Lower Minnesota River Model (LMRM)
Technical Meeting #10, October 29, 2008
Notes by Cathy Larson, Metropolitan Council

- Sixteen people representing seven organizations attended the meeting. The groups represented were the Met Council, LMRWD, MPCA, U of M, USACE, USGS, and Xcel Energy. In the morning we received updates on the project as a whole and two pieces: nutrient research and model calibration. In the afternoon, we reviewed and discussed major findings of the six-year project. Below are notes that are posted with other documents at www.metrocouncil.org/environment/Water/LMRM. Copies of the presentations are available upon request.

Project Update (Cathy Larson, Met Council)

- Sponsors. The six-year project is funded by the Met Council, LMRWD, MAC, MPCA, USACE, and USGS. Dozens of staff from these agencies and more have contributed to the field, lab, and data work. Thank you to everyone for your contributions to river science.
- Schedule. The USACE-ERDC has nearly completed the model calibration. They will wrap up the calibration and draft a report by the end of the year. When the model is ready, the Met Council will test different loading scenarios to understand how the river might respond. Finally, the Met Council plans to complete an overall summary report for the project by next spring.
- Reports. We completed three reports on nutrient dynamics (ERDC), oxygen dynamics ($HydrO_2$), and summer field surveys (MPCA). We have two more to write in the coming months: modeling report (ERDC) and project summary (MCES). The reports are or will be posted on the LMRM website.
- Funding. The project was awarded an additional $65,000 in federal cost-share funding for fiscal year 2008 to be equally matched by the Met Council. Originally, we proposed a field study of the effects of barge traffic on water quality; however, the funds were needed to complete the modeling work. The ERDC prepared a scope for the remaining modeling tasks, and the Met Council and USACE are executing an amendment to their agreement.
- Next Meeting. The Council will host a final meeting in spring 2009. The proposed topics are scenario results, project conclusions, future monitoring and modeling recommendations, and TMDL applications.

Nutrient and Sediment Research: More Findings (Bill James, USACE-ERDC)

- Last fall Bill James completed a report on nutrient and sediment research, which is posted on the LMRM website. Since completing the report, Bill has further explored the data. The new results along with many of the earlier results were recently published in *Biogeochemistry* (90:75-92) in the article *Phosphorus dynamics and loading in the turbid Minnesota River (USA): controls and recycling potential.* The ERDC generously provided fifty reprints. Contact Cathy Larson to request one. The information presented by Bill at the meeting is covered in these two documents, so I will provide only a few notes here, taken mainly from the conclusions to his talk.
- Allochthonous suspended solids buffer SRP during higher flows. [In this system, allochthonous generally refers to materials originating in the greater watershed upstream of Jordan. SRP is soluble reactive phosphorus (also known as orthophosphate P or dissolved inorganic P)—the form of phosphorus readily used by algae.]
- Algae can assimilate the phosphorus loosely bound to suspended solids usually on the falling limb of the hydrograph (that is, when flows decline after a peak). Flow is a major factor controlling algal growth in the Minnesota River: high flows wash out algae while low flows allow growth.
- Allochthonous particulate P (PP) is composed of ~ 50:50 biologically labile and refractory forms. Approximately 70% of the open sites on suspended particles are filled by P. [Under the right condi-

tions, labile forms can be easily transformed or recycled into biologically available SRP. Refractory forms usually remain bound to particles and unavailable for algal uptake.]

- Most of the allochthonous PP from the Minnesota River is transported downstream to the Mississippi River where it can be deposited and recycled.
- Rates of P release from river-bed sediments are relatively high in the lower Minnesota River but do not appear to represent a major contribution to the annual P budgets. Release rates are most strongly related to concentrations of iron-bound P in the sediment. Release rates per unit iron-bound P are generally higher in Spring Lake and Lake Pepin due to particle sorting (that is, more fine particles settle in the lakes).
- As flows decline, P dynamics become regulated by algae and point source. For example, during the low-flow summer period of 2006, algae assimilated soluble P inputs in the upper reaches. The algal community was probably not P-limited in the lower reaches and began senescing. Point-source inputs were not assimilated, resulting in a buildup of SRP near the confluence with the Mississippi River.
- On an annual basis, inputs from the Minnesota River upstream of Jordan dominated the P budget.
- Soluble P = 30-42%, labile PP =29-36%, refractory PP = 28-36% of the annual total P load.

Particulate Phosphorus and Chlorophyll (Dr. Robert Megard, University of Minnesota)

- While working on transparency, Dr. Megard was impressed by the Council's long-term water-quality database. He decided to tap the database and explore phosphorus and chlorophyll relationships in the Minnesota River, Jordan to Fort Snelling, 1978-2007, and Mississippi River, Anoka-Lake Pepin, 1996-2006. He applied log-log plots in his analysis.
- In the Minnesota River, phytoplankton chlorophyll is independent of total and dissolved phosphorus but appears related to particulate P (PP) and particulate Kjeldahl nitrogen (PKN). Of course, particulate P and N include the P and N in phytoplankton among other forms. The group discussed possible methods for discerning the P in phytoplankton from P in other suspended particles.
- In the Mississippi River and Lake Pepin, chlorophyll is also independent of total and dissolved P but appears related to particulate P. Relationships among chlorophyll, PP, and PKN in the Mississippi River are similar to those in the Minnesota River.
- In the Mississippi River (and possibly the Minnesota River), transparency is independent of chlorophyll, PP, and PKN. However, in the three major rivers upstream of Lake Pepin and in Lake Pepin itself, turbidity and transparency depend strongly on suspended solids, especially volatile suspended solids (that is, organic matter). Even though they represent a portion of volatile suspended solids, phytoplankton appears to be a small contributor to turbidity.
- In the Minnesota River, turbidity and PP change linearly with non-volatile suspended solids (that is, inorganic solids), but chlorophyll does not. At NVSS > 25 mg/L, chlorophyll concentrations appear to decrease in a roughly linear manner.
- These are preliminary results. Dr. Megard will continue to explore these relationships.

CE-QUAL-W2 Modeling Update (Dave Smith, USACE-ERDC)

- Since our meeting in July, the Council and ERDC have finished building models for the four earlier years: 1988 and 2001-2003. The models were run using the same coefficients as in the 2004-2006 models. Models of the years 2001-2003 performed well out of the gate, but the model of the drought year 1988 needs more work (e.g., overestimates DO and underestimates ammonium-N in summer).
- As at previous meetings, Dave reviewed the model data requirements, input-file construction, computational mesh (grid segmentation), and time step. The grid has been further refined. Total run time is now 200-400 minutes per year. Years with lower flows require longer run times.
- Model calibration for the years 2004-2006 has also been improved. The biggest changes were to distinguish algae from other BOD inputs and engage the four organic matter systems: labile dissolved, labile particulate, refractory dissolved, and refractory particulate. These changes allow the model to

simulate the decomposition of organic matter from algae, its related oxygen demand, and mineralization from organic to inorganic forms of P and N. This improved model performance for DO, ammonia, SRP, and other systems, especially in the summer low-flow periods of 2003 and 2006.

- The model does not appear to be sensitive to sediment oxygen demand (SOD), but this will be further tested in the 1988 model. Currently, SOD rates in the model are based on field measurements at six locations from an assessment in July 2006. The rates vary by location and temperature.
- The model simulates discharge, water elevation, temperature, total dissolved solids, inorganic suspended solids, phosphate, ammonia, nitrate, silica, BOD, three groups of phytoplankton, four forms of organic matter, and DO**.** In addition, a number of variables can be derived from the model results, such as total suspended solids, chlorophyll, and total phosphorus. Stakeholders can request results for specific variables if they have an interest.
- Dave presented selected results and performance statistics for the seven years and made additional plots and animations available at an FTP site for people to review in detail. As in other model applications, performance generally worsens as you move downstream so the best test is performance at the most downstream station, Fort Snelling (mile 3.5).
- Performance varies by variable. For example, Dave compared excellent statistics for nitrate-N compared to poor statistics for ammonium-N. This may be due in part to the high number of low concentrations and values below detection for ammonium-N.
- Along with the models and inputs, the ERDC will provide tools to generate plots of the model results and performance statistics when the project is complete.
- Dave reviewed the challenges of modeling the Black Dog intake and outfalls with a limited data set, and we discussed some approaches (e.g., leave it as is, remove it, and leave it as is but lag it). Later in the meeting, Gary Rott, MPCA, showed some results from continuous DO monitoring within and immediately downstream of the outfall structures in September 2008. If you average all results, there was no net change; however, the results varied day to day.
- Areas targeted for additional work are 1988, organic matter, and Black Dog, but we need to complete the calibration soon in order to draft a report by the end of the year.

Summarizing Six Years of Work (Cathy Larson, Met Council, and stakeholders)

- Through a number of charts and tables from the various studies, Cathy attempted to summarize the major findings of our six-year project. She covered the following topics: hydrodynamics, sediment bed, water quality, nutrients, oxygen, phytoplankton, light, and point sources. Other partners provided input.
- Because this material is covered in previous notes and documents, it will not be repeated here. This initial attempt at summarizing was the first step toward writing the project summary report. We will review the conclusions at our final meeting.