The Mississippi River: Water Quality Trends Over 30 Years

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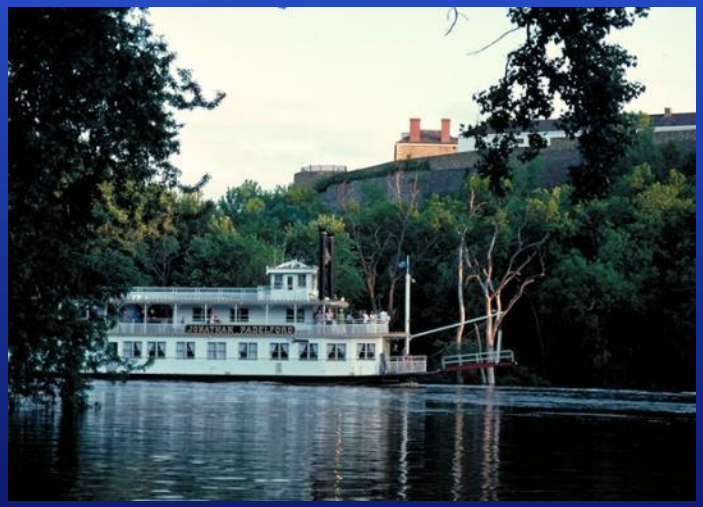
[1]**National Park Service**, [2] St. Croix Watershed Research Station, [3]Metropolitan Council Environmental Services



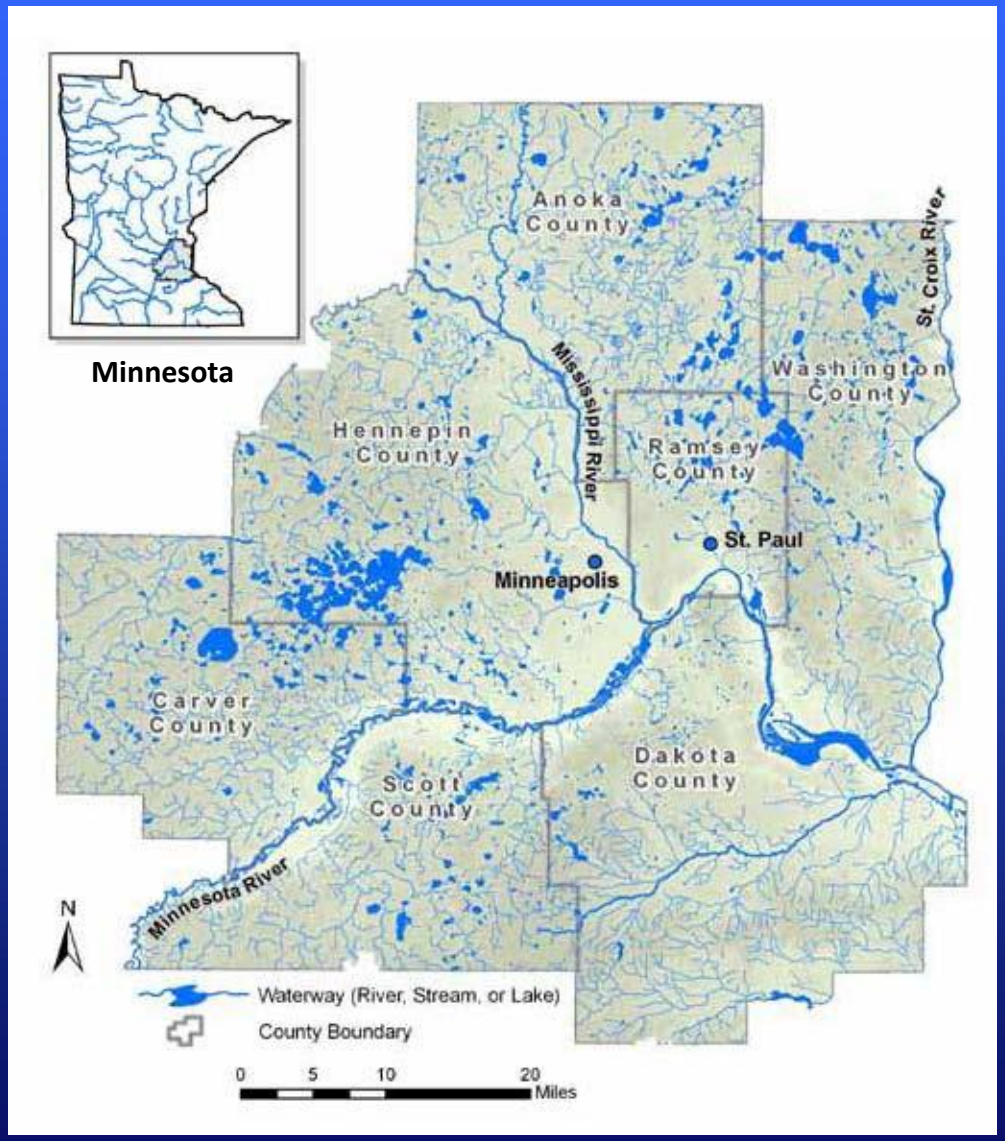
Metropolitan Council Environmental Services

St. Croix Watershed Research Station

GREAT LAKES INVENTORY AND MONITORING NETWORK

Photo credits: John Anfinson & David VanderMeulen

Area Overview



Map: Metropolitan Council Environmental Services (MCES)

Photo credits: top-MCES, bottom - MN Pollution Control Agency

- The Mississippi River is a major contributor to the ecology, culture, politics and economy of the North American continent.
- Established by Congress in 1988, the 72-mile riverine park passes through the heart of the Twin Cities Metropolitan Area

Photo credit: John Anfinson

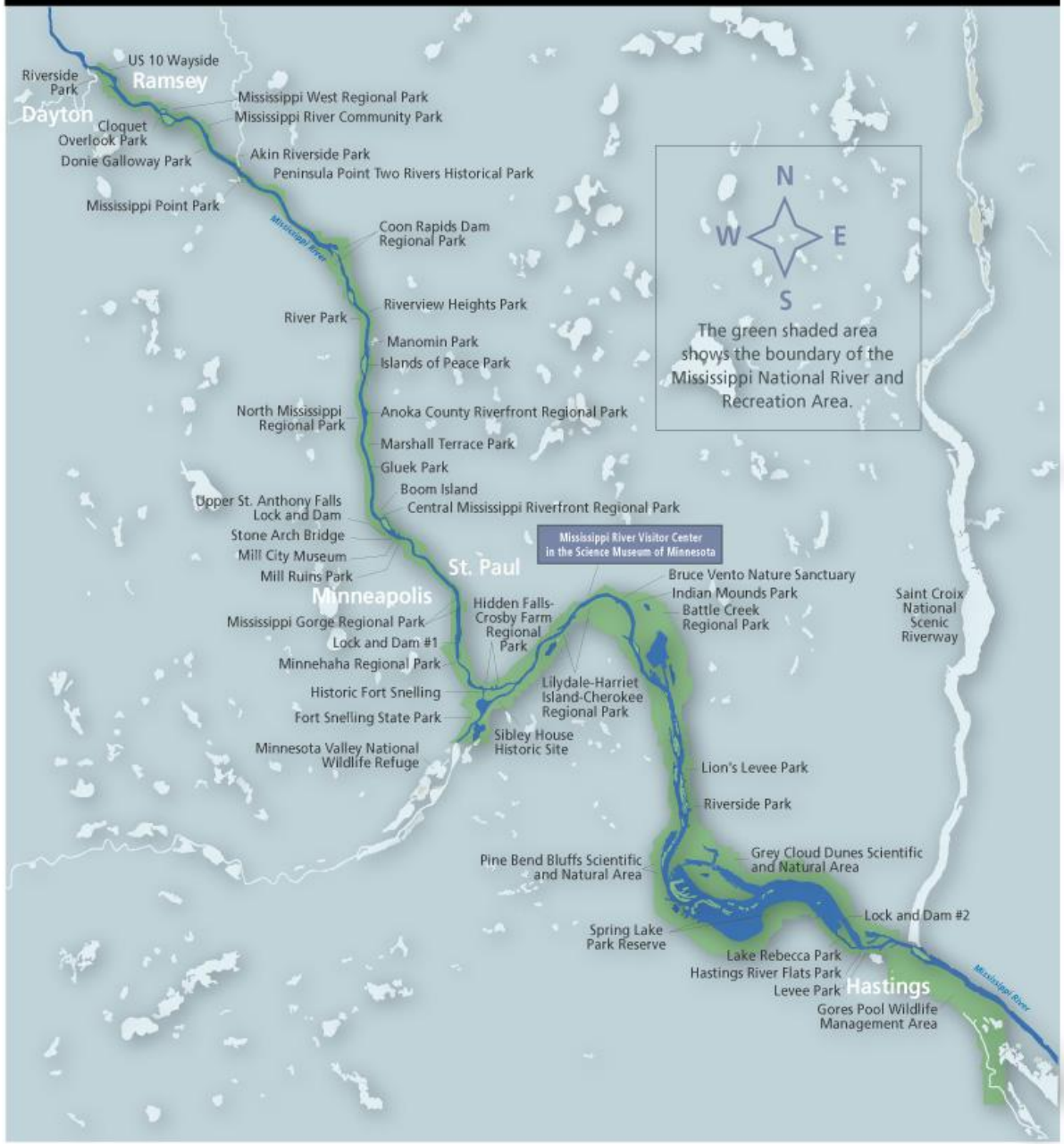
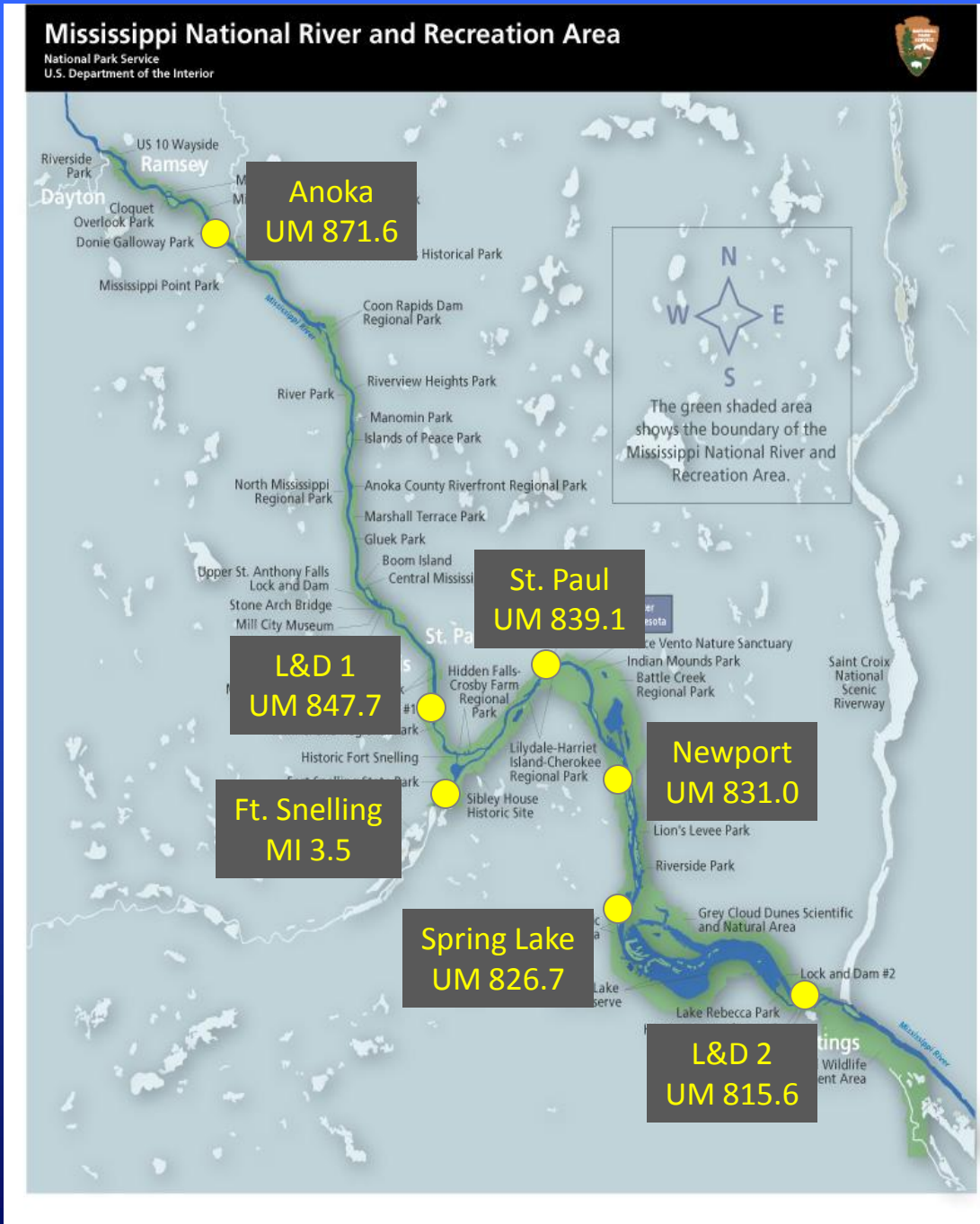


Photo credit: MCES

Sewage Mats on the Mississippi: June 1933

MCES – Water Quality Monitoring

- Measure compliance with state standards/criteria
- Meet NPDES permit requirements
- Assess WWTP operation
- Determine biological health of rivers
- Obtain information on sources and WQ impacts of nonpoint source pollutants
- ***Document long-term trends in WQ***
- Project future WQ conditions



Metropolitan Council Environmental Services

Study Rationale & Objective

- The park protects a prominent and highly developed stretch of the Mississippi River within the Twin Cities Metropolitan Area.
- Water quality affected by point/ nonpoint source pollutants, and is a high priority management concern for staff, partners, and stakeholders.
- Evaluate water quality trends in the park over three decades using long-term (1976-2005) monitoring data.

Photo credit: David VanderMeulen

Methods

- MCES dataset: weekly to monthly sampling (15 variables; 6 presented here), daily at Metro WWTP, 1976-2005
- MCES dataset: 6 Miss. R. sites, 1 site on Minn. R., Metro WWTP site
- MCES performed all laboratory analyses
- Performed flow corrections, where appropriate
- Evaluated geographical and seasonal patterns using long-term median conditions for each river site.
- Evaluated long-term trends using seasonal Kendall trend test and Sen's slope estimator

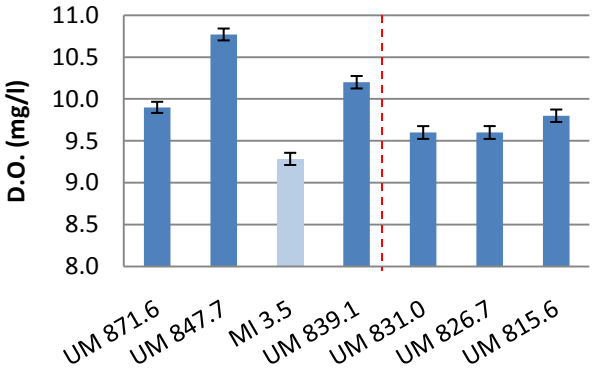
Photo credit: MCES

Geographical Patterns

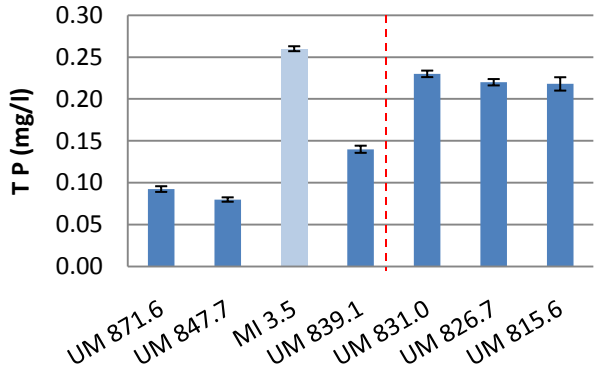
Median Concentrations, 1976-2005

Upstream ⟶ Downstream

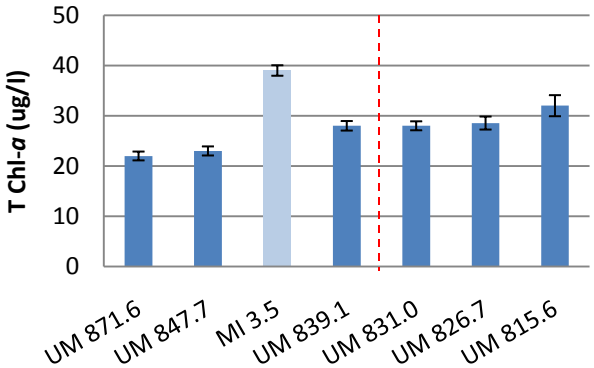
Dissolved Oxygen



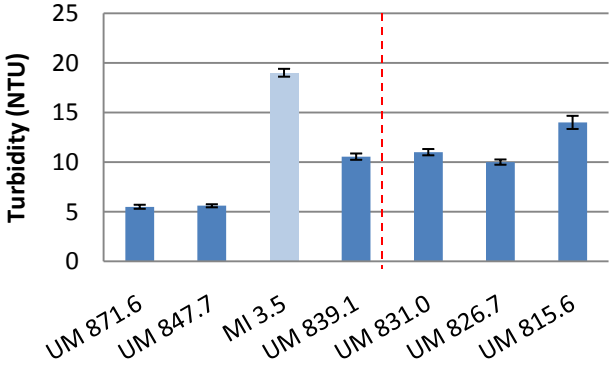
Total Phosphorus



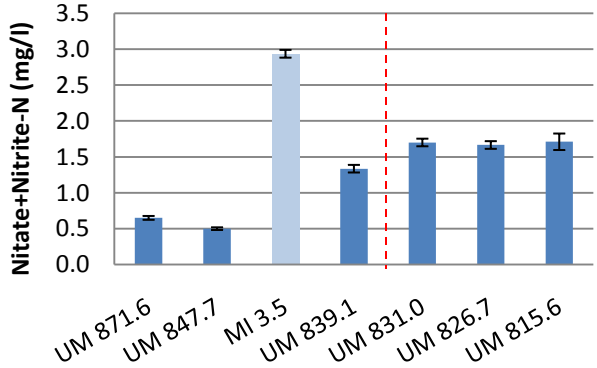
Chlorophyll-*a*



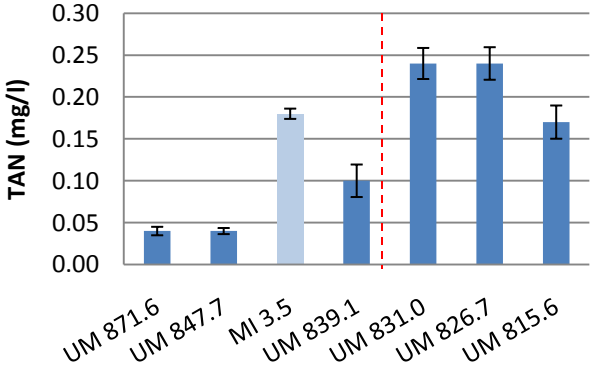
Turbidity



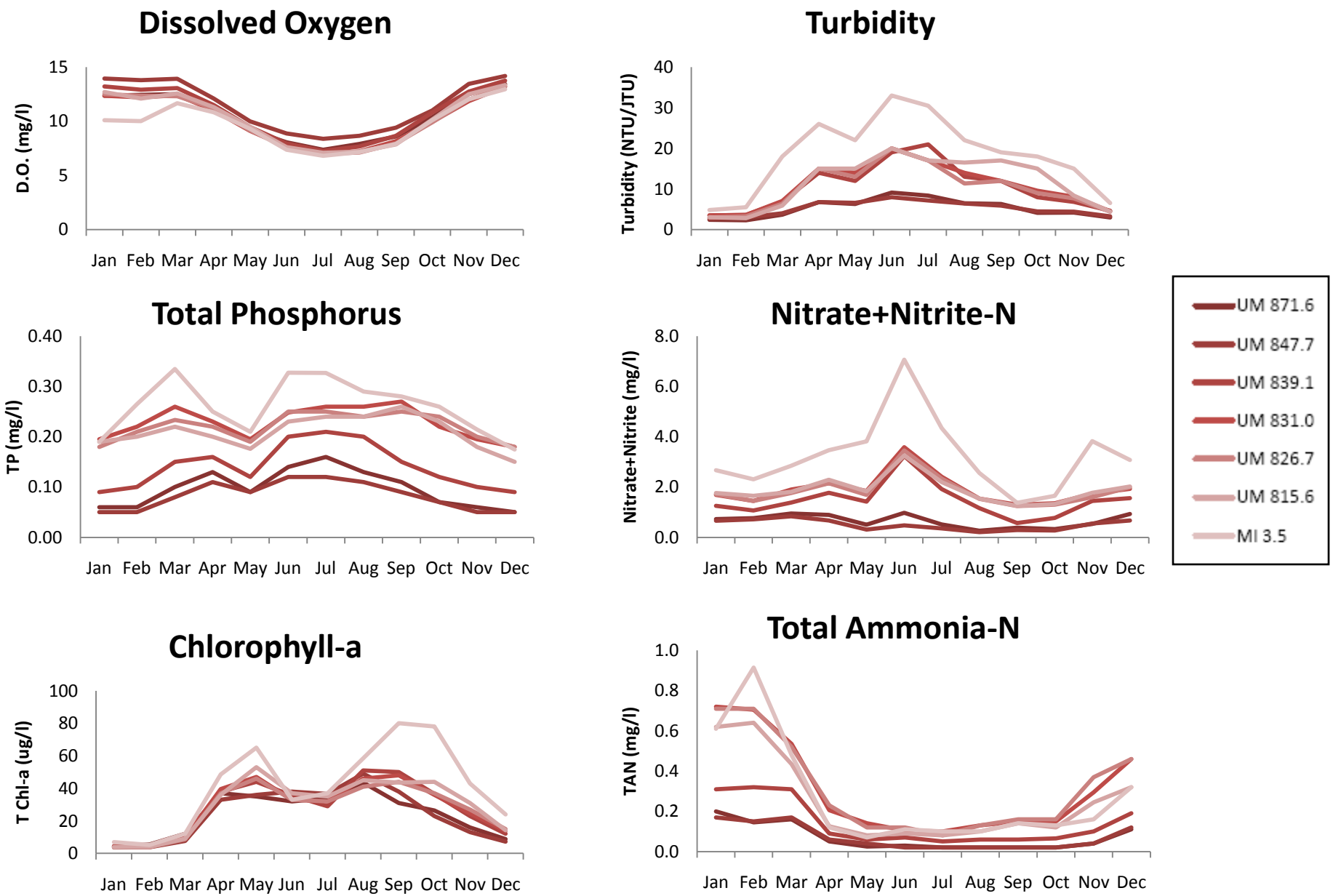
Nitrate+Nitrite-N



Total Ammonia-N

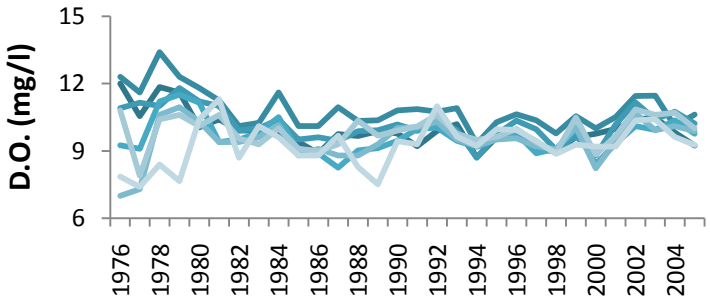


Seasonal Patterns – Monthly Median Concentrations, 1976-2005

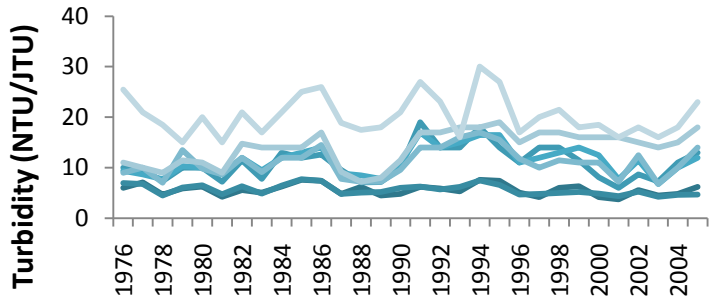


Trends Over Time – Annual Median Concentrations

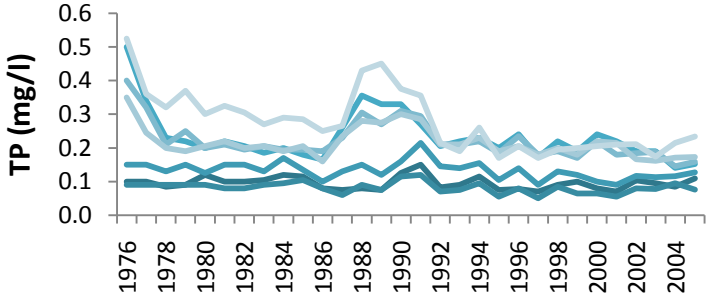
Dissolved Oxygen



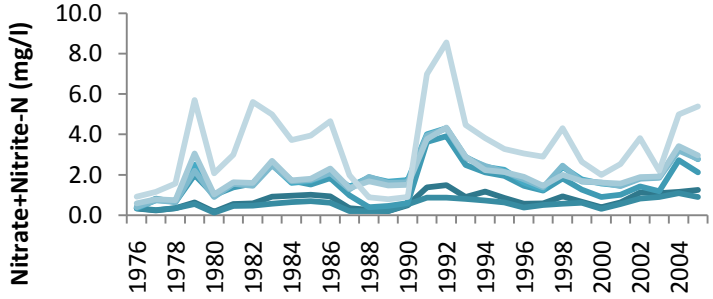
Turbidity

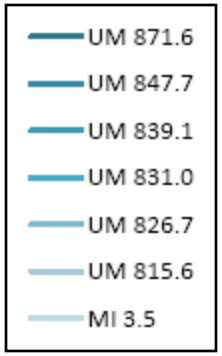


Total Phosphorus

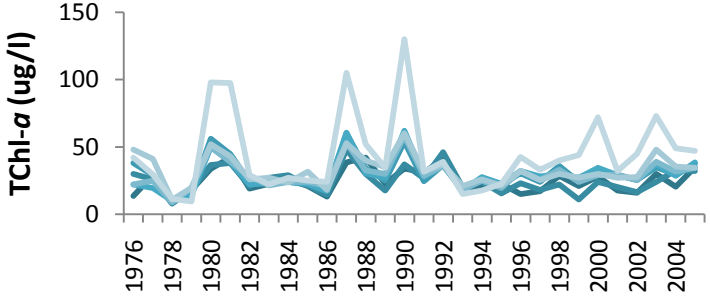


Nitrate+Nitrite-N

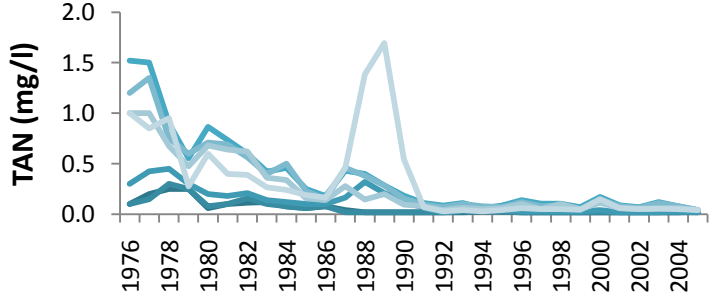




Chlorophyll-*a*



Total Ammonia-N

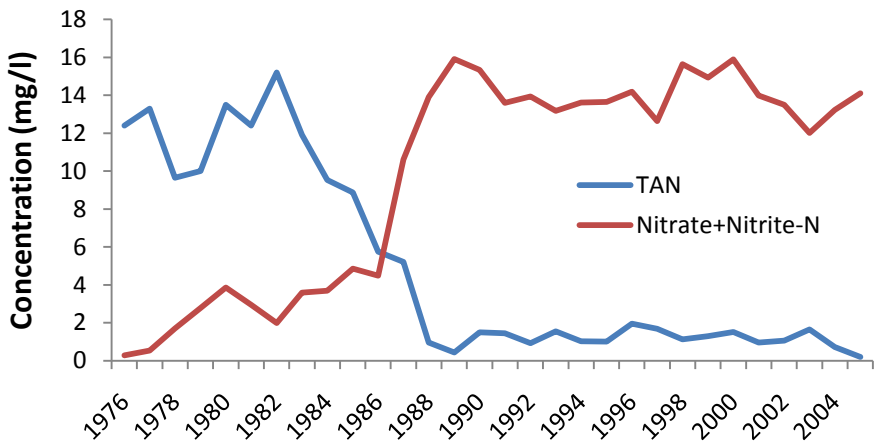


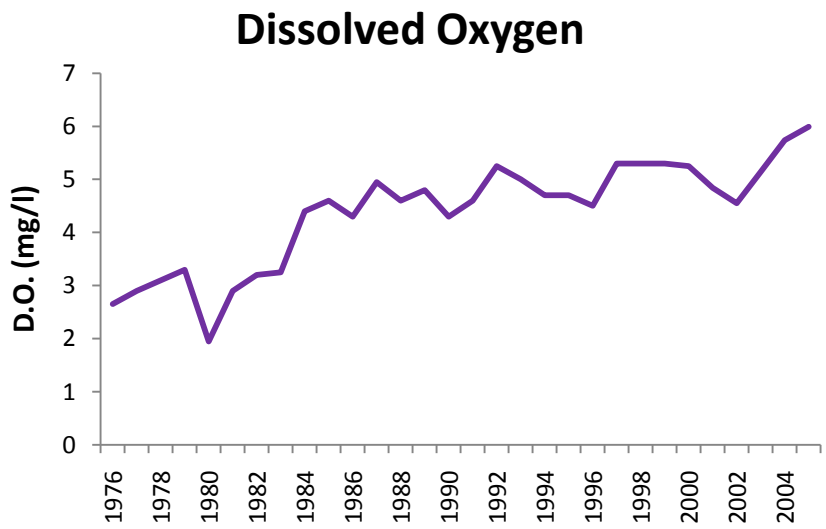
Trends Over Time, 1976-2005

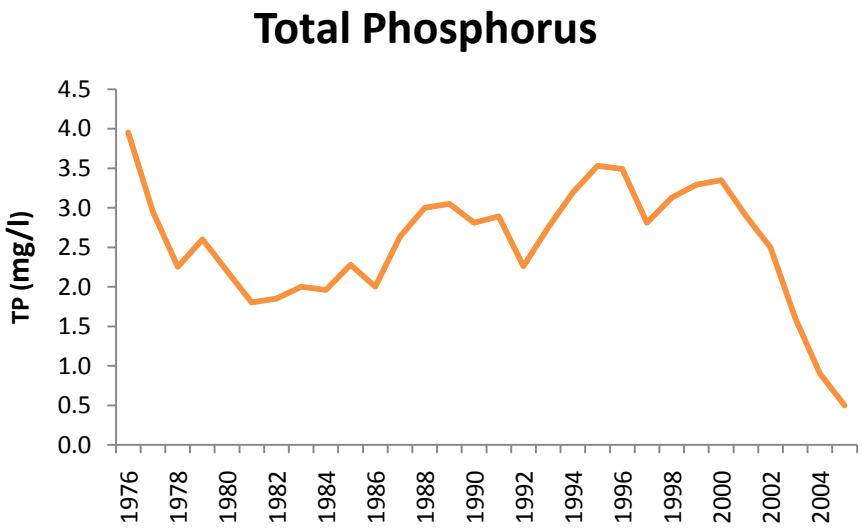
	UM 871.6 (Anoka)	UM 847.7 (L&D 1)	MI 3.5 (Ft. Snelling)	UM 839.1 (St.Paul)	Metro WWTP	UM 831.0 (Newport)	UM 826.7 (Spring L.)	UM 815.6 (L&D 2)
Flow	↑	↑	↑	↑	**n.s.**	↑	↑	↑
DO	**n.s.**	**n.s.**	↑	↑	↑	↑	↑	↑
Turb	↓	↓	↓	↓	↓	↓	↓	**n.s.**
TSS	↓	↓	↓	↓	↓	↓	↓	**n.s.**
TP	↓	↓	↓	↓	**n.s.**	↓	↓	↓
Chl-*a*	**n.s.**	**n.s.**	↑	↑	**no data**	↑	↑	**n.s.**
TN	**n.s.**	**n.s.**	**n.s.**	**n.s.**	↓	**n.s.**	**n.s.**	**n.s.**
NO_3-N	↑	↑	**n.s.**	**n.s.**	↑	↑	↑	↑
TAN	↓	↓	↓	↓	↓	↓	↓	↓

n.s. = no significant trend detected

Metro WWTP Changes – Annual Median Concentrations







% Change in **Concentration** vs. **Load** 1976-2005

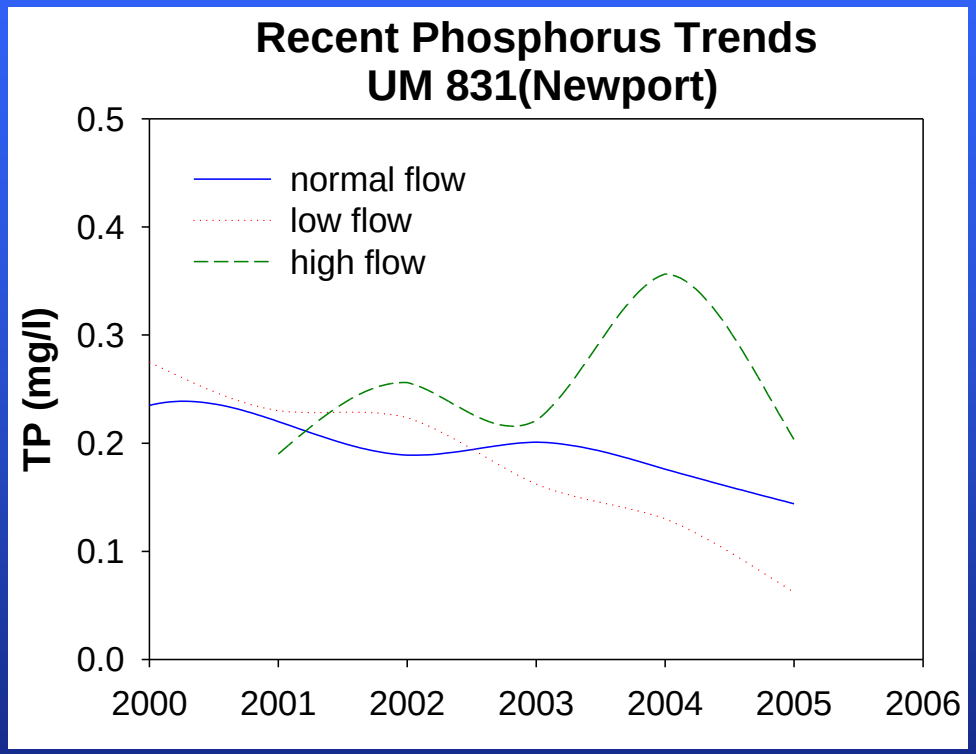
Load = Concentration x Flow (↑)

Variable		UM 871.6 (Anoka)	UM 847.7 (L&D 1)	MI 3.5 (Ft. Snelling)	UM 839.1 (St. Paul)	UM 831.0 (Newport)	UM 826.7 (Spring L.)	UM 815.6 (L&D 2)
TP	*Conc*	-15	-27	-71	-29	-30	-37	-28
	Load	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**
TSS	*Conc*	-20	-40	-62	-32	-20	-26	n.s.
	Load	**n.s.**	**-14**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**
TAN	*Conc.*	-214	-234	-221	-230	-300	-284	-353
	Load	**-129**	**-133**	**-142**	**-182**	**-238**	**-251**	**-271**
NO_3-N	*Conc*	49	58	n.s.	n.s.	59	53	47
	Load	**62**	**68**	**27**	**37**	**53**	**55**	**51**

n.s. = no significant trend detected

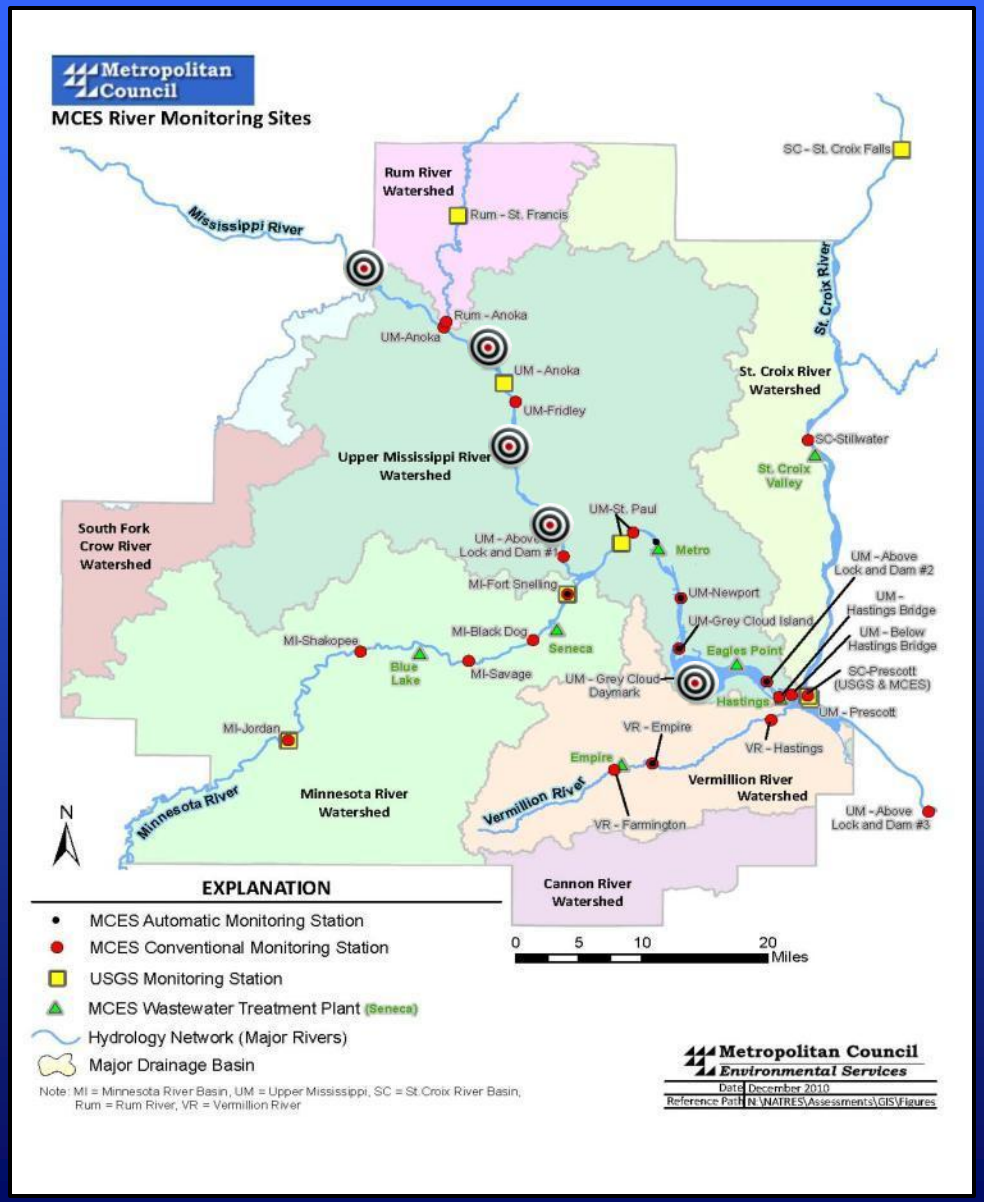
Future Work

- Explore new approaches to overcome methodological constraints (e.g., Hirsch et al. 2010. JAWRA).
- Focus on describing the *nature* of change (timing, magnitude, circumstances).
- Employ new graphical tools to extract and communicate additional information.



http://water.usgs.gov/nrp/proj.bib/Publications/2010/hirsch_moyer_etal_2010.pdf

NPS - Great Lakes I&M Monitoring Network



Draft Nutrient and Sediment Standards for MN Rivers

Site	TSS (mg/L)	TP (ug/L)	Chl a (ug/L)
UM 880	31[1]	100[3]	20[3]
UM 868	31[1]	100[3]	20[3]
UM 862	31[1]	100[3]	20[3]
UM 852	31[1]	100[4]	35[4]
UM 822	32[2]	na[5]	35[4]

Minneapolis STAR and Tribune 1A Metro Thursday

Some shiver, others rejoice at mayfly blizzard

Photo credit: MCES

Photo credit: MCES

Photo credit: NPS Great Lakes I&M Network

Photo credit: www.greatriverpark.org

Conclusions

- Monitoring record for this stretch of river is very rich; unique opportunity to understand effects of past and future management actions on water quality.
  - Inputs from the Minnesota River, the Metro Plant, and other sources result in an upstream-to-downstream increase in nutrients and chlorophyll (and turbidity).
  - Improvements in D.O., TP, and TAN appear strongly linked to improved wastewater treatment practices.
- NPS water quality monitoring data will be compared with MN water quality standards and improvement plans.
- Increasing nitrate concentrations and Gulf Hypoxia point to the rising need to reduce nitrogen discharges.

Photo credit: David VanderMeulen – Mississippi River at New Orleans, LA, March 2011

Acknowledgements

- Sue Magdalene and Dan Engstrom, Science Museum of MN, St. Croix Watershed Research Station
- Kent Johnson and monitoring staff of Metropolitan Council Environmental Services
- Mississippi National River and Recreation Area
- NPS Great Lakes Inventory & Monitoring Network

Photo credit: www.greatriverpark.org

MISS Trends, 1976-2005

Variable	UM 871.6	UM 847.7	MI 3.5	UM 839.1	UM 831.0	UM 826.7	UM 815.6	MetroPlant
Flow	↑	↑	↑	↑	↑	↑	↑	**n.s.**
Temp	↑	↑	↓	↑	↑	**n.s.**	**n.s.**	↑
pH	n.s.	n.s.	n.s.	n.s.	↑	↑	n.s.	↓
Cond	↑	↑	n.s.	n.s.	↑	↑	↑	no data
DO	**n.s.**	**n.s.**	↑	↑	↑	↑	↑	↑
TKN	↓	↓	↓	↓	↓	↓	↓	↓
NO_3-N	↑	↑	n.s.	n.s.	↑	↑	↑	↑
NO_2-N	↑	↑	↓	↑	↑	n.s.	n.s.	n.s.
NH_3-N	↓	↓	↓	↓	↓	↓	↓	↓
TP	↓	↓	↓	↓	↓	↓	↓	**n.s.**
OP	↓	↓	↓	↓	↓	↓	↓	no data
Chl-*a*	**n.s.**	**n.s.**	↑	↑	↑	↑	**n.s.**	**no data**
TSS	↓	↓	↓	↓	↓	↓	**n.s.**	↓
VSS	↓	↓	↓	↓	↓	↓	n.s.	no data
Turb	↓	↓	↓	↓	↓	↓	**n.s.**	↓
TN	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	↓
NO_x-N	↑	↑	**n.s.**	**n.s.**	↑	↑	↑	↑

n.s. = no significant trend detected

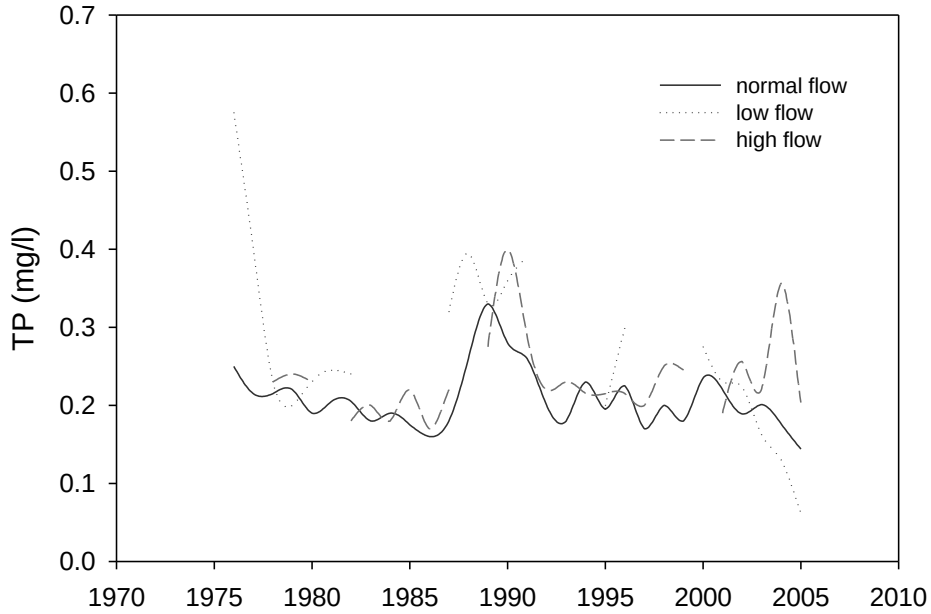
Source: MCES, SCWRS, NPS

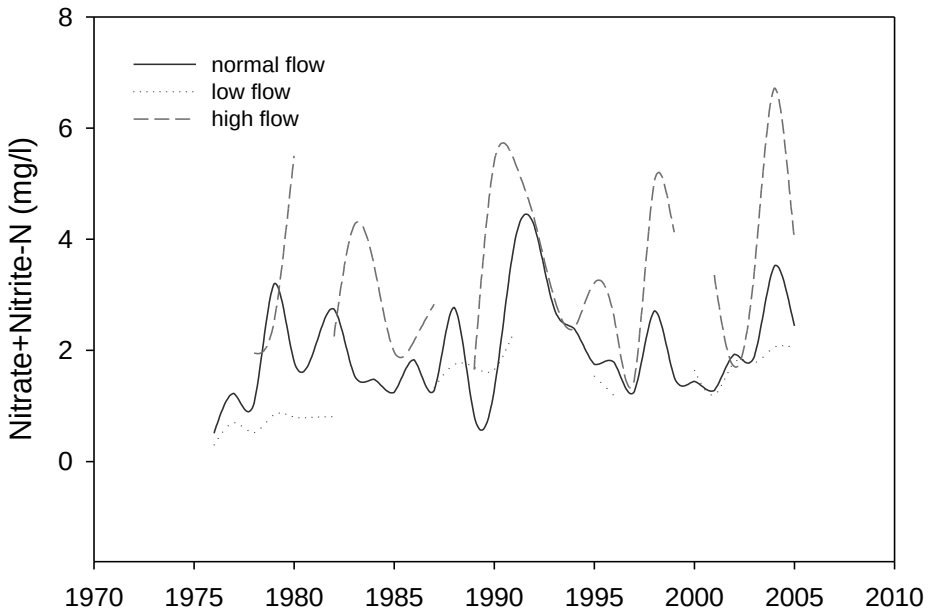
Mississippi National River and Recreation Area water quality: assessing past and monitoring future changes

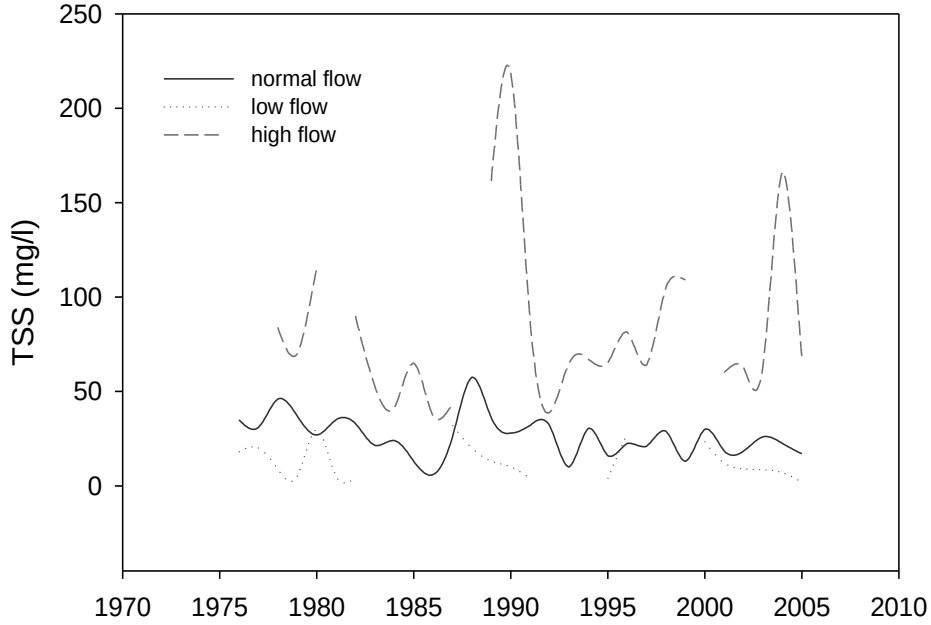
B. Moraska Lafrancois[1], S. Magdalene[2], D. K. Johnson[3], and D. VanderMeulen[1]

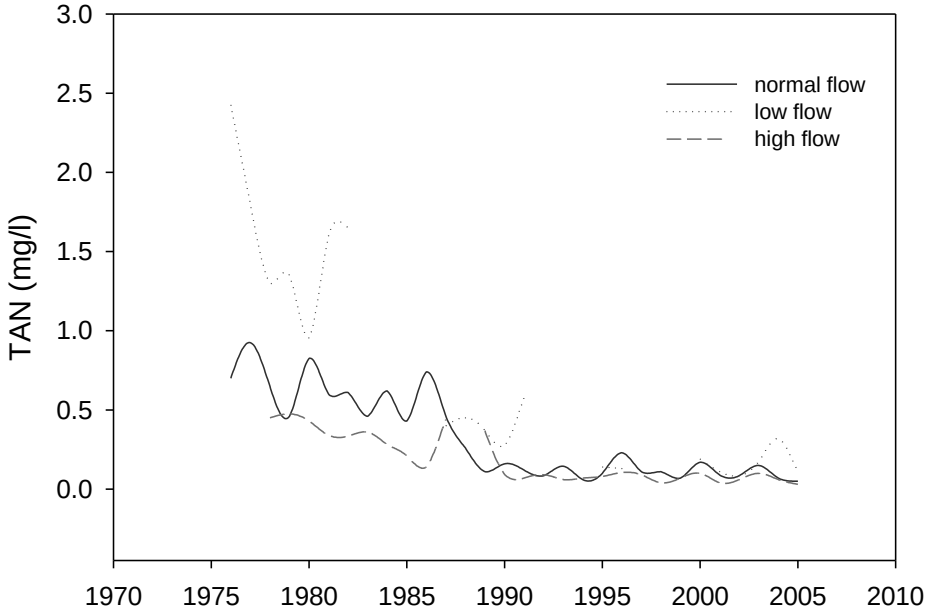
[1]National Park Service, [2] St. Croix Watershed Research Station, [3]Metropolitan Council Environmental Services

Mississippi National River and Recreation Area (MISS) protects a highly developed 72-mile stretch of the Mississippi River within the Twin Cities Metropolitan Area. Long-term (1976-2005) water quality data collected by the Metropolitan Council at six sites within MISS were used to evaluate spatial, seasonal, and long-term concentration and loading trends. Over the period of record, spatial trends were driven largely by nonpoint source inputs from the Minnesota River and, to a lesser extent, by point source inputs from wastewater treatment facilities. Seasonal trends were generally related to hydrologic patterns. Changes in dissolved oxygen, phosphorus, and ammonia appeared strongly linked to improved wastewater treatment practices that reduced oxygen demand and phosphorus and ammonia concentrations. Recent monitoring begun by the National Park Service will help to fill in spatial gaps, contribute to this valuable long-term dataset, and evaluate changes in variables of management interest locally (e.g., phosphorus) and nationally (e.g., nitrate).


TP (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1970
1975
1980
1985
1990
1995
2000
2005
2010
normal flow
low flow
high flow


Nitrate+Nitrite-N (mg/l)
0
2
4
6
8
1970
1975
1980
1985
1990
1995
2000
2005
2010
normal flow
low flow
high flow


TSS (mg/l)
0
50
100
150
200
250
1970
1975
1980
1985
1990
1995
2000
2005
2010
normal flow
low flow
high flow


TAN (mg/l)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
normal flow
low flow
high flow