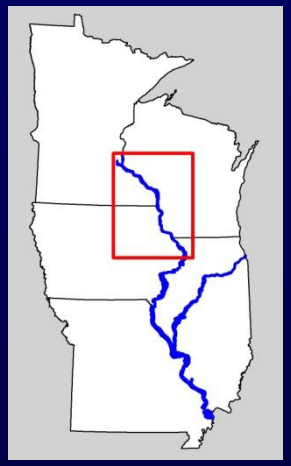
Island Construction -- Rebuilding Natural Levees to Restore Connectivity in the Northern Reaches of the Upper Mississippi River

Jeff Janvrin – Wisconsin Dept. of Natural Resources
Jon Hendrickson – U.S. Army Corps of Engineers, St. Paul District
Jim Nissen – USFWS Upper Miss. River Wildlife and Fish Refuge

Differences in Human Induced Changes to Connectivity on the Upper Mississippi River

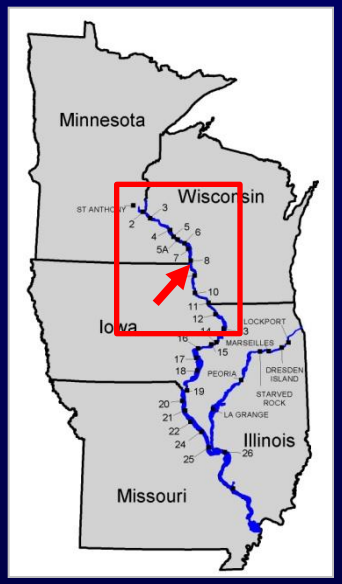
Impounded



Impounded/ Leveed

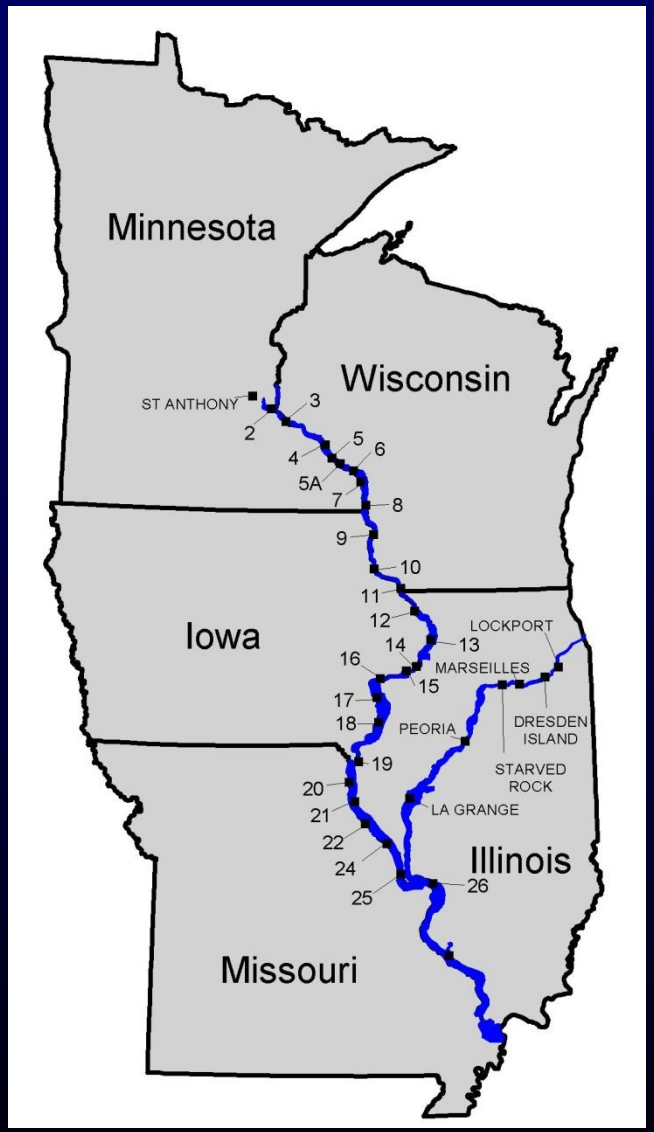
Open River/ Leveed

Restoration of Connectivity: What does it mean in the Northern Reaches of the Mississippi River?



Reno Bottoms Backwater Complex, Pool 9

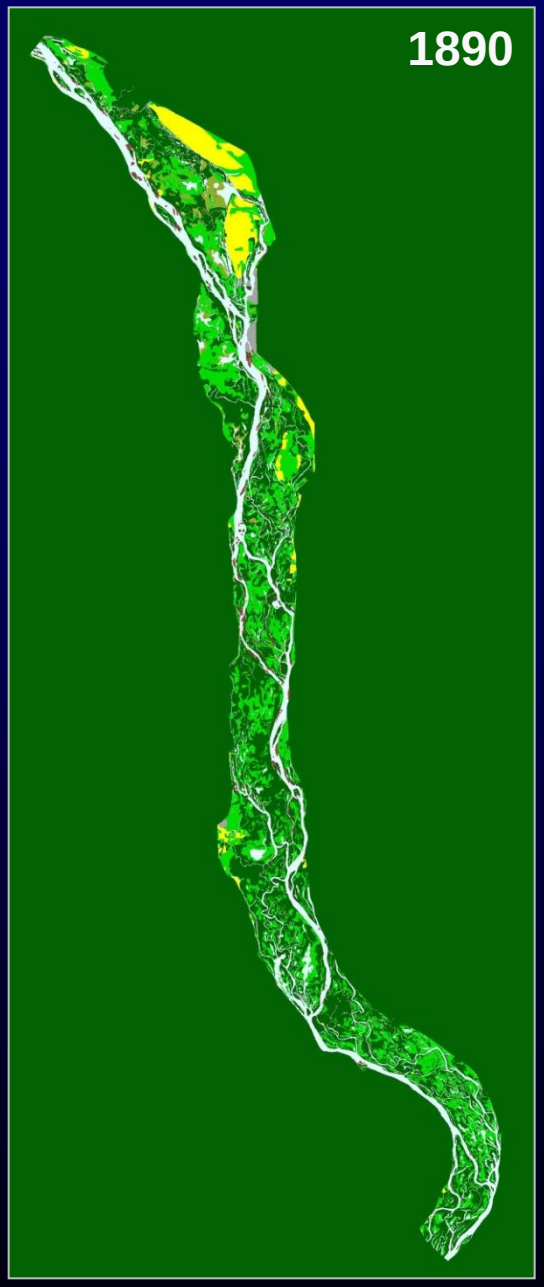
Locks And Dams on the Upper Mississippi River System



Late 1930's

Present

66 Miles

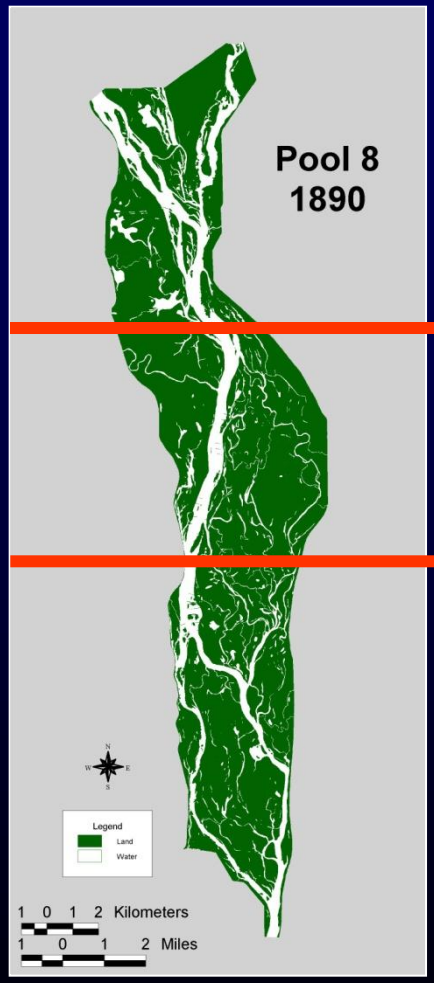

1890

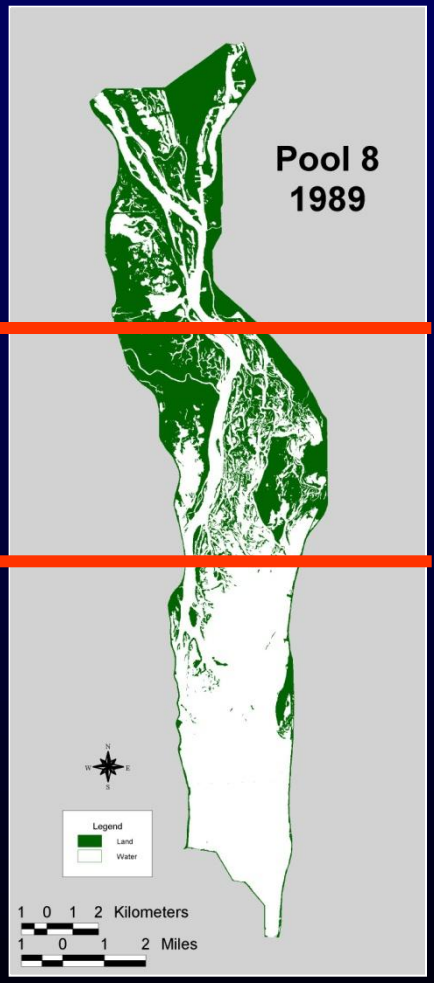

Lock and Dam 6
1989
Lock and
Dam 7
Lock and Dam 8
Lock and Dam 9


Minnesota
Wisconsin
Iowa
Illinois
Missouri
ST ANTHONY
LOCKPORT
MARSEILLES
PEORIA
DRESDEN ISLAND
STARVED ROCK
LA GRANGE


Land Cover
Open Water
Submersed Veg.
Marxh/Emergent Veg.
Sand/Mud
Urban
Agriculture
Grasses/Forbs
Forest

UPPER IMPOUNDED POOLS



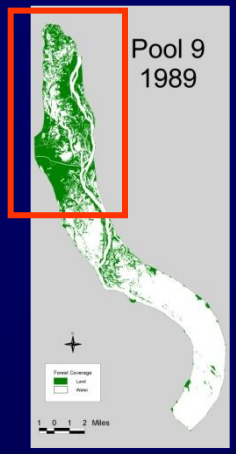


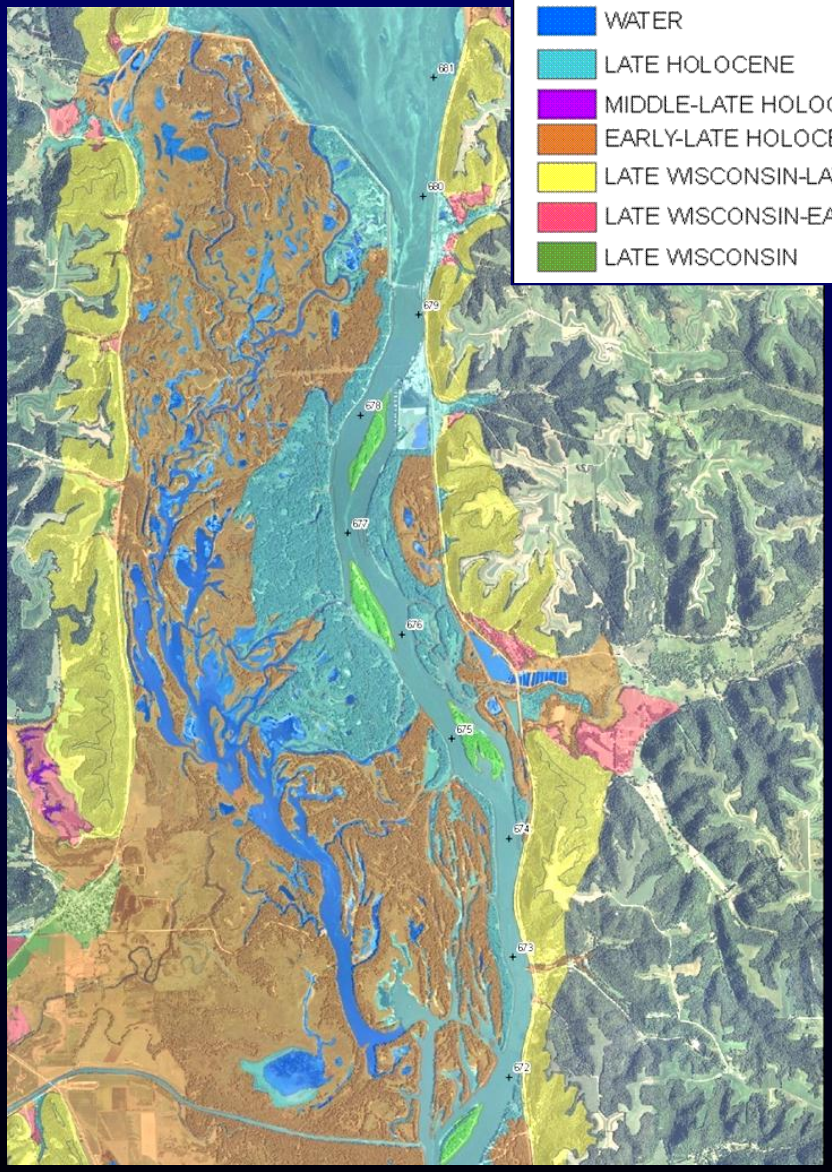
Which side is more natural?

Which side has a higher n (roughness) value?

How Old are Upper Mississippi River Floodplain Features?

Reno Bottoms Backwater Complex, Upper Pool 9, Upper Mississippi River





APPROXIMATE AGE

WATER	
LATE HOLOCENE	2,500 – 3,500 yrs. BP
MIDDLE-LATE HOLOCENE	2,500 – 6,700 yrs. BP
EARLY-LATE HOLOCENE	2,500 – 10,000 yrs. BP
LATE WISCONSIN-LATE HOLOCENE	2,500 – > 10,000 yrs. BP
LATE WISCONSIN-EARLY HOLOCENE	> 10,000 yrs. BP
LATE WISCONSIN	> 10,000 yrs. BP

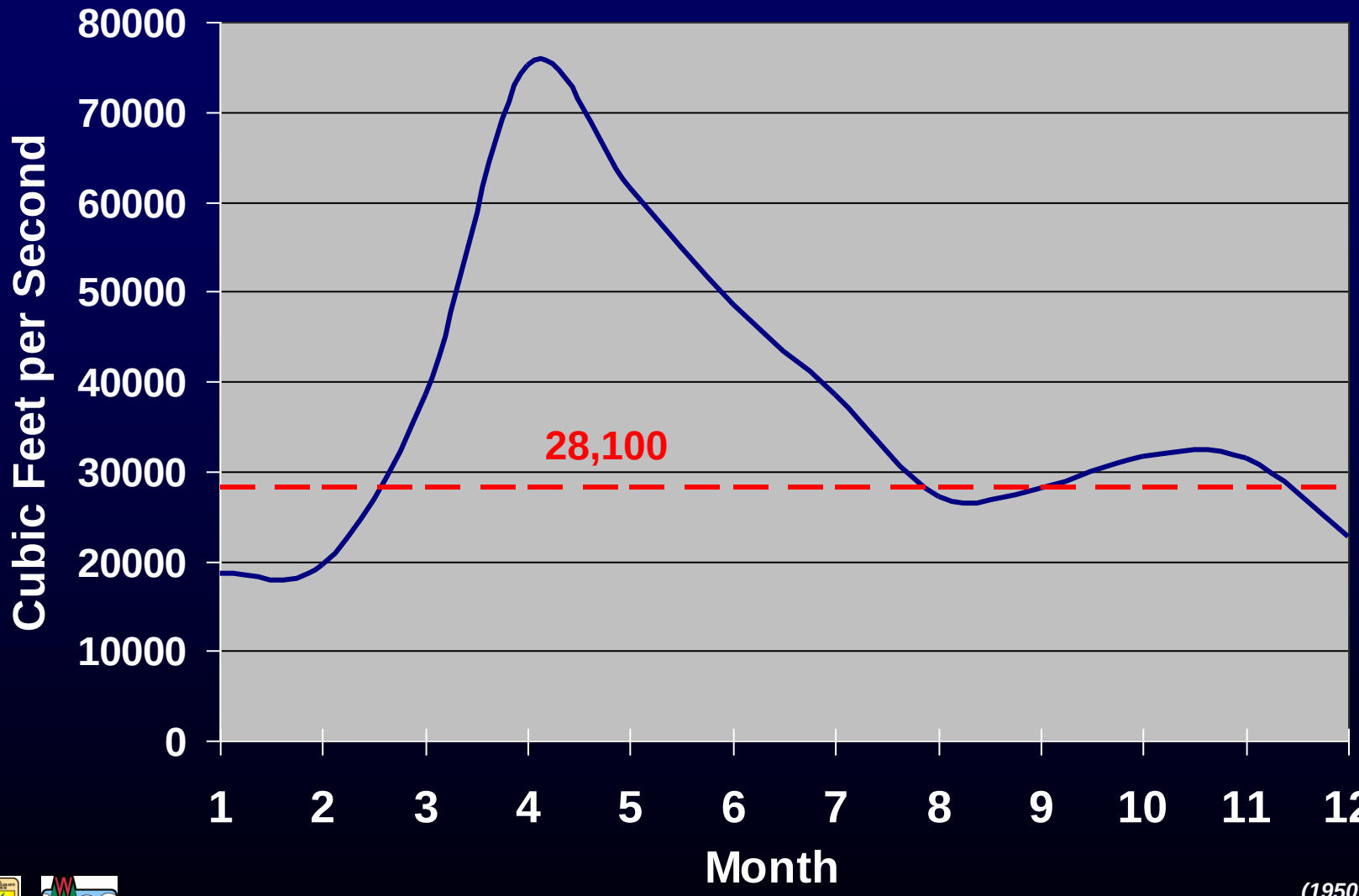
Lower Pool 8/Upper Pool 9

1890 Miss. River Commission Map

Natural River Levees

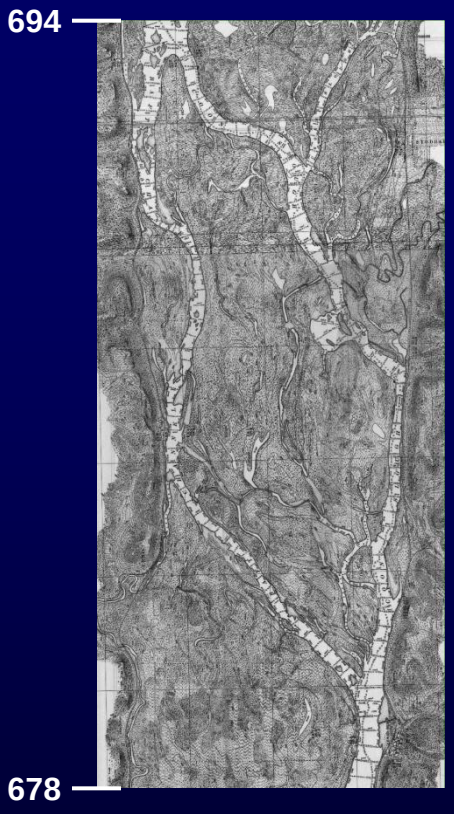
1890 Head of Raft Channel and Coon Slough

Genoa, L/D 8,
Average Monthly Discharge



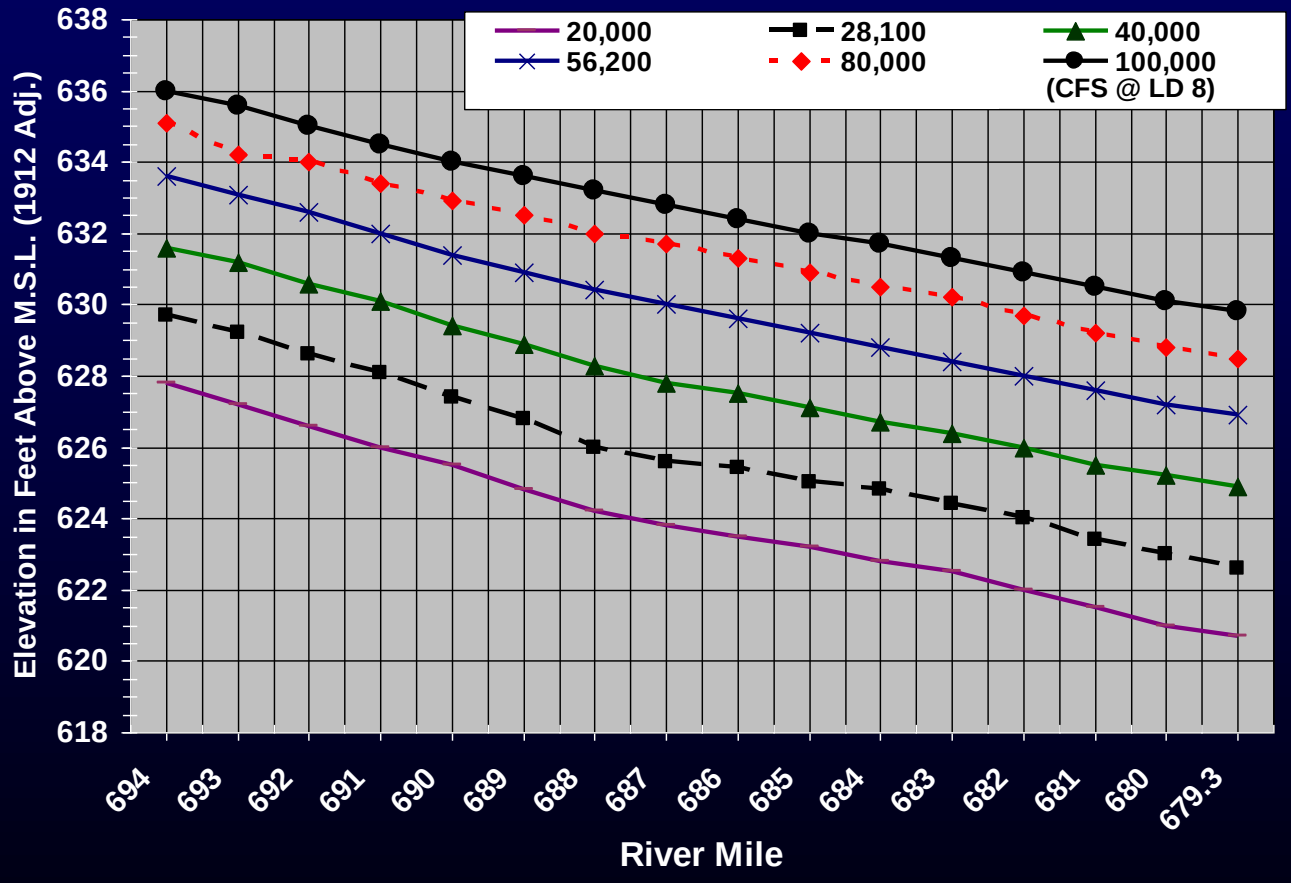
(1950 – 2009)

Stage Discharge Relationships for UMR, Lower Pool 8



1890 Miss. River Commission Map

100,000 CFS – Bank Full – 3% Duration Event
56,200 CFS – 23% Duration Event
28,100 CFS – "Average" – ~50% Duration Event
20,000 CFS – Low Flow – 75% Duration Event

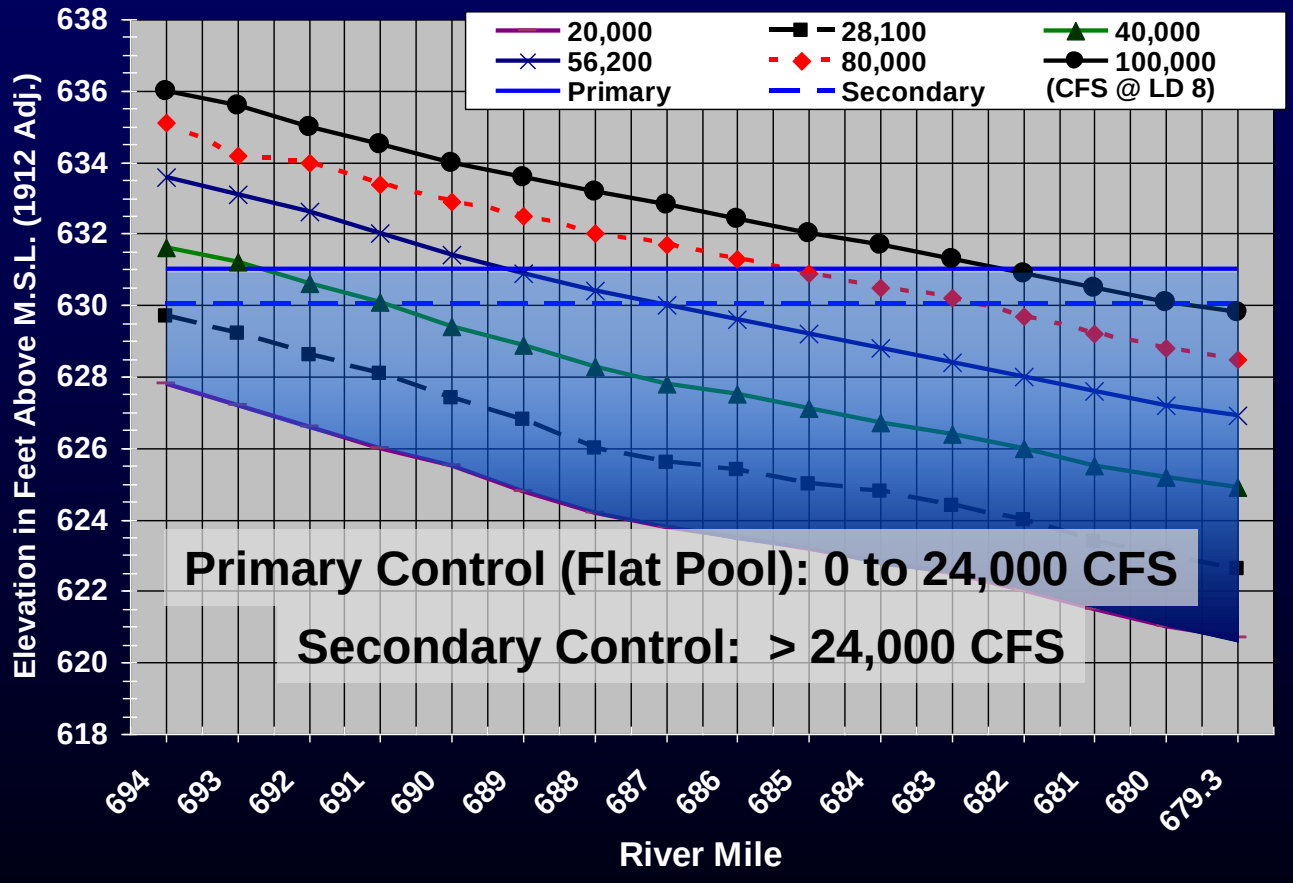


Stage Discharge Relationships for UMR, Lower Pool 8

1890 Miss. River Commission Map

Natural River Levees Become Islands (1938)

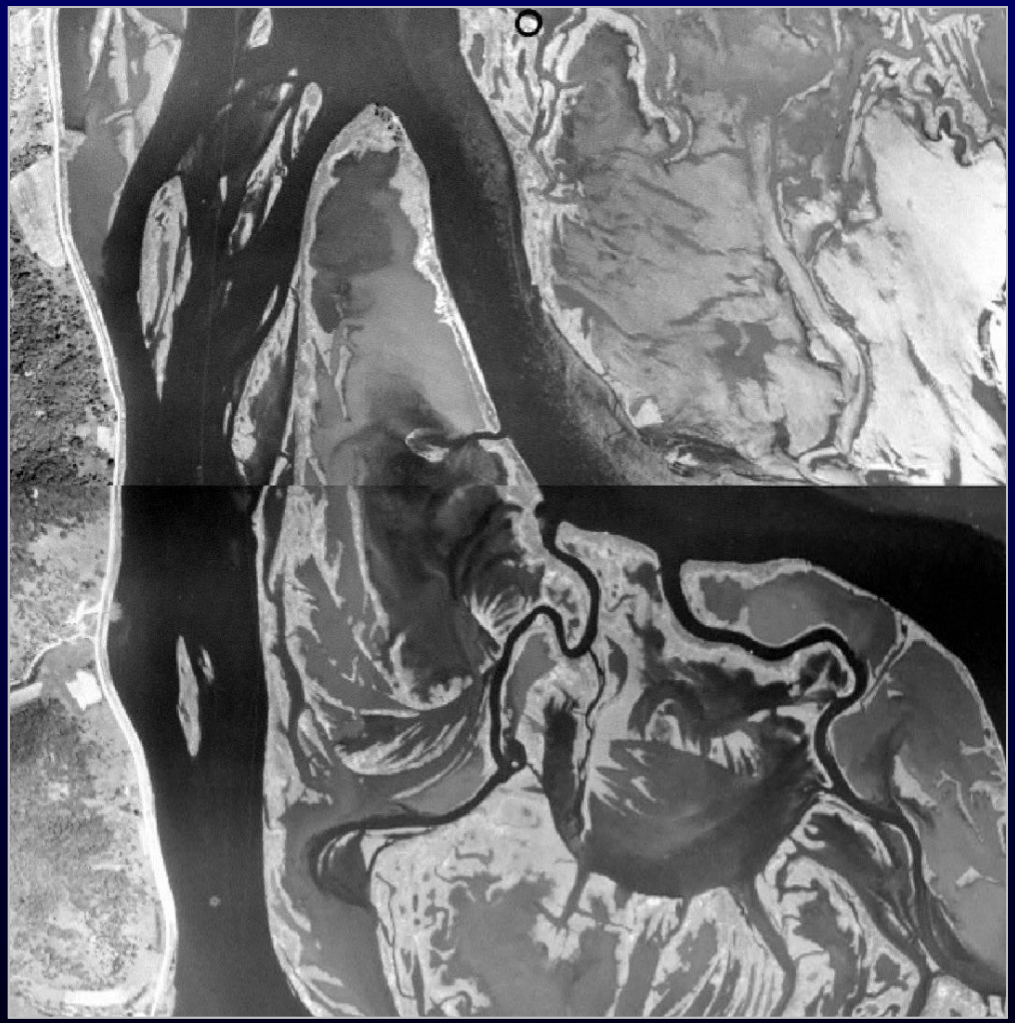
Affects of Impoundment



Lower Pool 8/Upper Pool 9

1890 Miss. River Commission Map

Natural River Levees



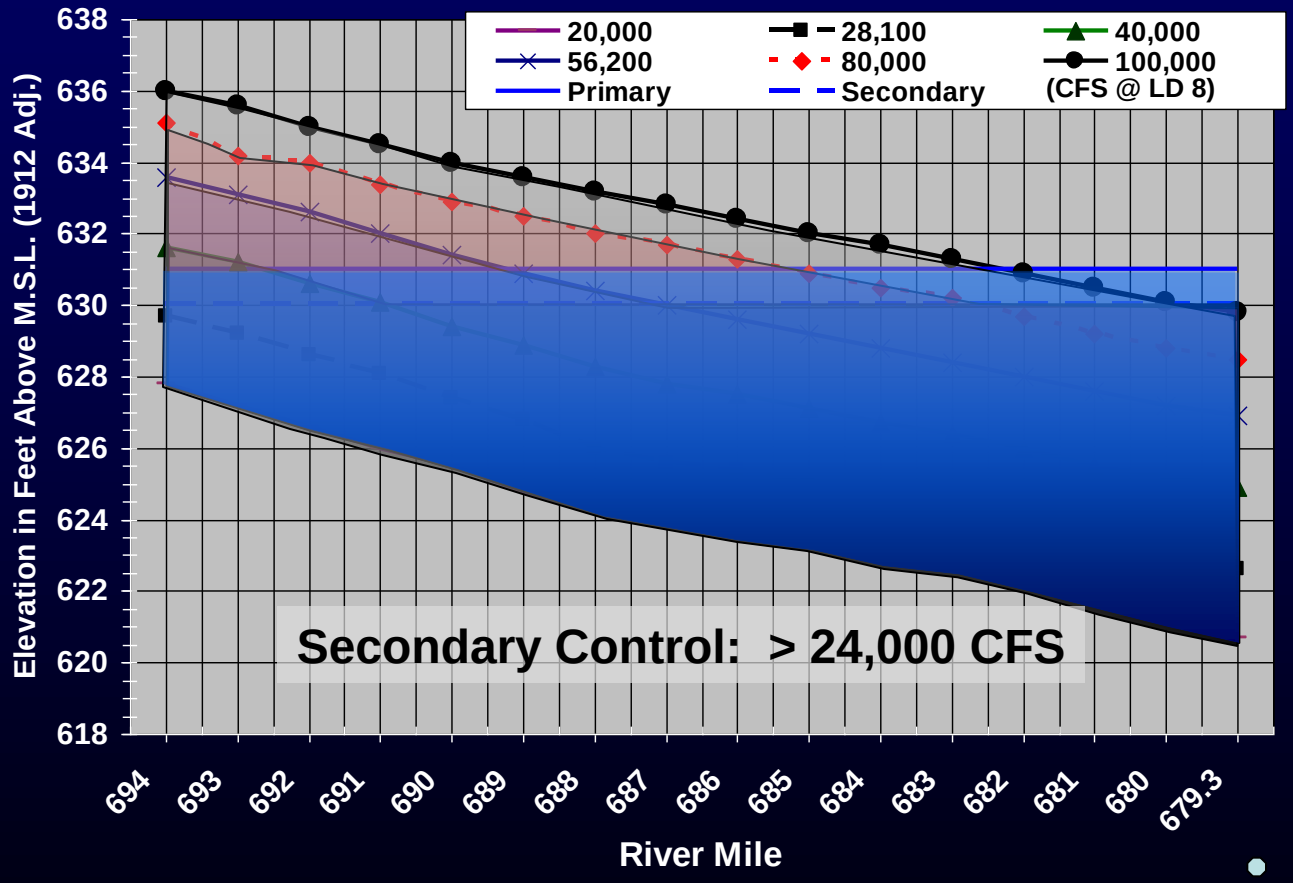
1938 Head of Raft Channel and Coon Slough

Stage Discharge Relationships for UMR, Lower Pool 8

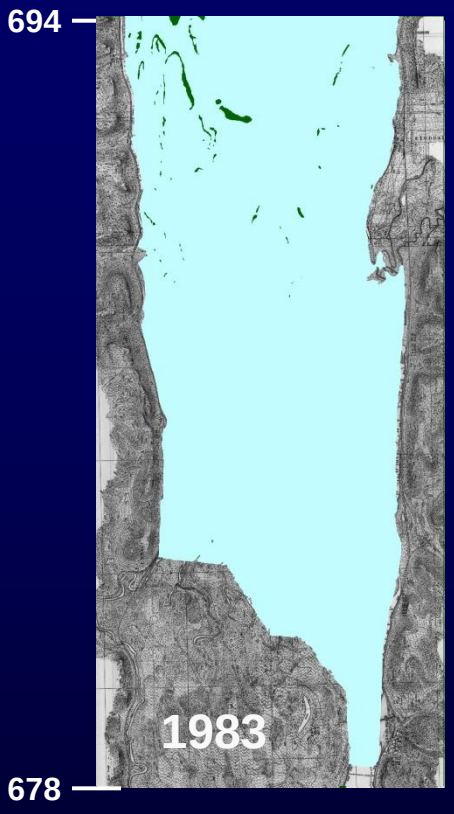
1890 Miss. River Commission Map

Natural River Levees Become Islands (1938)

Affects of Impoundment



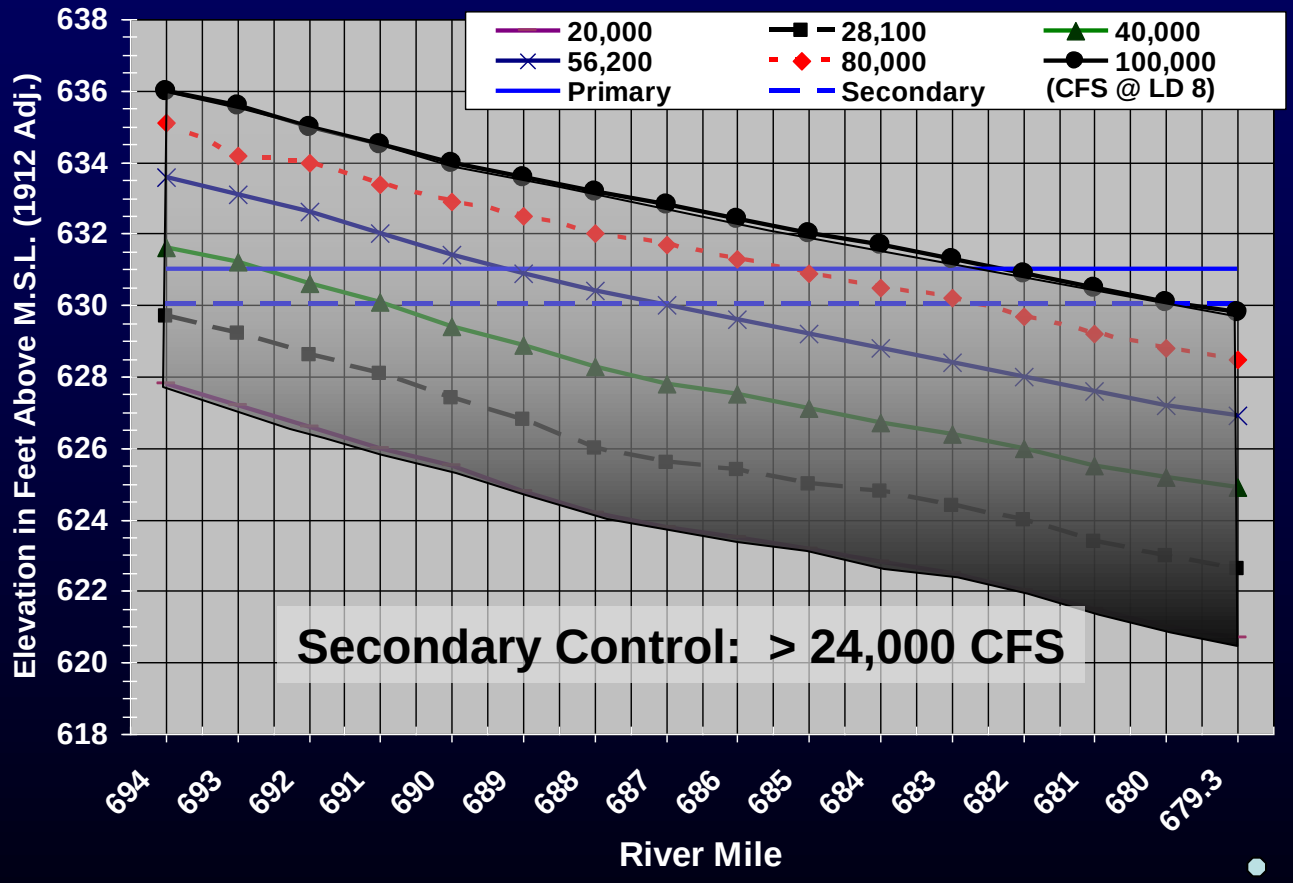
Stage Discharge Relationships for UMR, Lower Pool 8



1890 Miss. River Commission Map

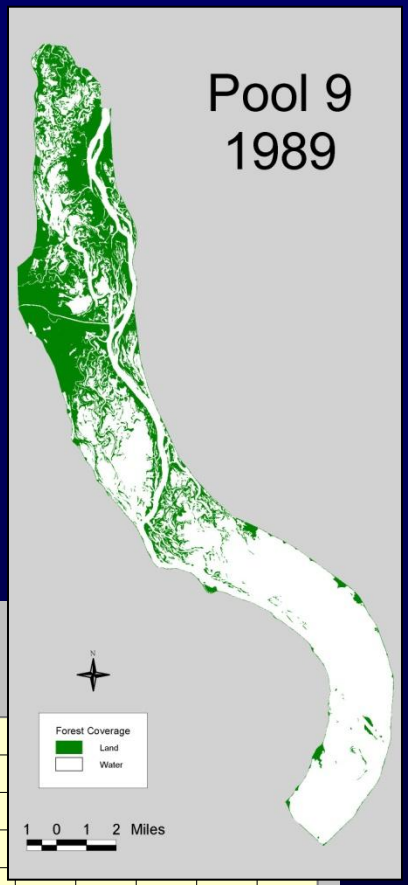
Natural River Levees Become Islands (1938)

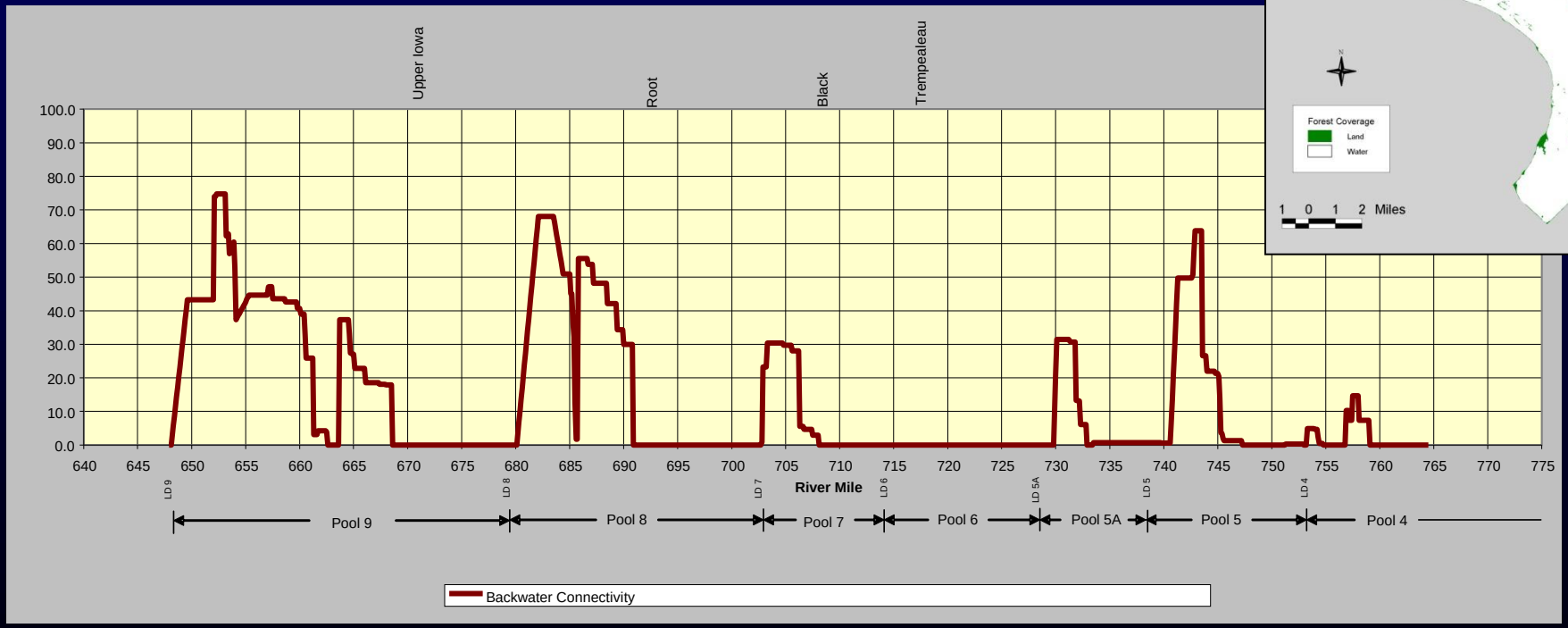
70+ Years of Pool Regulation Have Taken a Toll on Natural River Levees



Geomorphic Reach 3
Backwater Hydraulic Connectivity
for Moderate Flows (25% Duration Event)

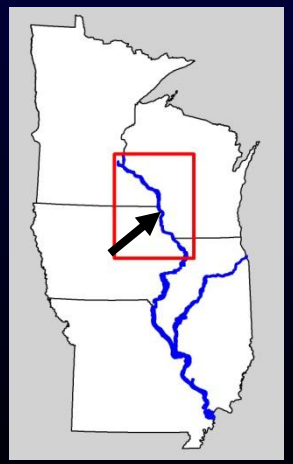
Backwater connectivity is plotted as percent of total river flow conveyed in backwaters.

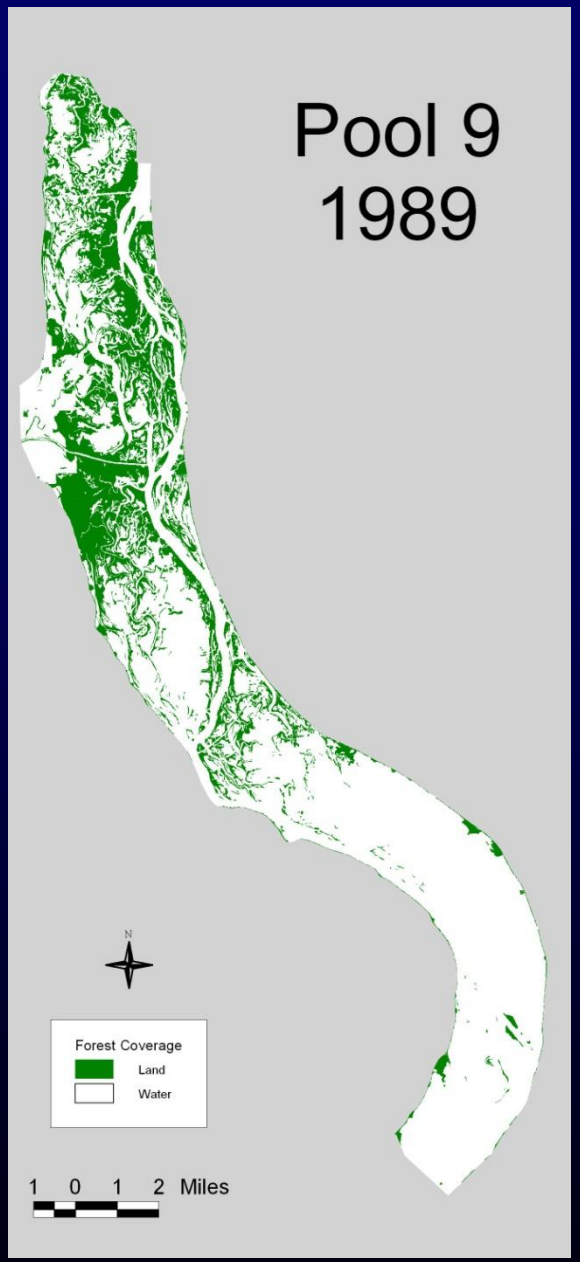




Forest Loss Resulted in a Loss of Roughness

In Pool 9, there has been a 58% loss in Forest coverage from 1890 to 1989



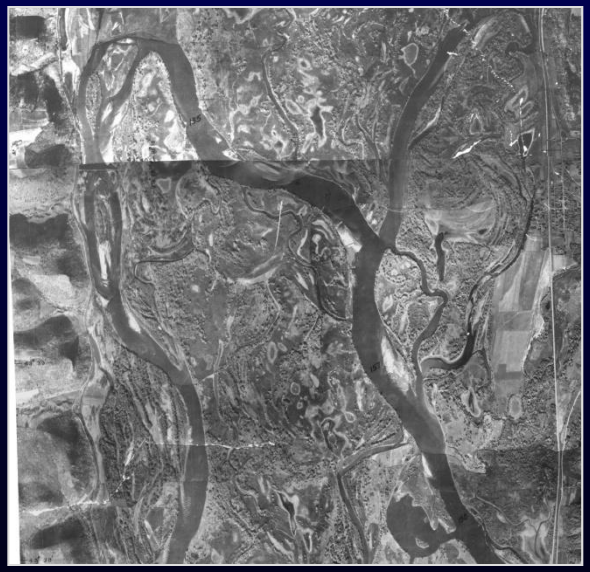


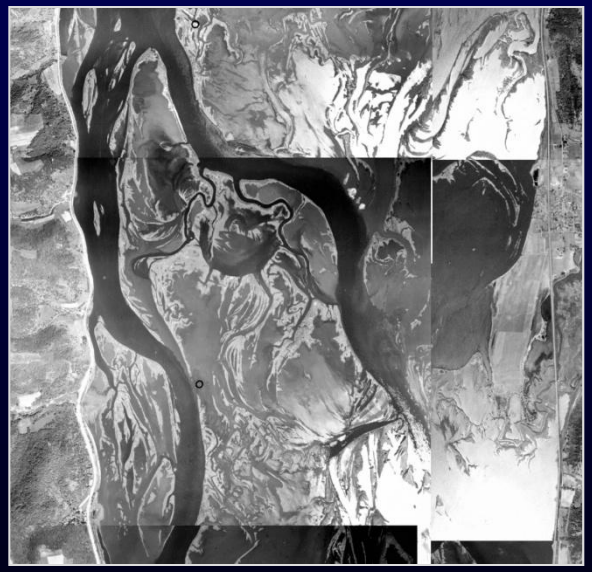
RESOURCE PROBLEMS

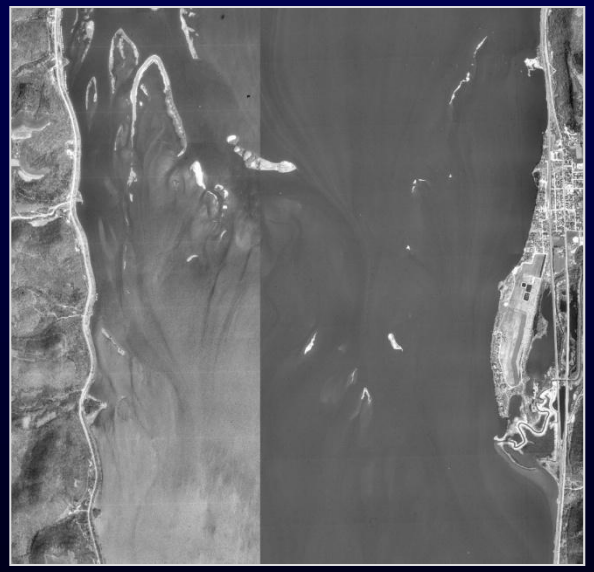
LOSS OF HABITAT AND RIVER FUNCTION THROUGH:

- Permanently Elevated Water Levels
- Land Loss and Erosion
- Increase in Connectivity
- Altered Sediment Transport/Deposition

1930 1938 1991







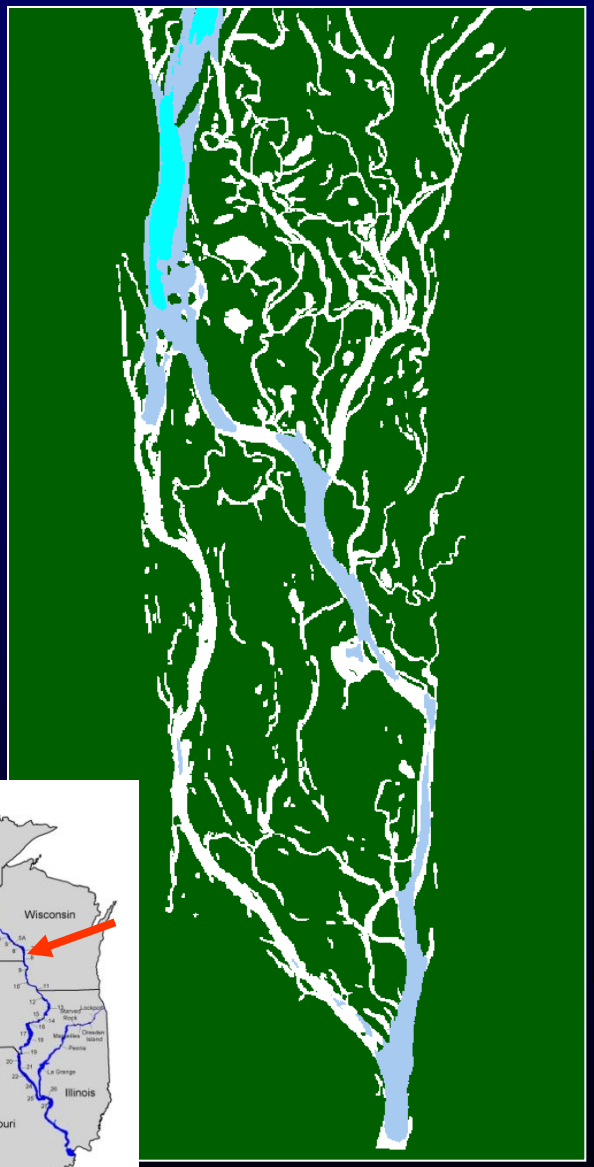
Habitat Loss in Lower Pool 8, near La Crosse, Wisconsin

RESOURCE PROBLEMS

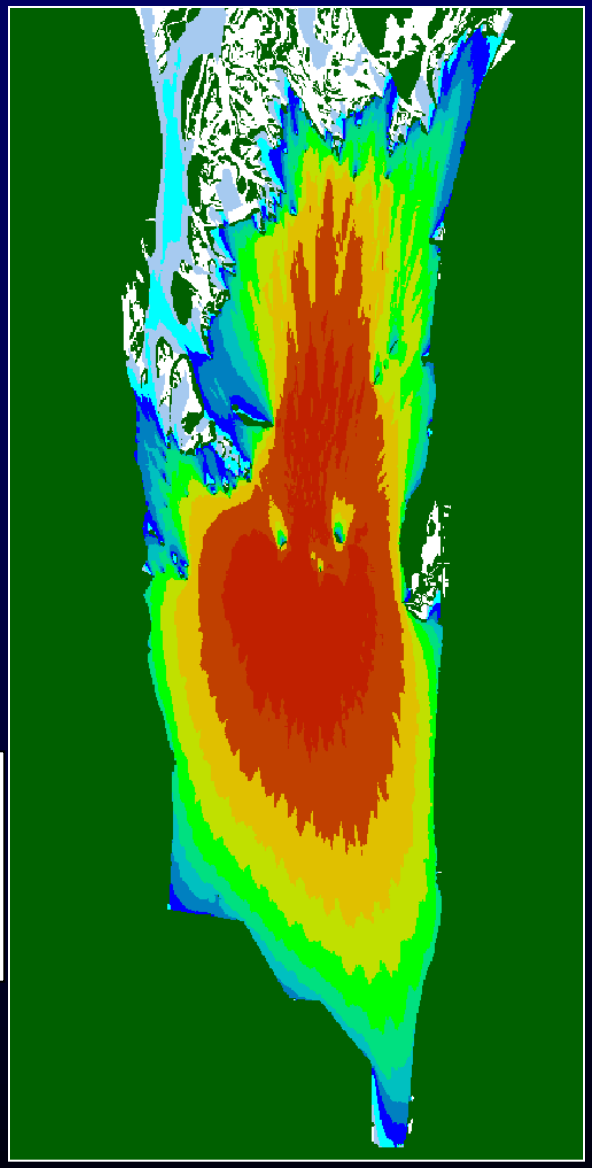
WIND FETCH

Lower Pool 8

Pre Lock and Dam
1937



1989



Lowest fetch

Highest fetch

Wind fetch graphic used with permission from Jim Rogala, USGS UMESC

RESOURCE PROBLEMS

1940

Loss of Bathymetric Diversity
(Lower Pool 8)

- < 0.3 m
- 0.3 to 1.8 m
- > 1.8 m

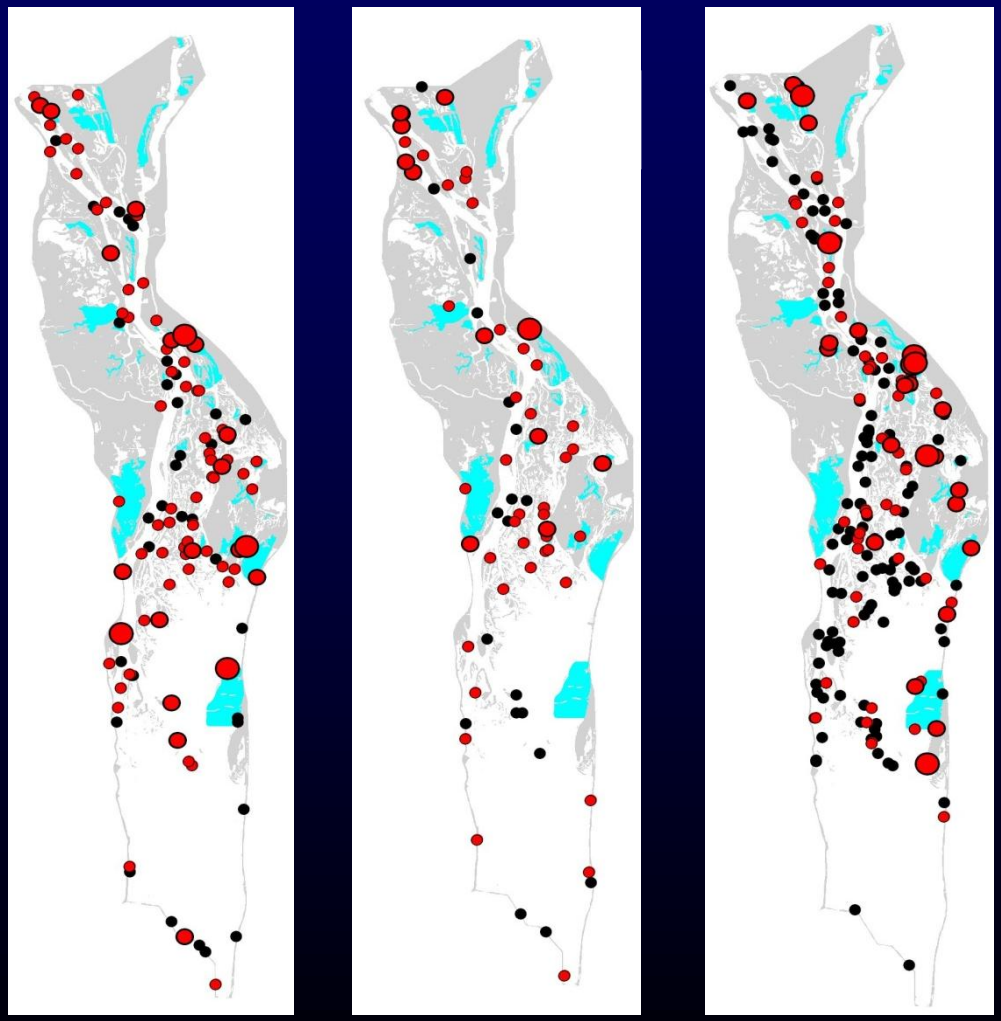
Used with permission from Jim Rogala, USGS UMESC

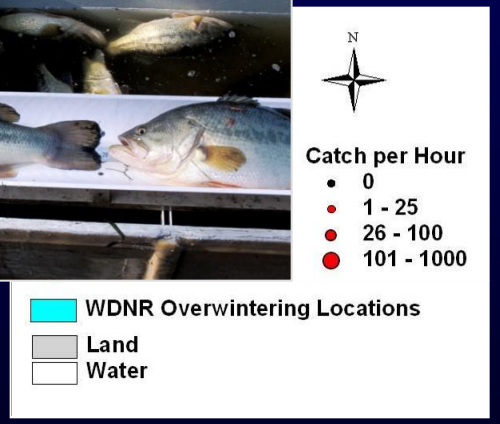
1990

Fisheries Response to Increased Connectivity

Largemouth Bass

Late Sept. Early Oct. Late Oct.



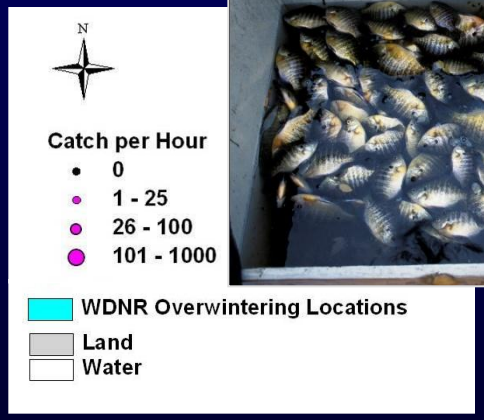


LTRMP day electro fishing
September and October, 1993-2006.

Source: Bartels, Janvrin and Giblin. 2006. Indirect evidence of fish migration to Upper Mississippi River backwaters in late fall.

Fisheries Response to Increased Connectivity

Bluegills



LTRMP day electro fishing
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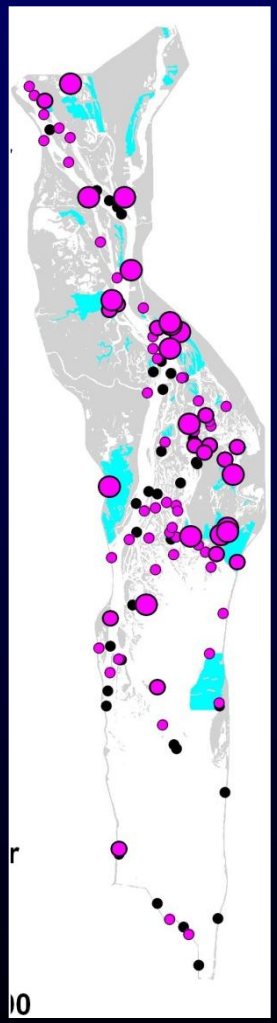
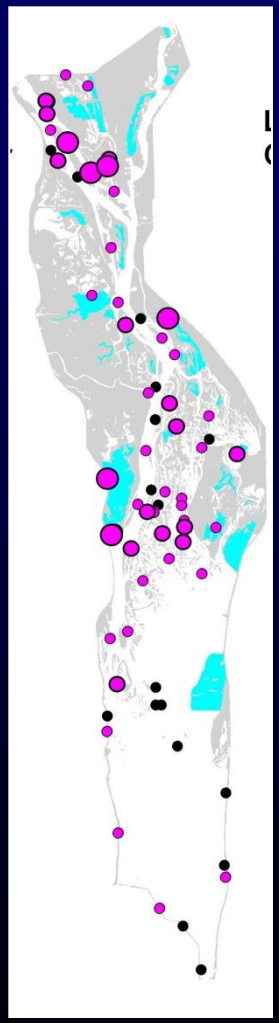
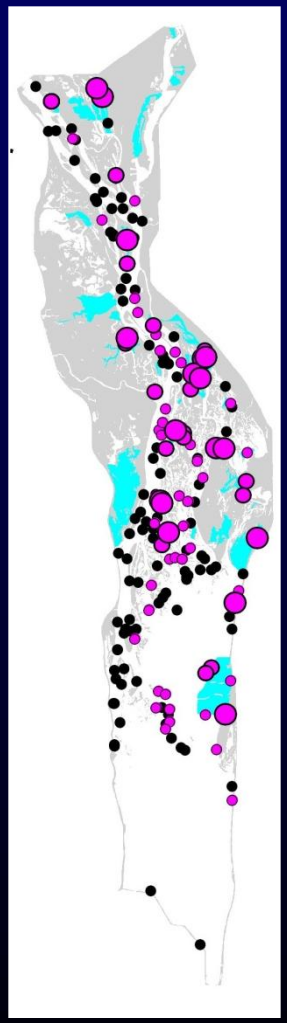
Late Sept.



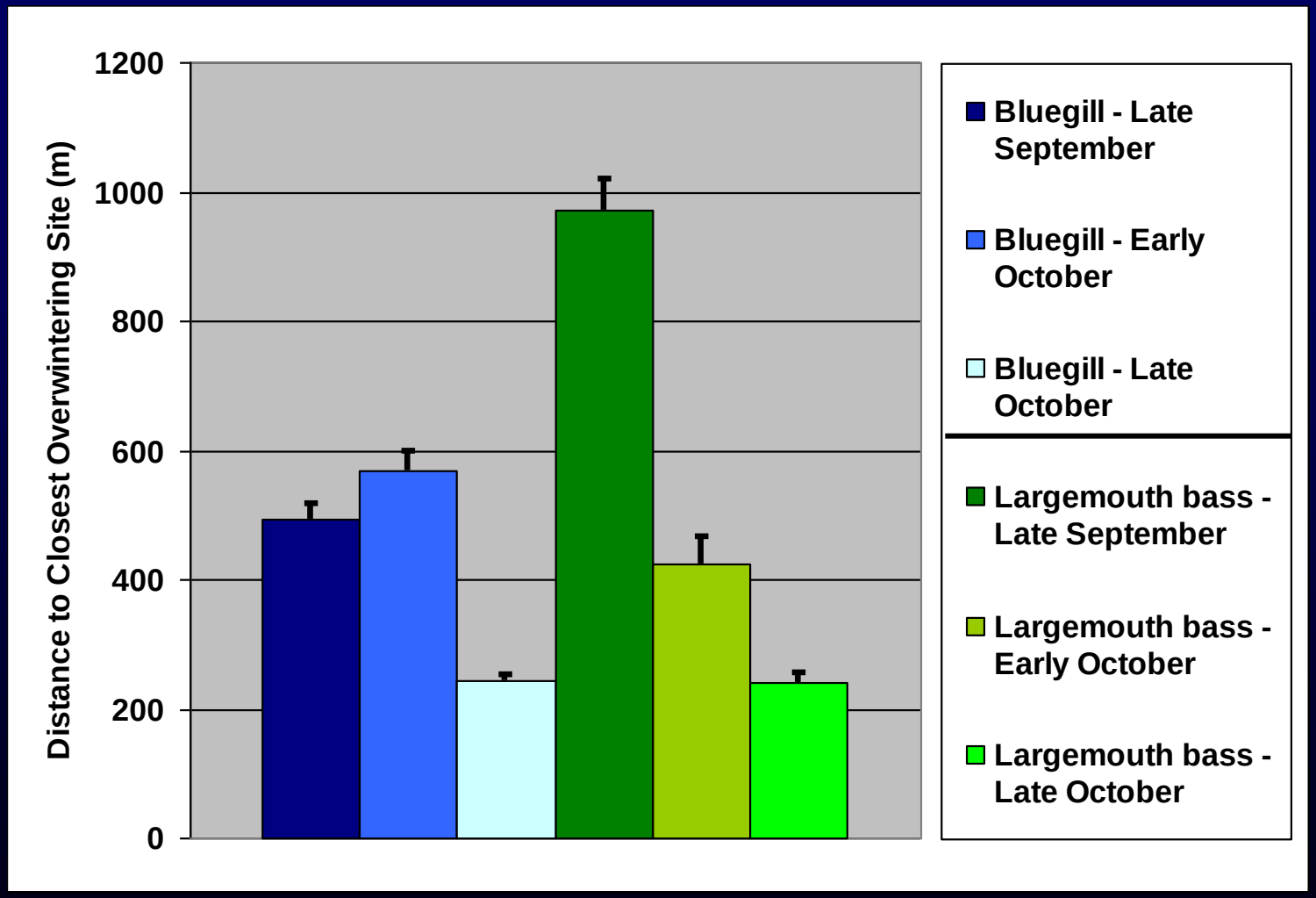
Early Oct.



Late Oct.



Mean linear distance from LTRMP sampling sites to the nearest WDNR identified centrarchid overwintering sites in Pool 8.

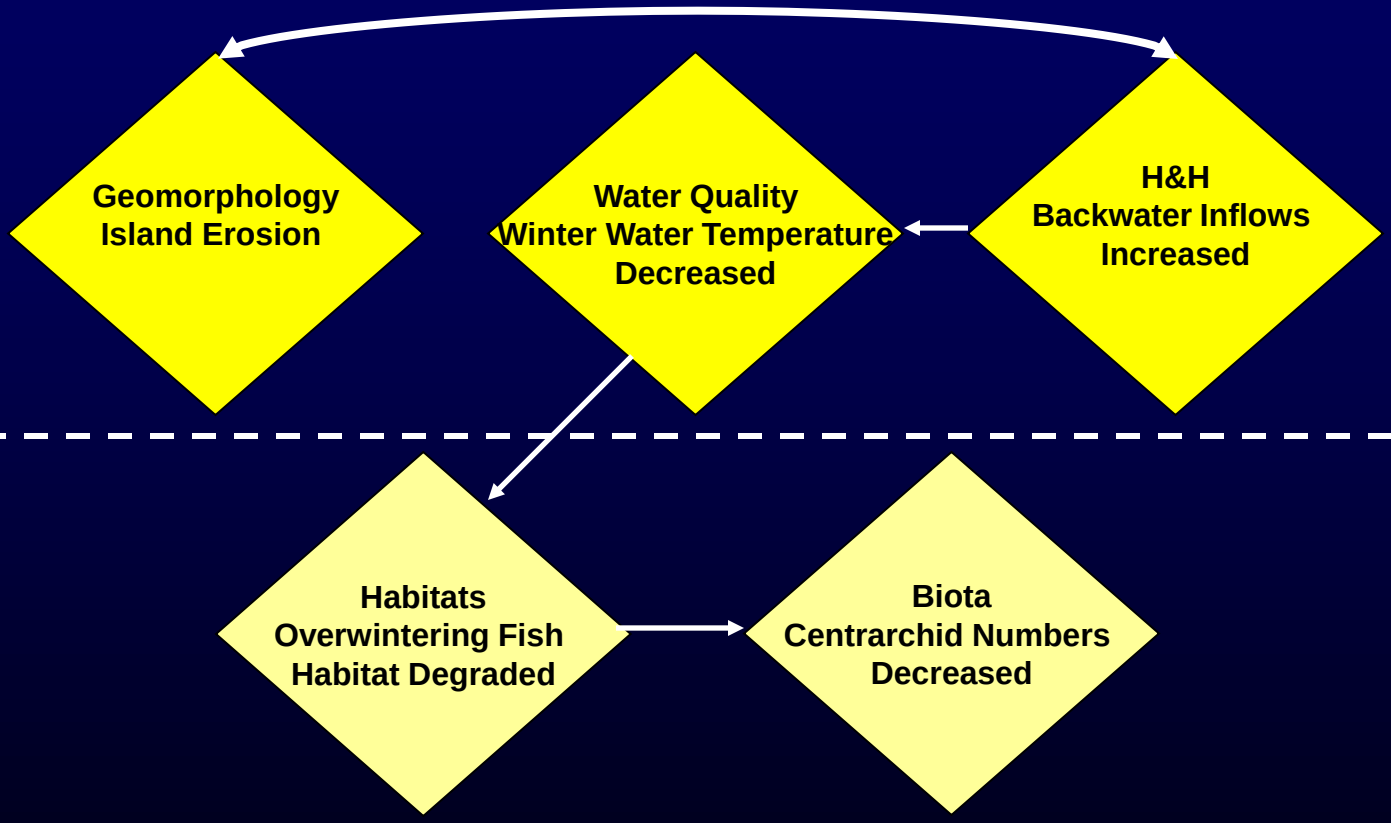


Source: Bartels, Janvrin and Giblin. 2006. Indirect evidence of fish migration to Upper Mississippi River backwaters in late fall.

Backwater Fisheries
Conceptual Model for Stressors and Responses

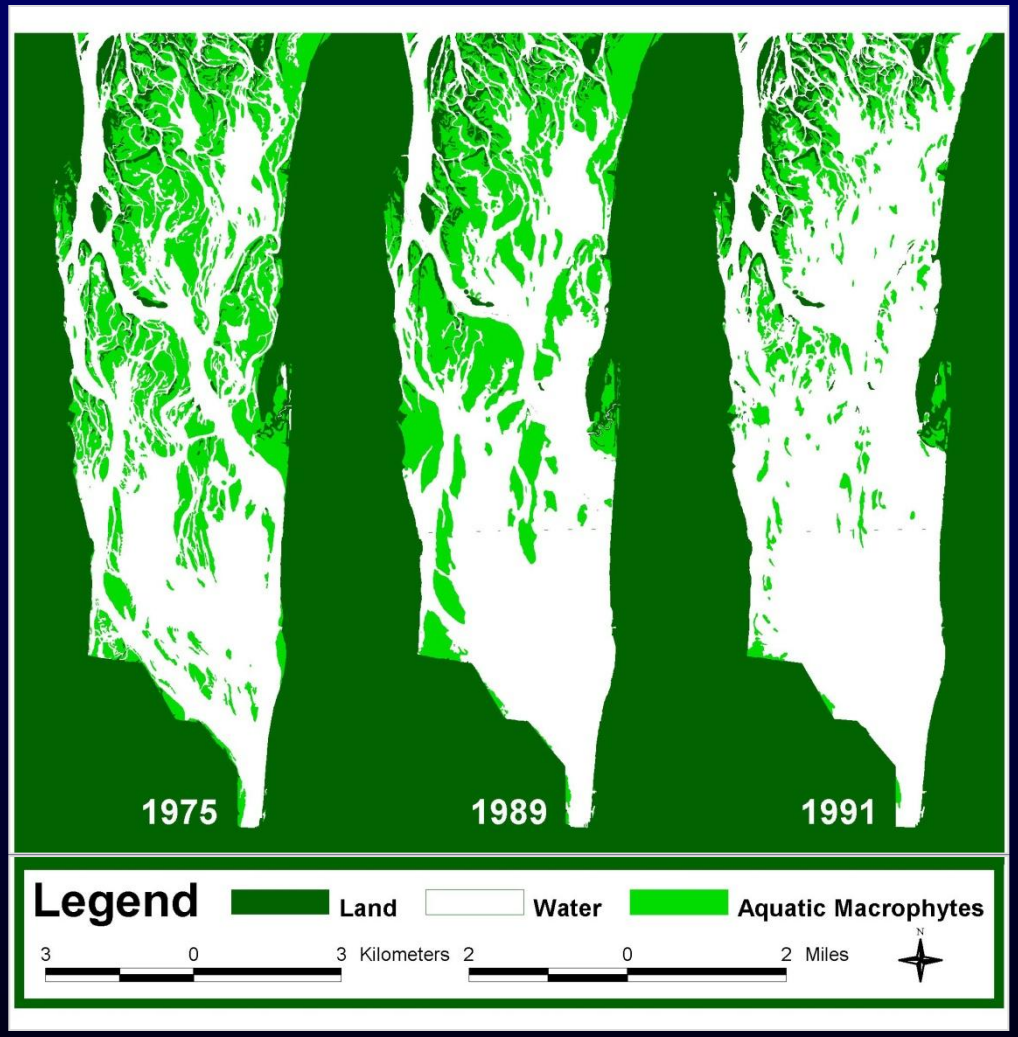
Physical & Chemical Processes

Habitat & Biota



Important variables: water velocities, water depth, water temperature and DO

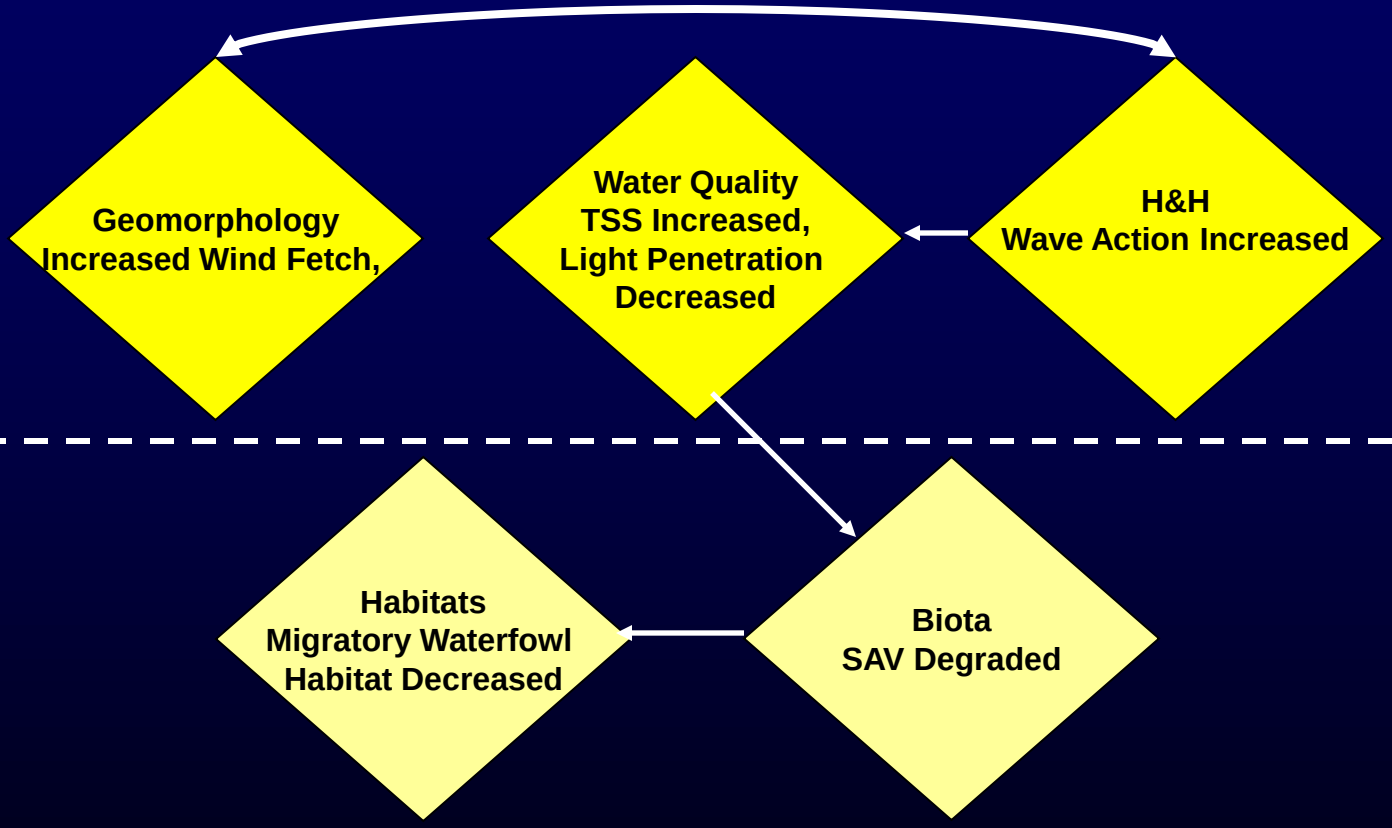
Aquatic Vegetation Response to Increased Connectivity



Waterbirds
Conceptual Model for Stressors and Responses

Physical & Chemical Processes

Habitat & Biota



Important variables: water levels, wind fetch, wind-driven wave action

Natural levees are an important geomorphic feature, separating flowing channels from backwaters (submerged floodplains).

ISLAND CONSTRUCTION PARTIALLAY RESTORES THIS FUNCTION

Shadow zone of islands

Lake Onalaska Islands

Aquatic vegetation in shadow zone of islands

Pool 8 Islands, Phase I

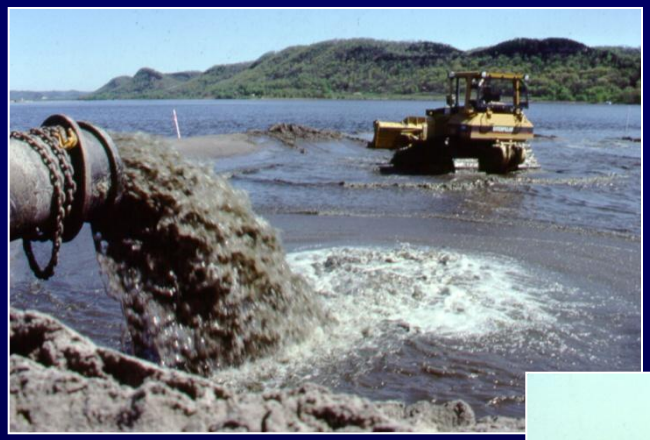
ENVIRONMENTAL MANAGEMENT PROGRAM

HABITAT REHABILITATION AND ENHANCEMENT PROJECTS
(66%)

LONG TERM RESOURCE MONITORING
(32%)

ECONOMIC IMPACTS OF RECREATION AND NAVIGATION MONITORING
(> 1%)

BUILDING AN ISLAND

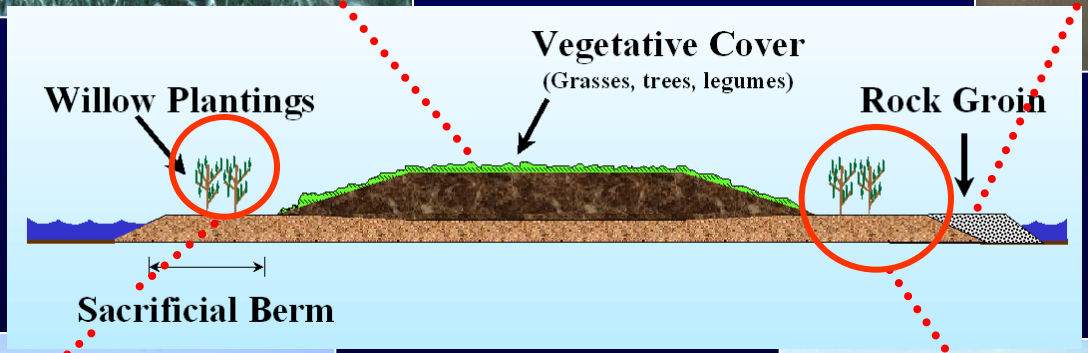


Constructing sand base with dredged material

Shaping fine material (topsoil)

Sand base and work limit stake

Design features to stabilize constructed islands.

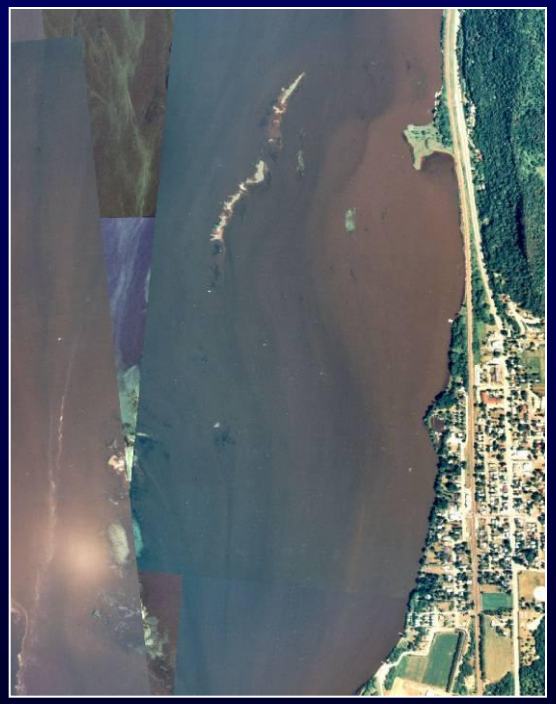


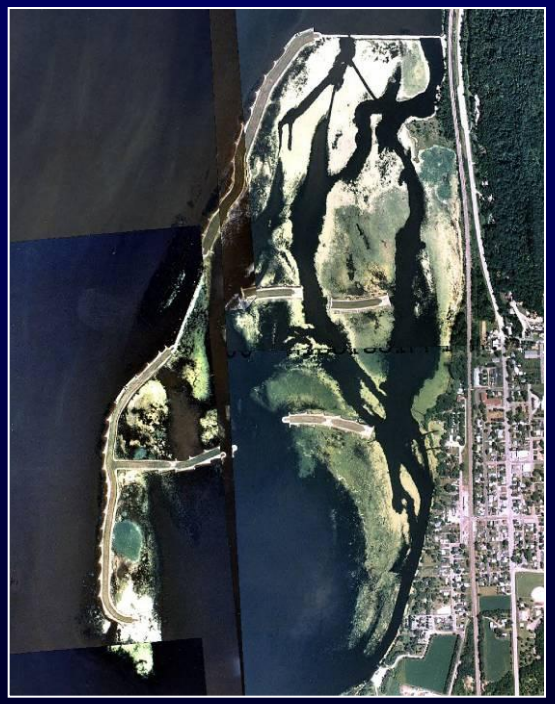
Subtle changes in island elevation to make islands stable during floods.

During flood of 1993

After flood **of** 1993

Pool 8 Islands Phase II, near Stoddard, Wisconsin

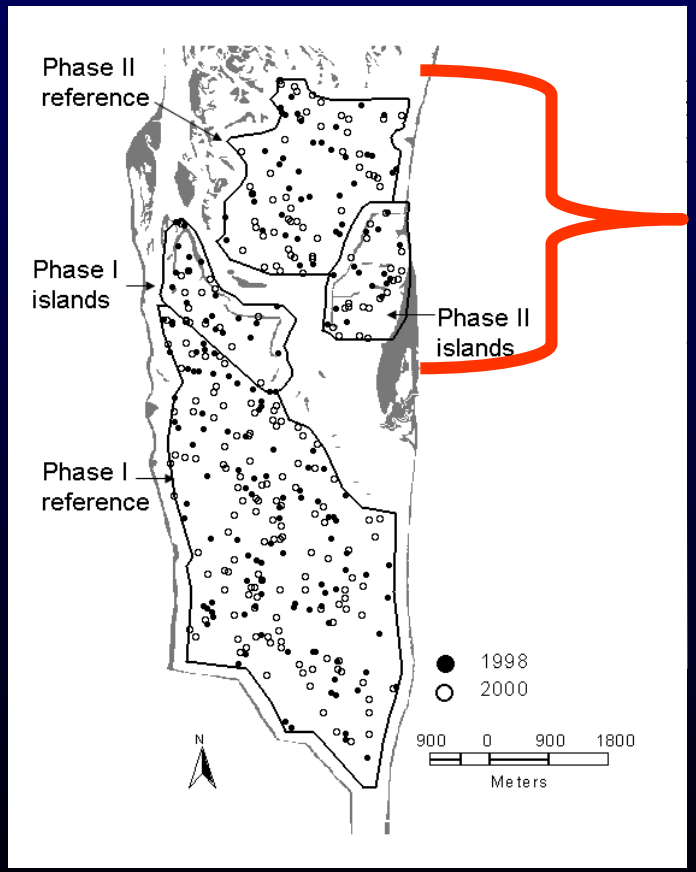


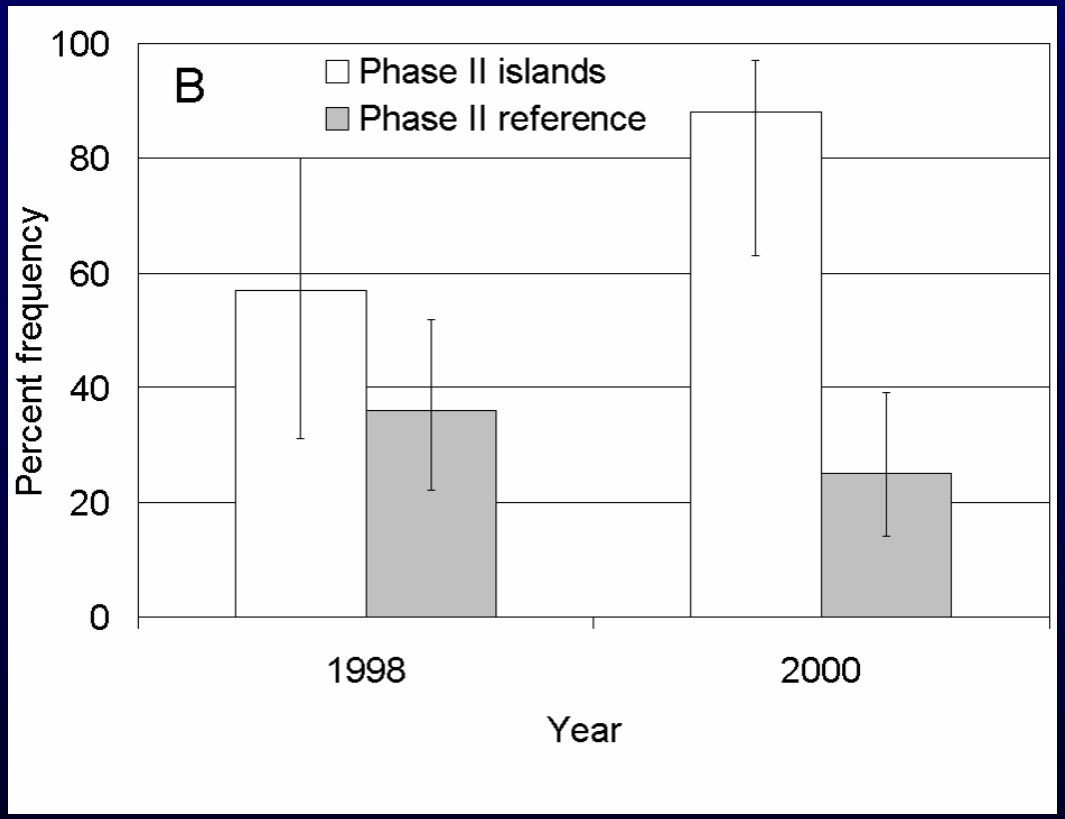


October 1961 **August 1994** **August 2000**

Constructed between Oct. 1997 and Summer 1999
$3.5 million, 640 acres affected

Observed Increase in Aquatic Vegetation was Significant





Graph and Figure from: Langrehr, Gray and Janvrin. 2007. Evaluation of Aquatic Macrophyte Community Response to Island Construction in the Upper Mississippi River. Lake and Reservoir Management 23:313-320

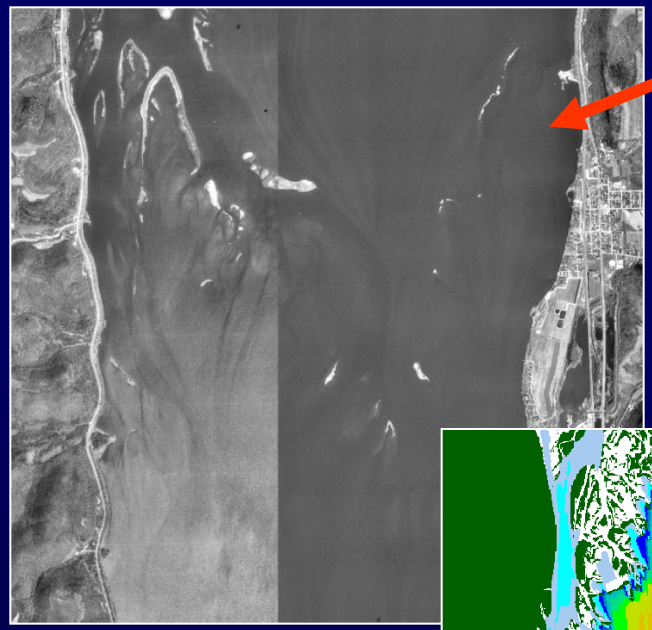
Criteria to Achieve Aquatic Vegetation Objectives

Source: Upper Mississippi River System Environmental Design Handbook
http://www.mvr.usace.army.mil/EMP/designhandbook.htm

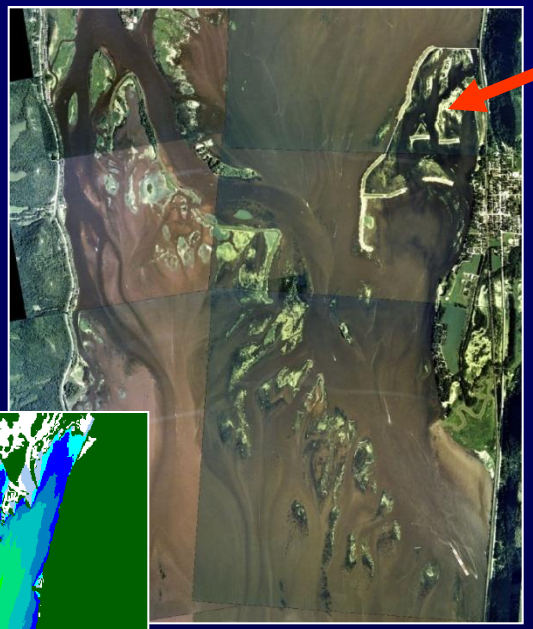
	Depth (feet)	Average Velocity (mps)	Water Clarity	Wind Fetch
Emergent Aquatics	0 - 2	< 0.03	Secchi* > 0.5 m or Turbidity* < 20 ntu *To be met as average during May 15 to Sept. 15 growing season *UMRCC Submersed Veg. WQ Criteria*	Wind fetch/plant growth relationship isn't clear, but can look at critical shear stress for sediment resuspension:
Submersed Aquatics	1.3 – 5.2	< 0.15		
Floating Aquatics	.6 – 2.6	< 0.06		

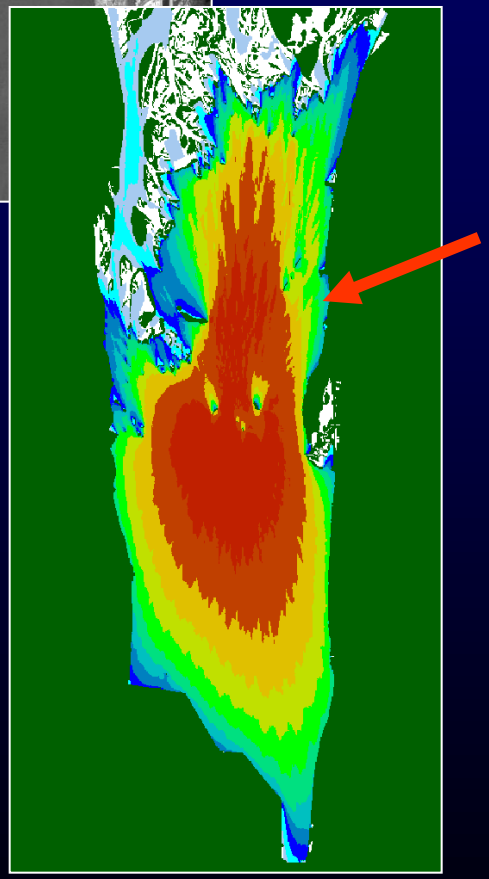
Water depth (ft)	1	2	3	4
Wind Fetch (ft)	1500	3500	6000	9000

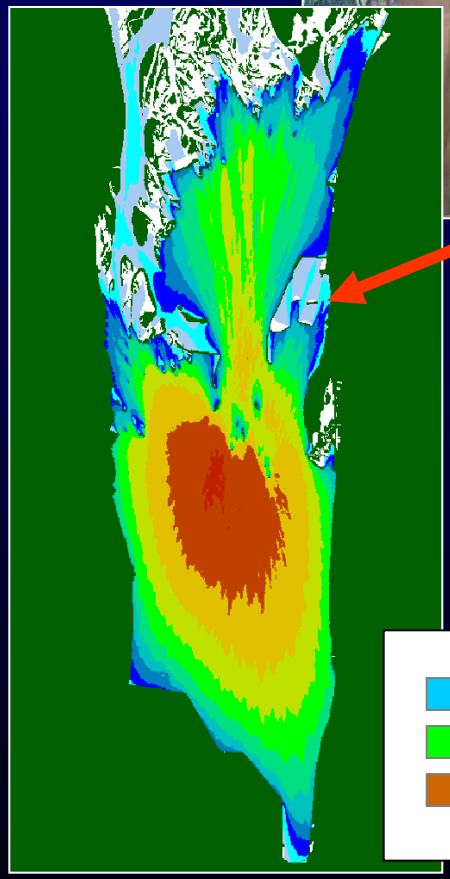
Phase II Design

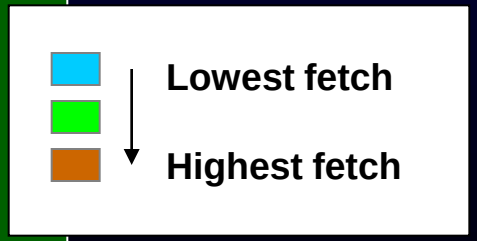


Criteria Met: Wind Fetch Reduced







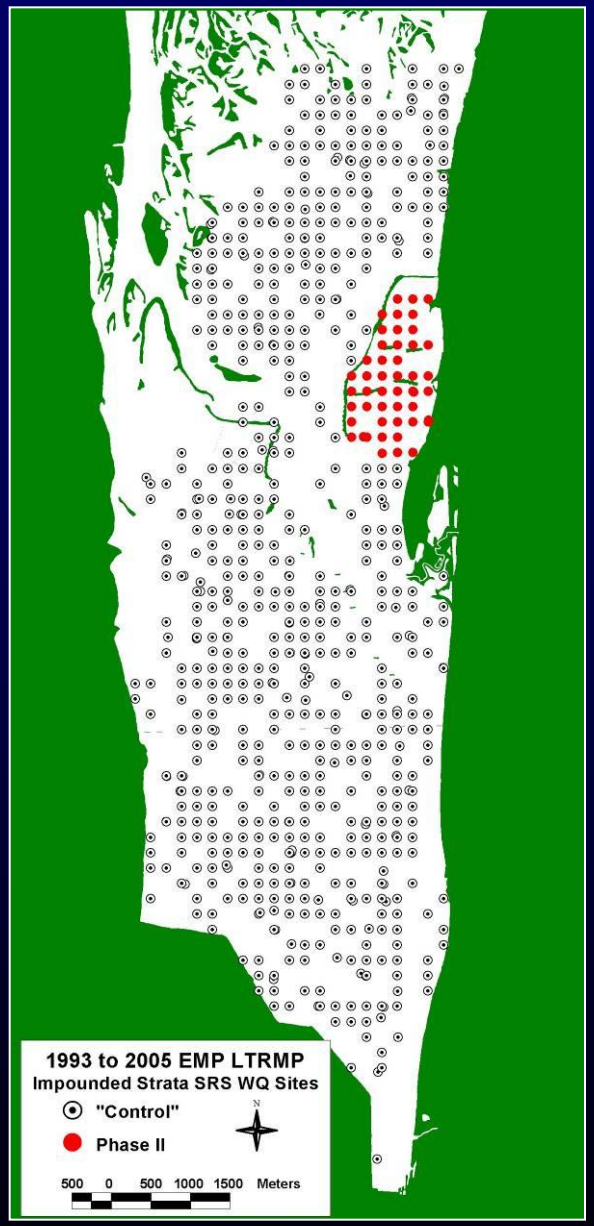


Wind fetch graphic used with permission from Jim Rogala, USGS UMESC

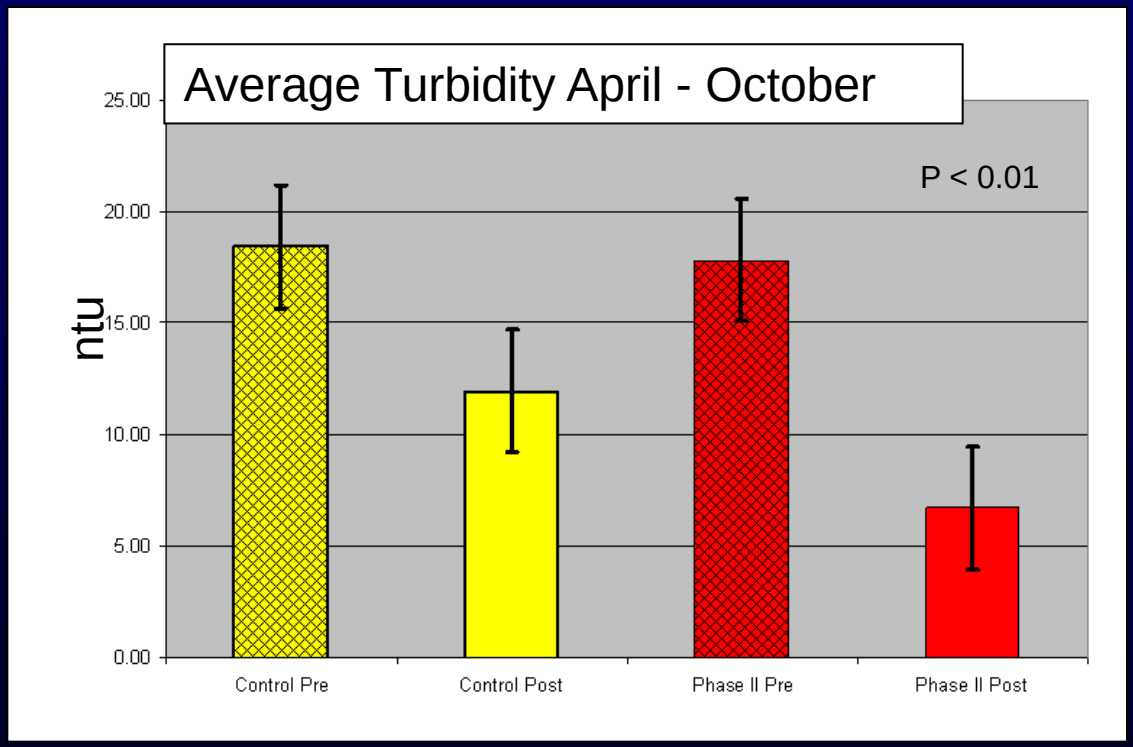
1989

1999

Why did vegetation increase?



Turbidity was significantly reduced
Criteria Met (<20 ntu)



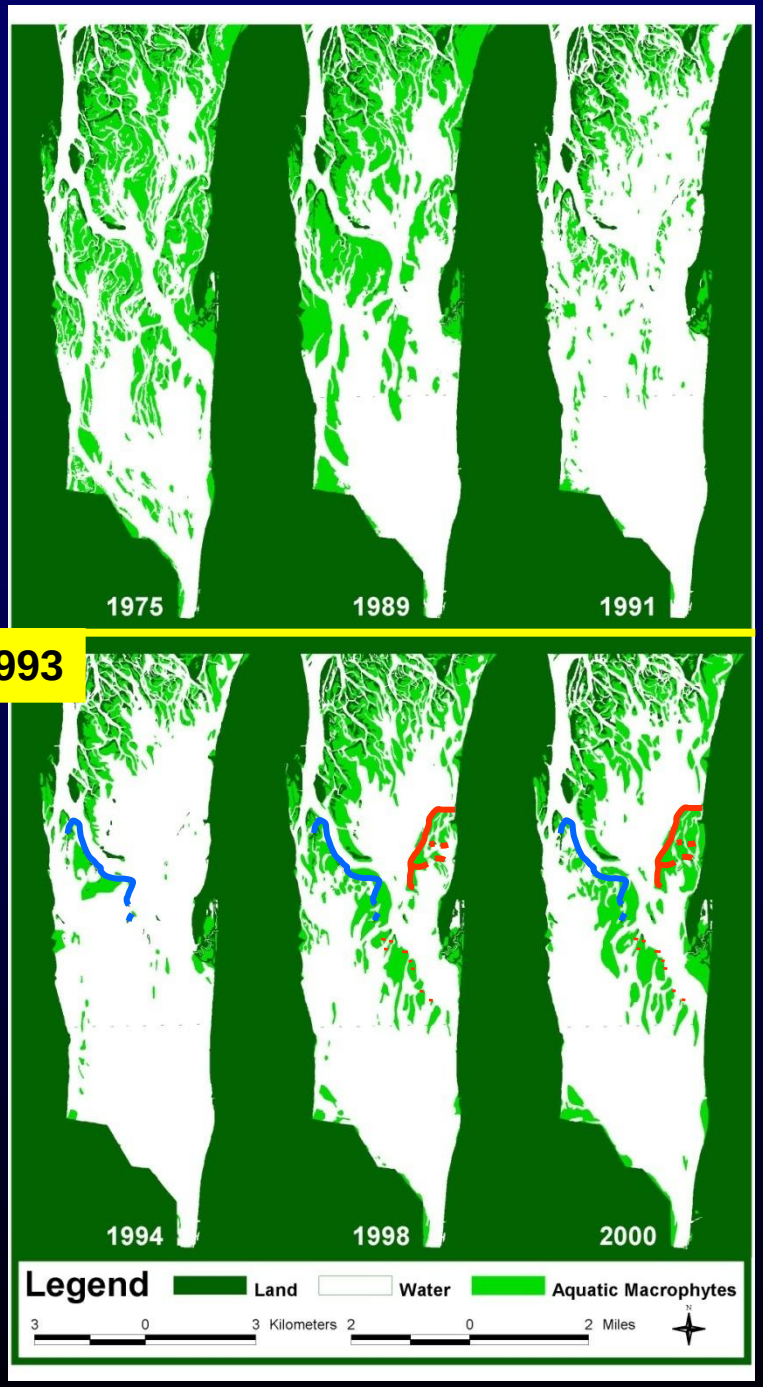
Pre = 1993-1997 Post = 1999 - 2005

Why did vegetation increase?

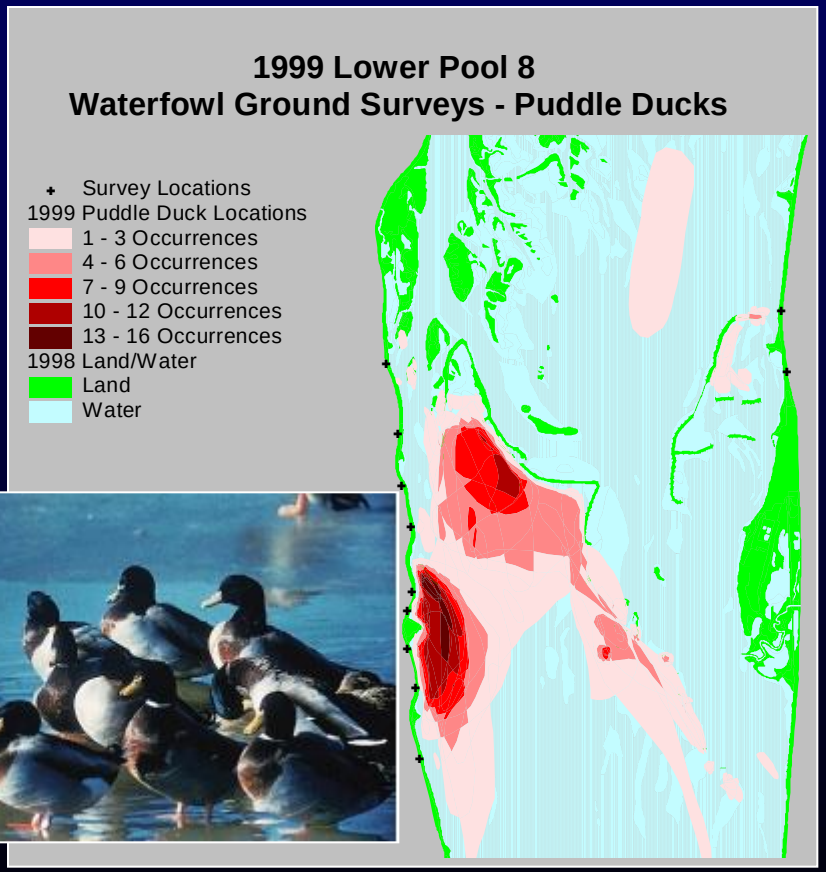
Criteria Met: Velocity Significantly Reduced

Pre = 1993-1997 Post = 1999 - 2005

Time Series of 1975 to 2000 Aquatic Vegetation Coverage in Lower Pool 8 Upper Mississippi River

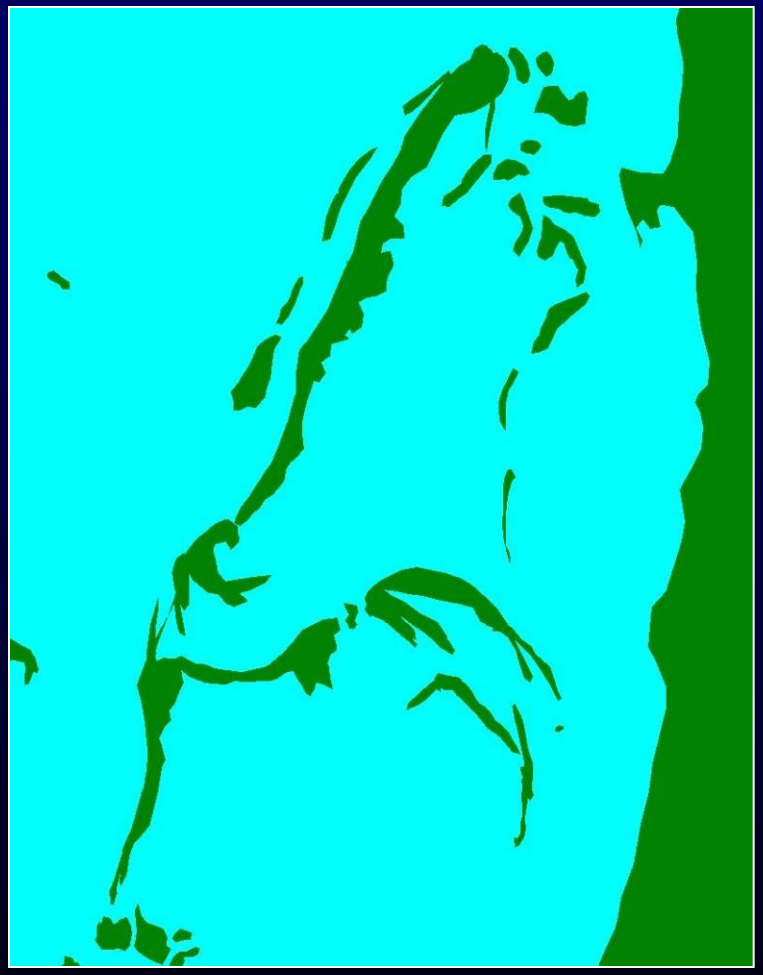


Pool 8 Islands Phase I Construction



Pool 8 Islands Phase II HREP
Features for Backwater Fisheries Habitat

1939



1999

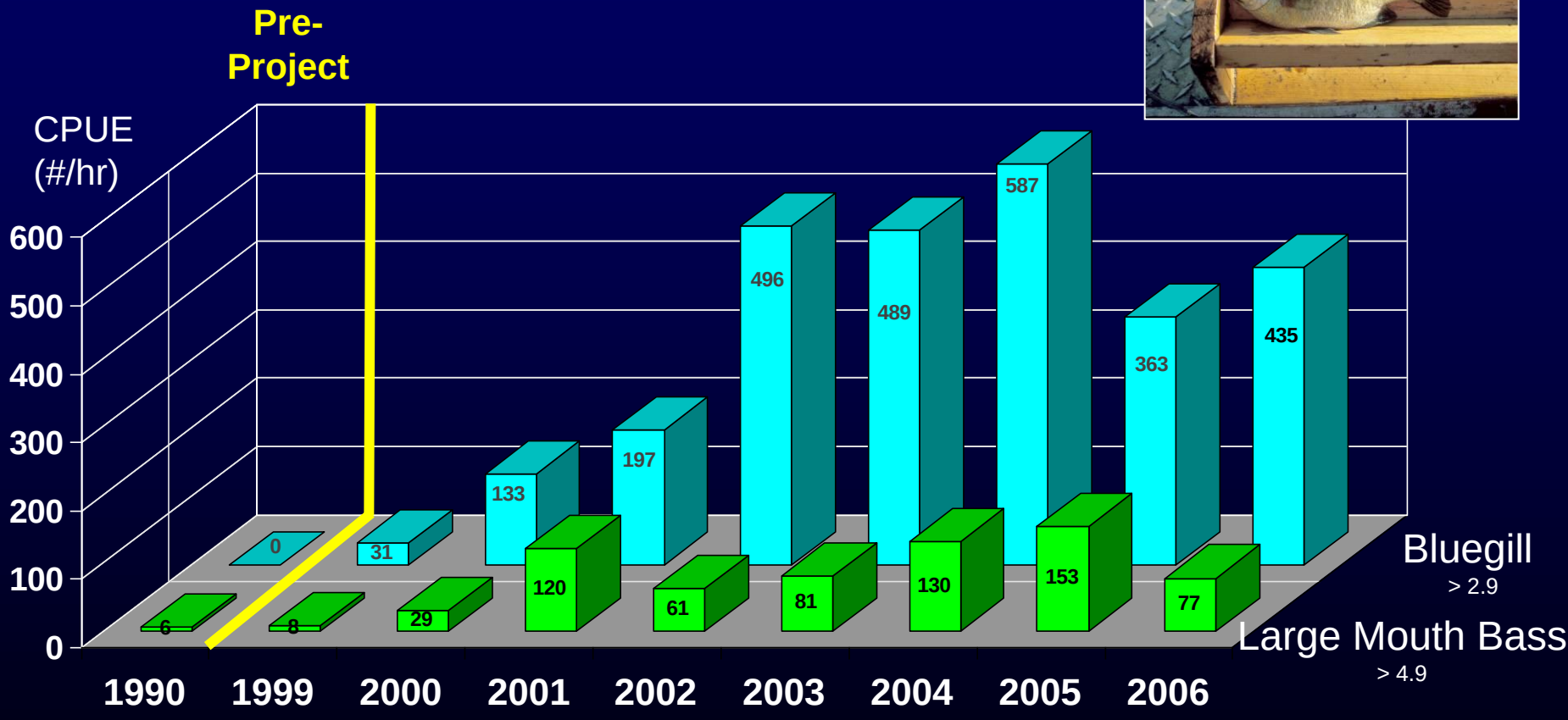
What Are Largemouth Bass and Bluegills "Looking" for in Over-wintering Habitat?

- Water Depths > 4 Feet
- Water Velocities < 0.01 feet per second
- Warm water temperatures (> 32 degrees Fahrenheit)
- Dissolved Oxygen ≥ 5 ppm

} Criteria

Pool 8 Islands Phase II

Pre- and Post-Project Fall Electro-fishing

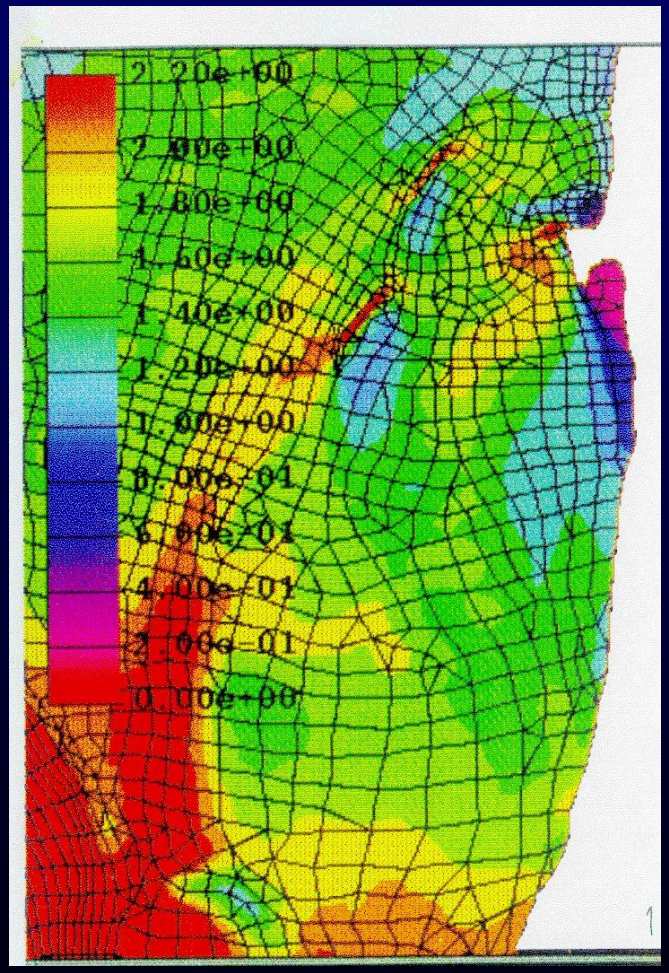


(Project began functioning as over wintering habitat November 1998)

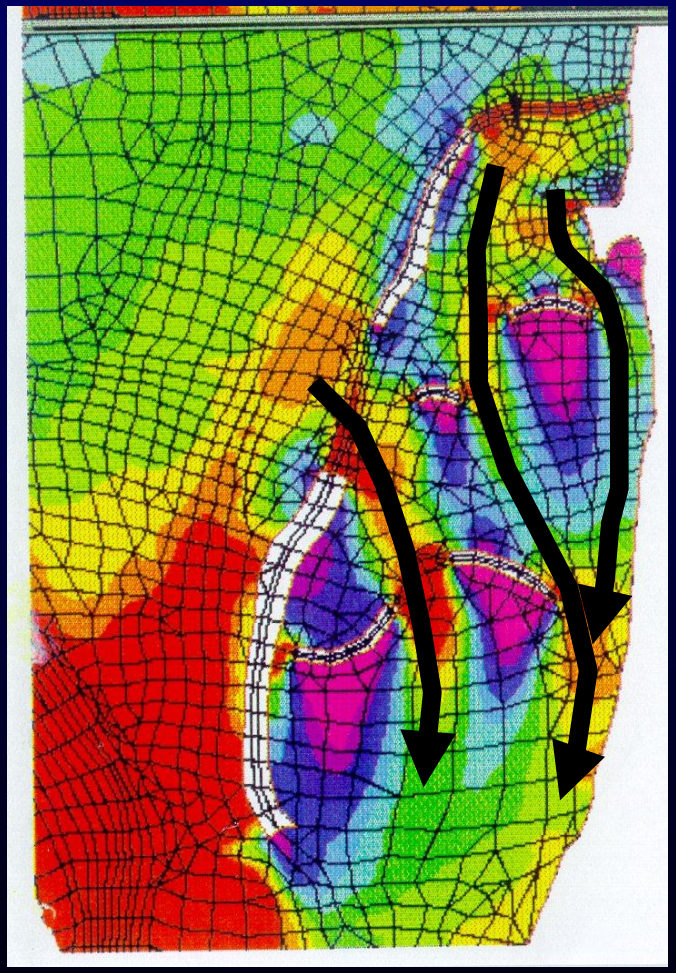
Pool 8 Islands Phase II
10 Year Flood Conditions

Velocity (ft/sec) Q(L/D 8) = 161,000

Pre-Project Conditions



Selected Plan



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STODDARD BAY DISCHARGE FOR PRE-PROJECT AND POST-PROJECT CONDITIONS

Stoddard Bay Discharge for Pre-project and Post-project conditions. Project Constructed in 1998.
Discharge in Stoddard Bay (y-axis) is plotted versus discharge at Lock and Dam 8 (x-axis).
Pre-Project conditions are represented by the blue diamonds (data) and the solid line which is numerical model results calibrated to the data.
Post-Project conditions are represented by the red triangles (data) and the dashed line which is from numerical modeling.
The river discharges at Lock and Dam 8 represented here vary from low discharge conditions to a 25-year flood event. A typical summer low discharge might be 20,000 cfs, and is exceeded about 75% of the time, while the 25-year flood event corresponds to a river discharge of 198,000 cfs.

Stoddard Bay Discharge (cfs)

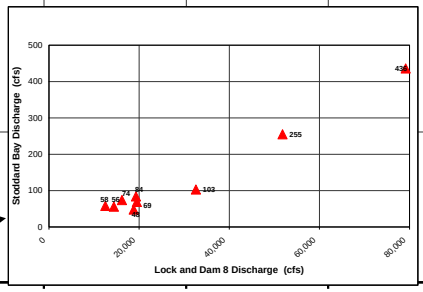
50,000
40,000
30,000
20,000
10,000
0

Discharge exceeded 75% of time
Discharge exceeded 25% of time
Stoddard Bay Sills overtopped
Discharge exceeded 5% of time
2-year flood
5-year flood
10-year flood
25-year flood

Typical Summer/Winter Low Flow Range
Bankfull Flow Range

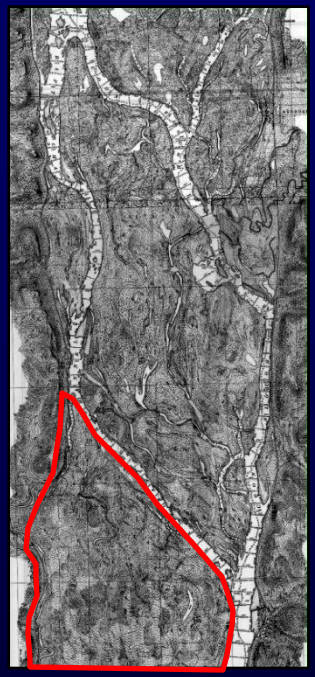
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000

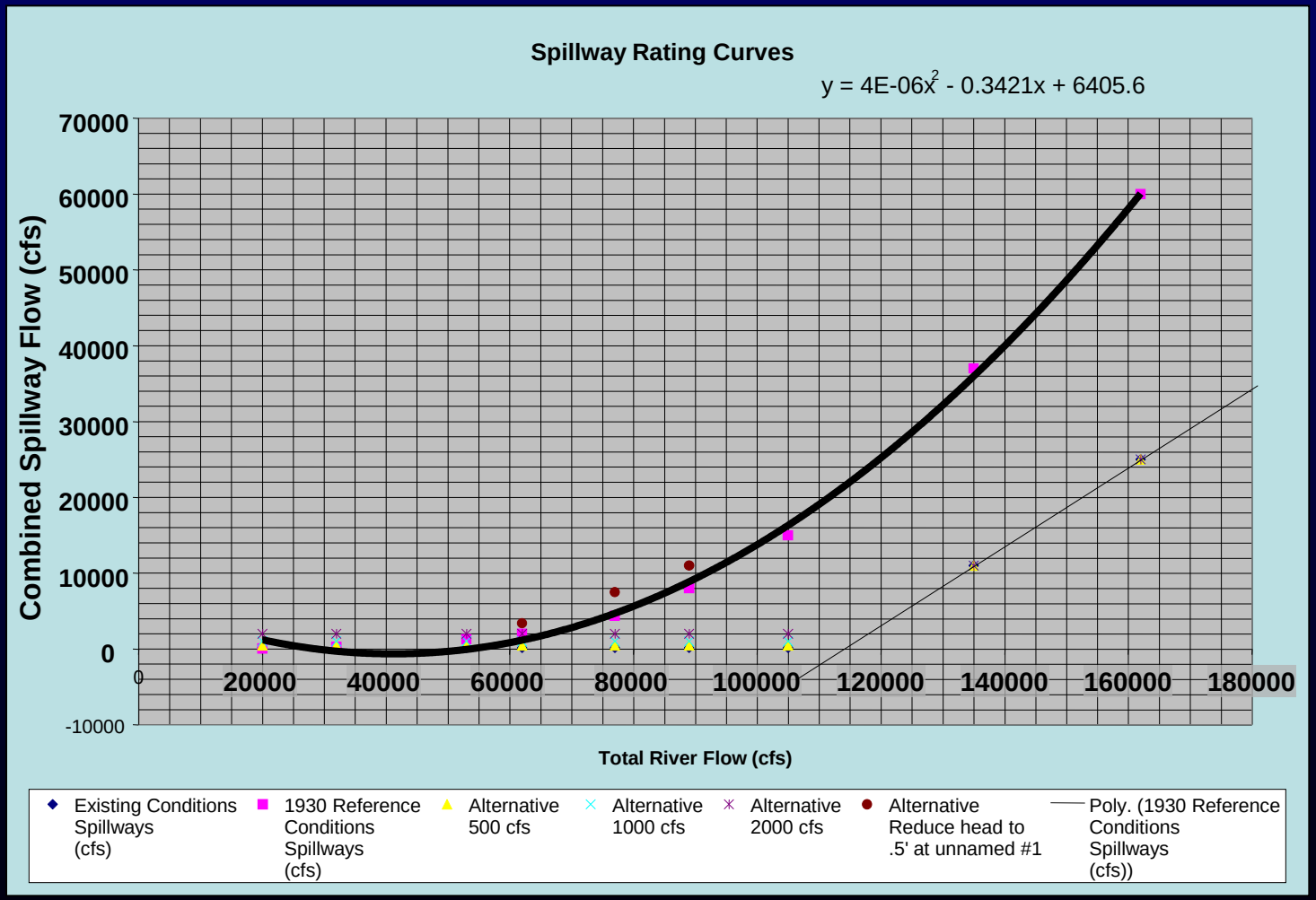
Lock and Dam 8 Discharge (cfs)



Pre-Project Data and Curve
Post-Project Data and Curve

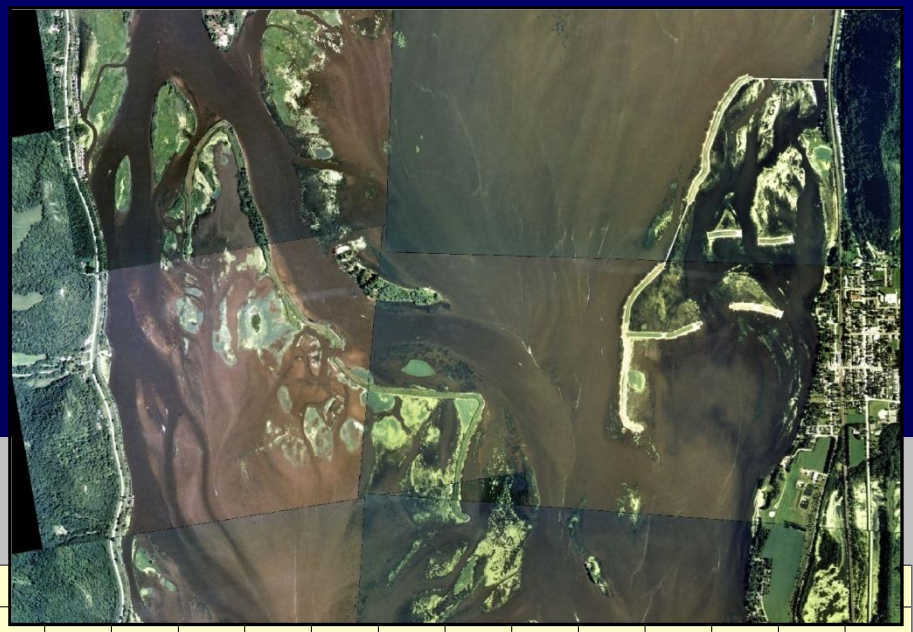
RENO BOTTOMS, POOL 9, MODELED PRE-DAM DISCHARGE TO BACKWATERS

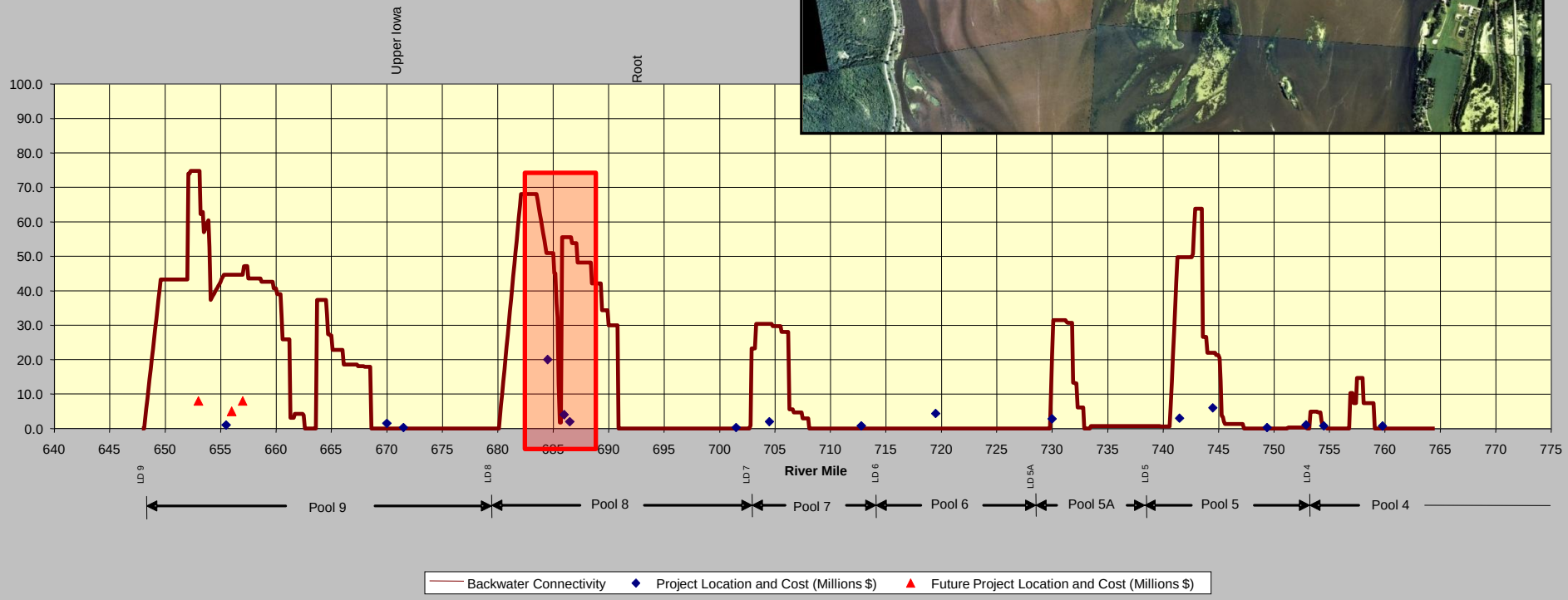




Geomorphic Reach 3 Backwater Hydraulic Connectivity for Moderate Flows (25% Duration Event)

Backwater connectivity is plotted as percent of total river flow conveyed in backwaters.

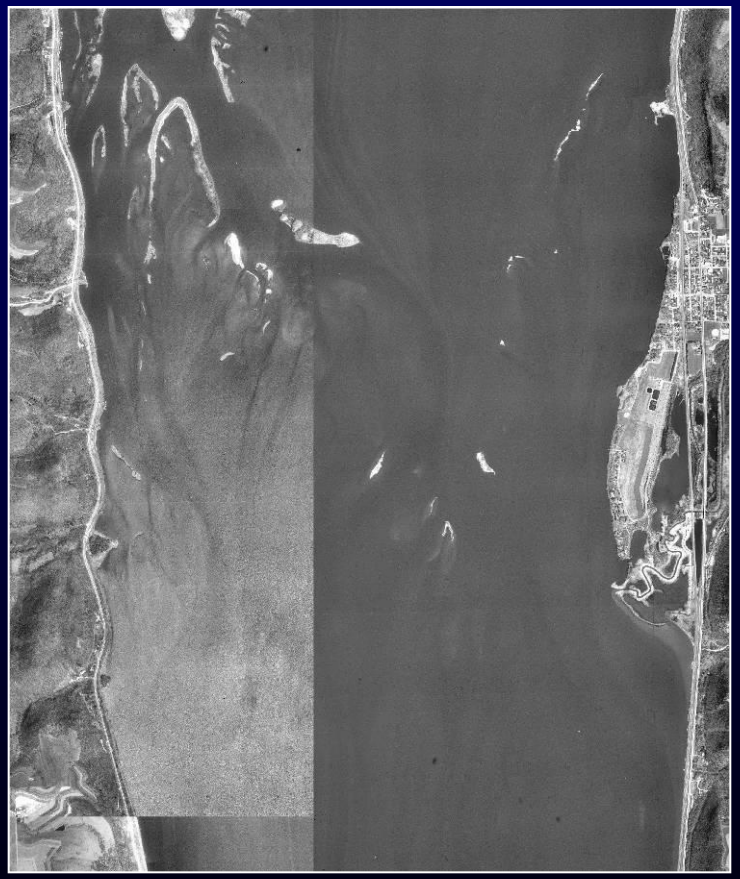




Projects are plotted at representative river mile from horizontal axis.
Cost is plotted in Millions of dollars from vertical axis.

Cumulatively, these projects are improving habitat conditions and “natural processes” in lower Pool 8

1991



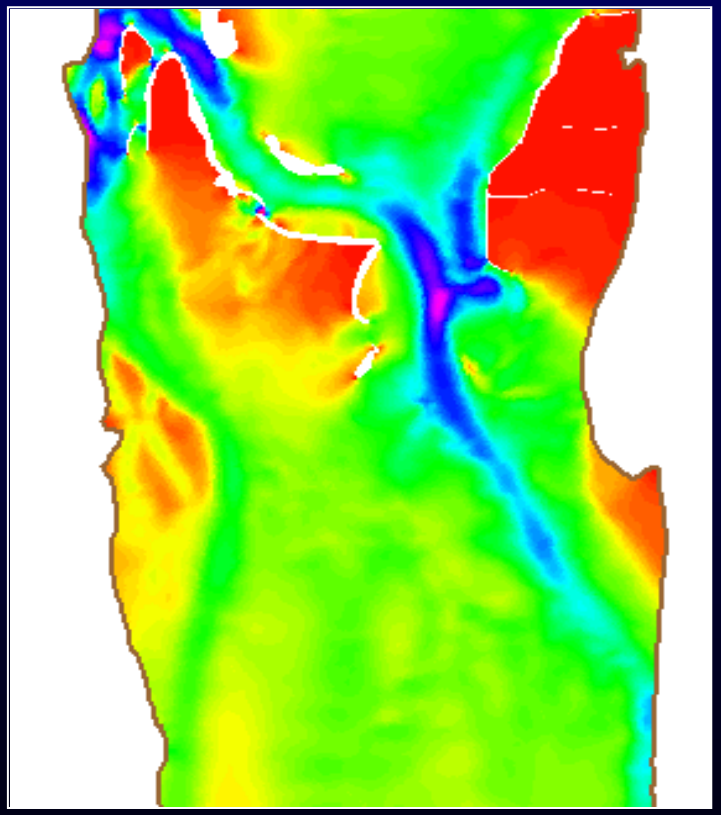
2009 - 2012

~~1999~~

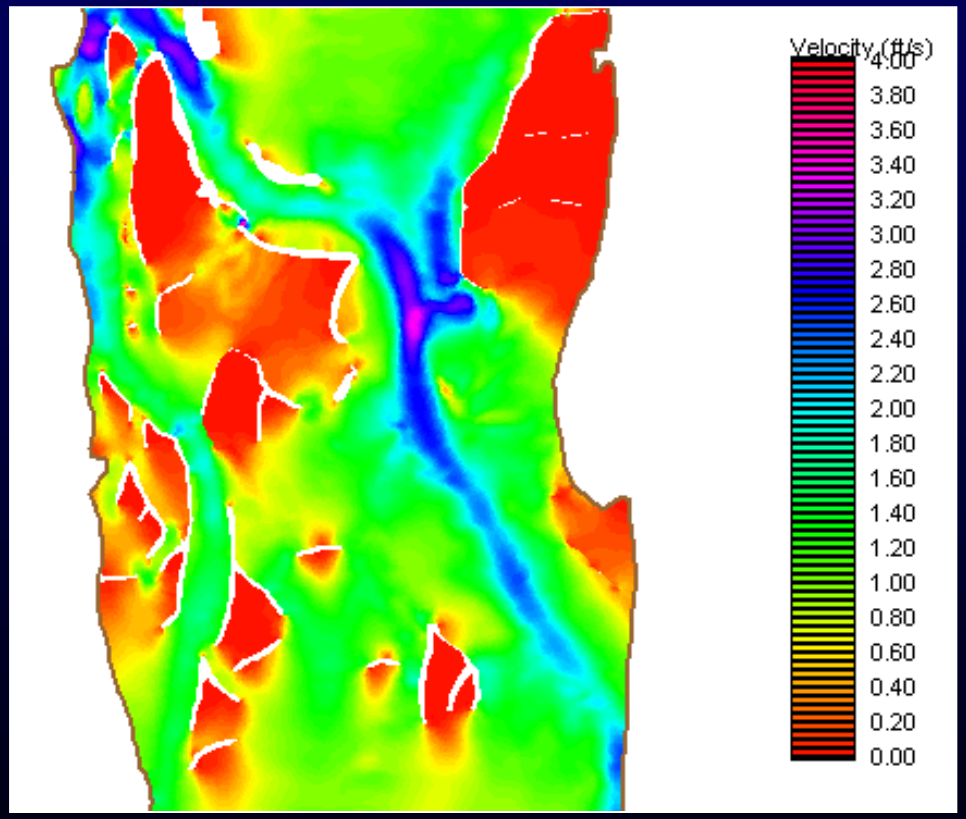
CUMULATIVE AFFECTS
Velocity Diversity And Sediment Transport

Hydraulic Model Results for 80,000 cfs
In the Pool 8 Islands Phase III Area

2001 Conditions



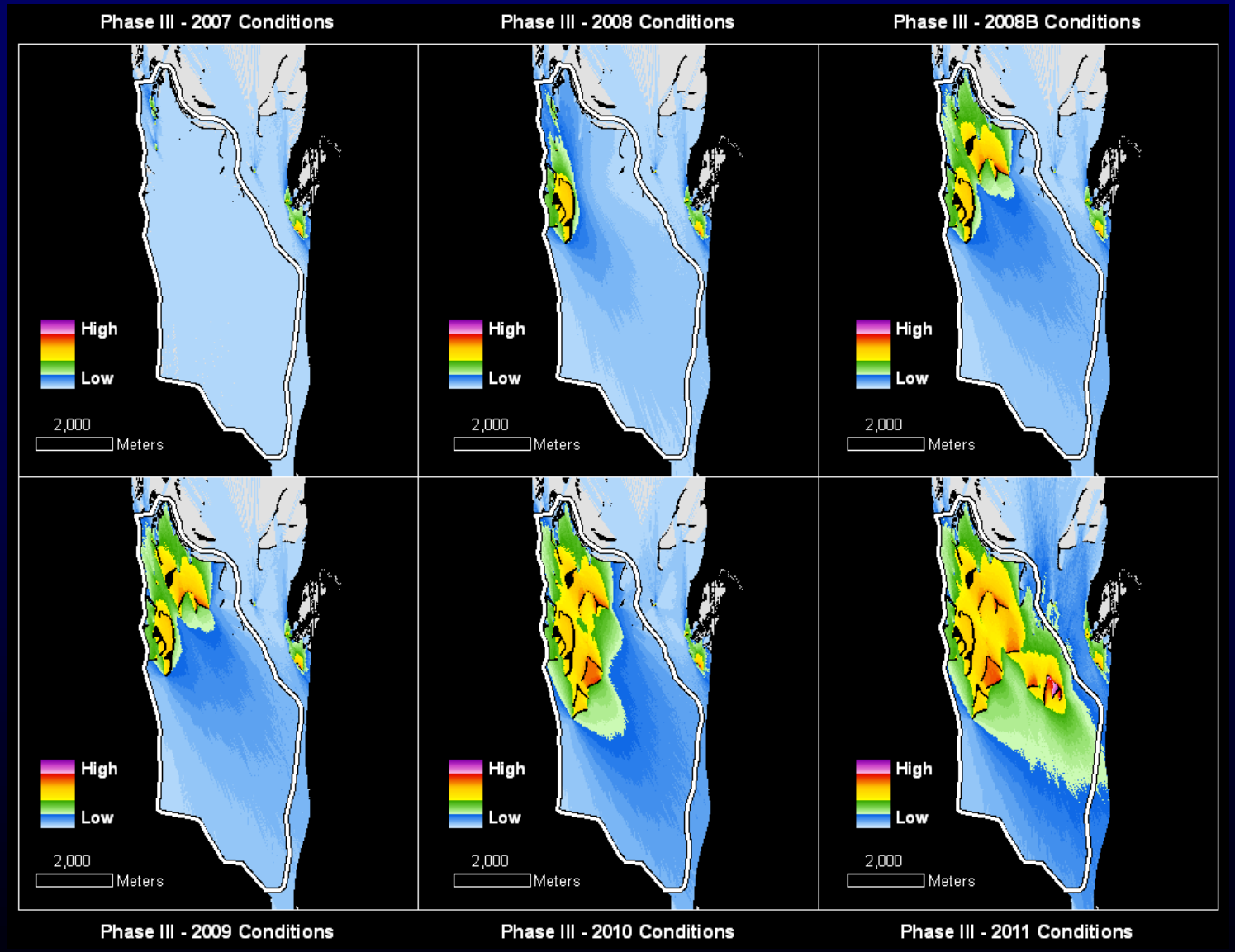
Predicted Change

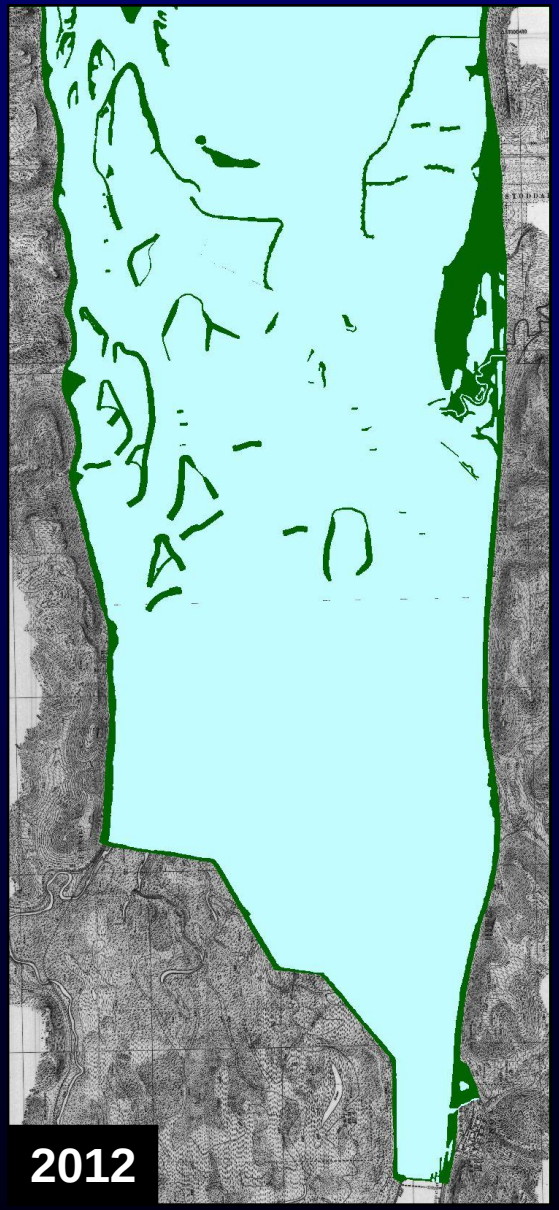


CUMULATIVE AFFECTS
Velocity Diversity And Sediment Transport

Areas of sand deposition in response to seed islands, and Pool 8 Islands, Phase I, were visible during 2001 1.5 foot drawdown of Pool 8.

Cumulative Affect on Reducing Wind Fetch and Sediment Resuspension





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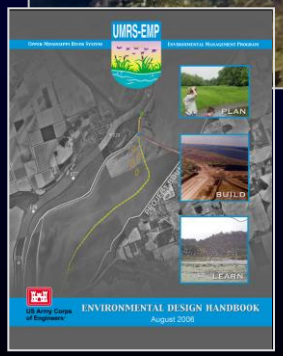
St. Paul District

Questions?

Pool 8 Islands, Phase III, Stages 2B and 3A, Aug. 2010



Environmental Management Program
Habitat Rehabilitation and Enhancement Projects

http://www.mvr.usace.army.mil/EMP/