Minnesota Pollution Control Agency

Regional Environmental Management

Impaired Waters Project

Computer model a useful tool in water quality research

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Advances in computer technology in recent years have greatly improved our ability to study the environment. In the vast Minnesota River Basin, it would be very difficult and expensive to conduct research in real terms across thousands of square miles of land and water. It would be impossible to accurately predict the impact on water quality of major changes in future land use or pollution sources. However, computer models can help. They enable scientists to closely estimate the effect on water quality of various impacts from urban waste water, storm water, and farm field runoff. This provides a useful tool in the development of Total Maximum Daily Load projects.

In the mid-1980s, using water quality monitoring, scientists identified a dissolved oxygen problem in the Lower Minnesota River Watershed. Phosphorus, a nutrient, contributes to Biochemical Oxygen Demand (BOD), which at high levels causes dissolved oxygen depletion. In 1985 scientists using a different model estimated that a Biochemical Oxygen Demand reduction of 40 percent was needed at Jordan for the Minnesota River to meet water quality standards. However, the scientists' estimate did not quantify the amount of phosphorus or direct BOD reduction needed in other parts of the Minnesota River to achieve the 40 percent BOD reduction at Jordan.

In 2001, the Minnesota Pollution Control Agency hired Tetra Tech EM, Inc., a private consulting firm, to develop a computer model for conducting research in the Minnesota River Basin. For more than a year they collected basin-wide data and verified base modeling assumptions. They then calibrated and validated the models for use by MPCA scientists.

Modeling project goals

The goals of this modeling project are:

- determine how much of the 40 percent reduction has been achieved since 1990;
- determine options for load allocations by watershed to further reduce the oxygen demand to the Lower Minnesota River Watershed;
- identify the most efficient and practical methods of attaining the reductions; and
- quantify pollutant contributions by tributary, land use, and pollutant source.

Results from the modeling study indicate that, with phosphorus reductions, it is possible to meet the dissolved oxygen standard in the Lower Minnesota River during low flow conditions. The results also will help individual watersheds in the Minnesota River Basin set phosphorus reduction goals.

What is a model?

A model is simply a mathematical representation of physical systems or processes. This particular model simulates both non-point source and point source pollutant loads from urban and rural areas. It enables scientists to develop different scenarios by inserting different values among many variables. They include weather, land use, observed flow, water quality, and point source data.

A scenario is simply a "what if" question that can be used to assess the relative benefits of alternative management activities. Although the model takes various land uses into account, it works at the large scale or regional level, and not at the individual field

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or community levels. For example, "What would be the impact on phosphorus and sediment levels in the Minnesota River if the basin goal is reached of 100,000 acres enrolled in the Conservation Reserve Enhancement Program?" The model would then calculate the changes in phosphorus and sediment loadings resulting from acreage enrolled in CREP. In the future a list of other possible scenarios will be developed in consultation with stakeholders.

How credible is the model?

The particular model used here is the Hydrologic Simulation Program-Fortran (HSPF) of the U.S. Environmental Protection Agency. It is a comprehensive model that allows integrated simulation of point source contributions along with land and soil contaminant runoff processes with instream hydraulic, water temperature, sediment transport, nutrient and sediment-chemical reactions. The model is being used nationally, for example, in the Chesapeake Bay. There a modeling study determined nutrient loading to the bay, the sources of the nutrients, and where progress was being made in nutrient reductions.

The Minnesota River Basin Model is tested (calibration and validation) against observed flow and water quality data. It is calibrated from 1986 through 1992 for hydrology, and from 1989 through 1992 for water quality and sediments. It is validated using the hydrology and available water quality and sediment data from 1980 through 1985.

The calibrated and validated model also was reviewed by researchers from the University of Minnesota, Metropolitan Council, Natural Resources Conservation Service, U.S. Geological Survey, and Minnesota Department of Agriculture. Comments were received, meetings held, and model revised based on their suggestions.

Which watersheds were modeled?

The modeling area covers about 12,200 square miles or about 260 miles of the mainstem of the Minnesota River, from the Lac qui Parle dam in western Minnesota to Jordan southwest of the Metro area. It includes ten of the basin's 13 major watersheds: Blue Earth, Chippewa, Cottonwood, Hawk Creek, Le Sueur, Lower Minnesota, Middle Minnesota, Redwood, Yellow Medicine, and Watonwan. It does not include Lac qui Parle, Pomme de Terre, and Upper Minnesota watersheds or the lower 40 miles of the Minnesota River mainstem. While the headwater watersheds have important water quality issues, they do not make a significant contribution to the Lower Minnesota River's oxygen demand problem. Other models cover the lower reach of the Minnesota River.

What will happen as a result of this TMDL?

Once the load allocations are assigned to each watershed, it will be up to the watersheds to determine how to reach the targets. The MPCA will provide financial and technical assistance to point and non-point sources as needed. Financial assistance will increasingly be targeted at Total Maximum Daily Load projects.

The MPCA will continue to treat point and non-point sources as it has in the past. Regulated parties such as cities, industries, and feedlots will continue to be regulated. Although non-regulated efforts will be voluntary, the Clean Water Act requires that waters be improved to meet the standards. If the results of this effort are not enough to clean up the river, the allocation and implementation plan may be reexamined and more efficient/effective programs emphasized.

For more information

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