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A MODEL FOR WATER CIRCULATION AND SOLUTE TRANSPORT IN POOL NO. 2 OF THE MISSISSIPPI RIVER

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I. INTRODUCTION

Pool No. 2 of the Mississippi River is the backwater created by Lock and Dam No. 2. This backwater covers large areas and encompasses the Mississippi River main stem and the water bodies adjacent to it from Lock and Dam No. 2 river mile 815.4 upstream from Hastings, Minnesota, to river mile 828, St. Paul Park. Using navigation charts published by the U.S. Army Corps of Engineers, it was determined that the approximate area of Pool No. 2 is 8 sq. miles [12]*. Figure 1 shows the area under consideration.

The Mississippi River is a major asset to the Metropolitan area because of its great recreational potential in proximity to the large urban centers. The river stretch through the urban areas and Pool No. 2 downstream from the population centers are aesthetically attractive. The potential for use of this water body for recreation is great and it will become even more appealing as costs of transportation to other recreational areas become higher. At the present time the river's water quality discourages recreational activities for many people and creates hazardous swimming conditions.

Past studies [12] have indicated that during low summer flows the Mississippi River in the previously described reach essentially behaves as a lake with such typical hydraulic features as wind drift currents, stratification, density currents, etc. During low flow, such as occurred in 1976 and 1977, the river also has particularly low water quality. In this study the question of water circulation and the effects of the wind on it are addressed. The transport of dissolved materials through the body of water is then analyzed and the results are compared with dye tracing measurements.

As Figure 1 shows, Pool No. 2 consists of several distinct water bodies. Not all of them are well connected to the river main stem. However, the stumpfields of the lower pool, Spring Lake, and Baldwin Lake share wide open areas with the main stem through which large amounts of water can flow. It was therefore considered appropriate to simulate Pool No. 2 as a series of interconnected water bodies, in which the exchange rates of water will be a function of river flow rate, river geometry,

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* Numbers in brackets indicate references on page 51.

and weather, particularly wind.

The information to be obtained from such an analysis is important for further modelling of the low flow water quality and waste load allocation downstream from St. Paul.

V. CONCLUSIONS

The computer program "POOL2" developed in this study simulates the flow distribution and the transport of dissolved material in the Mississippi River downstream from St. Paul. The program is particularly suitable to make predictions under low flow conditions in the river when wind driven circulation becomes significant or predominant. The model will simulate the approximate flow distribution in the pool under time-variable wind and river flow. A time-scale of 6 hours has been used. The model results have been compared to results from dye studies and the agreement has been found to be good enough for the purpose of a water quality model. The model POOL2 can be extended to predict the effects of discharges from the Metropolitan Waste Treatment Plant at Pig's Eye on water quality in the Mississippi. Because POOL2 uses a very short time step itis particularly suitable to simulate those water quality parameters which show a very dynamic behavior, e.g. dissolved oxygen or suspended solids. Program "POOL2" is flexible and inexpensive to run. A typical run will require 45 sec of process time on the Cyber 7400 at the University of Minnesota Computer Center.

The most important new features of the POOL2 model are the inclusion of the wind effect in the circulation of water, the short time step which gives a more realistic circulation picture, and the approach used in modelling the transport of material through the system.

The effect of wind was found to be important in the prediction of water movements in a shallow impoundment such as Pool No. 2 of the Mississippi River, especially under low flow conditions, a fact that has been traditionally overlooked by modellers of aquatic environments.

The cells-in-series model employed for the modelling of mass transport provides a very flexible and reliable alternative to the most often used dispersion model. It accounts for the dispersive process through the number of segments used and it also handles complex systems involving a network of water bodies as well as reversing flows.

The quasi-steady state employed for the hydrodynamic part of the model and the unsteady state used in the mass transport modelling allow the study of aquatic systems under time variable flow conditions through adjustment of the time interval. The time scales for both the hydraulic and the mass transport aspects of the model can thus be reduced to a few hours, as necessity dictates, and therefore be of greater accuracy than the dispersion model where time scales in the order of days are usually employed for the determination of the important parameters.

The macroscopic approach, i.e., the analysis and modelling of the bulk characteristics of the system, was used in this study because of the size and complexity of the system.

The two most obvious extensions of this study can be the modelling of a number of non-conservative constituents (e.g. dissolved oxygen, phytoplankton, etc.), and the inclusion of stratification effects.