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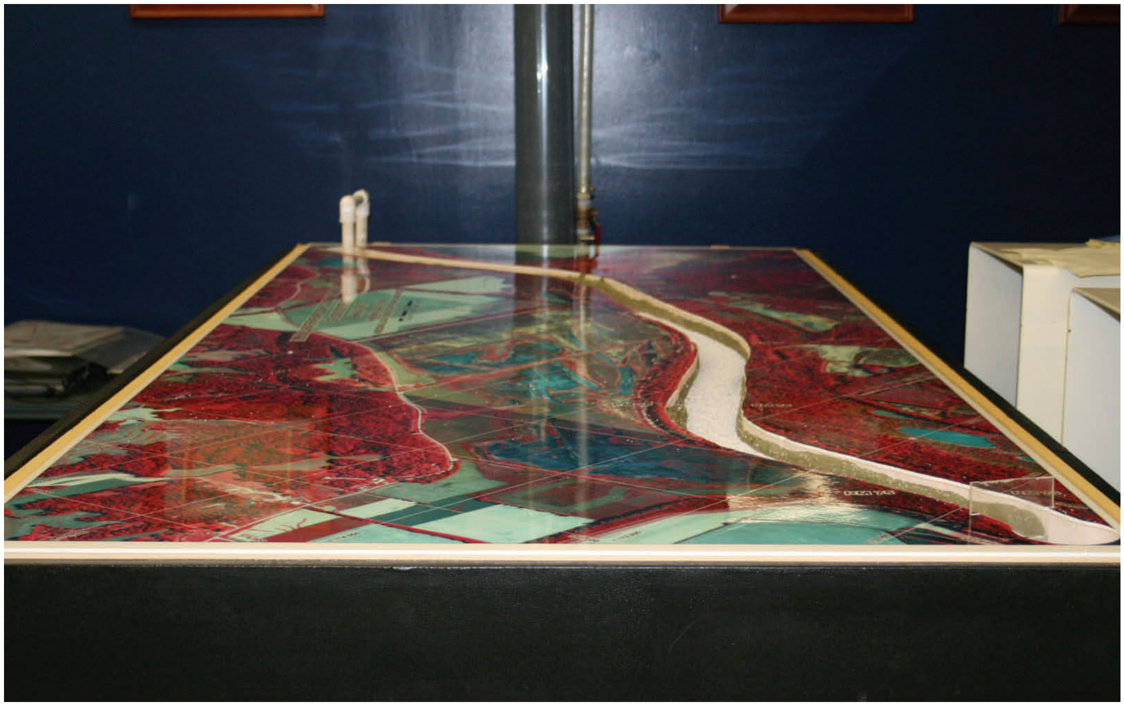
US Army Corps of Engineers
St. Louis District

ILLINOIS RIVER HYDRAULIC SEDIMENT RESPONSE MODEL STUDY



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U.S. ARMY CORPS OF ENGINEERS
ST. LOUIS DISTRICT
HYDROLOGIC AND HYDRAULICS BRANCH
APPLIED RIVER ENGINEERING CENTER
FOOT OF ARSENAL STREET
ST. LOUIS, MISSOURI 63118

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In Cooperation With:
Illinois Department of Natural Resources
Missouri Department of Conservation
U.S. Fish and Wildlife Service
River Industry Action Committee

APPLIED RIVER ENGINEERING CENTER

INTRODUCTION

The U.S. Army Corps of Engineers, St. Louis District, conducted a sedimentation improvement study from below the LaGrange Lock and Dam at River Mile (RM) 80.0 to RM 74.5 near Meredosia Island. This study was funded by the American Recovery and Reinvestment Act of 2009. The main objective was to reduce or eliminate repetitive maintenance dredging between RM 78.0 to RM 76.0.

The study was conducted between June, 2009 and February, 2010 using a physical hydraulic sediment response (HSR) model at the Applied River Engineering Center, U.S Army Corps of Engineers, St. Louis District. The model study was performed by Mr. Ivan Nguyen, Hydraulic Engineer, under direct supervision of Mr. Robert Davinroy, P.E., Chief of River Engineering Section for the St. Louis District.

Table I: Other personnel involved in the study

Leonard Hopkins, P.E.	Hydrologic and Hydraulic Branch Chief
June Jeffries, PE	Project Manager
Peter Russell, P.E.	Hydraulic Engineer
Ashley N. Cox	Hydraulic Engineer
Brian Johnson	Natural Resource Planner
Lance Engle	Dredging Project Manager
Amanda Oliver	Ecologist
Joyce Collins	U.S. Fish and Wildlife Service
Butch Atwood	Illinois Department of Natural Resources
Ed Henleben	River Industry Action Committee (RIAC)
Jasen L. Brown, P.E.	Hydraulic Engineer

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BACKGROUND

1. Problem Description

Illinois River, miles 80.0 to 0.0 is part of St. Louis District Waterway System. Many of the commodities that are transported by waterways to the Mississippi River travel through this reach. Sediment deposition in the navigation channel just downstream of the LaGrange Lock and Dam between RM 78.0 and 76.0 has made it necessary to perform repetitive channel maintenance dredging.

In the model study reach, over the past three years (2005-2008), approximately 1.17 million cubic yards of material has been dredged at a cost of about $2.8 million dollars. Repetitive dredging is the current solution for maintaining an appropriate navigation channel at this location. Any reduction in dredging through this reach while maintaining the navigation will increase the efficiency of waterways transportation.

2. Study Purpose and Goals

The purpose of this Hydraulic Sediment Response (HSR) Model study was to evaluate various design alternatives intended to reduce or eliminate repetitive channel maintenance dredging between RM 78.0 to 76.0.

The goals of this model study are as follows:

- Design of river structures that significantly reduce or eliminate the need for repetitive channel maintenance dredging between RM 80.0 and 74.5.
- Ensure that any structures recommended by this report do not have negative impacts on the navigation channel.
- Ensure that any structures recommended by this report either maintains or improves existing environmental conditions present between RM 80.0 and 74.5.

3. Study Reach

The study comprised a 5.5-mile stretch of the Illinois River, between RM 80.0 – 74.5 near LaGrange, IL. The study reach was located in Beardstown, Illinois. Plate 1 is a location and vicinity map of the study reach.

LaGrange Lock and Dam was located just upstream of the study reach and was considered in the entrance condition of the model. The pool above the lock and dam act provides flow to the reach. At RM 76.0 there are two consecutive islands formed as one. An analysis of hydrographic surveys showed that the island's side channel was near or at the same elevation of the island. Therefore, at most stages flow was restricted or non-existent through this channel.

Currently, no river training structures exist within this reach of the Illinois River. At RM 78.8, a small tributary entered the reach. A small localized eddy effect on the LDB was observed in the field at this tributary entrance. A 2005 aerial photograph illustrating the characteristics through the study reach is shown on Plate 2.

Sediment samples were taken in the reach and showed that the bed consisted mostly of consolidated clay material and some sand. The study reach was fairly straight with no major meandering pattern. Also, slow velocity of water was observed in the field throughout the reach. Therefore, banklines showed no sign of significant erosion. Field photographs of the study reach between RM 78.5 and 74.5 are shown on Plate 3.

Hydrographic surveys taken in 2000, 2002, 2003, 2004, 2006, 2007, 2008 and 2009 are shown on Plates 4-12. Due to the considerable repetitive maintenance dredging in the study reach, many of the surveys showed adequate navigation depths when in reality many areas of the channel shoaled considerably. A good example where the crossing between miles 78.0 and 77.0 has shoaled prior to the dredge cut is shown on Plate 11 in the July 2009 survey.

4. Study Reach Channel Characteristics and General Trends

A comparison of the above mentioned hydrographic surveys showed that the following bathymetric trends have remained relatively constant since 2000.

Table II: Bathymetric trends from RM 80.0 to 74.5.

Note: All elevations in the surveys are referenced to Minimum Pool Elevation (MPE)

River Miles	Description
80.0 – 79.0	The thalweg was located along the right descending bank (RDB) with depths between -10 feet and -16 feet. A sandbar was located on the right descending bank (LDB).
79.0 – 78.0	At RM 78.7 the thalweg crossed to the LDB in the bend and a sandbar developed on the RDB of the bend. Near RM 78.0 the thalweg showed depths between -8 feet and -10 feet and crossed to the RDB. Repetitive dredging occurred between mile 79.0 and 78.0.
78.0 – 77.0	Shoaling occurred along most of the crossing between Miles 78.0 and 77.0. The pre-dredge survey is shown on Plate 11. The thalweg crossed to the LDB at RM 77.0.
77.0 – 76.0	A sandbar developed along the RDB between miles 77.0 and 76.0. The thalweg crossed to the LDB around RM 76.5. Repetitive dredging has occurred between mile 77.0 and 76.0.
76.0 – 74.5	A sandbar on the LDB occurred along most of the navigation channel from 75.8 to 75.2. Around RM 75.0 the thalweg crossed to the LDB. Repetitive dredging occurred between mile 76.0 and 75.0.

MODEL DESCRIPTION

1. Scales and Bed Materials

The model employed a horizontal scale of 1 inch = 300 feet, or 1:3600, and a vertical scale of 1 inch = 90 feet, or 1:1080, for a 1.67 to 1 distortion ratio of linear scales. This distortion supplied the necessary forces required for the simulation of sediment transport conditions similar to those observed in the prototype. The bed material was granular plastic urea, Type II, with a specific gravity of 1.40. Plate 14 is a photograph of the hydraulic sediment response model used in this study.

2. Appurtenances

The HSR model insert planform was constructed according to the 2005 high-resolution aerial photography of the study reach. The insert was then mounted in a standard HSR model flume. The riverbanks of the model were constructed from dense polystyrene foam and modified during calibration with clay and galvanized steel mesh. Rotational jacks located within the hydraulic flume controlled the slope of the model. The measured slope of the insert and flume was approximately 0.015 inch/inch. River training structures in the model were constructed of galvanized steel mesh to generate appropriate scaled roughness.

Flow into the model was regulated by customized computer hardware and software interfaced with an electronic control valve and submersible pump. This interface was used to automatically control the flow of water and sediment into the model. Discharge was monitored by a magnetic flow meter interfaced with the customized computer software. The water surface in the model was manually checked with a mechanical three dimensional point digitizer. Resultant bed configurations of all tests were measured and recorded with a three dimensional laser scanner.

HSR MODEL TESTS

1. Model Calibration

The calibration of the model involved the adjustment of water discharge, sediment volume, model slope, and entrance conditions of the model. These parameters were refined until the measured bed response of the model was similar to that of the actual river.

In all model tests, a steady state flow was simulated in the channel. This served as the average design energy response of the river. Because of the constant variation experienced in the actual river, this steady state flow was used to theoretically analyze the ultimate expected sediment response. The flow was held steady at a constant flow rate of 1.17 Gallons per Minute (GPM) during model calibration and for all design alternative tests. An important factor during the modeling process is the establishment of an equilibrium condition of sediment transport. The high steady flow in the model simulated an average energy condition representative of the river's channel forming flow and sediment transport potential at bank full stage.

2. Base Test

Model calibration was achieved when it was determined through qualitive comparisons that the base test surveys showed similar bathymetric trends to several prototype surveys of the model reach. The resultant bathymetry of the calibrated model bed response served as the base test (Plate 15). The base test served as the comparative bathymetry for all design alternative tests.

As stated previously (page 5), most of the surveys obtained since 2000 show that periodic maintenance dredging has occurred, so the hydrographic surveys did not reflect the amount of ultimate shoaling that would likely occur in the absence of dredging. Some indication of shoaling is shown on Plate 11, but again, the ultimate bathymetric trend is not fully captured by this survey. Thus, calibration of the model base test involved accounting for historical dredge cuts and disposals as shown on Plate 13. The final base test is shown on Plate 15 compared against both a 2009 pre-dredge and post dredge survey along with overlays of the historical dredging. The following trends were observed in the model base test:

- The thalweg entered the study reach along the RDB at RM 79.5.
- The thalweg crossed to the LDB and remained between RM 79.0 to 78.0.
- The thalweg crossed to the RDB between River Mile 78.0 to 77.2 with depths between -6 ft to -10 ft. This has been a constant source of dredging as shown on the 2009 pre-dredge survey.
- The thalweg crossed to the LDB sharply and remained from Mile 77.0 to 76.5. Sediment built up along the RDB with depths between -6ft and -8ft.
- Deposition formed along the opposite LDB between miles 76.8 and 75.0.
- Deposition occurred at the right side of Towhead Island at depths between +1 and +3 feet.
- The thalweg crossed to the RDB after hitting Towhead Island and remained along the RDB through the end of the model.
- The alternating bar pattern demonstrated in the model was consistent with the past historical dredging and thus was considered representative of what could be expected to occur in the river with no dredging.

3. Design Alternative Tests

The testing process consisted of installing alternative structures in configurations that could alter the model bathymetry in a manner intended to deepen or widen the channel for navigation while creating habitat diversity. Evaluation of each alternative was accomplished through a qualitative comparison to the model base test bathymetry. Degradation is a lowering in elevation of the river bed and is the desired result in the river channel at RM 78.0, 77.5, 77.1, 76.5 and 76.2. Aggradation is the raising in elevation of the river bed and, in this case, is an unwelcome consequence of degradation. Furthermore, 8 possible dredge locations were established from RM 79.0

to 75.0. Each was designated with a letter from A to H. All alternatives would be evaluated base on how many dredge locations can be eliminated. Dredge locations are shown on Plate 13.

Alternative 1

Table I: River Training Structures, See Plate 16

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	Dike	+2	180
	79.4	Dike	+2	250
	79.2	Dike	+2	250
	78.9	Dike	+2	225
	77.8	Dike	+2	200
	78.7	Dike	+2	250
	78.5	Dike	+2	250
	78.3	Dike	+2	225
	78.2	Dike	+2	225
	75.8	Dike	+2	225
	75.6	Dike	+2	350
	75.4	Dike	+2	325
	75.3	Dike	+2	350
	75.1	Dike	+2	275
	75.0	Dike	+2	250
RDB	78.8	Dike	+2	250
	78.7	Dike	+2	300
	78.5	Dike	+2	300
	78.4	Dike	+2	250
	76.9	Dike	+2	150
	76.8	Dike	+2	200
	76.7	Dike	+2	200
	76.5	Dike	+2	200
	76.3	Dike	+2	200

Table II: Alternative 1 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5			X
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2			X
Dredging Area H	75.5			X

Alternative 2

Table I: River Training Structures, See Plate 17

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	Dike	+2	180
	79.4	Dike	+2	250
	79.2	Dike	+2	250
	78.9	Dike	+2	200
	78.8	Dike	+2	100
	78.0	Dike	+2	150
	77.9	Dike	+2	250
	77.8	Dike	+2	250
	77.6	Dike	+2	250
	77.5	Dike	+2	275
	77.3	Dike	+2	200
	77.1	Dike	+2	125
	77.1	Dike	+2	100
	76.3	Dike	+2	100
	76.1	Dike	+2	100
	75.8	Dike	+2	225
	75.6	Dike	+2	350
	75.4	Dike	+2	325
	75.3	Dike	+2	350
	75.1	Dike	+2	275
	75.0	Dike	+2	250
RDB	78.7	Dike	+2	140
	78.6	Dike	+2	275
	78.4	Dike	+2	250
	78.3	Dike	+2	200
	78.2	Dike	+2	150
	78.0	Dike	+2	150
	77.1	Dike	+2	150
	77.0	Dike	+2	250
	76.8	Dike	+2	250

Table II: Alternative 2 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5			X
Dredging Area C	78.0	X		
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 3

Table I: River Training Structures, See Plate 18

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	Dike	+2	180
	79.4	Dike	+2	250
	79.2	Dike	+2	250
	78.9	Dike	+2	200
	78.8	Dike	+2	100
	78.0	Dike	+2	150
	77.9	Dike	+2	250
	77.8	Dike	+2	250
	77.6	Dike	+2	250
	77.4	Dike	+2	275
	77.3	Dike	+2	200
	77.2	Dike	+2	125
	77.0	Dike	+2	100
	76.4	Dike	+2	100
	76.3	Dike	+2	100
	76.2	Dike	+2	100
	75.8	Dike	+2	225
	75.6	Dike	+2	350
	75.4	Dike	+2	325
	75.3	Dike	+2	350
	75.1	Dike	+2	275
	75.0	Dike	+2	250
RDB	78.8	Dike	+2	140
	78.7	Dike	+2	275
	78.5	Dike	+2	250
	78.3	Dike	+2	200
	78.2	Dike	+2	100
	77.2	Dike	+2	200
	77.0	Dike	+2	200
	76.8	Dike	+2	200
	76.7	Dike	+2	200

Table II: Alternative 3 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5			X
Dredging Area C	78.0	X		
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2			X
Dredging Area H	75.5			X

Alternative 4

Table I: River Training Structures, See Plate 19

Bank	Structure	Type	Height MPE(ft)	Length (ft)
LDB	79.5	Dike	+2	180
	79.4	Dike	+2	250
	79.2	Dike	+2	250
	78.9	Dike	+2	225
	77.8	Dike	+2	200
	77.7	Dike	+2	250
	77.5	Dike	+2	250
	77.3	Dike	+2	225
	77.2	Dike	+2	225
	75.8	Dike	+2	225
	75.6	Dike	+2	350
	75.4	Dike	+2	325
	75.3	Dike	+2	350
	75.1	Dike	+2	275
RDB	78.7	Dike	+2	250
	78.6	Dike	+2	300
	78.4	Dike	+2	300
	78.3	Dike	+2	250
	77.2	L-Dike	+2	350
	77.1	L-Dike	+2	350
	77.0	L-Dike	+2	450
	76.8	L-Dike	+2	450
	76.5	L-Dike	+2	450
	76.3	L-Dike	+2	450
	76.2	L-Dike	+2	450

Table II: Alternative 4 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5	X		
Dredging Area C	78.0		X	
Dredging Area D	77.5			X
Dredging Area E	77.0		X	
Dredging Area F	76.5			X
Dredging Area G	76.2		X	
Dredging Area H	75.5	X		

Alternative 5

Table I: River Training Structures, See Plate 20

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	L-Dike	+2	350
	79.4	Dike	+2	250
	79.2	Dike	+2	250
	78.9	Dike	+2	225
	77.8	Dike	+2	200
	78.9	L-Dike	+2	350
	78.8	L-Dike	+2	400
	77.5	Dike	+2	200
	77.3	Dike	+2	225
	75.8	Dike	+2	225
	75.6	Dike	+2	350
	75.4	Dike	+2	350
	75.3	Dike	+2	350
RDB	78.7	Dike	+2	250
	78.6	Dike	+2	300
	78.4	Dike	+2	300
	77.2	L-Dike	+2	250
	77.1	L-Dike	+2	250
	77.0	L-Dike	+2	350
	77.5	L-Dike	+2	350
	77.4	L-Dike	+2	350
	77.3	L-Dike	+2	350

Table II: Alternative 5 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5			X
Dredging Area C	78.0	X		
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 6

Table I: River Training Structures, See Plate 21

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	L-Dike	+2	350
	79.4	L-Dike	+2	250
	79.1	Dike	+2	250
	78.9	Dike	+2	225
	78.8	Dike	+2	200
	78.5	Armoring	-12	1900
	77.9	Dike	+2	400
	77.8	Dike	+2	200
	77.5	Dike	+2	225
	77.3	Dike	+2	225
	76.8	Armoring	-12	725
	76.2	Dike	+2	100
	76.1	Dike	+2	125
	76.0	Dike	+2	125
	75.6	Dike	+2	250
	75.5	Dike	+2	325
	75.3	Dike	+2	350
	75.2	Dike	+2	250
RDB	78.7	Dike	+2	250
	78.6	Dike	+2	300
	78.4	Dike	+2	300
	77.2	Dike	+2	250
	77.1	Armoring	-12	2000
	77.2	L-Dike	+2	300
	77.1	L-Dike	+2	300
	77.0	L-Dike	+2	400
	77.3	L-Dike	+2	400
	77.2	L-Dike	+2	400
	77.1	L-Dike	+2	400
	75.3	Armoring	-12	1800

Table II: Alternative 6 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5	X		
Dredging Area C	78.0			X
Dredging Area D	77.5			X
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 7

Table I: River Training Structures, See Plate 22

Bank	Chevron	Type	Height MPE (ft)	Length (ft)
LDB	79.5	L-Dike	+2	450
	79.4	Dike	+2	250
	79.2	Dike	+2	250
	78.9	Dike	+2	225
	77.8	Dike	+2	200
	77.8	Dike	+2	350
	77.5	Dike	+2	400
	77.3	Dike	+2	200
	75.7	Dike	+2	225
	75.5	Dike	+2	225
	75.3	Dike	+2	350
	75.1	Dike	+2	350
RDB	78.7	Dike	+2	250
	78.6	Dike	+2	300
	78.4	Dike	+2	300
	77.2	Dike	+2	250
	77.2	Dike	+2	250
	77.1	L-Dike	+2	400
	76.9	L-Dike	+2	400
	76.3	Chevron	+2	380
	76.2	Chevron	+2	380

Table II: Alternative 7 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5			X
Dredging Area C	78.0	X		
Dredging Area D	77.5			X
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2			X
Dredging Area H	75.5			X

Alternative 8

Table I: River Training Structures, See Plate 23

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	L-Dike	+2	350
	79.4	L-Dike	+2	250
	79.1	Dike	+2	250
	78.9	Dike	+2	225
	78.8	Dike	+2	200
	78.5	Armoring	-12	1600
	77.9	Dike	+2	400
	77.8	Dike	+2	200
	77.5	Dike	+2	225
	77.3	Dike	+2	225
	76.8	Armoring	-12	2300
	76.2	Dike	+2	350
	76.1	Dike	+2	350
	76.0	Dike	+2	350
	75.1	Dike	+2	350
RDB	78.7	Dike	+2	250
	78.6	Dike	+2	300
	78.5	Dike	+2	300
	78.4	L-Dike	+2	450
	77.2	L-Dike	+2	450
	77.1	Dike	+2	225
	77.0	Dike	+2	225
	75.3	Armoring	-12	2400

Table II: Alternative 8 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5	X		
Dredging Area C	78.0	X		
Dredging Area D	77.5			X
Dredging Area E	77.0		X	
Dredging Area F	76.5			X
Dredging Area G	76.2			X
Dredging Area H	75.5	X		

Alternative 9

Table I: River Training Structures, See Plate 24

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.5	L-Dike	+2	350
	79.4	L-Dike	+2	250
	79.1	Dike	+2	250
	78.9	Dike	+2	225
	78.8	Dike	+2	200
	78.5	Armoring	-12	3400
	77.9	Dike	+2	400
	77.8	Dike	+2	200
	77.5	Dike	+2	225
	77.3	Dike	+2	225
	76.8	Armoring	-12	3400
	76.2	Dike	+2	350
	76.1	Dike	+2	350
	76.0	Dike	+2	350
	75.1	Dike	+2	350
RDB	78.7	Dike	+2	250
	78.6	Dike	+2	300
	78.5	Dike	+2	300
	78.4	L-Dike	+2	450
	77.2	L-Dike	+2	450
	77.1	Dike	+2	225
	77.0	Dike	+2	225
	75.3	Armoring	-12	4000

Table II: Alternative 9 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5	X		
Dredging Area C	78.0		X	
Dredging Area D	77.5			X
Dredging Area E	77.0		X	
Dredging Area F	76.5			X
Dredging Area G	76.2		X	
Dredging Area H	75.5	X		

Alternative 10

Table I: River Training Structures, See Plate 25

Bank	Structure	Type	Height MPE (ft)	Length ft)
LDB	79.5	L-Dike	+2	350
	79.4	L-Dike	+2	250
	79.1	Dike	+2	250
	78.9	Dike	+2	225
	78.8	Dike	+2	200
	78.5	Armoring	-12	3000
	77.8	Dike	+2	400
	77.6	Dike	+2	200
	77.5	Dike	+2	225
	77.3	Dike	+2	225
	77.3	Armoring	-12	2700
	75.7	Dike	+2	225
	75.5	Dike	+2	300
	75.1	Dike	+2	225
RDB	78.7	Dike	+2	200
	78.6	Dike	+2	250
	78.5	Dike	+2	300
	78.3	Dike	+2	200
	77.1	Dike	+2	150
	76.9	Dike	+2	150
	76.7	Dike	+2	150
	76.3	Chevron	+2	300
	76.2	Chevron	+2	300
	75.4	Armoring	-12	4000

Table II: Alternative 10 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5			X
Dredging Area C	78.0		X	
Dredging Area D	77.5			X
Dredging Area E	77.0		X	
Dredging Area F	76.5			X
Dredging Area G	76.2		X	
Dredging Area H	75.5	X		

Alternative 11

Table I: River Training Structures, See Plate 26

Bank	Structure	Type	Height MPE (ft)	Length ft)
LDB	79.5	L-Dike	+2	320
	79.2	Dike	+2	150
	79.0	Dike	+2	150
	78.9	Dike	+2	150
	77.8	Chevron	+2	350
	77.5	Chevron	+2	350
	77.3	Chevron	+2	350
	75.7	Dike	+2	225
	75.6	Dike	+2	325
	75.4	Dike	+2	225
	75.1	Dike	+2	225
RDB	78.5	Dike	+2	150
	78.3	Dike	+2	150
	77.0	Dike	+2	150
	76.9	L-Dike	+2	375
	76.2	L-Dike	+2	350

Table II: Alternative 11 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5			X
Dredging Area C	78.0		X	
Dredging Area D	77.5			X
Dredging Area E	77.0			X
Dredging Area F	76.5		X	
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 12

Table I: River Training Structures, See Plate 27

Bank	Structure	Type	Height MPE (ft)	Length ft)
LDB	79.5	Dike	+2	125
	79.2	Dike	+2	150
	79.0	Dike	+2	150
	78.9	Dike	+2	125
	77.8	Dike	+2	150
	77.7	L-Dike	+2	400
	77.4	Chevron	+2	400
	77.3	Chevron	+2	400
	76.2	Dike	+2	75
	76.1	Dike	+2	75
	75.7	Dike	+2	225
	75.6	Dike	+2	225
	75.3	Dike	+2	300
	75.1	Dike	+2	225
1RDB	78.7	Dike	+2	125
	78.5	Dike	+2	150
	78.2	Dike	+2	125
	77.1	Dike	+2	125
	76.9	L-Dike	+2	350
	76.8	Dike	+2	150
	76.3	Chevron	+2	350
	76.2	Chevron	+2	350

Table II: Alternative 12 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5			X
Dredging Area C	78.0		X	
Dredging Area D	77.5			X
Dredging Area E	77.0			X
Dredging Area F	76.5			X
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 13

Table I: River Training Structures, See Plate 28

Bank	Structure	Type	Height MPE (ft)	Length ft)
LDB	79.3	Dike	+2	150
	79.0	Dike	+2	150
	78.8	Dike	+2	125
	78.0	Dike	+2	125
	77.7	Dike	+2	150
	77.4	Dike	+2	150
	77.2	Dike	+2	125
	75.7	Dike	+2	125
	75.5	Dike	+2	225
	75.3	Dike	+2	200
	75.0	Dike	+2	200
1RDB	78.7	Dike	+2	125
	78.5	Dike	+2	150
	78.4	Dike	+2	125
	77.0	Dike	+2	125
	76.9	Dike	+2	125
	76.8	Dike	+2	125
	76.4	L-Dike	+2	550

Table II: Alternative 13 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5			X
Dredging Area C	78.0			X
Dredging Area D	77.5			X
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 14

Table I: River Training Structures, See Plate 29

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.7	Weir	-12	140
	78.6	Weir	-12	225
	78.5	Weir	-12	225
	78.4	Weir	-12	235
	78.3	Weir	-12	225
	78.2	Weir	-12	225
	78.1	Weir	-12	225
	77.8	Chevron	+2	520
	77.7	Chevron	+2	520
	77.6	Chevron	+2	480
	77.5	Chevron	+2	500
	77.3	Chevron	+2	480
	77.2	Chevron	+2	550
	76.90	Weir	-12	180
	76.85	Weir	-12	200
	76.8	Weir	-12	200
	76.75	Weir	-12	225
	76.7	Weir	-12	275
	76.65	Weir	-12	275
	76.60	Weir	-12	300
	76.55	Weir	-12	225
	76.5	Weir	-12	200

Table II: Alternative 14 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5			X
Dredging Area C	78.0		X	
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 15

Table I: River Training Structures, See Plate 30

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.8	Weir	-12	225
	78.75	Weir	-12	270
	78.7	Weir	-12	240
	78.5	Weir	-12	300
	78.4	Weir	-12	350
	78.3	Weir	-12	400
	78.2	Weir	-12	425
	77.9	Chevron	+2	500
	77.7	Chevron	+2	500
	77.5	Chevron	+2	500
	77.4	Chevron	+2	500
	77.2	Chevron	+2	500
	77.1	Chevron	+2	500

Table II: Alternative 15 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5			X
Dredging Area C	78.0	X		
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 16

Table I: River Training Structures, See Plate 31

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.8	Weir	-12	225
	78.75	Weir	-12	270
	78.7	Weir	-12	240
	78.5	Weir	-12	300
	78.4	Weir	-12	350
	78.3	Weir	-12	400
	78.2	Weir	-12	425
	77.9	Chevron	+2	500
	77.7	Chevron	+2	500
	77.5	Chevron	+2	500
	77.4	Chevron	+2	500
	77.2	Chevron	+2	500
	77.1	Chevron	+2	500
	76.9	Weir	-12	320
	76.8	Weir	-12	350
	76.7	Weir	-12	400
	76.6	Weir	-12	450
	76.5	Weir	-12	400

Table II: Alternative 16 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5	X		
Dredging Area C	78.0		X	
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 17

Table I: River Training Structures, See Plate 32

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.5	Weir	-12	300
	78.4	Weir	-12	350
	78.3	Weir	-12	400
	78.2	Weir	-12	425
	77.9	Chevron	+2	500
	77.7	Chevron	+2	500
	77.5	Chevron	+2	500
	77.4	Chevron	+2	500
	77.2	Chevron	+2	500
	77.1	Chevron	+2	500
	76.9	Weir	-12	320
	76.8	Weir	-12	350
	76.7	Weir	-12	400
	76.6	Weir	-12	450
	76.5	Weir	-12	400

Table II: Alternative 17 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5			X
Dredging Area C	78.0		X	
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2		X	
Dredging Area H	75.5			X

Alternative 18

Table I: River Training Structures, See Plate 33

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.9	Dike	+2	260
	79.1	Dike	+2	260
	79.2	Dike	+2	260
	78.8	Weir	-12	225
	78.75	Weir	-12	270
	78.7	Weir	-12	240
	78.5	Weir	-12	300
	78.4	Weir	-12	350
	78.3	Weir	-12	400
	78.2	Weir	-12	425
	77.9	Chevron	+2	500
	77.7	Chevron	+2	500
	77.5	Chevron	+2	500
	77.4	Chevron	+2	500
	77.2	Chevron	+2	500
	77.1	Chevron	+2	500
	76.9	Weir	-12	320
	76.8	Weir	-12	350
	76.7	Weir	-12	400
RDB	76.6	Chevron	+2	400
	76.4	Chevron	+2	400
	76.3	Chevron	+2	400

Table II: Alternative 18 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5	X		
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 19

Table I: River Training Structures, See Plate 34

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	77.9	Chevron	+2	500
	77.7	Chevron	+2	500
	77.5	Chevron	+2	500
	77.4	Chevron	+2	500
	77.2	Chevron	+2	500
	77.1	Chevron	+2	500
	76.9	Weir	-12	320
	76.8	Weir	-12	350
	76.7	Weir	-12	400
RDB	76.6	Chevron	+2	400
	76.4	Chevron	+2	400
	76.3	Chevron	+2	400
	75.8	Weir	-12	260
	75.7	Weir	-12	260
	75.6	Weir	-12	260
	75.5	Weir	-12	260
	75.4	Weir	-12	300
	75.3	Weir	-12	400

Table II: Alternative 19 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5		X	
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5			X
Dredging Area G	76.2		X	
Dredging Area H	75.5	X		

Alternative 20

Table I: River Training Structures, See Plate 35

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.8	Weir	-12	185
	78.75	Weir	-12	225
	78.7	Weir	-12	300
	78.5	Weir	-12	400
	78.4	Weir	-12	400
	78.3	Weir	-12	400
	78.2	Weir	-12	480
	77.8	Chevron	+2	525
	77.7	Chevron	+2	525
	77.6	Chevron	+2	525
	77.4	Chevron	+2	525
	77.3	Chevron	+2	525
	77.1	Chevron	+2	525
	76.9	Weir	-12	300
	76.8	Weir	-12	300
	76.7	Weir	-12	300
RDB	76.6	Chevron	+2	400
	76.4	Chevron	+2	400
	76.2	Chevron	+2	400
	76.9	Weir	-12	125
	76.8	Weir	-12	150
	76.7	Weir	-12	175
	76.6	Weir	-12	275
	76.5	Weir	-12	300
	76.45	Weir	-12	340
	76.4	Weir	-12	300
	76.3	Weir	-12	325

Table II: Alternative 20 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5	X		
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5	X		

Alternative 21

Table I: River Training Structures, See Plate 36

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	77.8	Chevron	+2	525
	77.7	Chevron	+2	525
	77.6	Chevron	+2	525
	77.4	Chevron	+2	525
	77.3	Chevron	+2	525
	77.1	Chevron	+2	525
	76.9	Weir	-12	300
	76.8	Weir	-12	300
	76.7	Weir	-12	300
RDB	76.6	Chevron	+2	400
	76.4	Chevron	+2	400
	76.2	Chevron	+2	400

Table II: Alternative 21 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9			X
Dredging Area B	78.5			X
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 22

Table I: River Training Structures, See Plate 37

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	78.75	Weir	-12	345
	78.7	Weir	-12	250
	78.5	Weir	-12	300
	78.4	Weir	-12	400
	78.3	Weir	-12	425
	77.8	Chevron	+2	525
	77.7	Chevron	+2	525
	77.6	Chevron	+2	525
	77.4	Chevron	+2	525
	77.3	Chevron	+2	525
	77.1	Chevron	+2	525
	76.9	Weir	-12	300
	76.8	Weir	-12	300
	76.7	Weir	-12	300
RDB	76.6	Chevron	+2	400
	76.4	Chevron	+2	400
	76.2	Chevron	+2	400

Table II: Alternative 22 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5	X		
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 23

Table I: River Training Structures, See Plate 38

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.4	Chevron	+2	450
	79.2	Chevron	+2	450
	79.0	Chevron	+2	450
	78.9	Chevron	+2	450
	78.75	Weir	-12	325
	78.7	Weir	-12	225
	78.5	Weir	-12	325
	78.4	Weir	-12	400
	78.3	Weir	-12	445
	77.8	Chevron	+2	525
	77.7	Chevron	+2	525
	77.6	Chevron	+2	525
	77.4	Chevron	+2	525
	77.3	Chevron	+2	525
	77.1	Chevron	+2	525
	76.9	Weir	-12	300
	76.8	Weir	-12	300
	76.7	Weir	-12	300
RDB	76.6	Chevron	+2	400
	76.4	Chevron	+2	400
	76.2	Chevron	+2	400

Table II: Alternative 23 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5	X		
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 24

Table I: River Training Structures, See Plate 39

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.4	Chevron	+2	450
	79.2	Chevron	+2	450
	79.0	Chevron	+2	450
	78.9	Chevron	+2	450
	78.7	Weir	-12	325
	78.6	Weir	-12	275
	78.5	Weir	-12	400
	78.4	Weir	-12	400
	78.3	Weir	-12	375
	78.2	Weir	-12	400
	77.8	Chevron	+2	420
	77.7	Chevron	+2	420
	77.6	Chevron	+2	420
	77.4	Chevron	+2	420
	77.3	Chevron	+2	420
	77.1	Chevron	+2	420
	76.9	Weir	-12	300
	76.8	Weir	-12	350
	76.7	Weir	-12	350
RDB	76.6	Chevron	+2	360
	76.4	Chevron	+2	360
	76.2	Chevron	+2	360

Table II: Alternative 24 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9		X	
Dredging Area B	78.5			X
Dredging Area C	78.0			X
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 25

Table I: River Training Structures, See Plate 40

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.4	Chevron	+2	420
	79.2	Chevron	+2	420
	79.0	Chevron	+2	420
	78.9	Chevron	+2	420
	78.75	Weir	-13	330
	78.7	Weir	-13	275
	78.5	Weir	-13	430
	78.4	Weir	-13	430
	78.3	Weir	-13	375
	77.8	Chevron	+2	375
	77.7	Chevron	+2	420
	77.6	Chevron	+2	420
	77.4	Chevron	+2	420
	77.3	Chevron	+2	420
	77.1	Chevron	+2	420
	76.9	Weir	-13	300
	76.8	Weir	-13	350
	76.7	Weir	-13	350
RDB	76.6	Chevron	+2	360
	76.4	Chevron	+2	360
	76.2	Chevron	+2	360

Table II: Alternative 25 Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5	X		
Dredging Area C	78.0	X		
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

Alternative 25A

Table I: River Training Structures, See Plate 41

Bank	Structure	Type	Height MPE (ft)	Length (ft)
LDB	79.2	Chevron	+2	420
	79.1	Chevron	+2	420
	78.9	Chevron	+2	420
	78.75	Weir	-13	330
	78.7	Weir	-13	275
	78.5	Weir	-13	430
	78.4	Weir	-13	430
	78.3	Weir	-13	375
	77.8	Chevron	+2	375
	77.7	Chevron	+2	420
	77.6	Chevron	+2	420
	77.4	Chevron	+2	420
	77.3	Chevron	+2	420
	77.1	Chevron	+2	420
	76.9	Weir	-13	300
	76.8	Weir	-13	350
	76.7	Weir	-13	350
RDB	76.6	Chevron	+2	360
	76.4	Chevron	+2	360
	76.2	Chevron	+2	360

Table II: Alternative 25A Bathymetry Change

Site	River Mile	Degradation	Aggradation	No Change
Dredging Area A	78.9	X		
Dredging Area B	78.5	X		
Dredging Area C	78.0	X		
Dredging Area D	77.5	X		
Dredging Area E	77.0	X		
Dredging Area F	76.5	X		
Dredging Area G	76.2	X		
Dredging Area H	75.5			X

CONCLUSIONS

1. Summary

Twenty five alternative design tests were conducted in this study. All alternatives sought to reduce or eliminate repetitive dredging in the channel from RM 78.0 to 76.0. The tests included standard dikes, chevrons, weirs, armoring and combinations of two or more.

2. Analysis

Designs implemented in the model sought to reduce dredging by either moderate or significant amounts between RM 78.0 and 76.0. The following table summarizes the effect of each design.

Table I: Alternatives Summarized

		Dredging Locations							
		A	B	C	D	E	F	G	H
Alt 1	Aggradation								
	Degradation					x		x	
	No Change	x	x	x	x		x		x
Alt 2	Aggradation								
	Degradation			x	x	x		x	x
	No Change	x	x				x		
Alt 3	Aggradation							x	
	Degradation			x		x			x
	No Change	x	x		x		x		
Alt 4	Aggradation								
	Degradation	x		x		x			x
	No Change		x		x		x	x	

		A	B	C	D	E	F	G	H
Alt 5	Aggradation								
	Degradation	x		x		x		x	x
	No Change		x		x		x		
Alt 6	Aggradation			x					
	Degradation					x		x	
	No Change	x	x		x		x		x
Alt 7	Aggradation							x	
	Degradation					x			
	No Change	x	x	x	x		x		x
Alt 8	Aggradation			x		x			
	Degradation						x		
	No Change	x	x		x			x	x
Alt 9	Aggradation	x		x			x	x	
	Degradation								
	No Change		x		x	x			x
Alt 10	Aggradation	x		x		x			
	Degradation								
	No Change		x		x		x	x	x
Alt 11	Aggradation	x		x				x	
	Degradation					x			
	No Change		x		x		x		x
Alt 12	Aggradation			x				x	
	Degradation								
	No Change	x	x		x	x	x		x
Alt 13	Aggradation							x	
	Degradation								
	No Change	x	x	x	x	x	x		x

		Dredging Locations							
		A	B	C	D	E	F	G	H
Alt 14	Aggradation	x		x				x	
	Degradation				x	x			
	No Change		x				x		x
Alt 15	Aggradation	x							
	Degradation		x	x	x	x			
	No Change						x	x	x
Alt 16	Aggradation	x		x					
	Degradation		x		x	x	x		
	No Change							x	x
Alt 17	Aggradation	x	x	x					
	Degradation				x	x	x		
	No Change							x	x
Alt 18	Aggradation	x		x					
	Degradation		x		x	x	x	x	
	No Change								x
Alt 19	Aggradation	x		x				x	
	Degradation				x	x	x		
	No Change		x						x
Alt 20	Aggradation	x							
	Degradation		x	x	x	x	x	x	x
	No Change								
Alt 21	Aggradation			x					
	Degradation				x	x	x	x	
	No Change	x	x						x
Alt 22	Aggradation	x		x					
	Degradation		x		x	x	x	x	
	No Change								x

		Dredging Locations							
		A	B	C	D	E	F	G	H
Alt 23	Aggradation			X					
	Degradation		X		X	X	X	X	
	No Change	X							X

Alt 24	Aggradation	X							
	Degradation		X	X	X	X	X	X	
	No Change								X

Alt 25	Aggradation								
	Degradation	X	X	X	X	X	X	X	
	No Change								X

Alt 25A	Aggradation								
	Degradation	X	X	X	X	X	X	X	
	No Change								X

As shown in the previous table, six alternatives had either a moderate or significant increase in width and depth at Miles 78.0 to 76.0. Alternatives 2, 18, 20, 22, 23, 24 and 25A meet the width and depth requirements so they will be analyzed.

Alternative 25A offered 7 out of 8 degradation dredge locations from RM 79.0 to 75.0. The overall design was simple; consisted of a series of bendway weirs and chevrons.

3. Recommendations

Alternative 25A is the recommended alternative (see Plate 41), due to its ability to increase width and depth of the navigation channel from RM 78.0 to 76.0. Alternative 25A included the testing of 11 chevrons and 9 weirs from RM 79.5 to 76.2. This combination of chevrons and weirs significantly improved the navigation channel, created bathymetric diversity, and if implemented in the river, could significantly reduce repetitive maintenance dredging.

4. Interpretation of Model Test Reults

In the interpretation and evaluation of the results of the tests conducted, it should be remembered that the results of these model tests were qualitative in nature. Any hydraulic model, whether physical or numerical, is subject to error as a result of the inherent complexities that exist in the prototype. Anomalies in actual hydrographic events, such as prolonged periods or high or low flows are not reflected in these results, nor are complex physical phenomena, such as the existence of underlying rock formations or other non-erodible variables. Flood flows were not simulated in this study.

This model study was intended to serve as a tool for the river engineer as a guide in assessing the general trends that could be expected to occur in the actual river from a variety of imposed design alternatives. Measures for the final design may be modified based upon engineering knowledge and experience, real estate and construction considerations, economic and environmental impacts or any other special requirements.

5. Phased Construction Testing

The Illinois River's annual funding is likely to be insufficient to pay out the total construction that would be required for the proposed alternative. Therefore, it was proposed that alternative 25A, which included 11 chevrons and 9 weirs, be constructed in different phases ranging from two to five years. Construction should begin downstream and gradually work upstream toward the LaGrange Lock and Dam.

The breakdown in different phases was based on structure types and locations. They were divided into equal increments of work load. The different phases of construction should not cause any unwanted problems as far as the navigation channel's depth and width. The following tables list recommended construction phases.

Table I: Three Phase Construction (three year plan)

Phases	Structures	RM	Remarks
Phase 1 of 3	3 Chevrons & 3 Weirs	76.9 – 76.3	No problems occurred (See Plate 42)

Phase 2 of 3	5 Chevrons	77.9 – 77.0	No problems occurred (See Plate 43)
Phase 3 of 3	6 Weirs & 3 Chevrons	79.3 – 78.3	No problems occurred (See Plate 44)

Table II: Two Phase Construction (two year plan)

Phases	Structures	RM	Remarks
Phase 1 of 4	8 Chevrons & 3 Weirs	77.9 – 76.3	No problems occurred (See Plate 45)
Phase 2 of 4	3 Chevrons & 6 Weirs	79.3 – 78.3	No problems occurred (See Plate 46)

Table III: Four Phases Construction (four year plan)

Phases	Structures	RM	Remarks
Phase 1 of 4	3 Chevrons & 3 Weirs	76.9 – 76.3	No problems occurred (See Plate 47)
Phase 2 of 4	5 Chevrons	76.9 – 76.7	No problems occurred (See Plate 48)
Phase 3 of 4	6 Weirs	77.9 – 77.0	No problems occurred (See Plate 49)
Phase 4 of 4	3 Chevrons	78.6 – 78.3	No problems occurred (See Plate 50)

Table IV: Five Phases Construction (five year plan)

Phases	Structures	RM	Remarks
Phase 1 of 5	3 Chevrons	76.5 – 76.3	No problems occurred (See Plate 51)
Phase 2 of 5	3 Weirs	76.9 – 76.7	No problems occurred (See Plate 52)
Phase 3 of 5	5 Chevrons	77.9 – 77.0	No problems occurred (See Plate 53)
Phase 4 of 5	6 Weirs	78.6 – 78.3	No problems occurred (See Plate 54)
Phase 5 of 5	3 Chevrons	79.3 – 78.8	No problems occurred (See Plate 55)

All tests showed that anyone of the 4 suggested phased construction approaches would be viable and not incur additional sediment problems in the navigation channel.

EXTENDED STUDY

1. Towhead Island Study

In collaboration with U.S. Fish and Wildlife Service and NESP Program, Towhead Island was chosen as a study location because of its mussel beds. During the calibration process, the island's side channel was closed off due to high elevation where flow was restricted during most stages. Therefore, the purpose of the study was to determine what would happen to the mussel bed if the side channel was opened and flow was introduced into it. The behaviors of Towhead Island were closely observed assuming project completion.

A. *Side Channel Closed*

The study showed when placing structures upstream of Towhead Island there was no significant changes to the island. Most of the energy coming through this area was deflected to the LDB, leaving very little flow on the RDB. Thus, no sediment transport was observed through the island's side channel (See Plate 57).

B. *Side Channel Open*

The study showed when placing structures upstream of Towhead Island and opening the side channel, slow sediment movement occurred along Towhead Island's side channel (See Plate 56). In order to have sediment flow along the island, three chevrons would have to shift forward along the RDB. However, by doing so would jeopardize the 300ft minimum channel width. Therefore, the location of three chevrons didn't change in the suggested alternative 25A. After numerous scans, the study showed that there is not enough energy to transport sediment along Towhead Island's side channel (See Plate 56).

2. Conclusion

The test was initiated based on past surveys showed mussel beds near and around Towhead Island. Alternative 25A which included three chevrons upstream on Towhead Island showed no significant navigation and environmental impacts when the side channel open or closed.

FOR MORE INFORMATION

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APPENDIX OF PLATES

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