

The Metropolitan Council led a cooperative effort to develop a water-quality model of the lower 40 miles of the Minnesota River, which is located in the southwest metro area. Six federal, state, and local agencies sponsored the project, and many groups provided technical assistance. The goal was to build a planning tool for wastewater facilities and watersheds. The partners chose a well accepted and widely applied model, CE-QUAL-W2, and conducted a three-year monitoring program to support it.

The Lower Minnesota River lies at the juncture of two contrasting landscapes: a predominantly agricultural watershed to the west and an expanding metropolitan area to the east. It is a valuable natural resource and home to one of only four national wildlife refuges in an urban area. Approaching its confluence with the Mississippi River in the heart of the Twin Cities, the Minnesota River becomes a working river accommodating a dredged navigation channel for barge traffic, two major wastewater treatment facilities, an electrical power generating plant, and stormwater from municipalities and an international airport.



The Lower Minnesota River is listed as impaired by low oxygen levels and high turbidity by the Minnesota Pollution Control Agency (MPCA). These problems have been linked to excess levels of algae, nutrients,

and sediment. The pollutants come from point (specific) sources, like industrial and wastewater pipes, and nonpoint (diffuse) sources, like runoff from farms, lawns, feedlots, and parking lots.



The model will be used to set appropriate pollutant limits for discharges from point sources and establish goals for reducing pollutant loads from watersheds. The Council plans to use the model for wastewater facility planning for future growth in the southwest. The MPCA plans to use the model to reevaluate allowable pollutant loads to the Lower Minnesota River from point and nonpoint sources.

## Monitoring water quality

For many years, the Council has conducted river, stream, lake, and effluent monitoring in the metro area, including five stations on the Minnesota River near Jordan, Shakopee, Savage, Black Dog, and Fort Snelling. The Council and local groups monitor water quality in a number of tributaries, and the Council monitors effluent quality at the Blue Lake and Seneca wastewater treatment facilities, which discharge to the Minnesota River.

For three years, 2004-2006, the water-quality monitoring programs were enhanced to fulfill model data requirements. More intensive monitoring was conducted at low river flows during the summer to capture

water quality under critical conditions for oxygen. Special studies were designed to answer specific questions, such as whether groundwater inputs were significant, and to support key model inputs, such as the rates of oxygen production and respiration by algae. The study attempted to measure all major sources and sinks of oxygen and nutrients using a variety of methods from sending a scuba diver to the river bed to capture sediment rates to floating a dome on the surface to capture atmospheric rates.

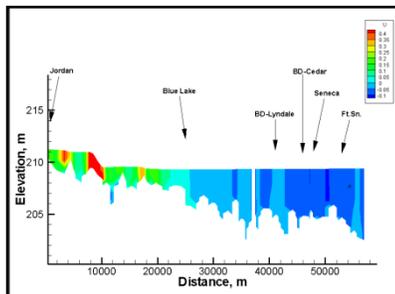


## Modeling water quality

The CE-QUAL-W2 model is a computer program containing a set of equations that attempts to describe all relevant processes impacting water quality in a river. For example, to understand how algae affect oxygen levels, the model must describe the relationships of algae to nutrients, light, temperature, flow, and grazers as well as the relationships of living and dead algae to oxygen production and demand.

A computer model cannot perfectly mimic a river, but modelers can test how close it comes. The Lower Minnesota River Model was tested against seven years of data representing a wide range of conditions. Low oxygen and high algal levels

are most often a problem at low flows in summer, while sediment and nutrient loads are associated with high flows. The model was tested against the special data collected during 2004-2006 plus data from 1988 (drought year), 2001 (flood year), and 2002-2003 (normal years). Graphs were plotted and statistical tests were applied to evaluate how well model results matched actual measurements.



## Select findings

Hydrodynamics—the physics of water movement—play a prominent role in water quality. For a majority of the year, river flow is the main driver of water quality. Greater depths and slower velocities in the navigation channel increasingly affect water quality at lower flows in summer.

Despite efforts to reduce sediment loads to the river, concentrations of suspended solids remain high. Particles suspended in the river reduce light and water clarity, which in turn negatively impact algae and other aquatic life.

Nutrient levels are high as well. Nitrate is the most abundant form of nitrogen, and orthophosphate represents a third of the phosphorus. Both forms are dissolved and readily available to fuel algae. Roughly one-half of the phosphorus in particles can be easily recycled to orthophosphate under certain conditions, which may impact downstream sites on the Mississippi River. Phosphorus dynamics were

complex with physical factors dominating at higher flows, and biological factors (algae) playing an increasing role at lower flows.



During 2004-2006, the headwaters upstream of Jordan contributed over 88% of the sediment and nutrient loads to the Lower Minnesota River. At lower flows, the portion of nutrient loads contributed by the Blue Lake and Seneca facilities increased. The lower 40 miles were a deposition zone (sink) for sediment and phosphorus but a source of ammonium nitrogen.

High levels of nutrients in the Minnesota River support high levels of algae. Under summer low-flow conditions, algae appear to die off in the lower reaches as greater depths and slower currents move algae out of the narrow light zone in this turbid river. As a result, less oxygen is produced and algal decomposition leads to nutrient recycling and oxygen demand.

Algal production and respiration are strong components of oxygen dynamics in the river, especially during summer low-flow conditions when respiration tends to outpace production. Decomposition of non-living organic matter (e.g., dead algae, leaves, grass, crop residue, and wastewater) in the water and sediment bed is also a factor.

Effluent quality at the Blue Lake and Seneca facilities has improved greatly since the 1980s. While current loads have little effect on oxygen levels in the river, they con-

tinue to enrich the river with nutrients. Discharges from the power plant and airport may also impact river water quality but additional study of these sources is needed.

As demonstrated in test results, the Lower Minnesota River Model is an acceptable tool for studying oxygen, nutrients, algae, and turbidity under a variety of conditions. The model will also facilitate decision making by allowing planners to test different management scenarios.

## Project sponsors

Metropolitan Council, U.S. Army Corps of Engineers, Minnesota Pollution Control Agency, U.S. Geological Survey, Lower Minnesota River Watershed District, Metropolitan Airports Commission

## For more information

On the Council's website, you can find more information:

- Lower Minnesota River Study [Project documents](#)
- Water-quality monitoring [River, tributaries, effluent](#)
- Water-quality management [Planning and practices](#)
- Wastewater treatment [Blue Lake and Seneca](#)

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