Examining Impaired Waters from Different Angles

Multi-Prong Monitoring to Support the Lower Minnesota River Model

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Sponsors

Metropolitan Council

Lower Minnesota River Watershed District

Metropolitan Airports Commission

Minnesota Pollution Control Agency

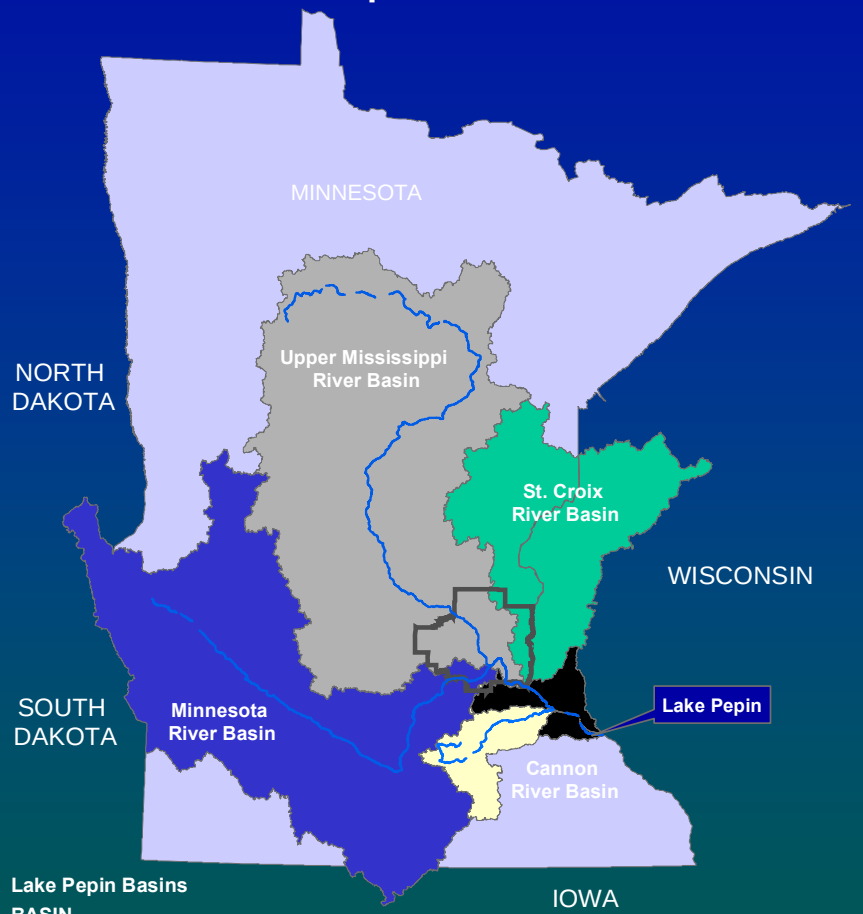
US Army Corps of Engineers

US Geological Survey

First, the truth about water-quality monitoring in Minnesota…

US Map: Minnesota River Basin Data Center

Lake Pepin Watershed



Lake Pepin Basins

BASIN

- Cannon River Basin
- Minnesota River Basin
- St. Croix River Basin
- Upper Mississippi River Basin
- HUC 07040001
- Major Rivers
- Metro Area

Feature	Area (Kilometers^2)
Lake Pepin Watershed	122,575
Minnesota	218,480
Lake Pepin Watershed with in Minnesota	105,368

Minnesota Pollution Control Agency

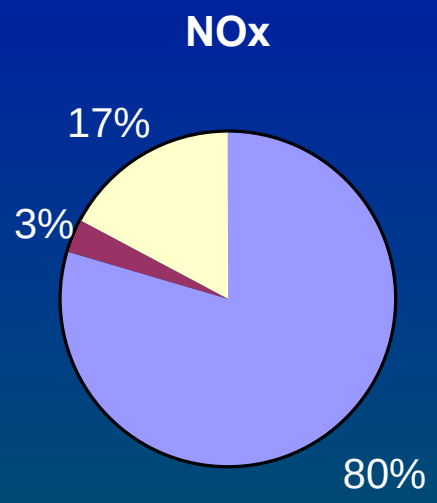
Sources Upstream of Lake Pepin

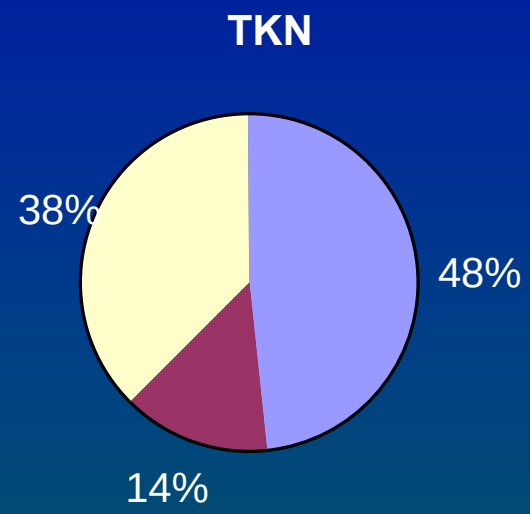
Mississippi River at Anoka

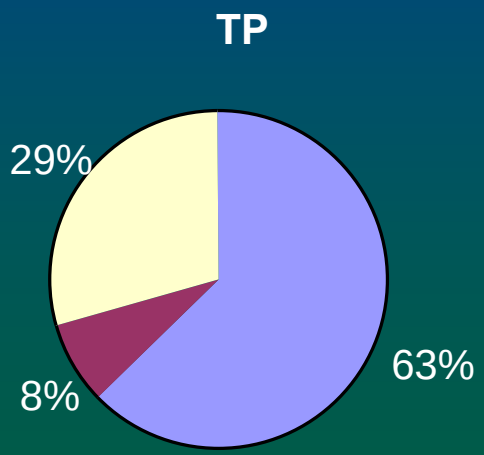
St. Croix River at Stillwater

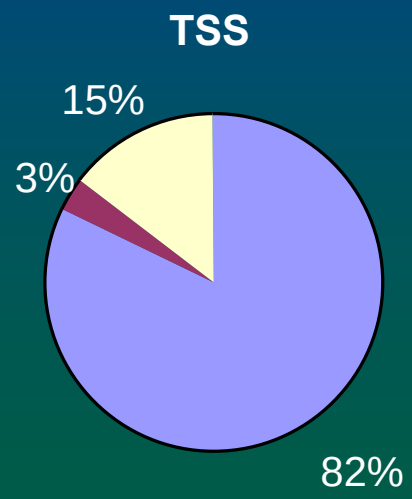
Minnesota River at Jordan

Based on Median Pollutant Mass Load (tonnes/year) from 1992 - 2001









Regional Progress in Water Quality, Metropolitan Council, 2004

Bridge Over Troubled Waters

- **Waste Load Allocation Study (1985)**
  - Lower Minnesota River: BOD/DO, NH4
  - Effluent limits for point sources
  - 40% reduction goal for nonpoint sources
- **Impaired Waters & TMDL Studies**
  - Lower Minnesota River: Oxygen (2006)
  - Mississippi & Minnesota Rivers: Turbidity (2009)
  - Lake Pepin: Nutrients (2009)
- **Water-Quality Models**
  - Minnesota River Basin, miles 300-40 (HSPF)
  - Mississippi River Model, Pools 2-4 (ECOM-RCA)
  - Lower Minnesota River, miles 40- 0 (?)

Lower Minnesota River

Minnesota Valley National Wildlife Refuge

Problems

- Oxygen, turbidity, bacteria, PCBs, mercury
- Excessive algae, nutrients, sediment

Stressors

- Large agricultural watershed
- Rapid growth in SW Metro Area
- Point-source dischargers
- Navigation

Scoping Workshop, February 2003

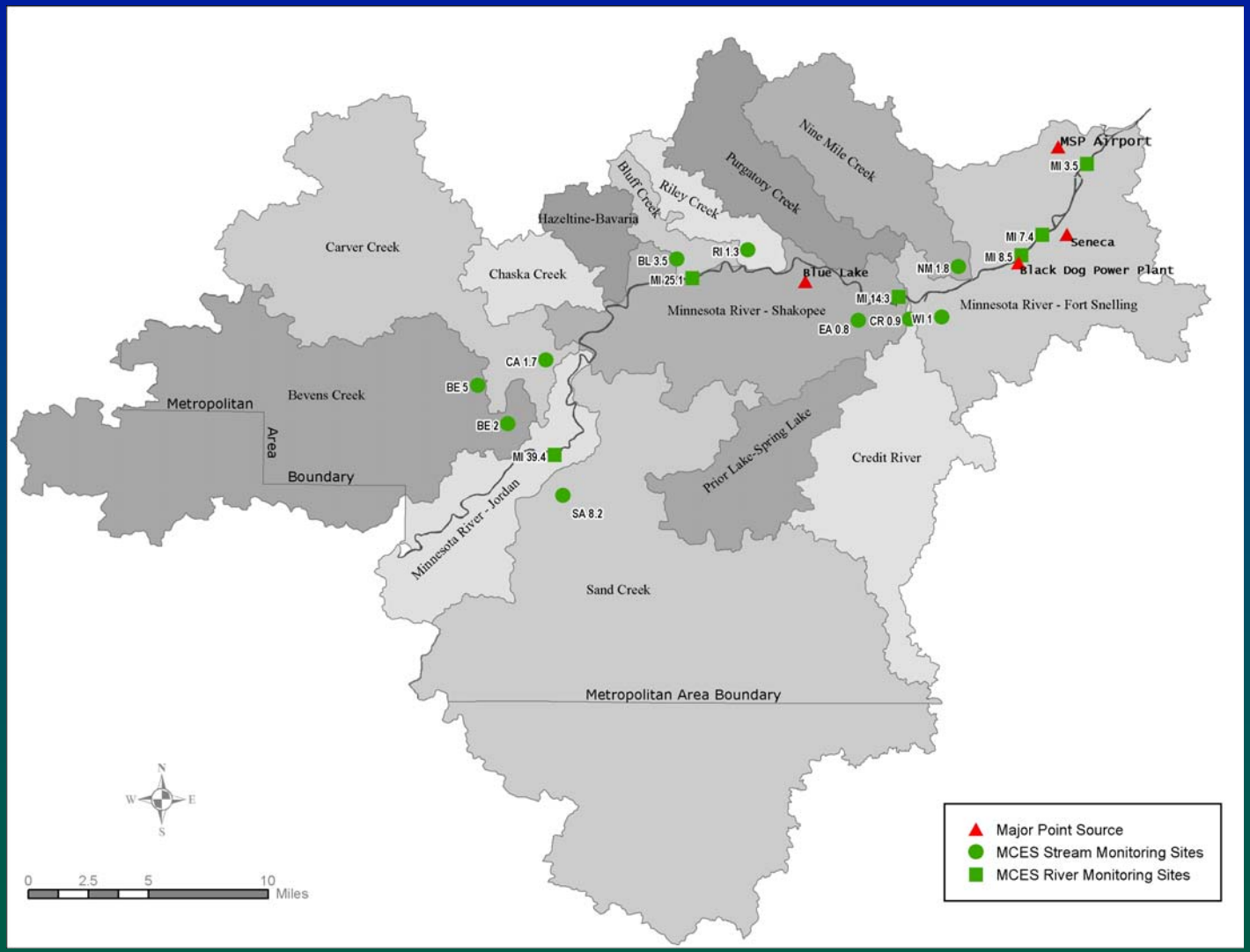
- What are the issues and our priorities?
  - Oxygen, ammonia, nutrients, sediment
- Which model should we apply?
  - CE-QUAL-W2 Model, USA-ERDC
  - Mississippi River Model, HydroQual & MCES
- What are the model data requirements?
  - CE-QUAL-W2 User Manual
  - Tom Cole & others, USA-ERDC
  - Pooled experience of partners

Monitoring Program, 2003-2006

- **Base monitoring over three years**
  - River, tributaries, and discharges
- **Intensive low flow monitoring**
  - River flow < 2000 cfs during June-Sept
- **Special field studies**
  - Hydrodynamics (e.g., mixing, ground water)
  - Oxygen (e.g., reaeration, oxygen demand)
  - Nutrients (e.g., P dynamics, sediment fluxes)
  - Algae (e.g., growth factors, oxygen balance)
  - Sediment (e.g., distribution, characteristics)

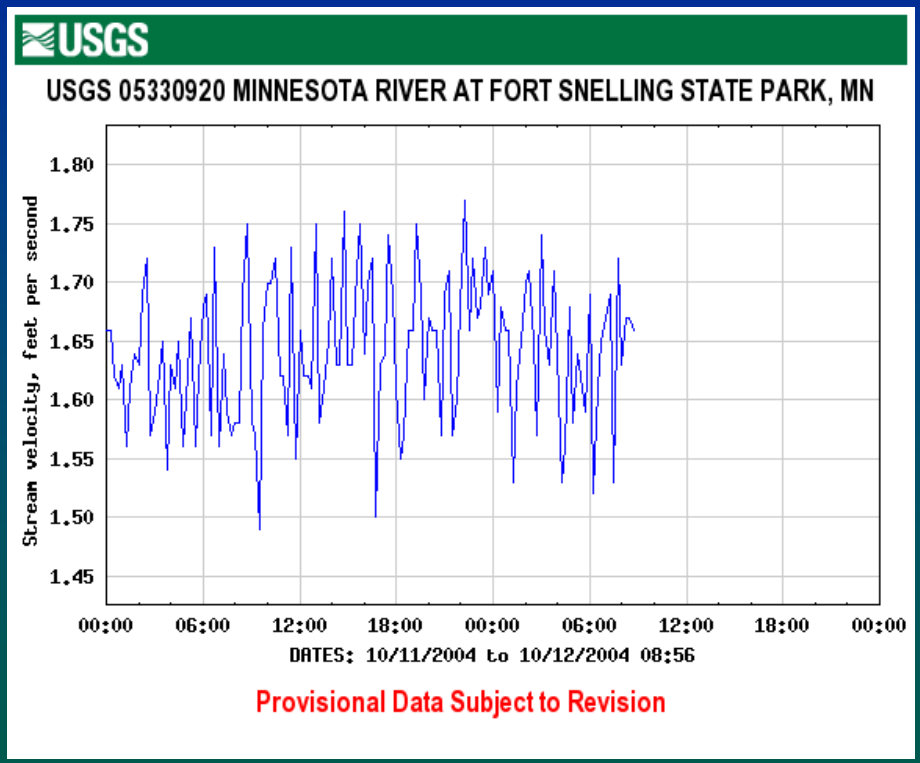
Long-Term Water-Quality Monitoring Program

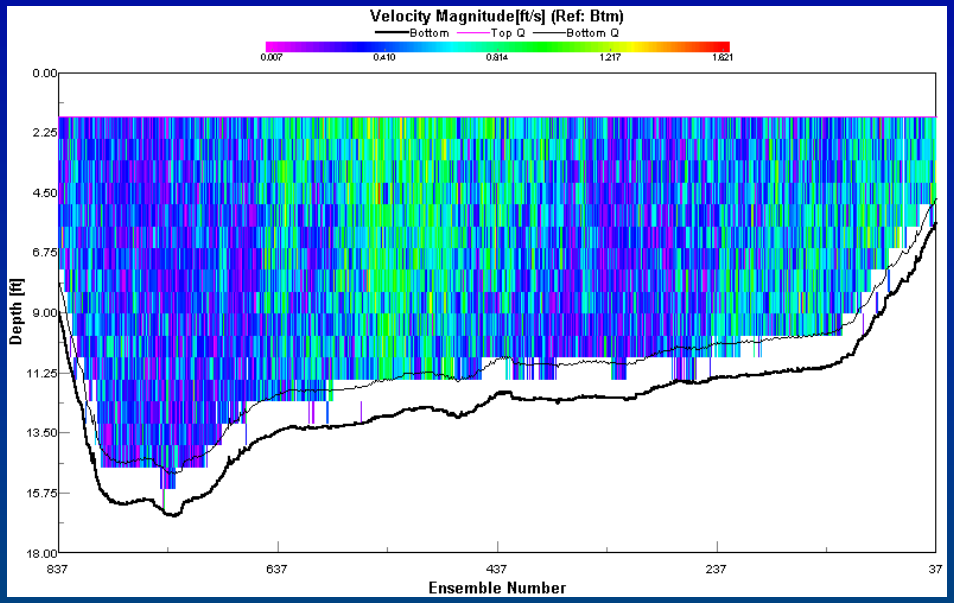
Metropolitan Council Environmental Services

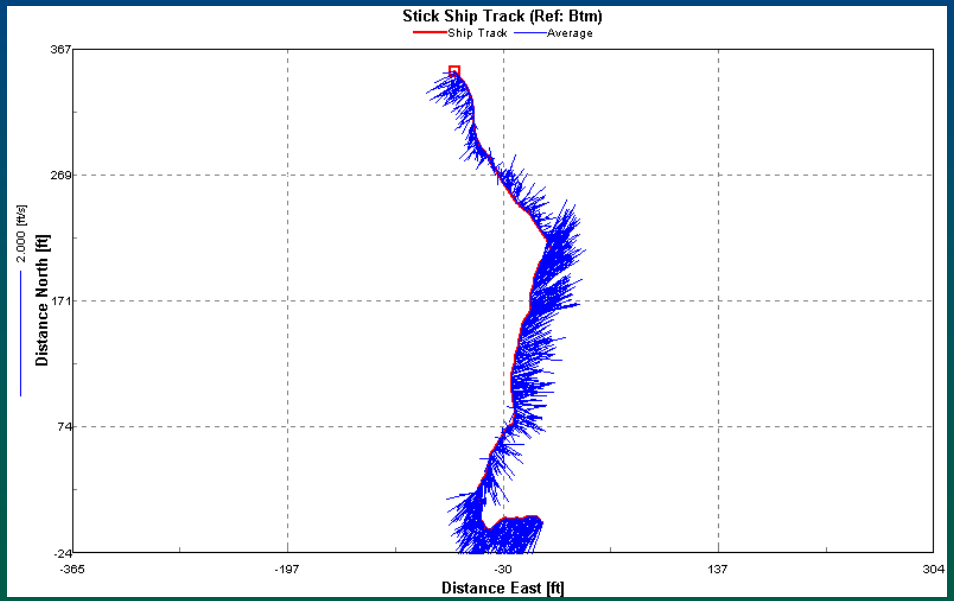


Cooperative Projects

USGS Minnesota Water Science Center







Ground-Water Inflows

- Conducted at low river flows in late summer
- Measured river flow at multiple sites with ADCP
- Measured tributary flows near base of bluff
- Estimated ground-water inflows or outflows by difference
- Concluded that ground-water inputs are minor

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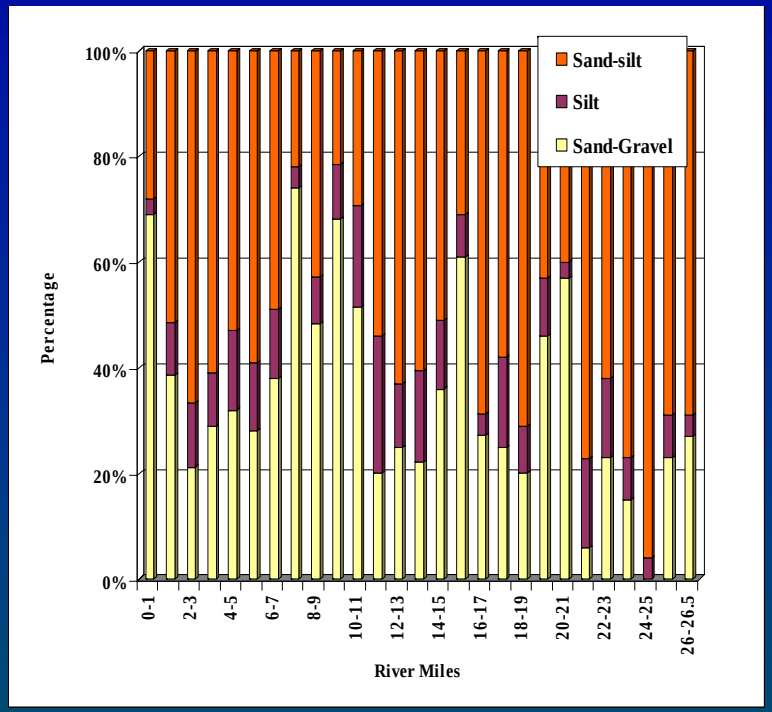

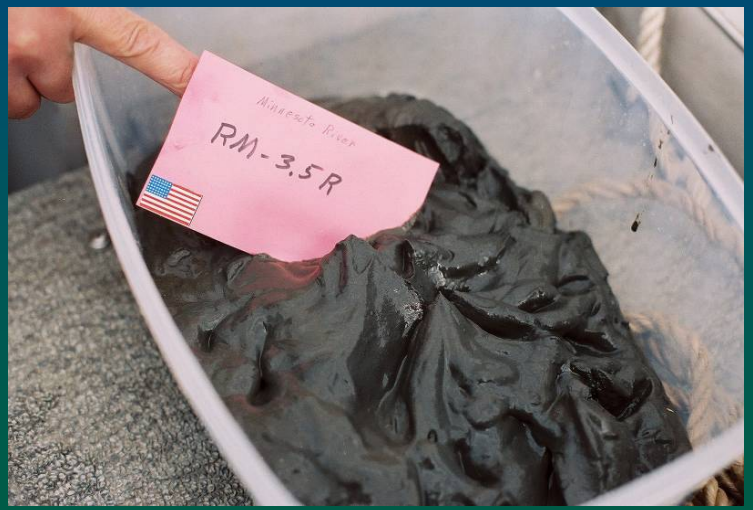

Sediment Bed Assessment

- Conducted at low river flows with seismic profiler
- Profiled sediment along shores and transects every 200 ft
- Collected some sediment cores and noted sediment type
- Metropolitan Council later mapped the sediment bed

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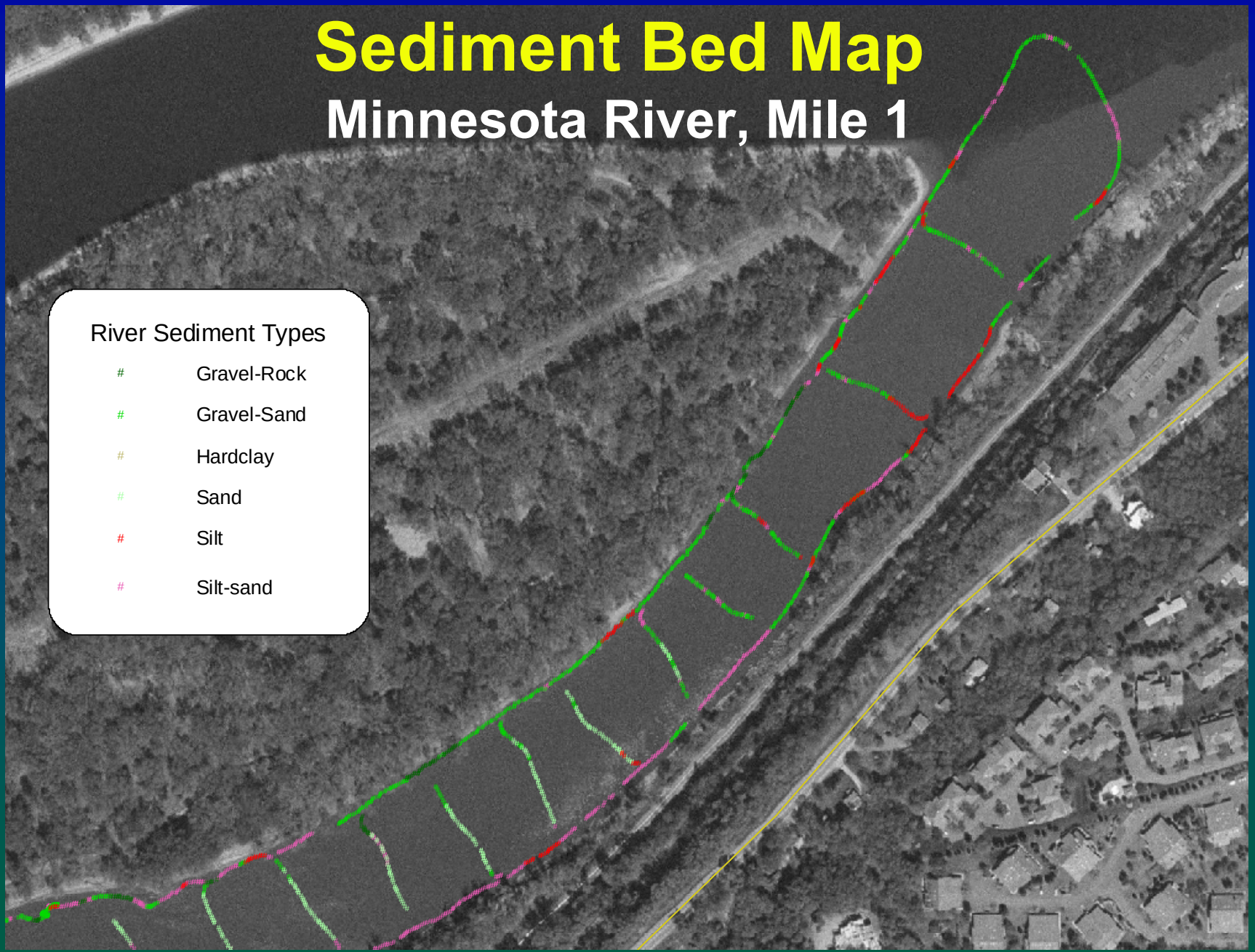
Sediment Bed Map

Minnesota River, Mile 1



Mixing Characteristics

Vertical Difference in Dissolved Oxygen > 0.5 mg/L

Date	Discharge	Average water temperature, degrees C	River Mile				
			39.4	25.1	14.3	8.5	3.5
July 29, '03	2880	27.0				YES	YES
Aug 21, '03	1160	27.1			YES	YES	YES
Sep 24, '03	554	16.4			YES	YES	YES
Apr 22, '04	1640	13.9				YES	YES
Jun 2, '04	16900	16.9					
Aug 11, '04	4880	20.0					

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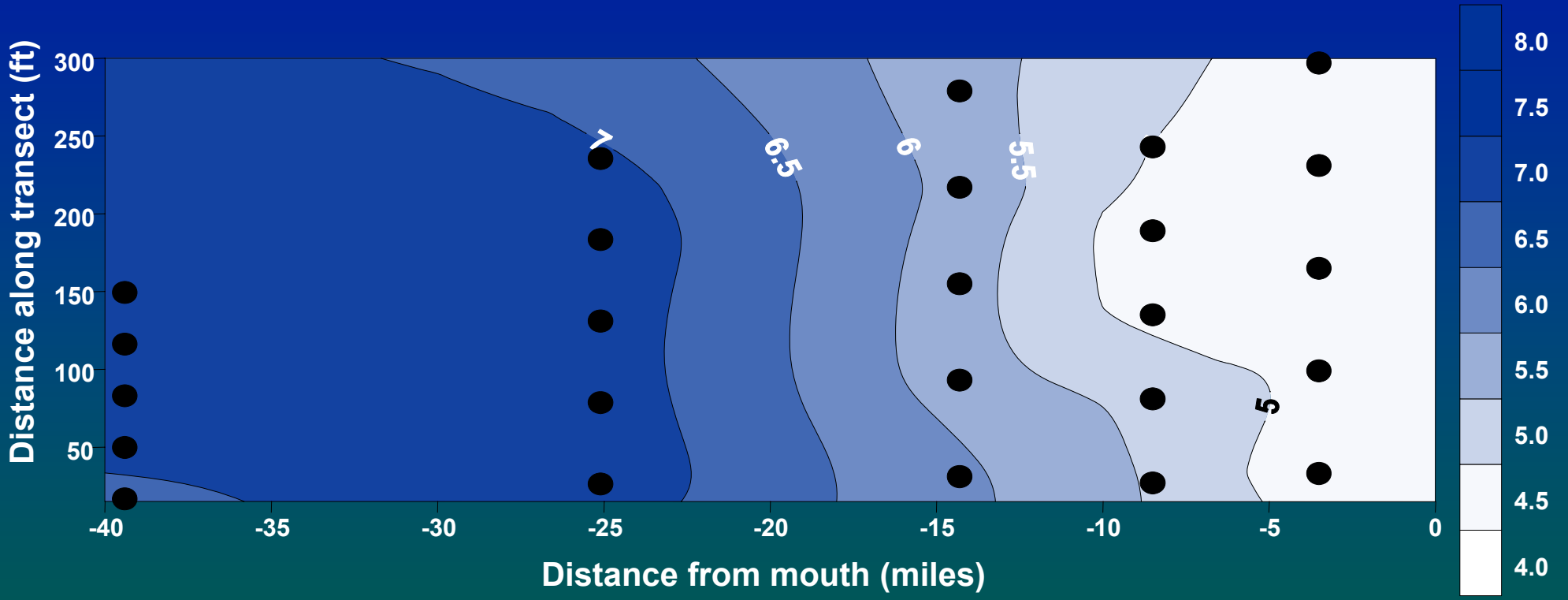
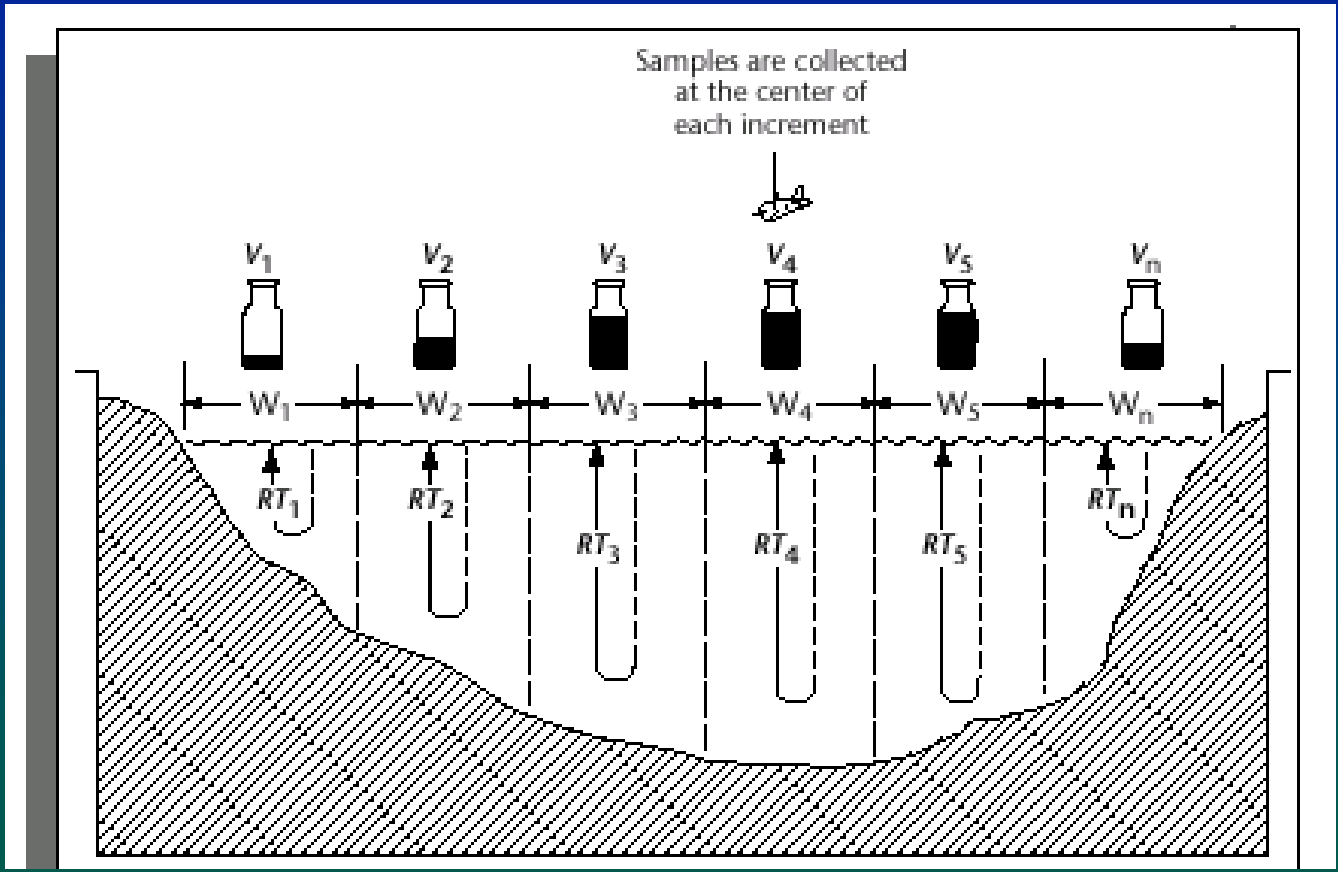
Surface Dissolved Oxygen (mg/L)

Lower Minnesota River, 8/21/03



Representative Sampling

Equal-Width-Increment Versus Discrete



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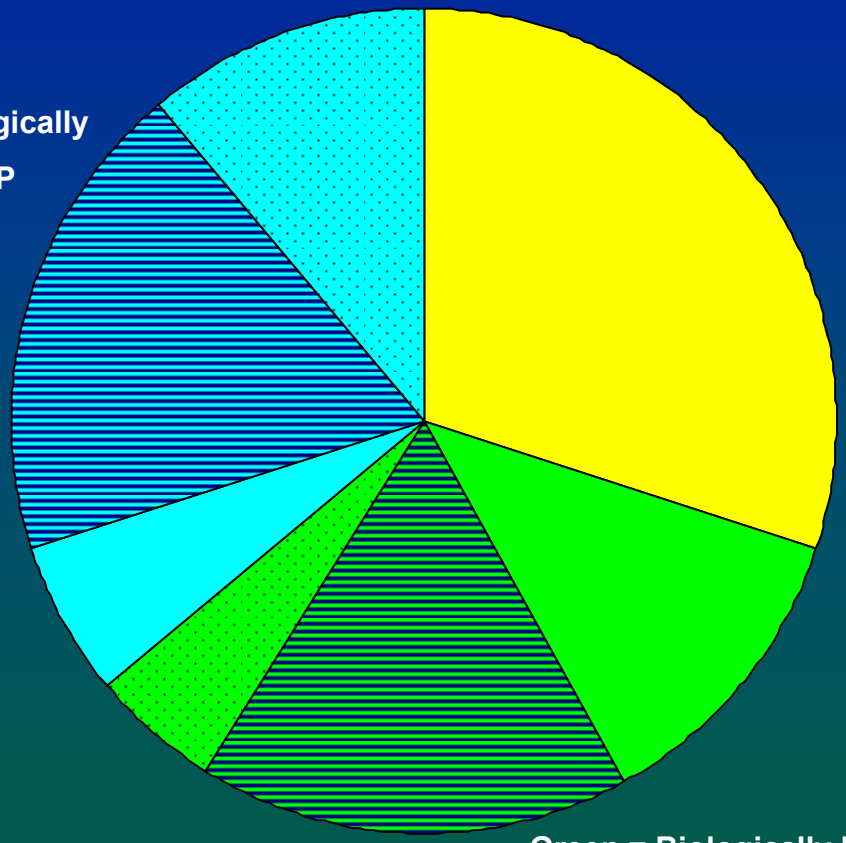
Nutrient Dynamics & Budgetary Analysis

US Army Engineer Research & Development Center

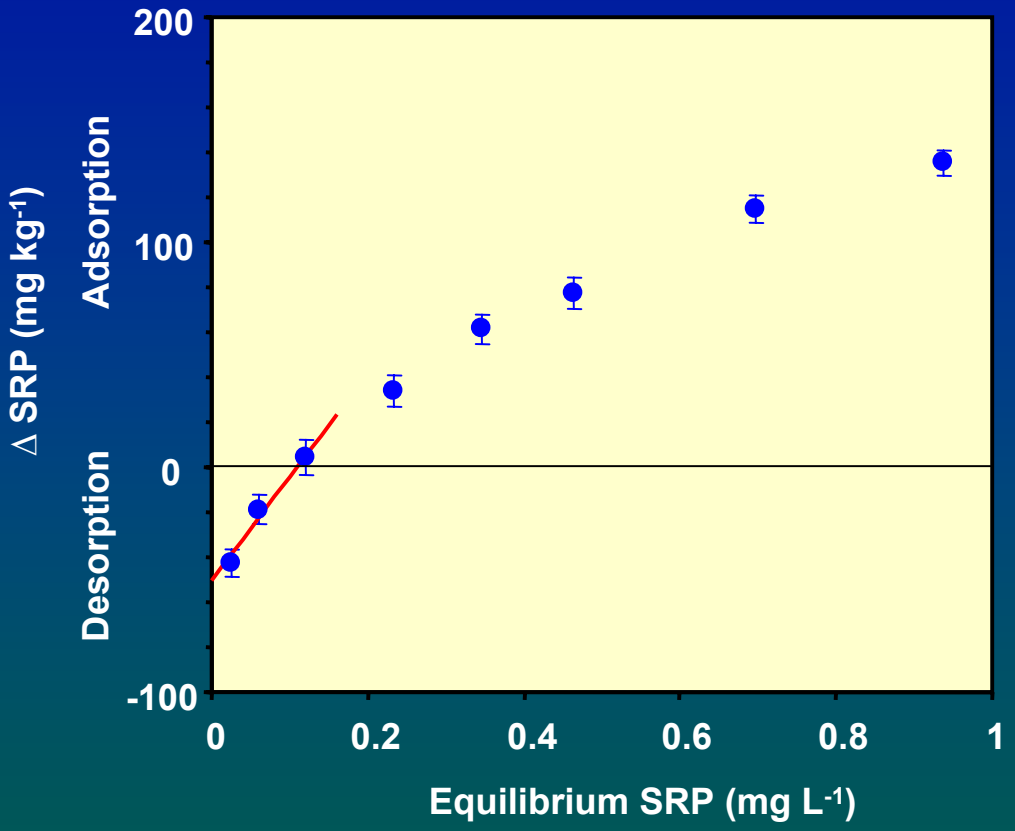
Eau Galle Aquatic Ecology Laboratory, Spring Valley, WS

Phosphorus Fractions: Soluble & Particulate

Percent of Load, Minnesota River at Jordan, 2006



Nutrient Dynamics and Budgetary Analysis of the Lower Minnesota River: 2003-2006, W.F. James, USA-ERDC, 2008



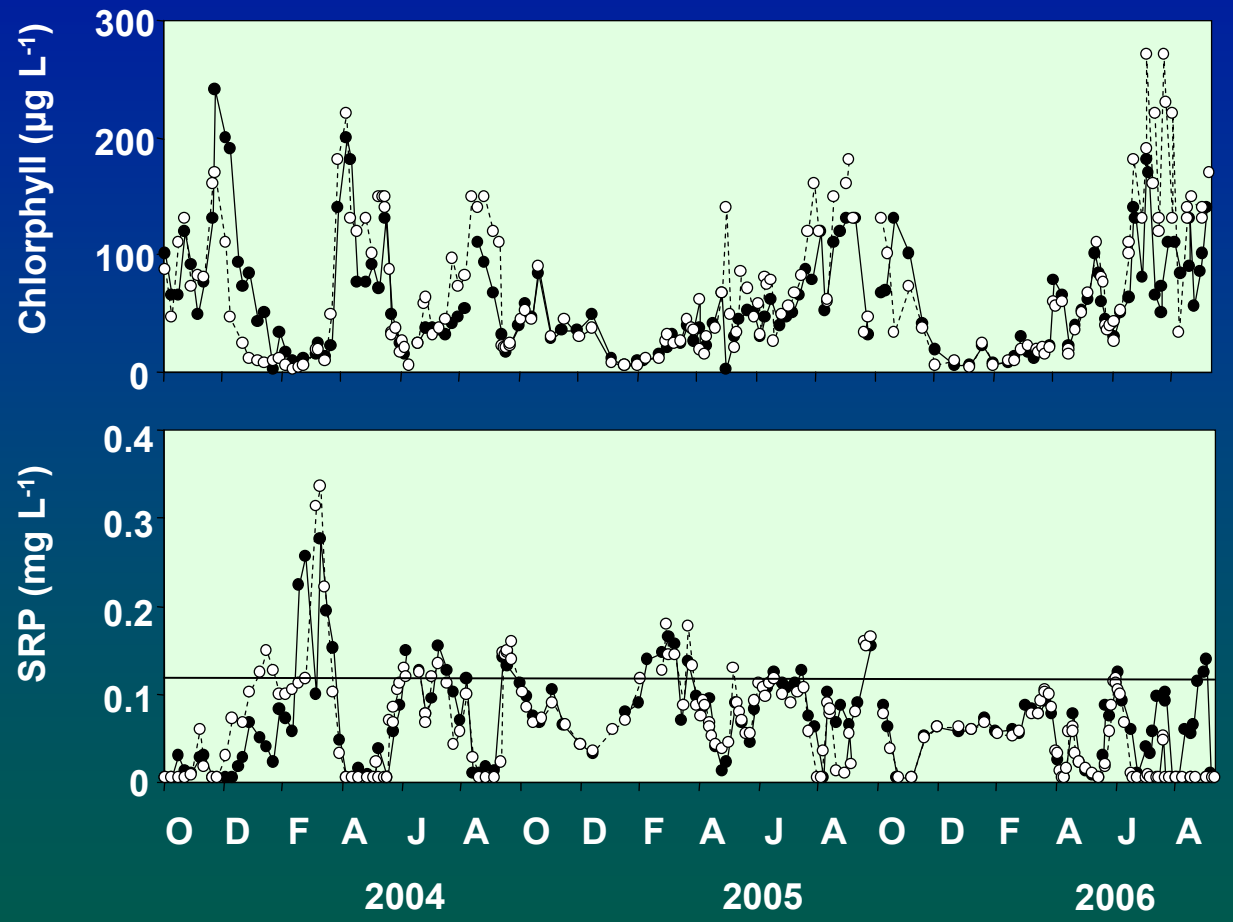
Phosphorus Sorption

- Measured equilibrium P concentration, the tipping point for P attachment to particles
- EPC roughly equals mean ambient SRP (.11 mg/L)
- Concluded that TSS buffers SRP at higher flows but algae & point sources regulate P dynamics at lower flows

Nutrient Dynamics and Budgetary Analysis of the Lower Minnesota River: 2003-2006, W.F. James, USA-ERDC, 2008

Chlorophyll-a & Soluble Reactive P Concentrations

Minnesota River at Jordan & Ft Snelling, 2004-2006



Nutrient Dynamics and Budgetary Analysis of the Lower Minnesota River: 2003-2006, W.F. James, USA-ERDC, 2008

Sediment P Release Rates

- Related to iron-bound P
- Related to silt content
- Mean Oxic = 4 $mg/m^2/d$
- Mean Anoxic = 21 $mg/m^2/d$
- <10% of total P budget

Nutrient Dynamics and Budgetary Analysis of the Lower Minnesota River: 2003-2006, W.F. James, USA-ERDC, 2008

Percent Load Contributions in 2006

Sample of Budgetary Analyses for 2004-2006

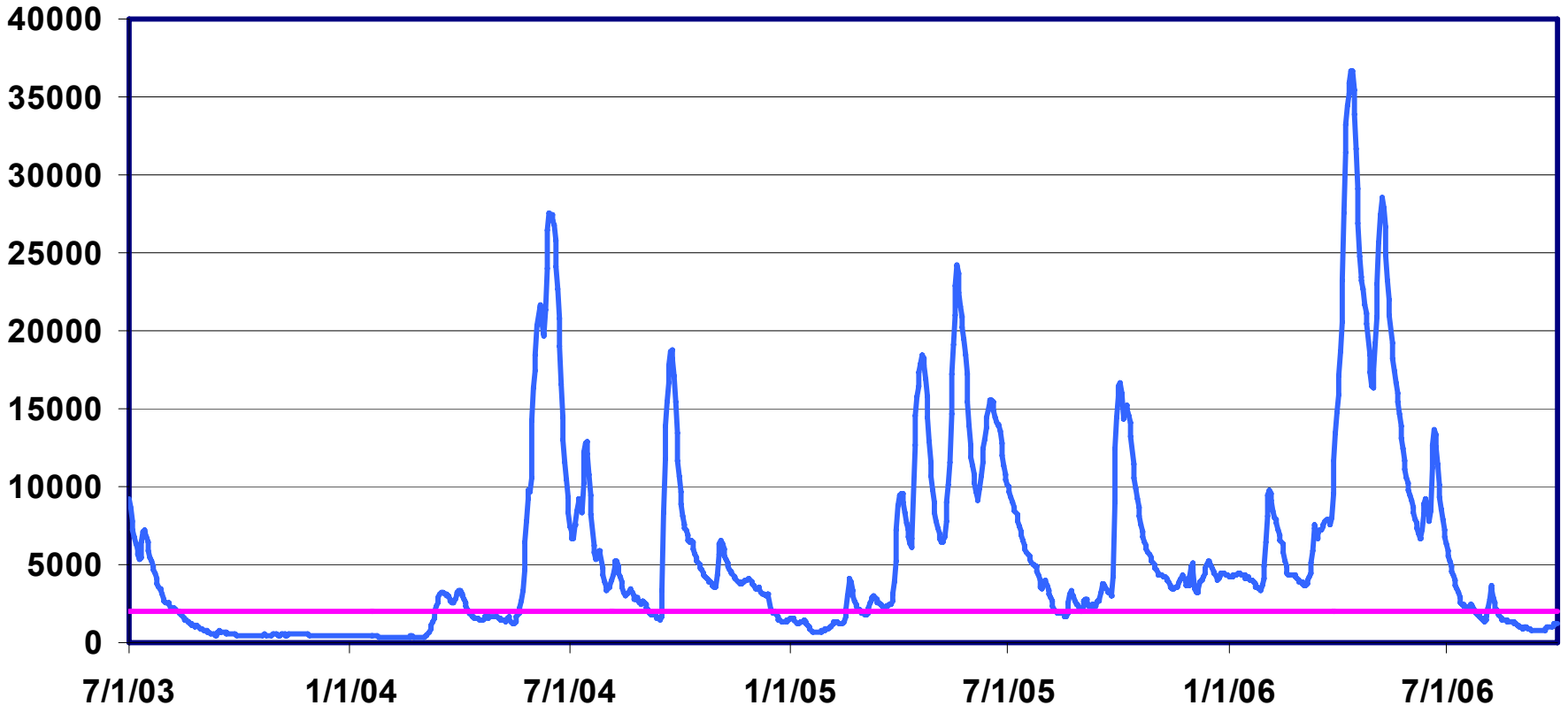
	Flow	TSS	TKN	NOX	NH4	TP	SRP
River at Jordan	95.0	91.6	92.9	97.3	89.1	88.4	82.9
Monitored Streams	3.6	8.4	5.5	1.2	6.7	7.4	4.4
Point Sources	1.5	0.0	1.6	1.5	4.2	4.2	12.7
Retention (-) or Export (+)	+1.1	-22.0	-3.6	-3.9	+43.2	-10.9	-12.7

Nutrient Dynamics and Budgetary Analysis of the Lower Minnesota River: 2003-2006, W.F. James, USA-ERDC, 2008

Summer Low Flow Studies

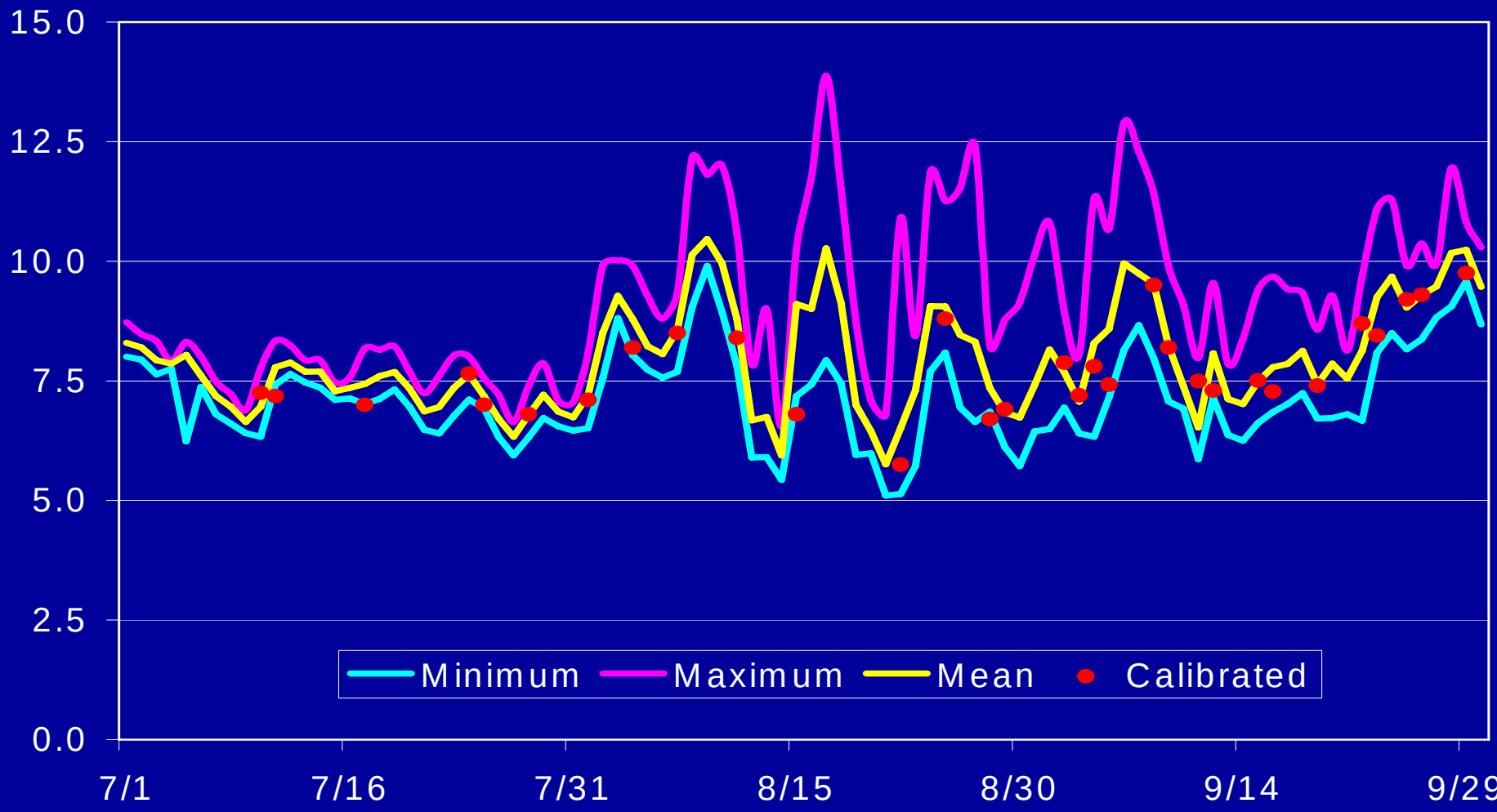
- Intensive river monitoring (MCES)
  - Weekly sampling at 10 sites for 8-12 weeks
- Synoptic sonde survey (MPCA)
  - Sondes suspended from buoys deployed for several days at 6 sites plus grab samples
- Oxygen dynamics assessment (HydrO_2)
  - Measure oxygen sources and sinks from the atmosphere, sediment, and water

Flow (cfs) near Jordan, July 2003 - Sept 2006
Compared to Low Flow Target of 2000 cfs



Dissolved Oxygen (mg/L), Minnesota River at Mile 3.5

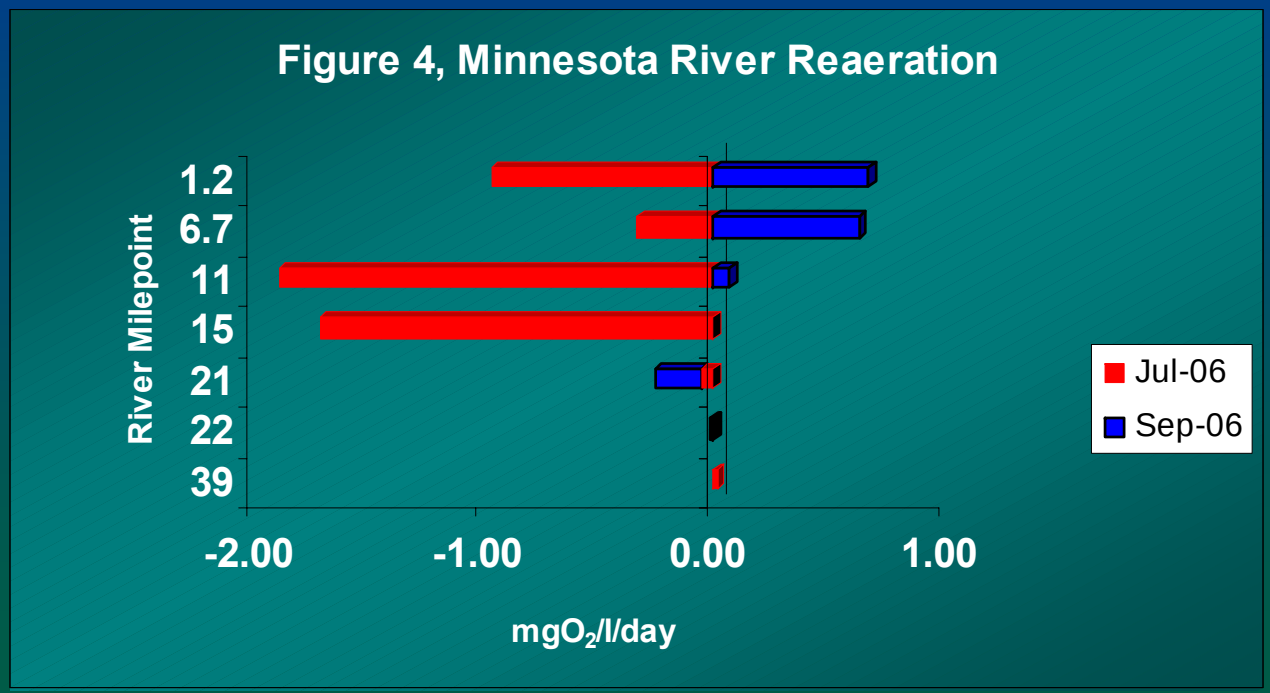
MCES Continuous Monitoring, July-September 2003



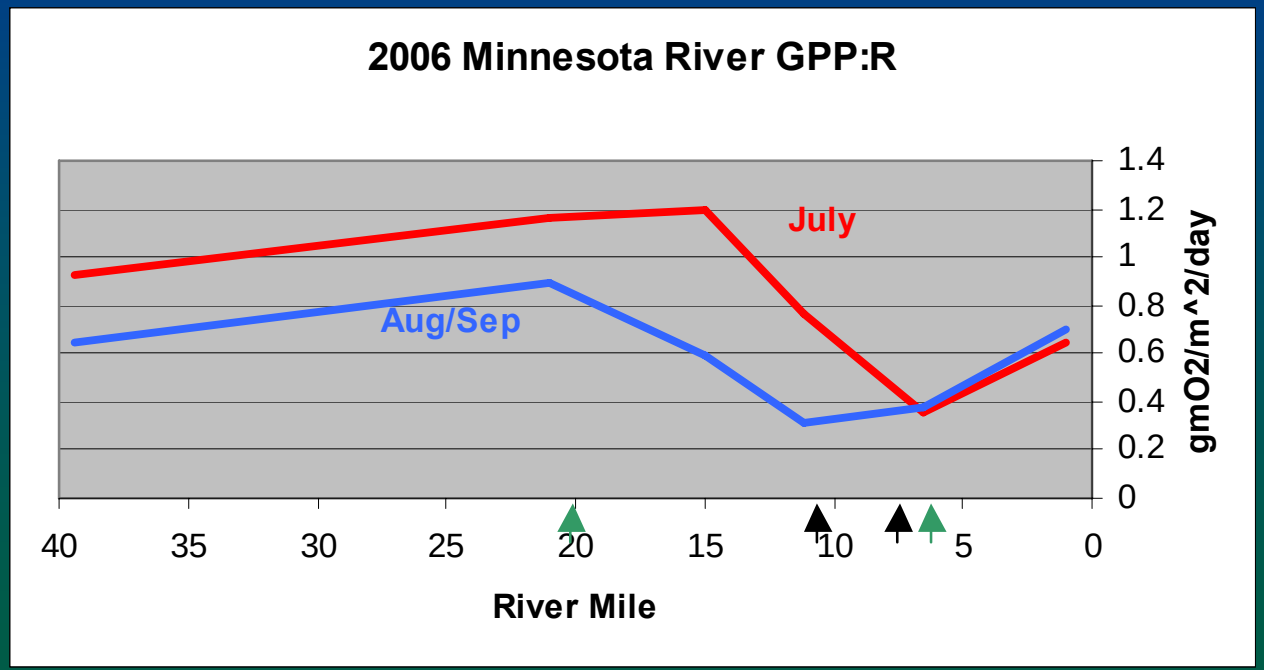
Oxygen Dynamics Assessment

$HydrO_2$, Inc. with MCES & MPCA

- Reaeration
- Atmospheric diffusion
- Community oxygen metabolism
- Water-column production and respiration
- Sediment oxygen demand
- Community substrate oxygen demand



Lower Minnesota River: Oxygen Dynamics Assessments, HydrO_2, Inc., 2007



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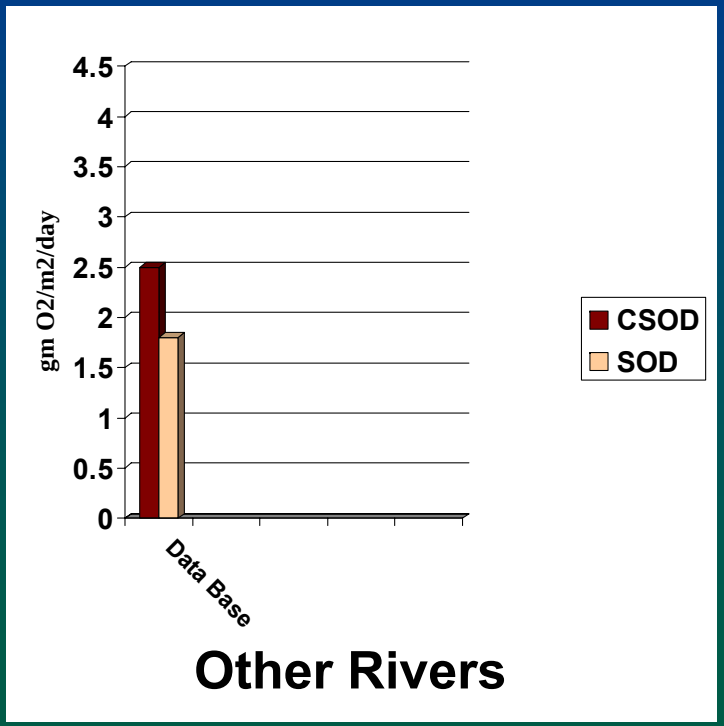
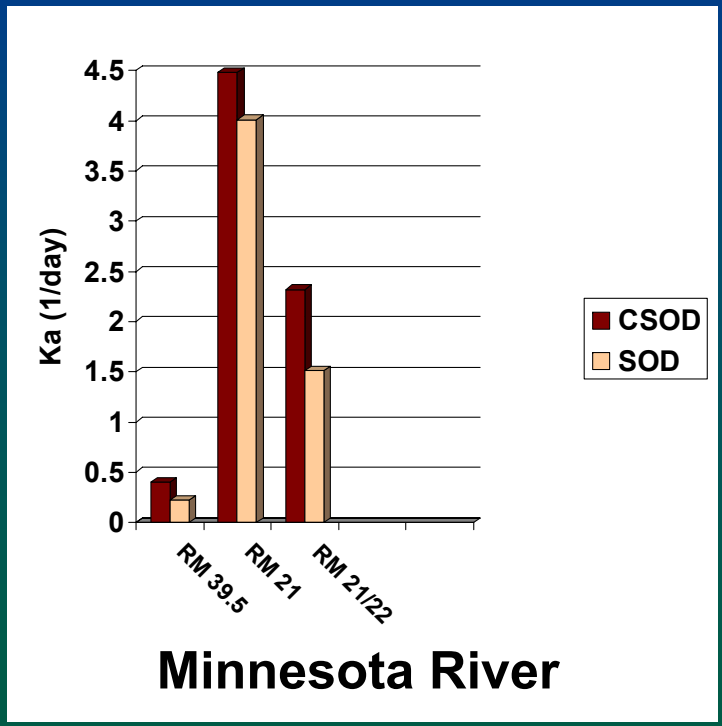




Lower Minnesota River: Oxygen Dynamics Assessments, HydrO_2, Inc., 2007

Challenges

- Equipment Deployment
- Navigation Effects
- Backwashing
- Black Dog Generating Plant
- High Quality Effluent
- CBOD Measurement
- TOC Measurement

Navigation Effects on Water Quality

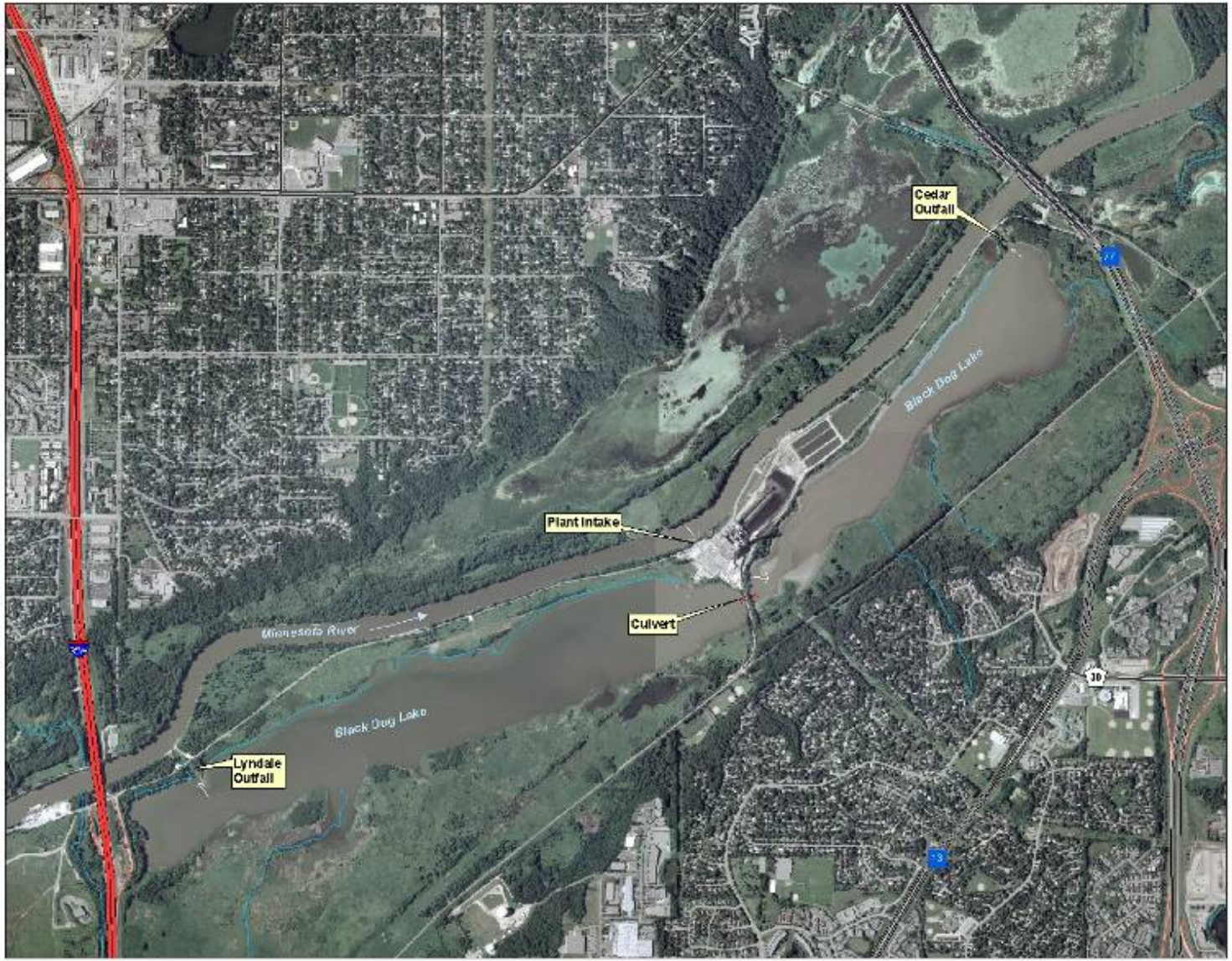
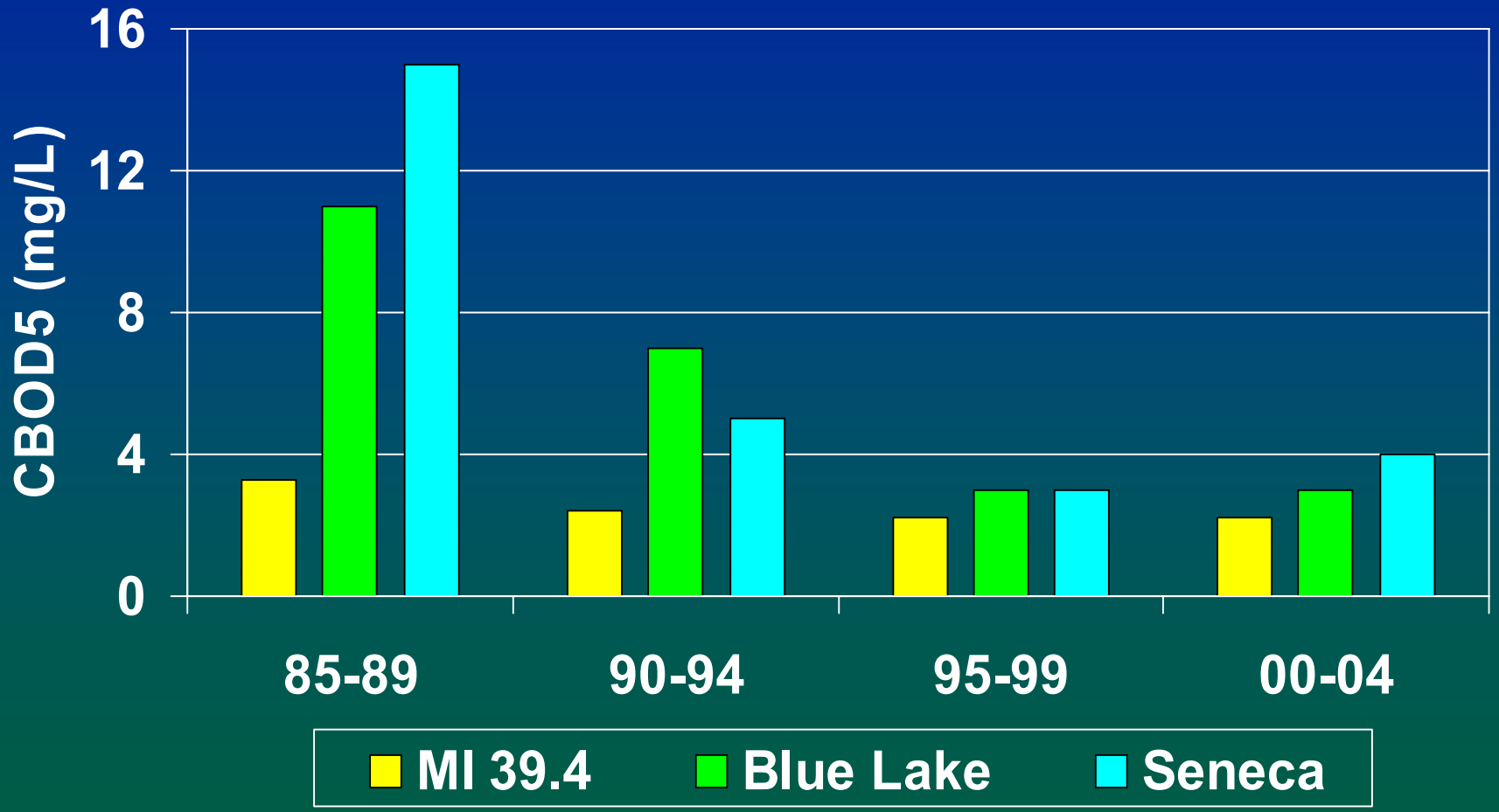


Figure 1

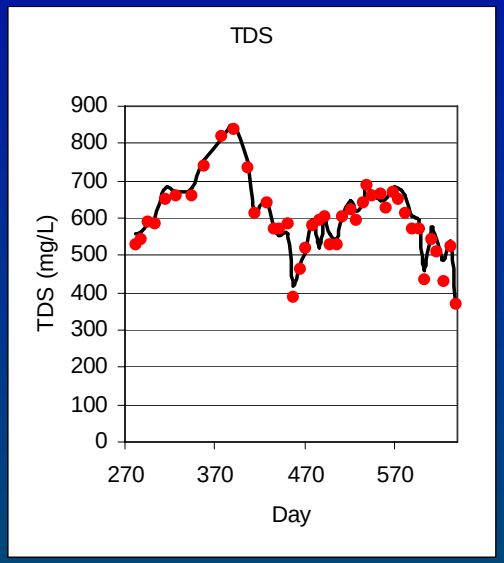
SITE LOCATION MAP
Black Dog Generating Plant

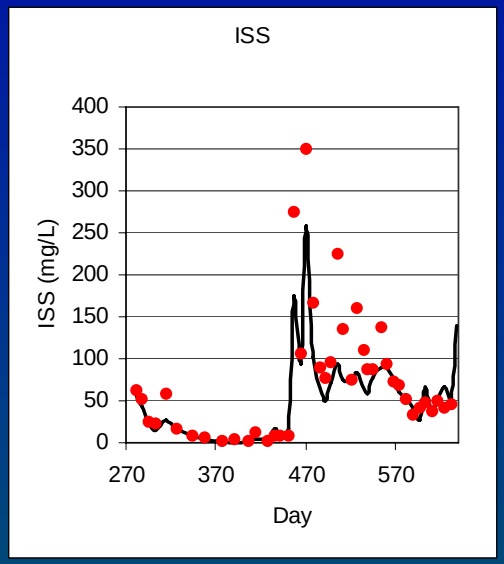
Mean Annual CBOD5 Concentration

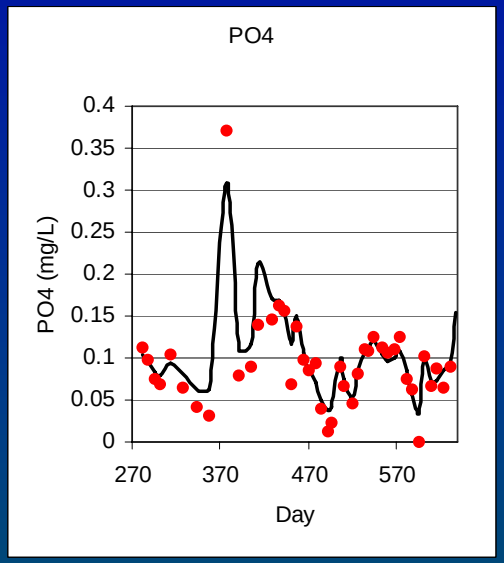
River and Effluent, 1985-2004

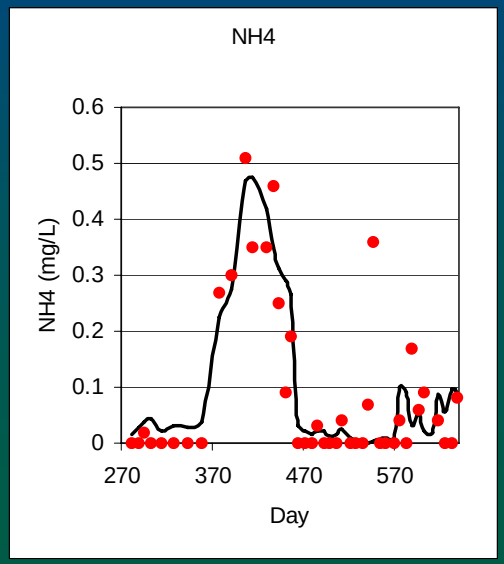


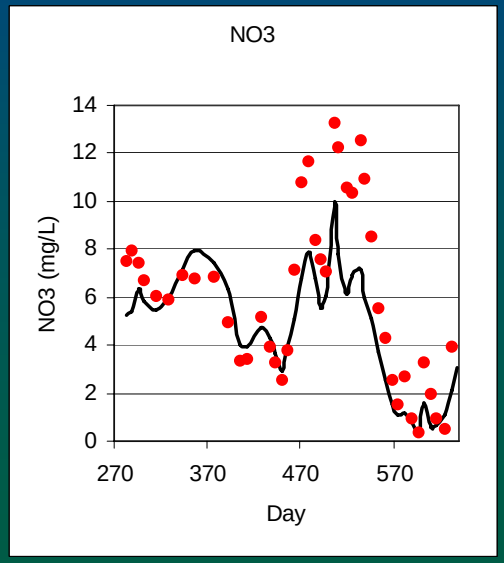
Preliminary Model Results

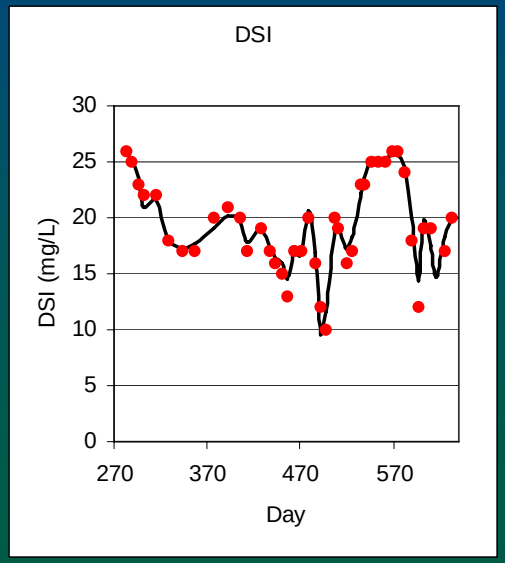












Paddle on down to our website:
www.metrocouncil.org/environment/Water/LMRM/