of the two sloughs. An increase in sediment would be associated with the increased flow down Whorehouse Slough, however the amount of additional sediment would probably not be significant.

EFFECTS ON TRUEDALE SLOUGH

The installation of a partial closure structure will have an effect on Truedale Slough. Flow through this slough will be reduced somewhat due to the reduction of flow in the entire Indian Slough system.

Field investigations of the area of Truedale Slough near where it enters Pontoon Slough indicated that virtually no flow was present and water depths were as little as 1 foot. Restoration of a low flowing water habitat (flows around 0.1 ft/s) for fish, through channel dredging was assessed using the 2-dimensional model. It appears that construction of the partial closure structure would not only lower flows in Indian Slough, but would further reduce flows through Truedale Slough. Dredging in the slough could increase flows so that existing conditions should be maintained. Given the extremely low velocities and the small head differential in the area, it is not possible to accurately calculate precise flows through this reach. Should a riffle pool complex be constructed in Indian Slough proper, flows should increase slightly in Truedale Slough.

EFFECTS ON ROBINSON LAKE

Robinson Lake is a backwater area downstream of Hershey Island on the Minnesota side of the main channel of the Mississippi River. This location is two miles downstream from the entrance to Indian Slough.

The installation of a partial closure structure at Indian Slough will result in an increase in water discharge and sediment discharge in the main channel. A study has been done to estimate the amount of additional sediment that will enter Robinson Lake as a result of the Indian Slough project.

A calibrated HEC-2 model of Pool 4 was previously developed to determine the flow split between the main channel and the Big Lake backwater areas. In the model, flow was limited to the main channel and right overbank between Teepeeota Point and Indian Slough. Discharges were adjusted by trial and error until the Wabasha Gage rating curve was matched. The HEC-2 model was also calibrated to reflect the observed discharge down the Hershey Island channel. This provided the pre-project discharges and stages for the main channel and right overbank (Robinson Lake area).

The total flow down the channel to the Robinson Lake area is subdivided in a series of branching channels. Two of these channels enter Robinson Lake. The flow distribution down the various channels was estimated based on the ratio of topwidths at each junction. The topwidths were measured between the limits of wooded vegetation. This was done to make sediment calculations more representative for the higher flow periods during which large amounts of sediment is transported. The banks of the frequently overtopped sand flats would not be appropriate for flows other than normal non flood flows. A check was done to see how well the method predicted the flow in the channels reentering the main channel between Hershey Island and the next downstream island. The measured flow in the channels was 24 percent of the total measured in the channel to the southwest of Hershey Island. The amount predicted by the described method was 31 percent. This is reasonable considering that the measured discharges were obtained during relatively low flow conditions. The method predicts that 34 percent of the flow split from the channel by Hershey Island enter channels directly tributary to Robinson Lake. Flow measurements of limited precision were made at these channels. They total about 31 percent of the flow split from the main channel by Hershey Island.

As was done for Indian Slough, an equation developed by Simons and Chen for GREAT 1 was used to predict bed material transport in the channel to the southwest of Hershey Island. The total bed material load in this channel for existing and post project conditions are 322 and 353 tons per day respectively. It was assumed that 34 percent (i.e. proportional to flow split) of this of bed material load enters the Robinson Lake area. The existing and post project condition bed material loading into Robinson Lake are 109 and 120 tons per day respectively or an increase in sediment load into Robinson lake of 11 tons per day. The remaining portion of bed material load would pass back into the main channel.

The suspended sediment equation developed for the Winona gage was used to predict the increase in suspended sediment for the channel southwest of Hershey Island. The loading changed from 216 to 238 tons per day for existing and project conditions respectively. The amount of this sediment entering Robinson Lake for these conditions would be 73 and 81 tons per day.

These sediment increases are small compared to the amount of sediment kept out of Indian Slough by the closure structure.

EFFECTS ON CATFISH SLOUGH

Catfish Slough leaves the main channel of the Mississippi River adjacent to Hershey Island, parallels the river, and enters Big Lake at the lakes mouth. A significant increase in the head differential between the Mississippi River and Big Lake could increase the likelihood of a breakout into Big Lake. Measurements taken after completion of the Weaver Bottoms project have not shown the increases in flow and stage, in the side channels opposite the project, that would have been expected (see next section). This may be true for this project as well.

Since Big Lake has a flat water profile with little head loss between the upstream and downstream ends, the lake's water surface elevation is equal to that of the Mississippi River at the lake's downstream end. Since the lake at present does not have much slope, a decrease in flow through the lake due to the partial closure of Indian Slough would not affect the water elevation.

However, there will be an increase in stage in the Mississippi River of about 0.4 feet. This would occur between a 2 and 5 year flood between the 2 and 5 year flood. Discharge-duration data was used to determine the average increase in stage that could be expected. The analysis indicated that an stage increase of 0.05 feet would be the average stage increase at the entrance to Catfish Slough. This increases the potential for erosion in Catfish Slough. This increases the potential for erosion in Catfish Slough.

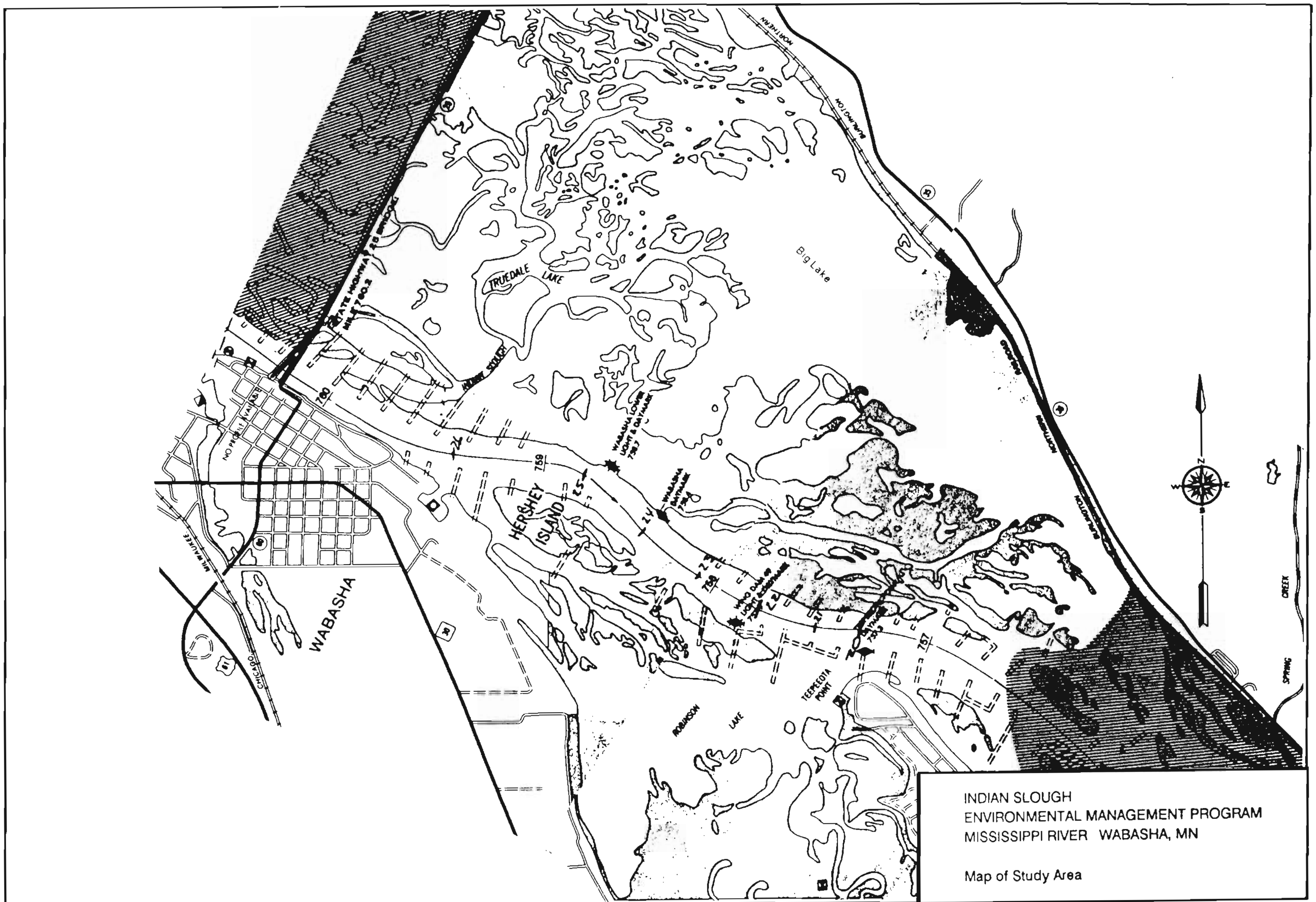
It is recommended that the existing entrance to Catfish Slough be armored to prevent erosion. Although the head differential between the Mississippi River and Big Lake does not appear to be significant, after project completion Catfish Slough should be monitored to ascertain if additional protection is required to prevent a breakout into Big Lake.

OBSERVATIONS FROM WEAVER BOTTOMS PROJECT

The Weaver Bottoms Project like the Indian Slough project, reduced the amount of flow into a major backwater area and thereby forced it into the channel. For the Weaver bottoms project, predicted stage change increases were about 0.1 and 0.6 feet for river discharges of 20,000 cfs and 60,000 cfs respectively. Operation of the dam, however, forces the stage at the control point to remain unchanged. This is accomplished by increasing the slope on the pool. This means the effects of the project on water surface elevations should be seen as a stage reduction at the dam's headwater stage gage at the downstream dam. The preliminary data since the projects completion (three years) indicate the control point rating curve has not shifted and the dam's headwater stages have been reduced only 0.1 feet for the higher recorded discharges (40,000 to 100,000 cfs). It appears that the main channel of the Mississippi River is carrying the additional discharge without significantly

altering stages. The cause of this is unclear. Changes in bed forms, and/or enlarging of the channel are possible theories. This data would indicate that the predicted stage increases which have been predicted as a consequence of the Indian Slough partial closure structure are overestimated.

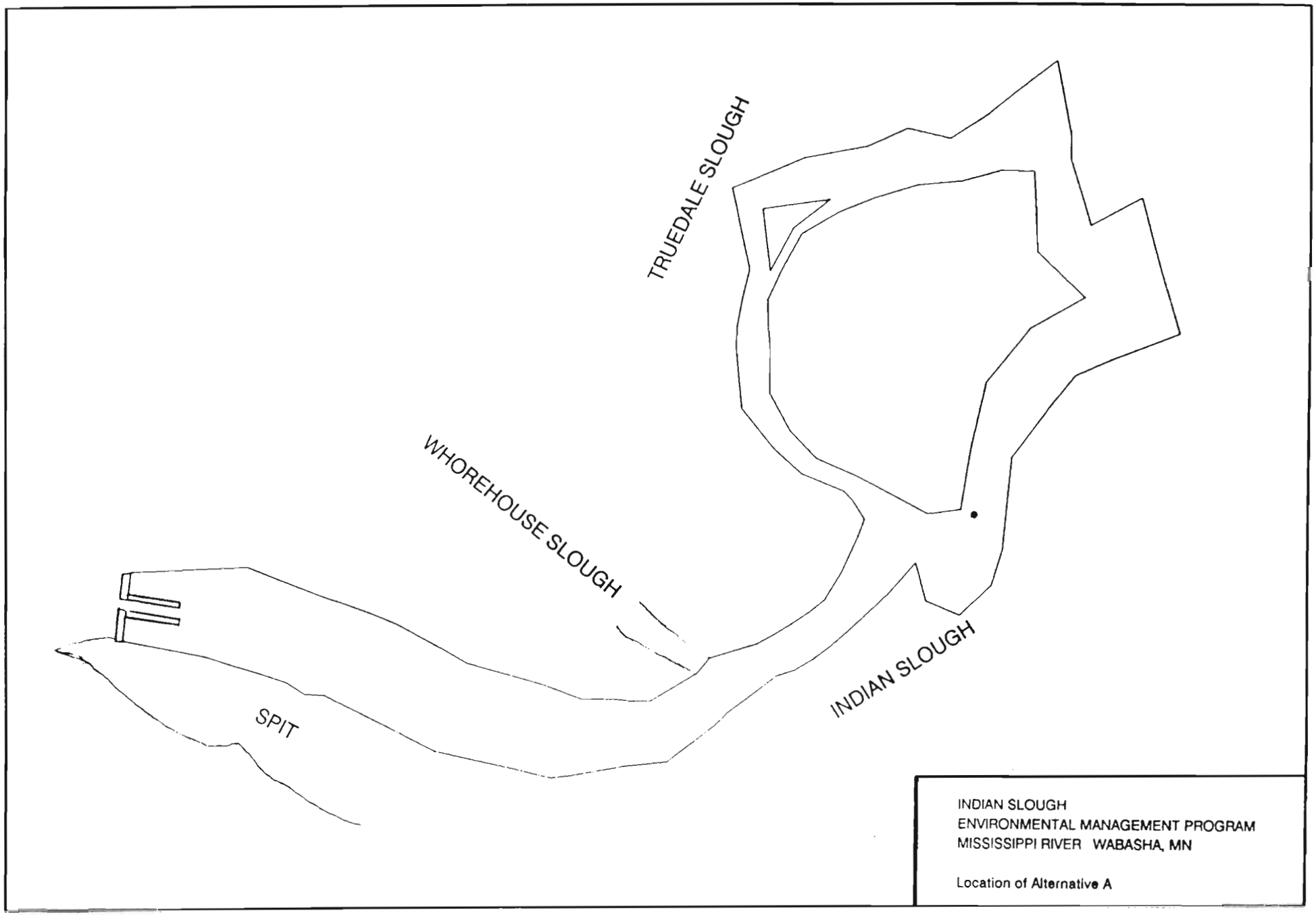
The Weaver Bottoms project was also expected to increase discharge into backwater sloughs on the opposite side of the river. Flow measurements taken since the projects completion show that discharge into the major sloughs does not rise above pre-project conditions until the Mississippi River discharge rises above 60,000 cfs. A rise in slough discharges was expected for all river discharges. This finding may indicate that the predicted increase in discharge and sediment transport into Robinson Lake may be overestimated.



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Map of Study Area

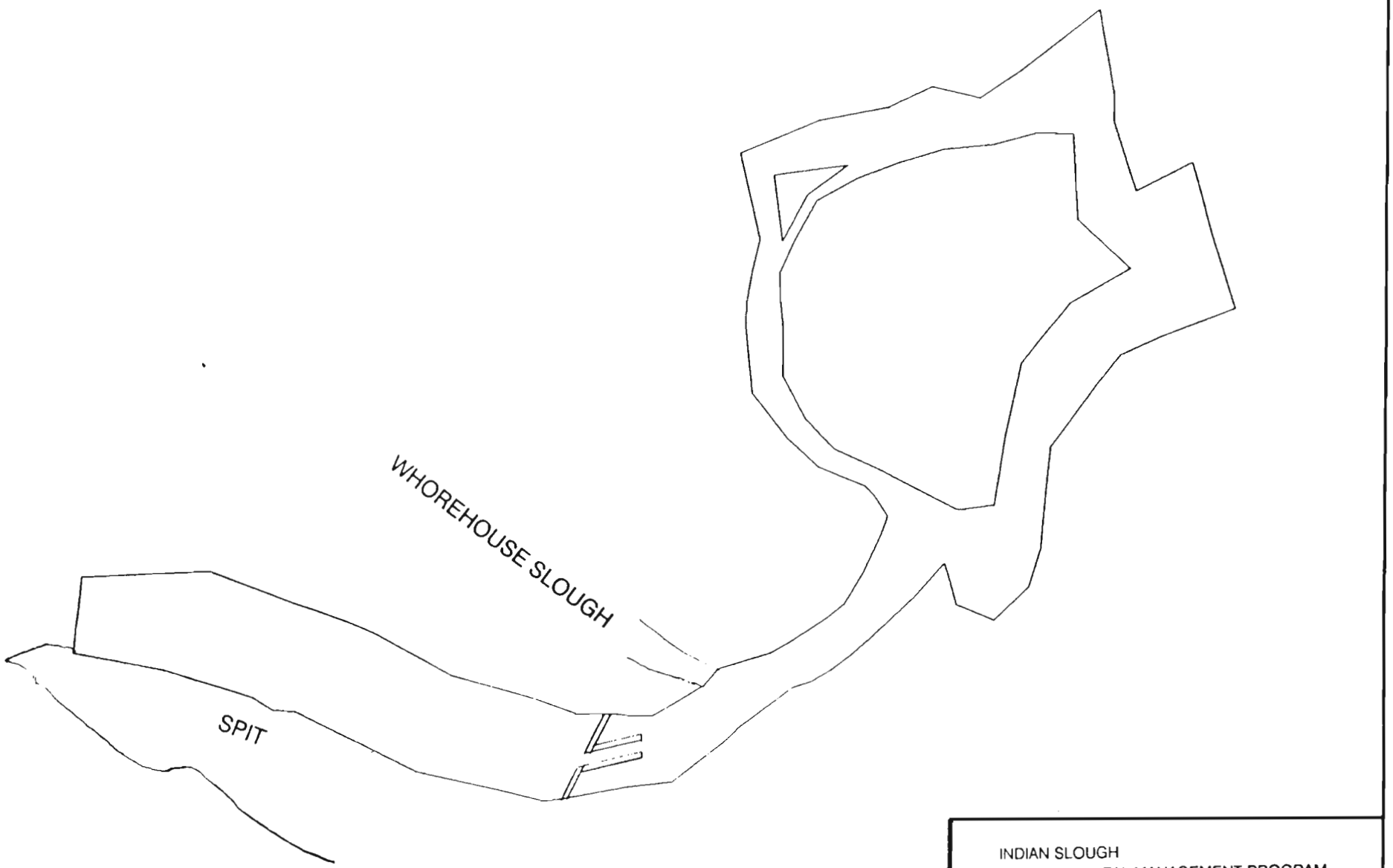
PLATE 1



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Location of Alternative A

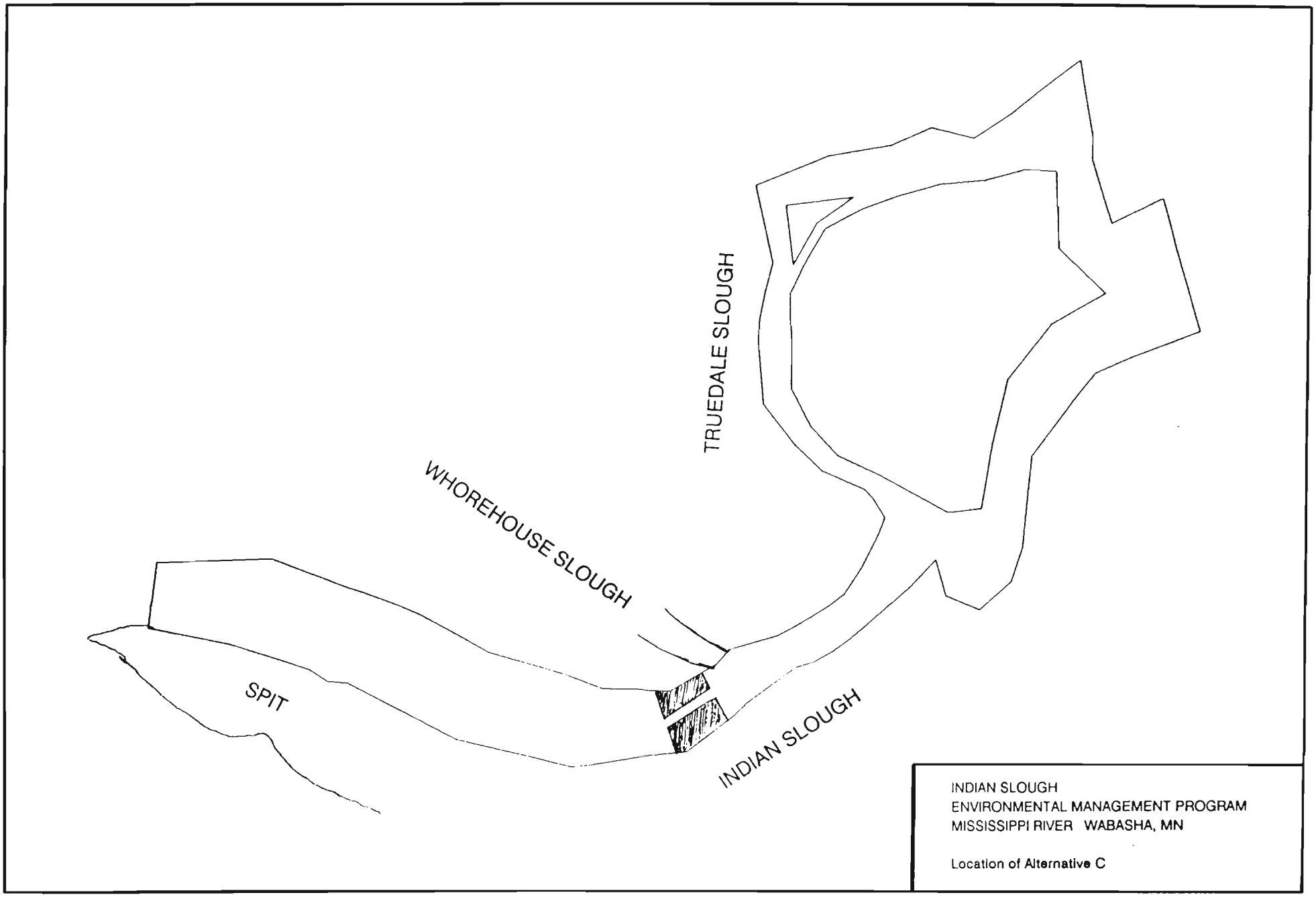
PLATE 2



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Location of Alternative B

PLATE 3



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Location of Alternative C

PLATE 4

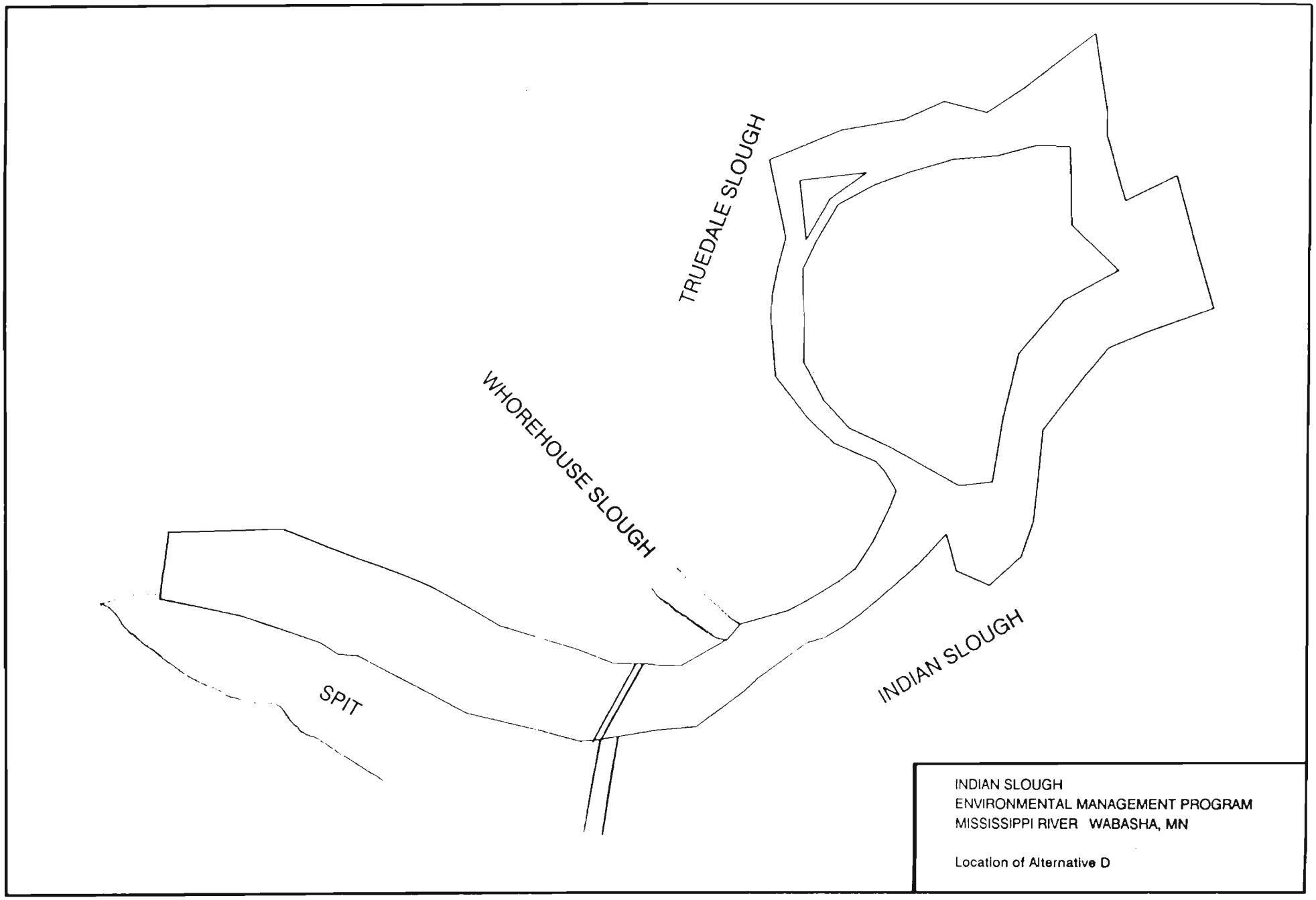

TRUEDALE SLOUGH
WHOREHOUSE SLOUGH
SPIT
INDIAN SLOUGH
INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN
Location of Alternative D

PLATE 5

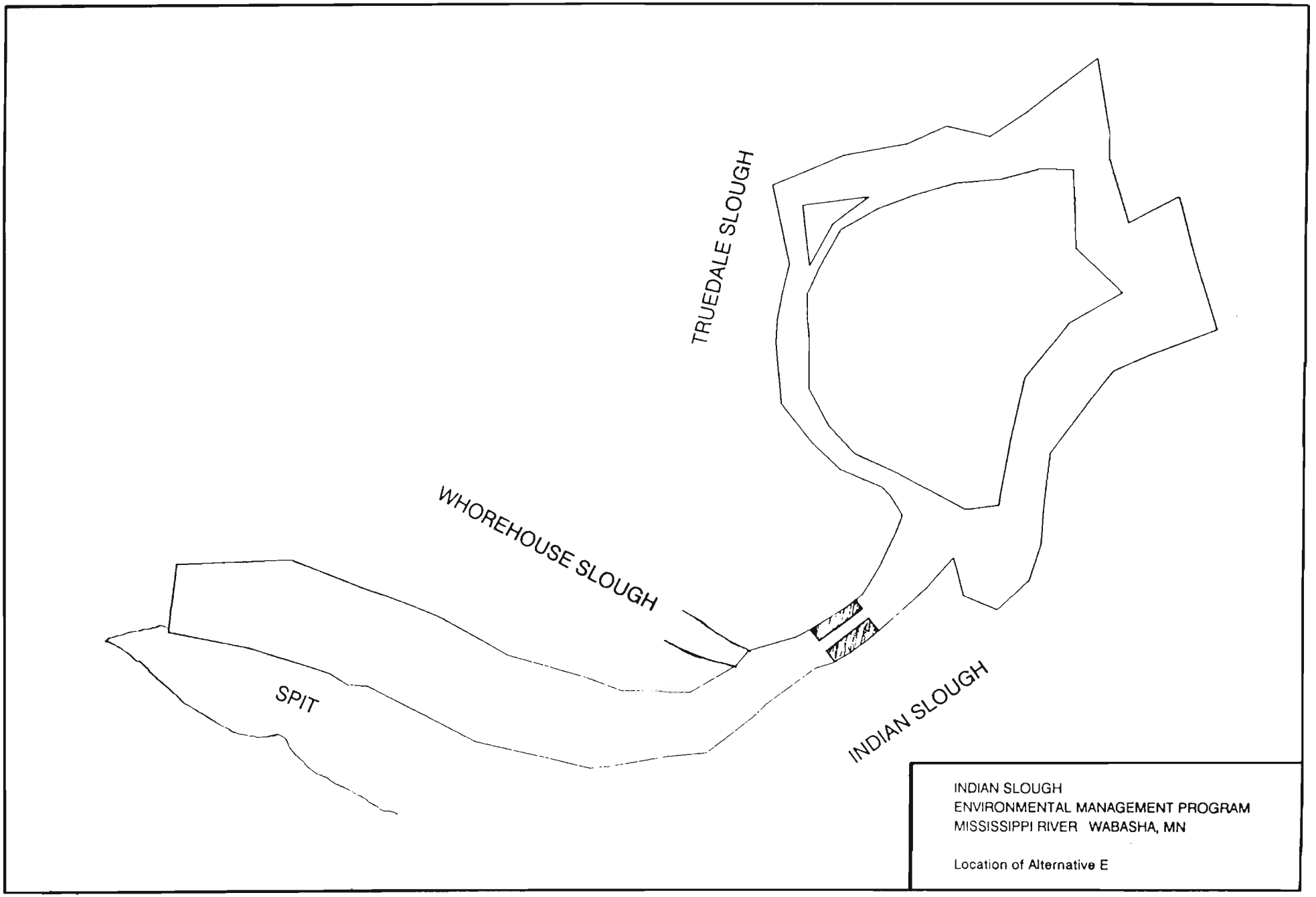
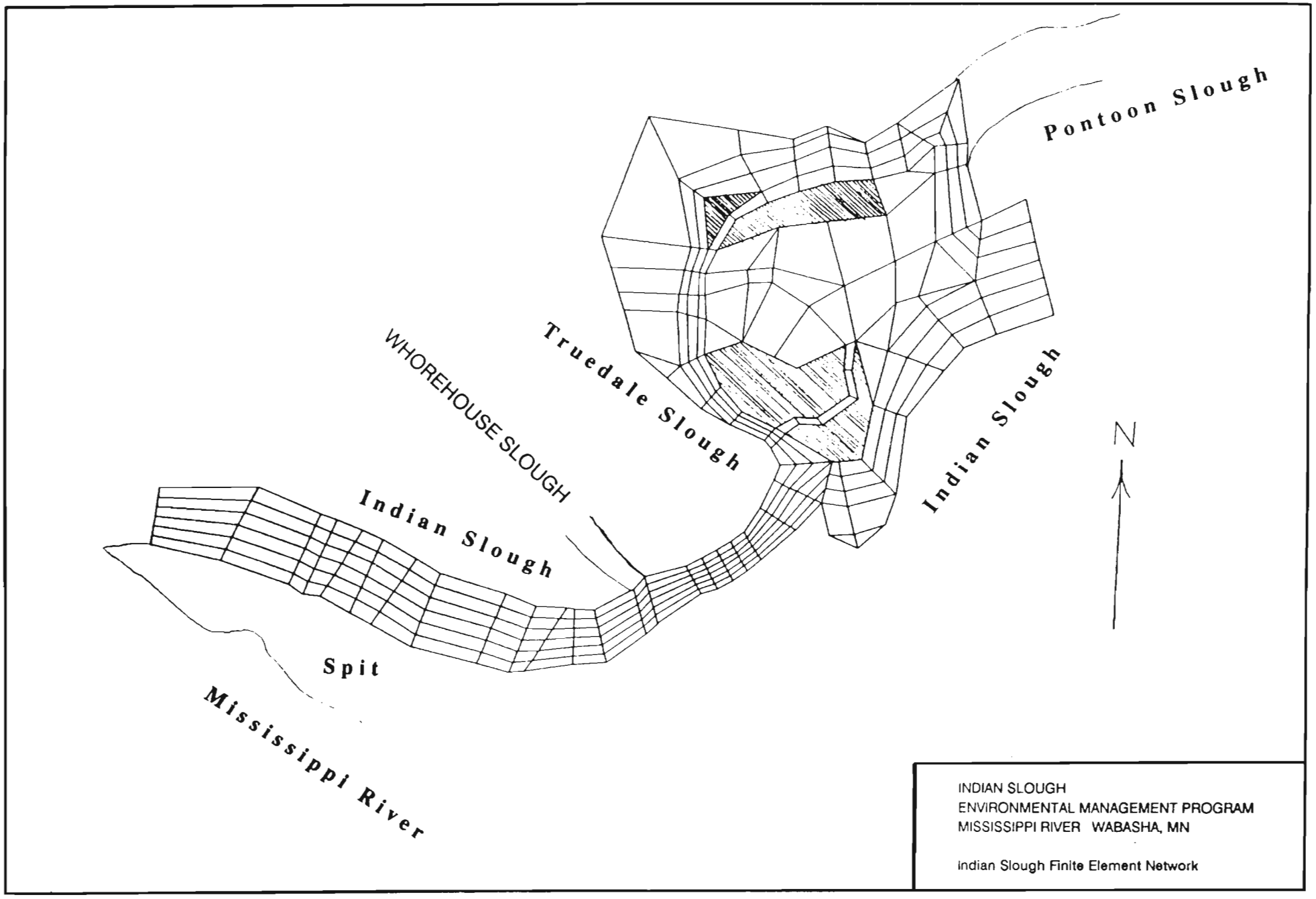

TRUEDALE SLOUGH
WHOREHOUSE SLOUGH
SPIT
INDIAN SLOUGH
INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN
Location of Alternative E

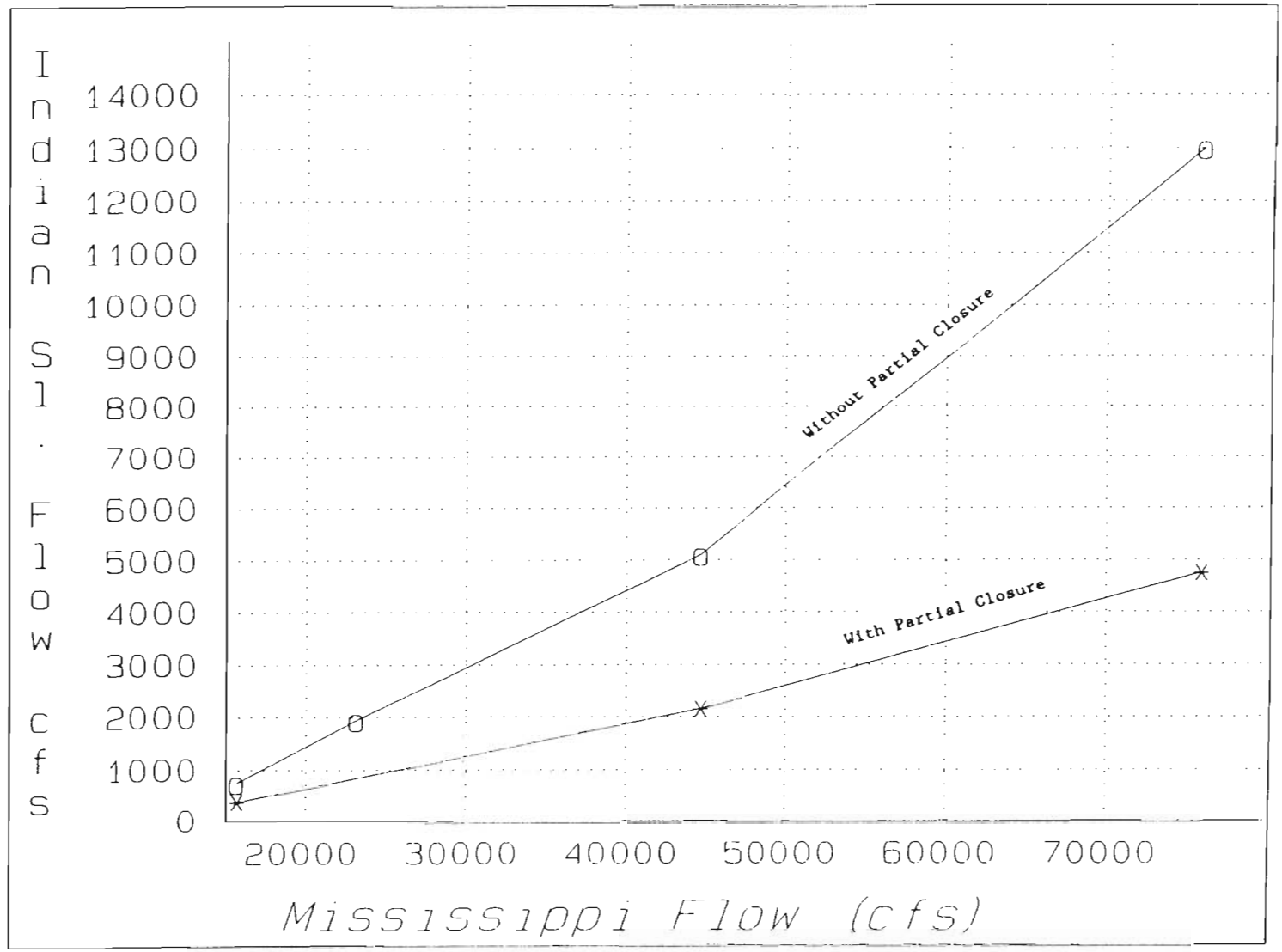
PLATE 6



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Indian Slough Finite Element Network

PLATE 7



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Indian Slough vs. Mississippi Flows

PLATE 8

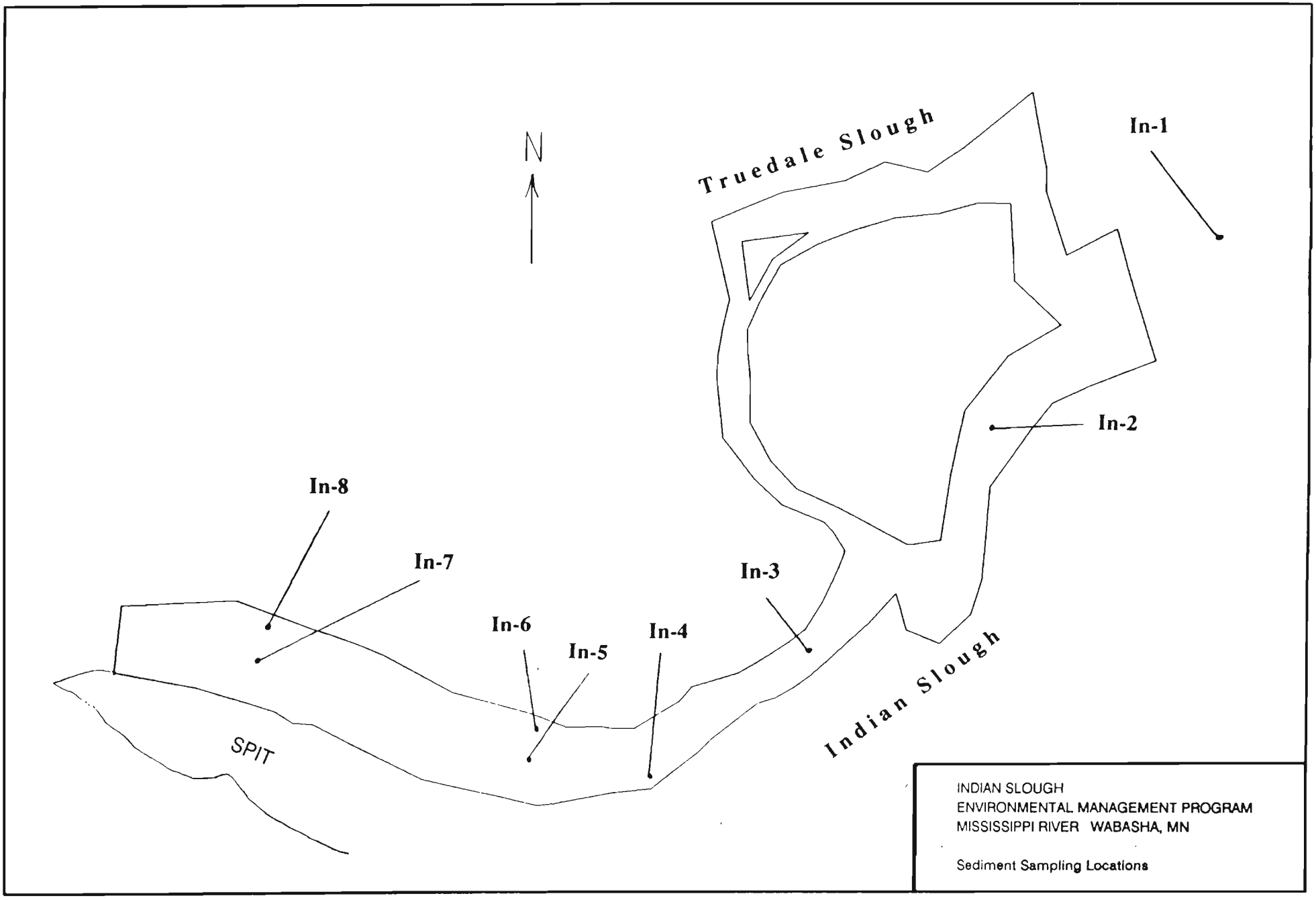
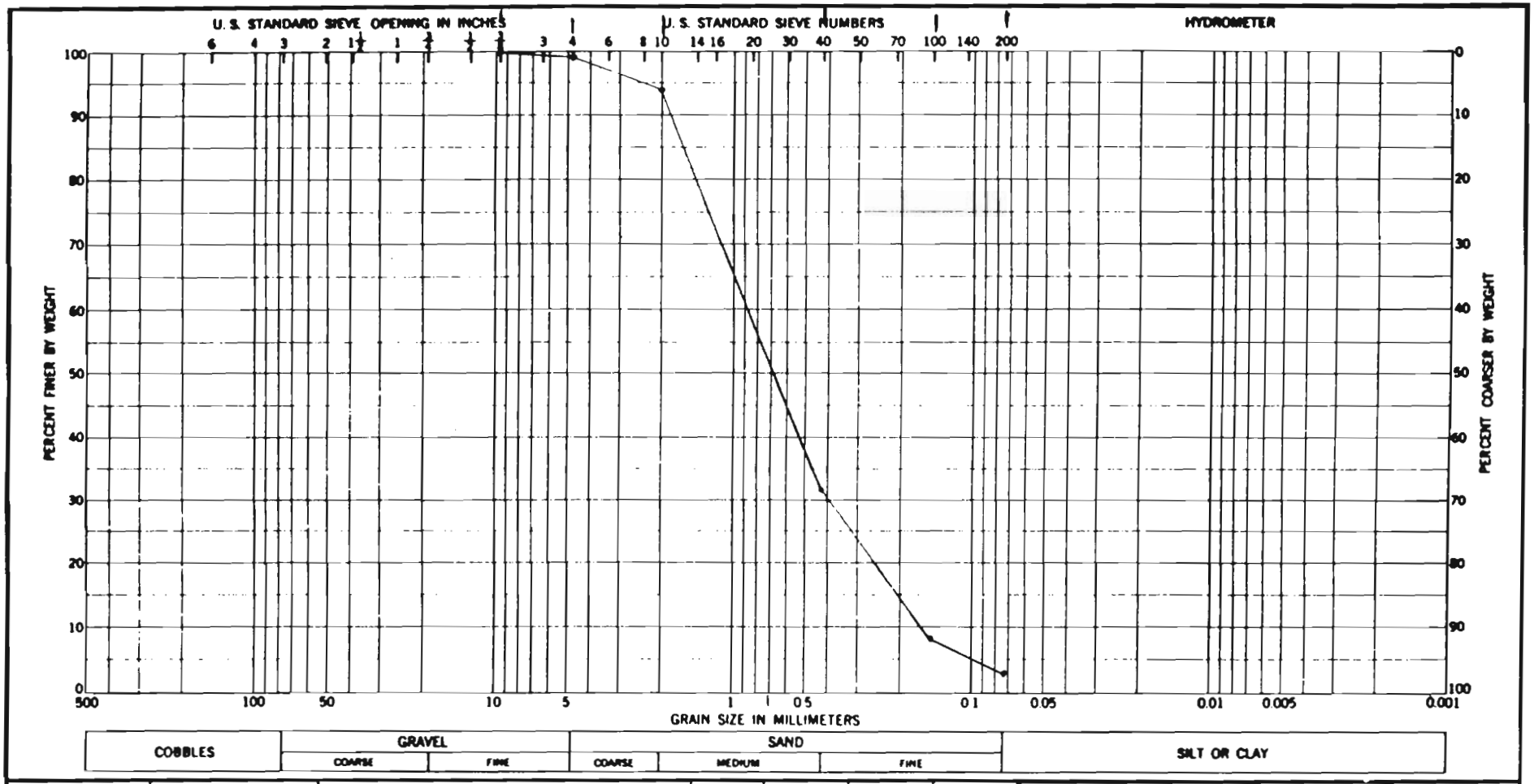

N
Truedale Slough
In-1
In-2
In-3
In-4
In-5
In-6
In-7
In-8
SPIT
Indian Slough
INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN
Sediment Sampling Locations

PLATE 9



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

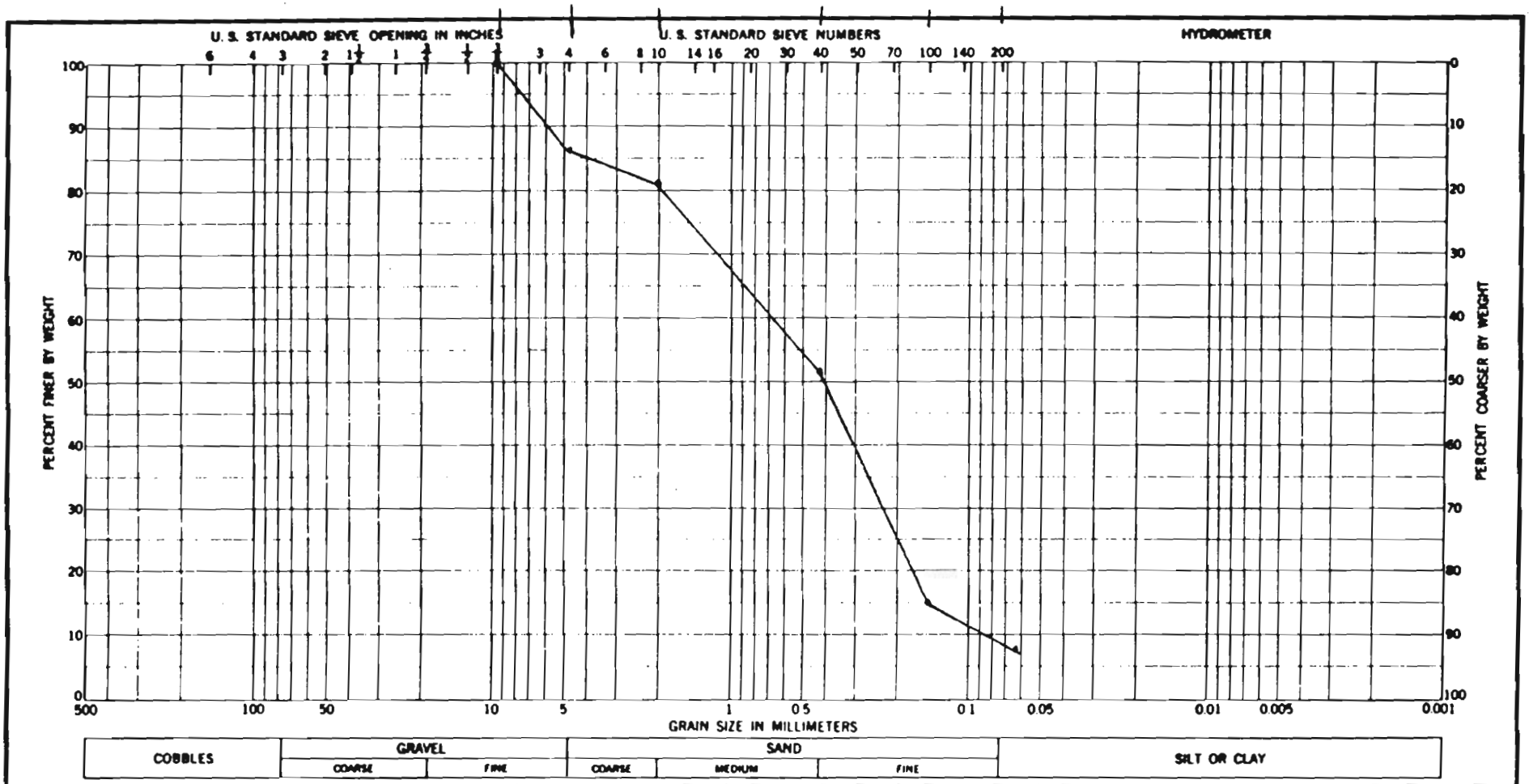
AREA - UPSTREAM OF PONTOON SLOUGH

SAMPLE # IN-1

ENG FORM 1 MAY 63 2087

d50 = 0.69 mm

PLATE 10



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

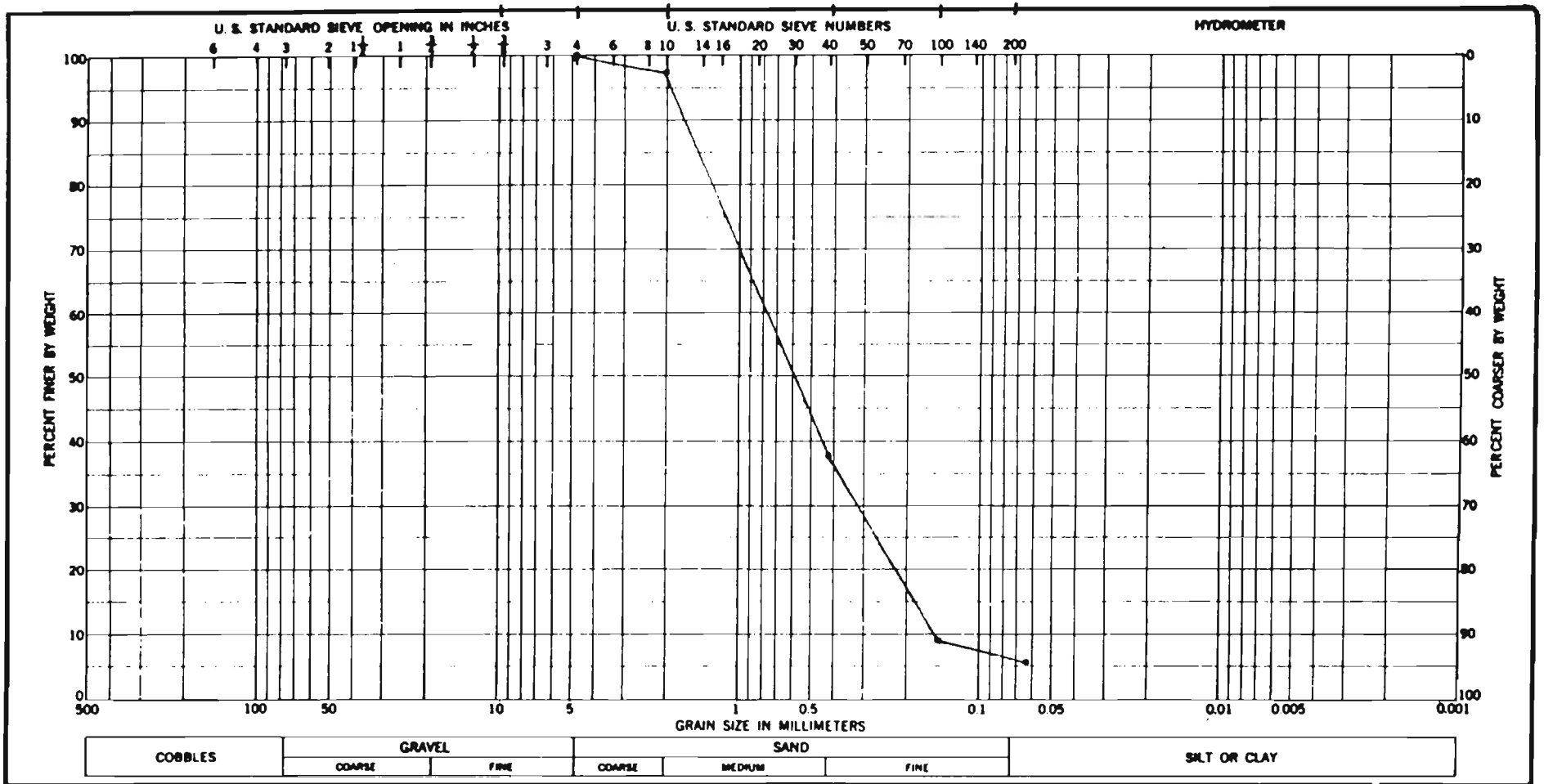
AREA - BETWEEN TRUEDALE & PONTOON SLOUGHS

SAMPLE # IN-2

ENG FORM 1 MAY 63 2087

d50 = 0.41 mm

PLATE 11



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

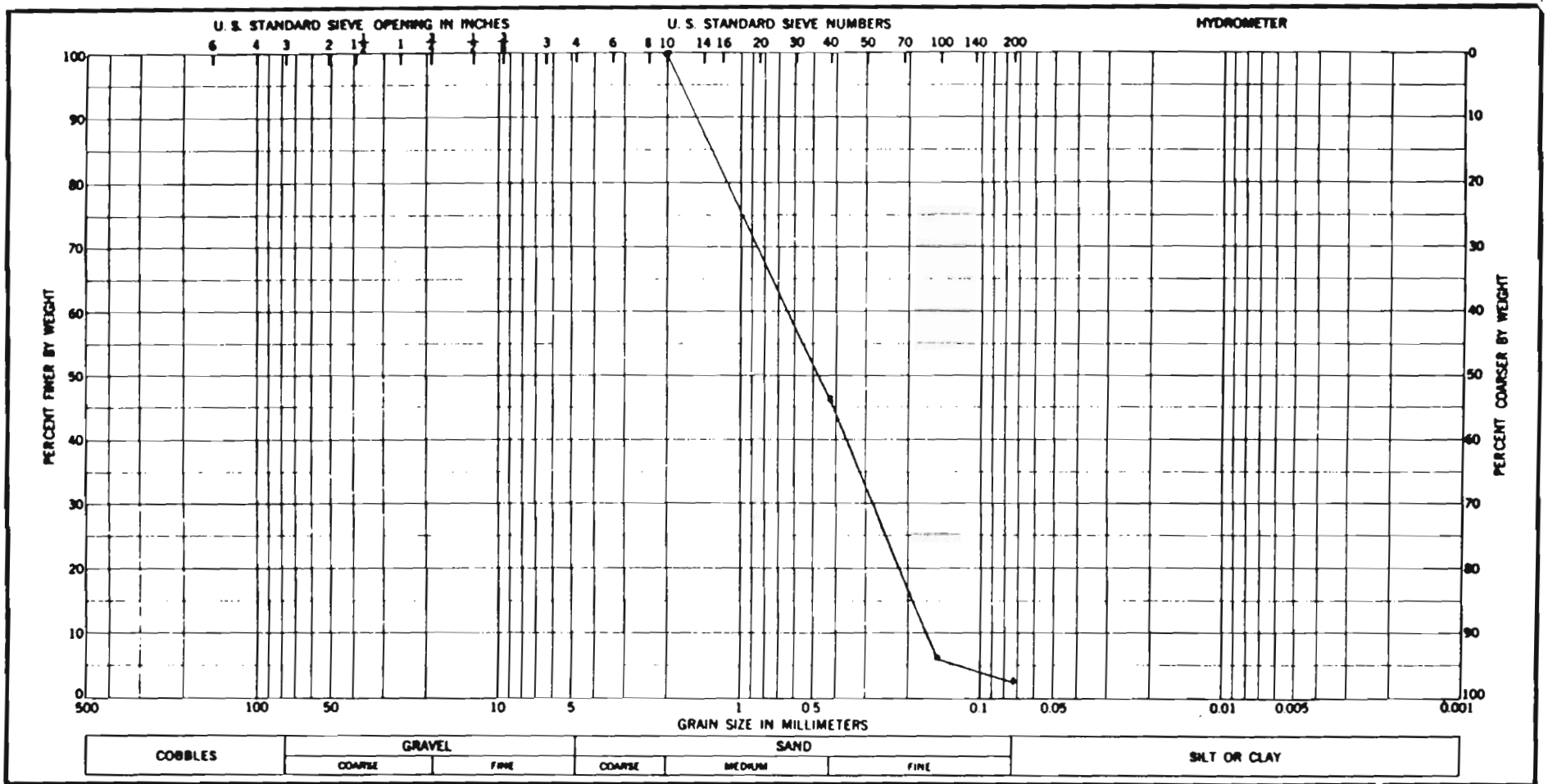
PROJECT - INDIAN SLOUGH

AREA - NARROWS UPSTREAM OF TRUEDALE SLOUGH

SAMPLE # IN-3

ENG FORM 1 MAY 63 2087

d50 = 0.59 mm



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

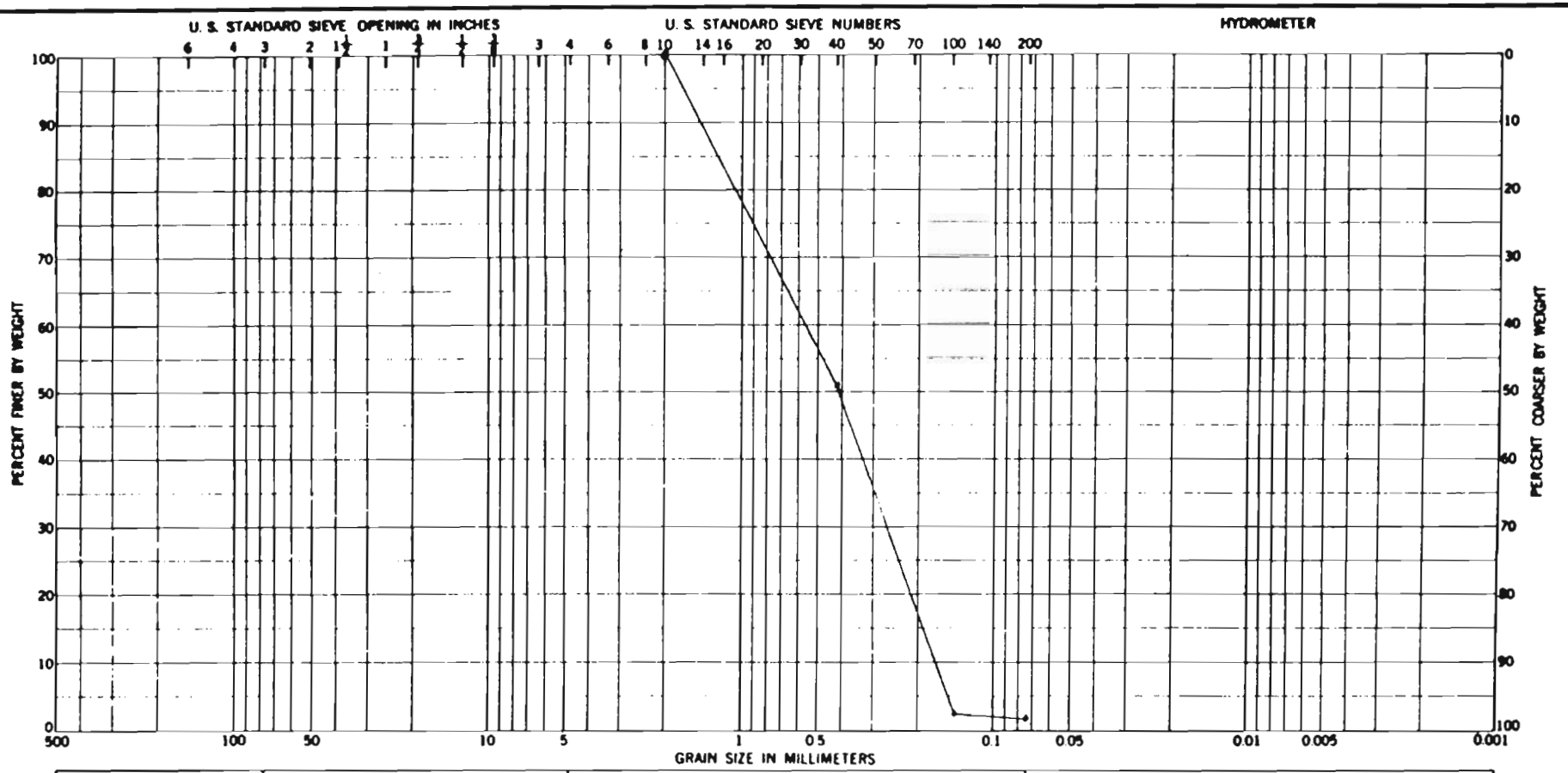
AREA - NEAR DISPOSAL AREA

SAMPLE # IN-4

ENG FORM 1 MAY 63 2087

d50 = 0.47 mm

PLATE 13



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

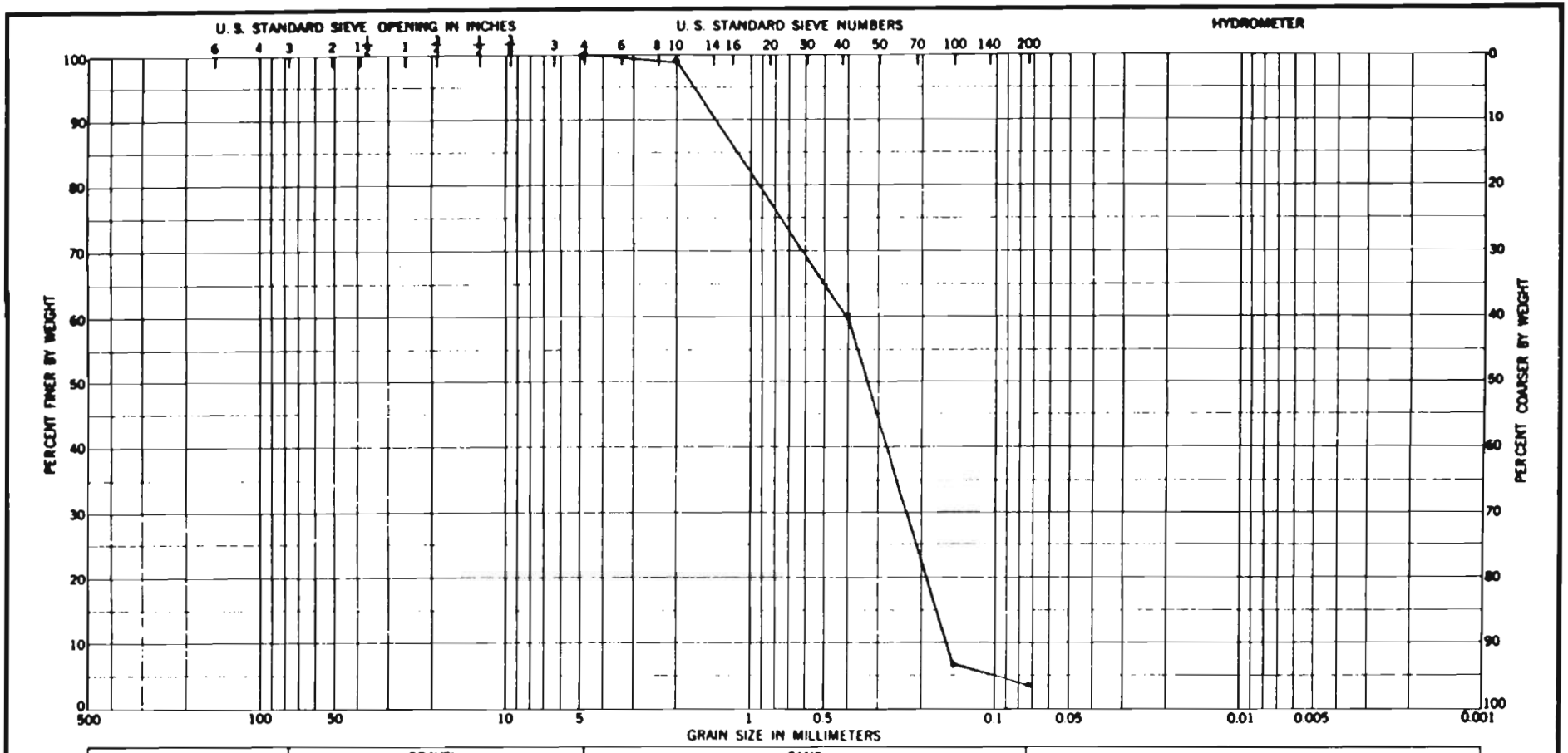
AREA - CENTER OF SLOUGH
MIDWAY DOWN SPLIT

SAMPLE # IN-5

ENG FORM 1 MAY 63 2087

d50 = 0.42 mm

PLATE 14



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

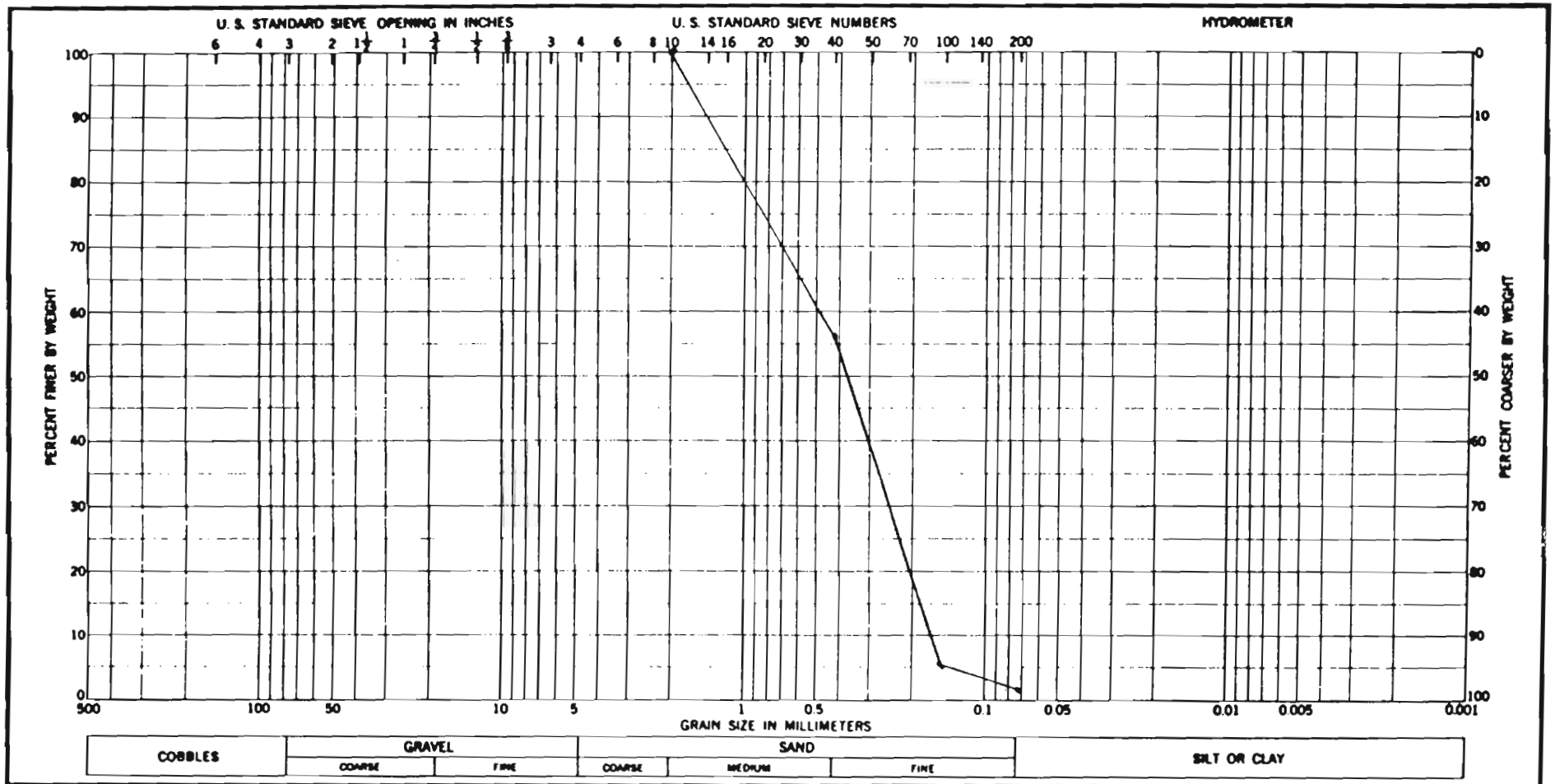
AREA - LEFT BANK OF SLOUGH
MIDWAY DOWN SPLIT

SAMPLE # IN-6

ENG FORM 1 MAY 63 2087

d50 = 0.34 mm

PLATE 15



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

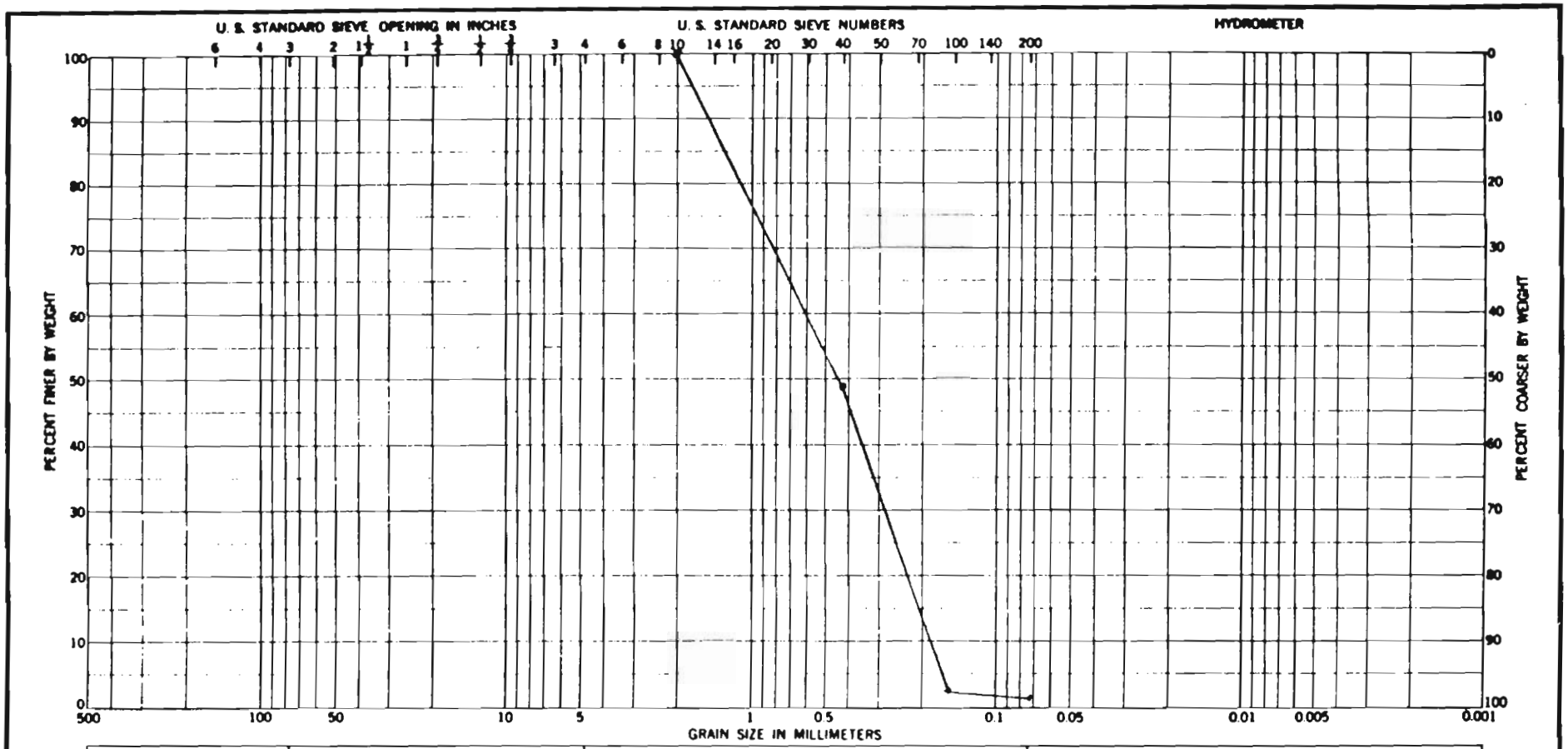
AREA - CENTER OF SLOUGH NEAR CHANNEL THROUGH SPLIT

SAMPLE # IN-7

ENG FORM 1 MAY 63 2087

d50 = 0.37 mm

PLATE 16



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

PROJECT - INDIAN SLOUGH

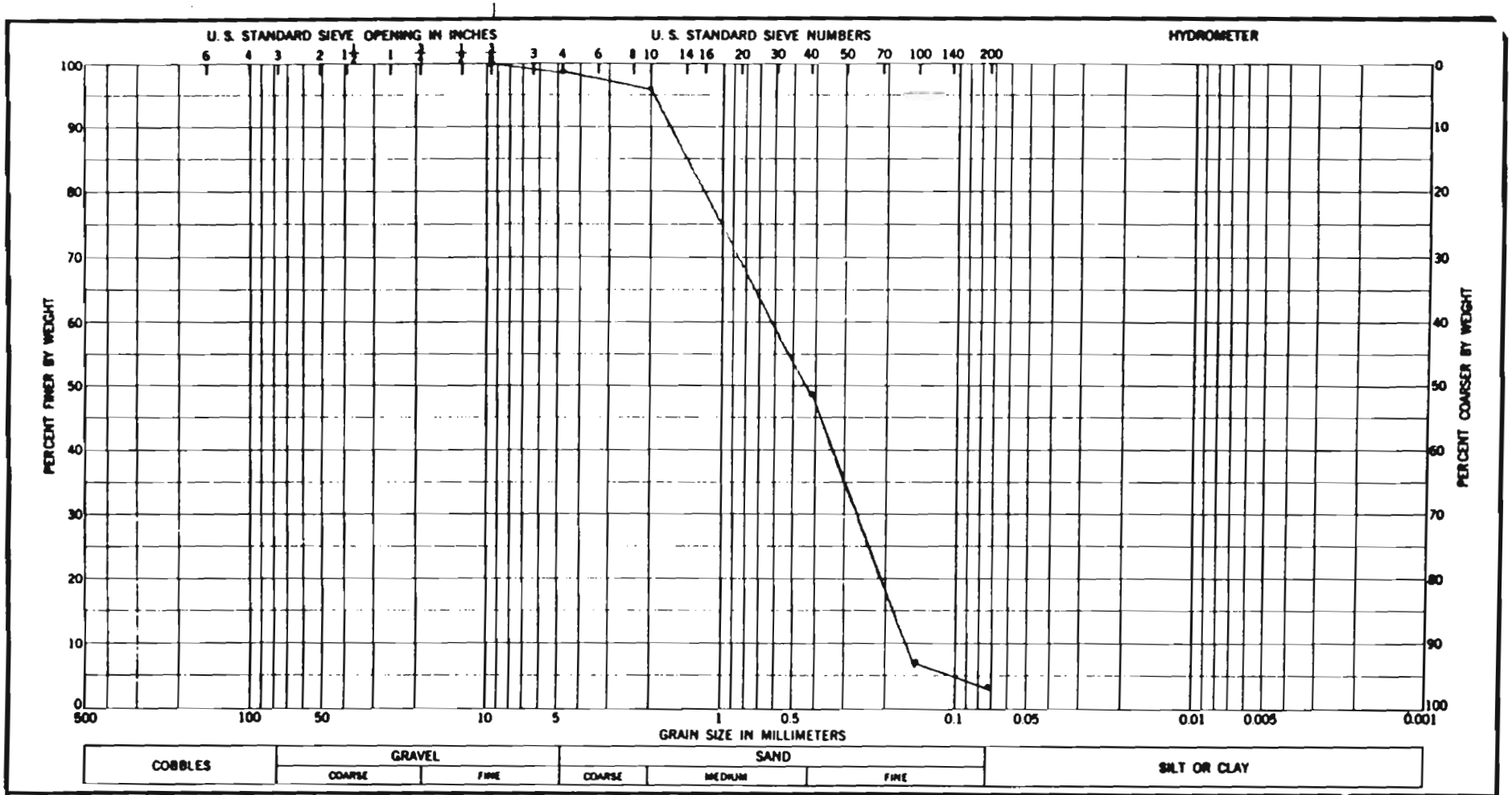
AREA - CENTER OF SLOUGH NEAR CHANNEL THROUGH SPLIT

SAMPLE # IN-8

ENG FORM 1 MAY 63 2087

d50 = 0.45 mm

PLATE 17



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

GRADATION CURVES

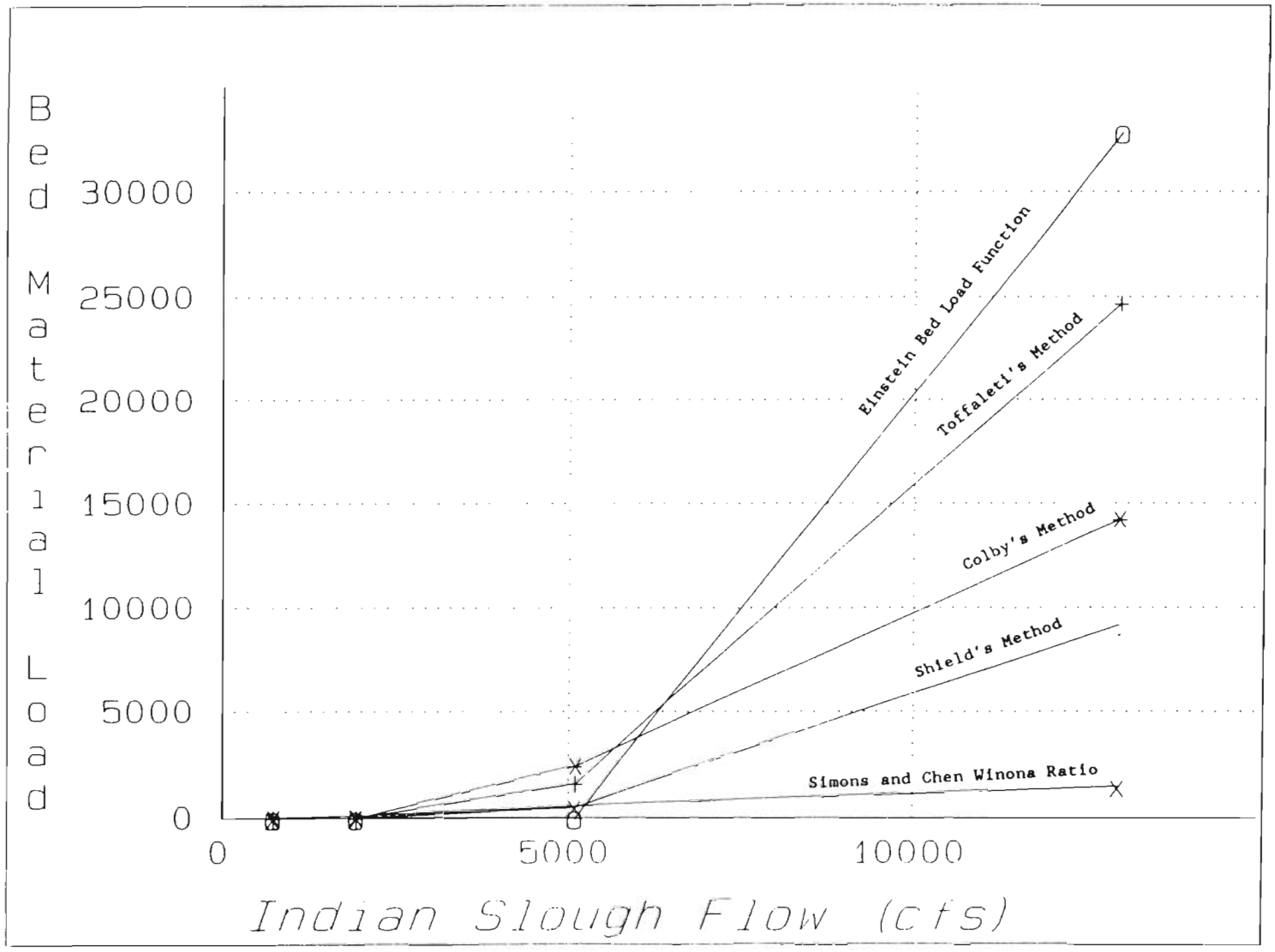
PROJECT - INDIAN SLOUGH

AVERAGE OF ALL SAMPLES

(IN-1 through IN-8)

ENG FORM 1 MAY 63 2087

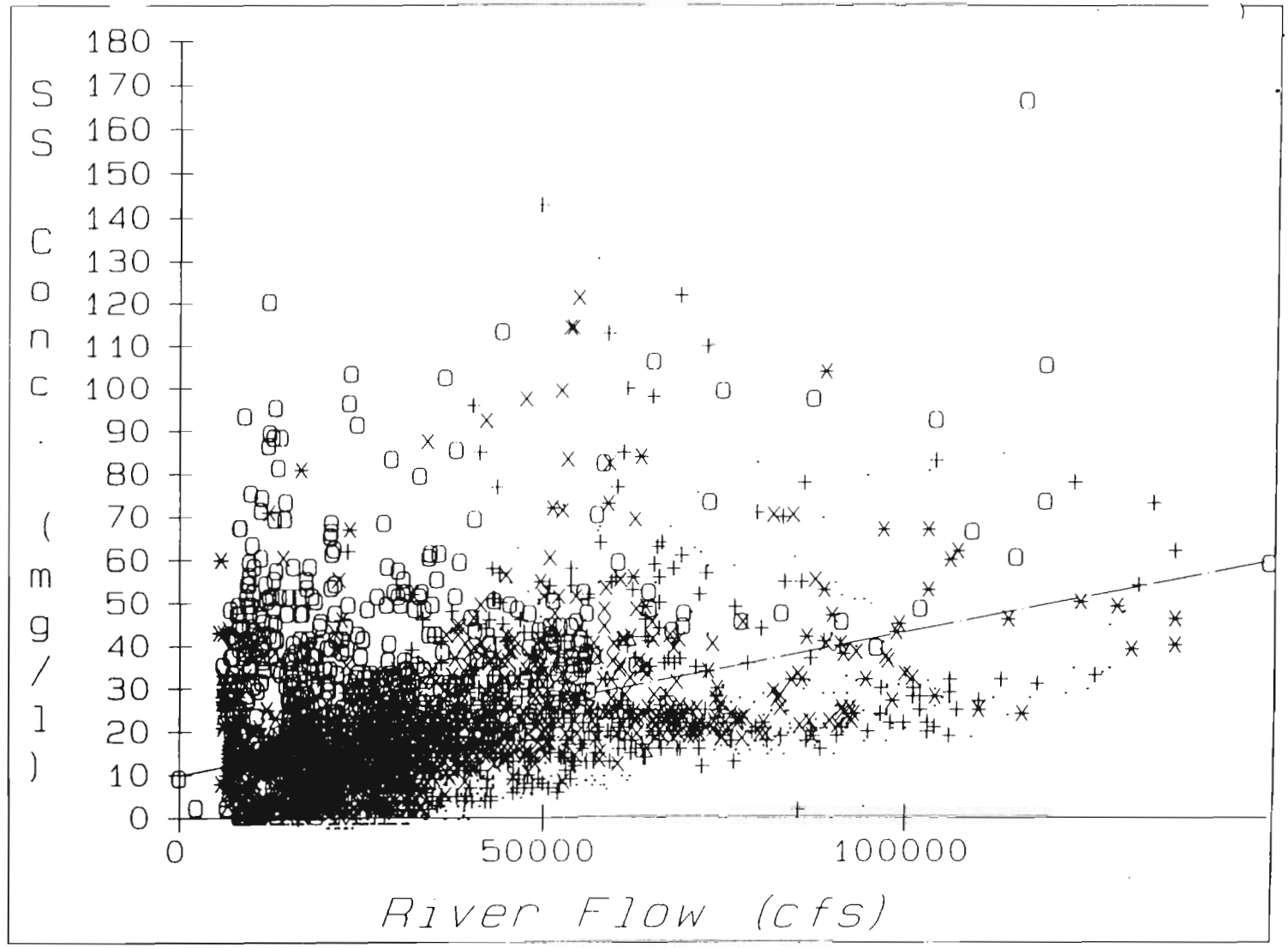
d50 = 0.45 mm



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Bed-Material Transport

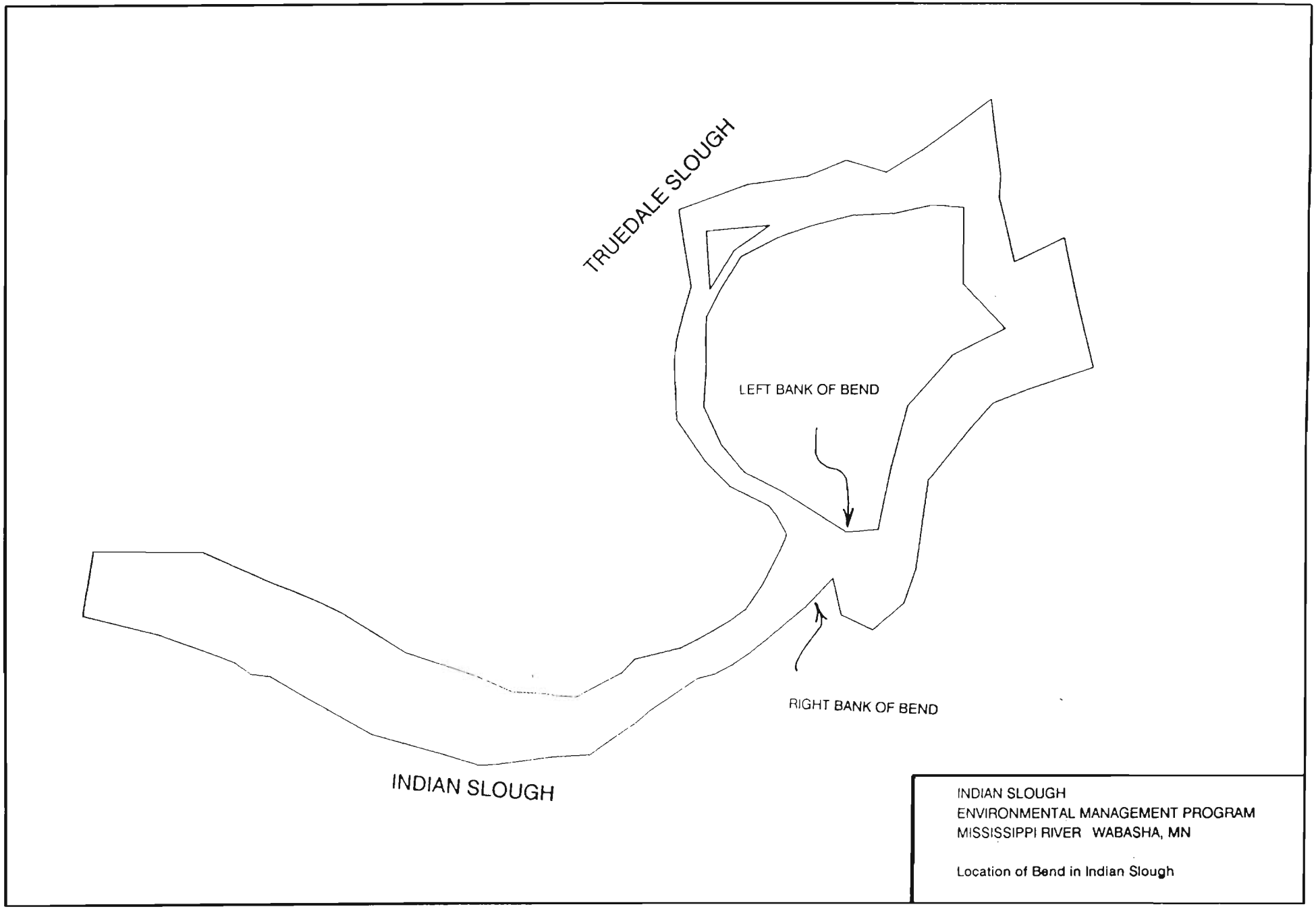
PLATE 19



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Suspended Sediment vs. Miss. Flow

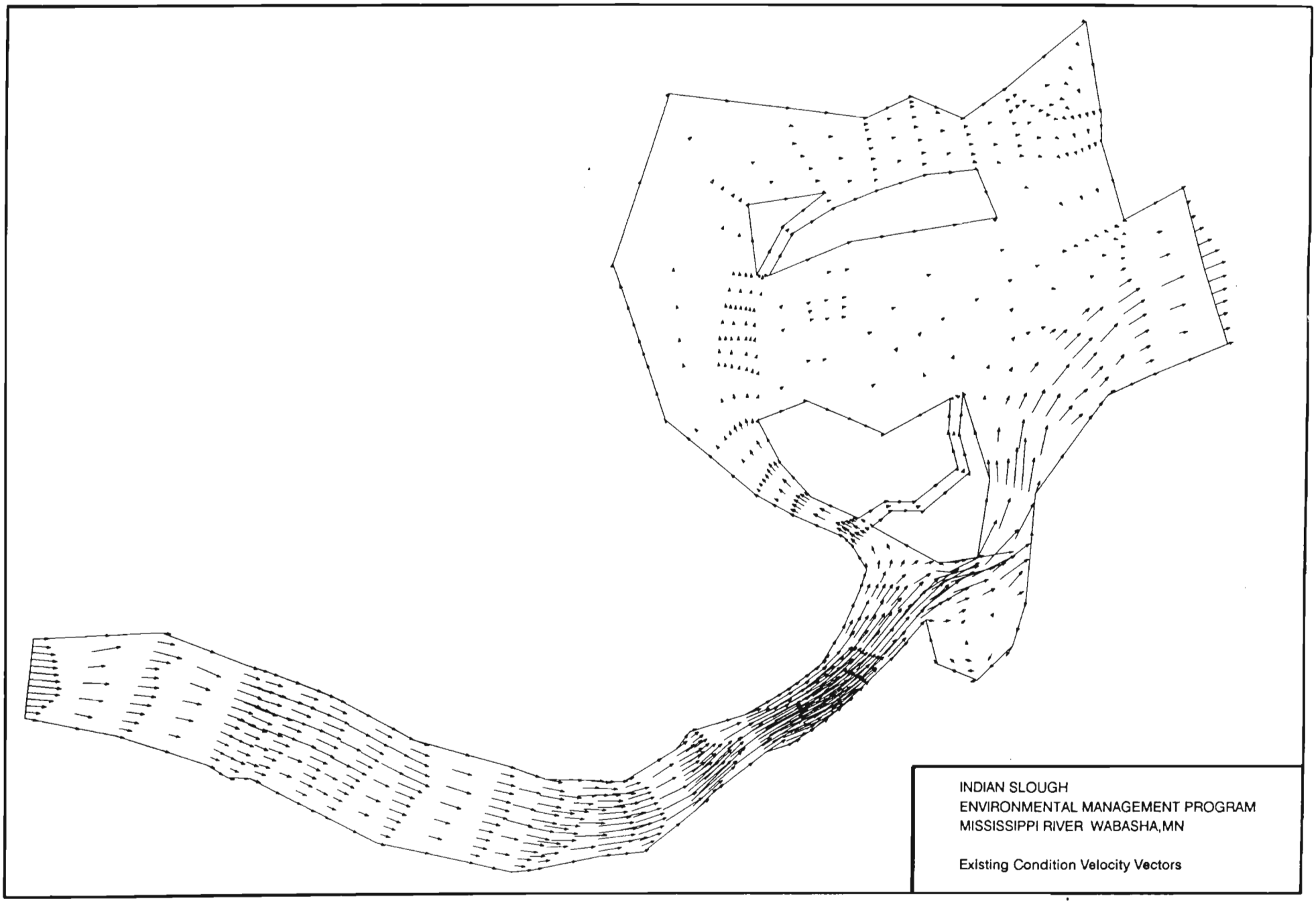
PLATE 20



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA, MN

Location of Bend in Indian Slough

PLATE 21



INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA,MN

Existing Condition Velocity Vectors

PLATE 22

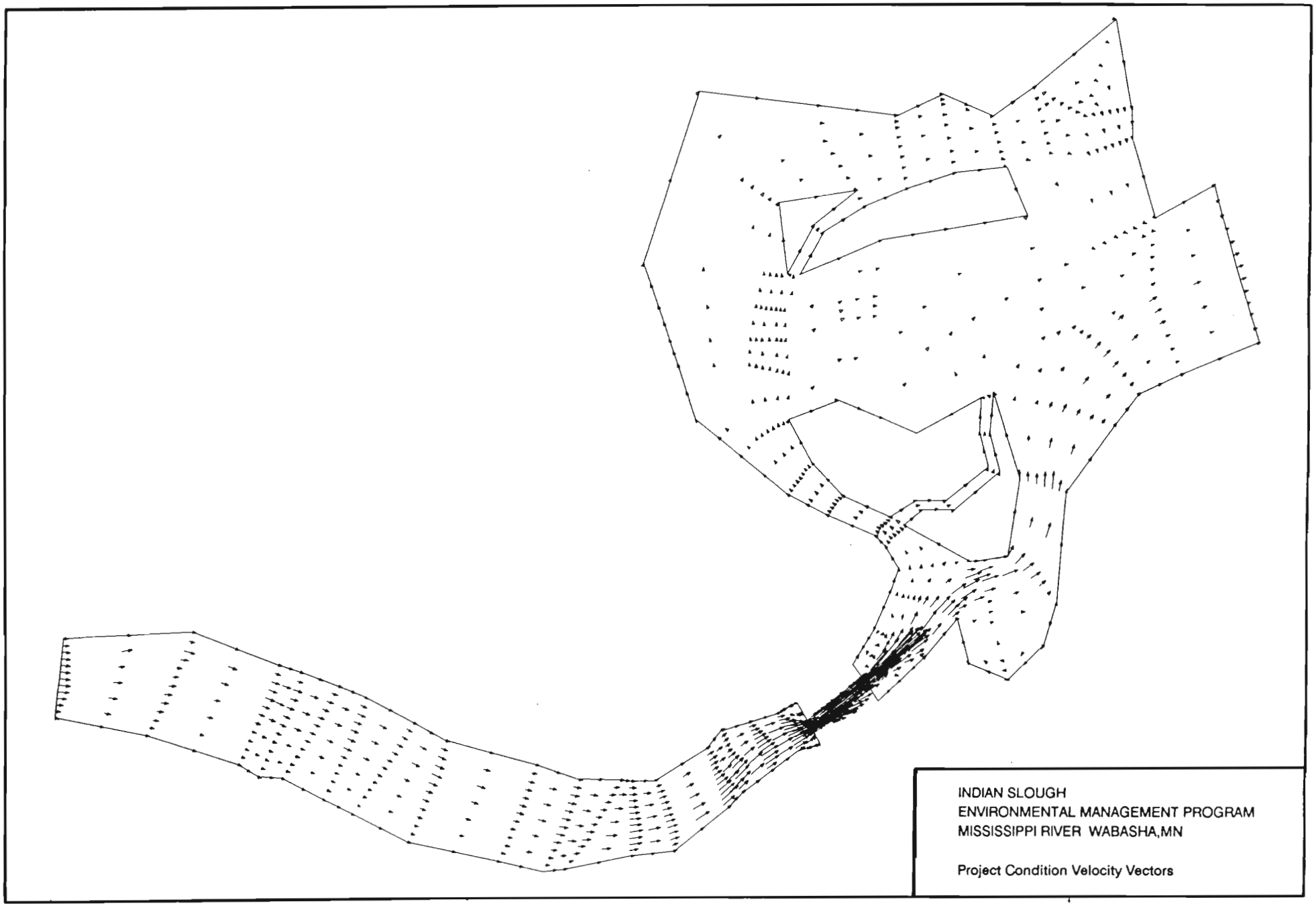

INDIAN SLOUGH
ENVIRONMENTAL MANAGEMENT PROGRAM
MISSISSIPPI RIVER WABASHA,MN
Project Condition Velocity Vectors

PLATE 23

APPENDIX B

COST ESTIMATE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
12.-.-.-	DREDGING - PARTIAL CLOSURE - ALT. B (USING 8" MINI-DREDGE)							
12.0.1.A	REMOVE ROCK WINGDAM (1)	JOB	1	20,000	20,000	5,000	25.0%	1,2
12.0.A.-	MOB. & DEMOB. WHOREHOUSE SLOUGH	JOB	1	8,000	8,000	2,000	25.0%	1,2
12.0.2.B	PIPELINE DREDGING (2)	C.Y.	7,200	3.20	23,000	6,900	30.0%	1,2
16.-.-.-	BANK STABILIZATION							
16.0.A.-	MOB. AND DEMOB.	JOB	1	10,000	10,000	2,500	25.0%	1,2
16.0.1.B	PLUG BREACH IN BANK UPSTREAM OF STRUCTURE							
16.0.1.B	FILL	C.Y.	500	10.00	5,000	1,300	26.0%	1,2
16.0.1.B	RIPRAP	C.Y.	250	33.00	8,300	2,100	25.3%	1,2
16.0.1.B	RIPRAP							
16.0.1.B	STRUCTURE	C.Y.	9,200	33.00	303,600	75,900	25.0%	1,2
16.0.1.B	CATFISH SLOUGH	C.Y.	200	33.00	6,600	3,300	50.0%	1,2
16.0.1.B	ROBINSON LAKE	C.Y.	600	33.00	19,800	19,800	100.0%	1,2,3
30.-.-.-	PLANNING, ENGINEERING AND DESIGN							
30.E.-.-	DESIGN RELATED ENGINEERING	JOB	1	28,500	28,500	2,900	10.2%	1
30.H.-.-	PLANS AND SPECIFICATIONS	JOB	1	53,300	53,300	5,300	9.9%	1
30.J.-.-	ENGINEERING DURING CONSTRUCTION	JOB	1	17,300	17,300	1,700	9.8%	1
31.-.-.-	CONSTRUCTION MANAGEMENT	JOB	1	32,800	32,800	0	0.0%	4
				SUBTOTAL	536,200			
				CONTINGENCIES	24.0%	128,700		
				TOTAL		$664,900		

REASONS FOR CONTINGENCIES

1. QUANTITIES UNKNOWNS
2. UNIT PRICE UNKNOWNS
3. ACCESS MAY REQUIRE WINTER CONSTRUCTION
4. NONE REQUIRED

NOTES

1. REMOVE WINGDAM FOR ACCESS
2. DISPOSAL AT CRATS ISLAND

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
12.-.-.-	DREDGING - BIGLAKE (USING 8" MINI-DREDGE)							
12.O.A.-	MOB. & DEMOB.	JOB	1	14,000	14,000	3,500	25.0%	1,2
12.O.1.-	DISPOSAL AREA (1)							
12.O.1.B	CLEARING AND GRUBBING	ACRE	3	2,500	7,500	1,900	25.3%	1,2
12.O.1.B	DIKE CONSTRUCTION							
12.O.1.B	6 ACRE SITE	C.Y.	14,000	1.10	15,400	4,600	29.9%	1,2
12.O.1.B	10 ACRE SITE	C.Y.	32,500	1.10	35,800	10,700	29.9%	1,2
12.O.2.B	PIPELINE DREDGING	C.Y.	46,000	4.00	184,000	46,000	25.0%	1,2
30.-.-.-	PLANNING, ENGINEERING AND DESIGN							
30.E.-.-	DESIGN RELATED ENGINEERING	JOB	1	9,700	9,700	1,000	10.3%	1
30.H.-.-	PLANS AND SPECIFICATIONS	JOB	1	28,450	28,500	2,900	10.2%	1
30.J.-.-	ENGINEERING DURING CONSTRUCTION	JOB	1	11,800	11,800	1,200	10.2%	1
31.-.-.-	CONSTRUCTION MANAGEMENT	JOB	1	16,400	16,400	0	0.0%	4
				SUBTOTAL	323,100			
				CONTINGENCIES	26.0%	71,800		
				TOTAL		$394,900		

REASONS FOR CONTINGENCIES

1. QUANTITIES UNKNOWNS
2. UNIT PRICE UNKNOWNS
3. UNKNOWN SITE CONDITIONS
4. NONE REQUIRED

NOTES

1. CLEARING AT DISPOSAL AREA

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
12.-.-.-	DREDGING - RIFFLE POOL COMPLEX (USING 8" MINI-DREDGE)							
12.O.A.-	MOB. & DEMOB.	JOB	1	6,000	6,000	1,500	25.0%	1,2
12.O.2.B	PIPELINE DREDGING	C.Y.	1,400	2.50	3,500	900	25.7%	1,2
16.-.-.-	BANK STABILIZATION							
16.O.A.-	MOB. AND DEMOB.	JOB	1	10,000	10,000	2,500	25.0%	1,2
16.O.1.B	RIPRAP	C.Y.	3,800	33.00	125,400	31,400	25.0%	1,2
30.-.-.-	PLANNING, ENGINEERING AND DESIGN							
30.E.-.-	DESIGN RELATED ENGINEERING	JOB	1	9,700	9,700	1,000	10.3%	1
30.H.-.-	PLANS AND SPECIFICATIONS	JOB	1	28,450	28,500	2,900	10.2%	1
30.J.-.-	ENGINEERING DURING CONSTRUCTION	JOB	1	11,800	11,800	1,200	10.2%	1
31.-.-.-	CONSTRUCTION MANAGEMENT	JOB	1	16,400	16,400	0	0.0%	3
				SUBTOTAL	211,300			
				CONTINGENCIES		19.6%	41,400	
				TOTAL			$252,700	

REASONS FOR CONTINGENCIES

1. QUANTITIES UNKNOWNS
2. UNIT PRICE UNKNOWNS
3. NONE REQUIRED