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WATER QUALITY MODELS AVAILABLE FROM EPA

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INTRODUCTION

As part of the national effort to implement the Clean Water Act, water quality planners and managers in the United States have increasingly used mathematical models to analyze water quality problems. These models are used in conducting evaluations of waste loads from point and nonpoint sources and in pollutant exposure assessments. To encourage the wider application of these techniques, EPA's Office of Research and Development established the Center for Water Quality Modeling to provide a focal point for water quality modeling activities. The Center supports models that range from simple techniques for preliminary analysis to sophisticated techniques for detailed planning. This paper describes the models supported by the Center and gives an overview of the Center's activities, which include distribution and maintenance of computer programs, training of users, and sponsorship of a users group.

The Center for Water Quality Modeling is located at EPA's Environmental Research Laboratory in Athens, Ga, which has long been involved in the development and application of mathematical models that predict the transport and fate of water pollutants. For selected water quality and pollutant loading models, the Center provides a central file and distribution point for computer programs and documentation. In addition, the Center sponsors workshops and seminars that provide both generalized training in the use of models and specific instruction in the application of individual simulation techniques.

SUPPORTED MODELS

The modeling packages currently available through the Center were selected from many candidate models by experienced users in EPA regulatory and regional offices and by the Center staff. Selection criteria included model utility and effectiveness, availability of adequate documentation, degree of acceptance and application by users, and the Center staff's experience with the software. A wide collection of analysis techniques is provided, ranging from simple desk-top techniques suitable for screening analysis through computerized steady-state models to sophisticated, state-of-the-art continuous simulation models. Modeling packages currently supported by the Center are:

Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants (Mills et al., 1982) -- a collection of formulae, tables and graphs for preliminary assessment of water quality in river basins. These desk-top procedures are designed for hand calculators. The manual includes a discussion of the environmental chemistry of synthetic organic chemicals and metals; a chapter on waste source estimation techniques; and simple methods for assessment of pollutant fate and transport in rivers, lakes and estuaries. Stream analysis techniques evaluate conservative substances, temperature, BOD, DO, total suspended solids, coliform bacteria, nutrients, and toxic organic chemicals. Lake analysis procedures include thermal stratification, sediment accumulation, toxic organic chemicals, phosphorus budget, eutrophication potential, and hypolimnion DO. Estuarine analyses include estuarine classification, temperature, BOD, DO, turbidity, sediment accumulation, and non-conservative substances. Additionally, methods are provided for initial dilution from a marine outfall. Procedures for assessment of heavy metal and groundwater problems are currently under development.

Exposure Analysis Modeling System (EXAMS) (Burns, Cline and Lassiter, 1982) -- a steady-state model designed for rapid evaluation of the behavior of synthetic organic chemicals in aquatic ecosystems. Starting from a description of the chemistry of a toxicant and the relevant transport and physical-chemical characteristics of the ecosystem, EXAMS computes exposure, the ultimate expected environmental concentrations resulting from a long-term steady pattern of pollutant loadings; fate, the distribution of the chemical in the environment and the fraction of the loadings consumed by each transport and transformation process; and persistence, the time required for effective purification of the system once the loadings cease. EXAMS is an interactive program and allows the user to specify and store the properties of chemicals and ecosystems, modify the characteristics of either via simple English-like commands, and conduct rapid, efficient evaluations of the probable fate of chemicals.

Stream Quality Model QUAL-II (Roesner, Gigure and Evenson, 1981) -- a steady-state model for conventional pollutants in streams and well-mixed lakes. It includes conservative substances, temperature, bacteria, BOD, DO, nitrogen, phosphorus and algae. QUAL-II is widely used for waste load allocations and discharge permit determinations in the United States and other countries. It has a 15 year history of application and is a proven, effective analysis tool.

Storm Water Management Model (SWMM) (Huber et al., 1981) -- a comprehensive model for simulation of urban runoff quantity and quality. All aspects of the urban hydrologic and quality cycles are simulated including surface runoff, transport through the drainage network, and storage and treatment (including cost). Alternate techniques are available for simulation in a sewer system -- a kinematic wave procedure for most problem assessment and a full-equation routing method for surcharged systems. SWMM can be used both for single event and for continuous simulation. It has been used in a planning context as well as for detailed design studies. SWMM also has a long history of use in the United States and Canada for urban drainage assessment and design.

Agricultural Runoff Management (ARM) (Donigian et al., 1977) and **Non Point Source (NPS)** (Donigian and Crawford, 1976) -- techniques for assessing agricultural and urban nonpoint source pollutant loadings. The models use the Stanford Watershed Model for the water balance and extend this model to the assessment of nonpoint source pollution from agricultural and urban areas. ARM can be used to study pollutants from agricultural lands such as sediment, nutrients and pesticides and includes detailed process descriptions for nutrient and pesticide fate on the land surface. NPS contains simpler algorithms and can be used on both urban and agricultural lands.

Hydrological Simulation Program - FORTRAN (HSPF) (Johanson et al., 1984) -- a model for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF incorporates the watershed-scale ARM and NPS models into a basin-scale analysis framework that includes fate and transport in stream channels. Simply put, the model uses such information as the time history of rainfall, temperature, and solar radiation; such land surface characteristics as land use patterns and soil properties; and land management practices to simulate the processes that occur in a watershed. The result of this simulation is a time history of the quantity and quality of runoff from an urban or agricultural watershed. Flow rate, sediment load, and nutrient and pesticide concentration are predicted. The program takes these results, along with information about the stream channels, and simulates instream processes, producing a time history of water quantity and quality at any point in a watershed -- the inflow to a lake, for example. HSPF includes an internal data base management system to process the large amounts of simulation input and output. It has been used in such diverse applications as evaluation of agricultural best management practices in Iowa and in a National Urban Runoff Program project near Washington, DC. A user-friendly editor to aid in developing program input is also available (Lumb and Kittle, 1983) as well as a comprehensive application guide (Donigian et al., 1984).

Water Analysis Simulation Program (WASP) (Di Toro, Fitzpatrick and Thomann, 1983) and its extension to toxic contaminants, **TOXIWASP** (Ambrose, Hill and Mulkey, 1983) -- a generalized modeling framework for contaminant fate and transport in surface waters. Based on the compartment modeling approach, WASP can be applied in 1, 2 or 3 dimensions. A variety of problems can be addressed with the selection of appropriate kinetic subroutines that may either be selected from a library or written by the user. WASP is designed to permit easy substitution of user-written routines into the program structure. Problems that have been studied using WASP include BOD-DO dynamics, nutrients and eutrophication, bacterial contamination, and toxic chemical movement. TOXIWASP combines a kinetic structure adapted from EXAMS with the WASP transport structure and simple sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the bed and overlying waters. WASP has been used in the Great Lakes and the Potomac estuary to assess eutrophication problems. TOXIWASP has been applied in Mississippi and in the Delaware estuary to examine fate and transport of toxic contaminants.

SUPPORT ACTIVITIES

In responding to requests for software, the Center provides a copy of the model documentation and a magnetic tape of the computer code, which is to be copied and returned to the Center. The Center also functions as a clearing house for correcting coding errors or other problems that are discovered as the techniques are applied. This vital information exchange function also helps users obtain correct computations when applying a model developed for one purpose to a new and different problem. New software releases periodically document code updates and corrections to known problems. Model maintenance activities focus on overcoming problems in the use of models; further development, refining, and extensions of these models is a separate research and development activity.

Instruction in the use of supported models is provided through workshops and technical seminars sponsored by the Center in cooperation with EPA's Center for Environmental Research Information (CERI). Instructors for these training activities are experts from the Athens and other ORD laboratories and from organizations that developed the models under EPA auspices. Workshops are open to all model users on a space-available basis.

The Center also sponsors the Storm Water and Water Quality Model Users Group (formerly SWMM Users Group). The Users Group meets semi-annually to exchange information on applications and results of model use. This forum enables the timely exchange of information on model refinements, code changes, and model adaptations as well as identification of problem areas and model use limitations. The meetings alternate between the United States and Canada and proceedings of the U S meetings are published by the Center. Users Group members receive copies of these proceedings free of charge. Proceedings of the Canadian meetings are published on an ad hoc basis by the meeting host and there is usually a nominal charge for these proceedings.

The Center periodically distributes, free of charge, a newsletter to Users Group members. The Users Group consists of a large number of model users and developers in international, federal, regional and state environmental management agencies and their consultants, and in private industry and academia. The newsletter provides helpful hints to model users and communicates information on scheduled workshops, model improvements and developments, the availability of technical documents, and planned meetings and conferences. More information about the Center is available from the author.

REFERENCES

Ambrose, R B, S I Hill, and L A Mulkey (1983) **Users Manual for the Toxic Chemical Transport and Fate Model TOXIWASP: Version I** EPA-600/3-83-005, U S EPA, Athens, Ga 30613.

Burns, L A, D M Cline and R R Lassiter (1982) **Exposure Analysis Modeling System (EXAMS)** EPA/600-3-82-023, U S EPA, Athens, Ga 30613.

Di Toro, D M, J J Fitzpatrick and R V Thomann (1983) **Water Quality Analysis Simulation Program (WASP) and Model Verification Program (MVP) - Documentation** EPA-600/3-81-044, U S EPA, Duluth, Mn 55804.

Donigian, A S et al. (1977) **Agricultural Runoff Management (ARM) Model Version II: Refinement and Testing** EPA-600/3-77-098, U S EPA, Athens, Ga 30613.

Donigian, A S and N H Crawford (1976) **Modeling Non Point Pollution from the Land Surface** EPA-600/3-76-083, U S EPA, Athens, Ga 30613.

Donigian, A S et al. (1984) **Application Guide for the Hydrological Simulation Program - FORTRAN (HSPF)** EPA-600/3-84-065, U S EPA, Athens, Ga 30613.

Huber, W C et al. (1984) **Storm Water Management Model User's Manual Version III** EPA-600/2-84-109a,b, U S EPA, Cincinnati, Oh 45268.

Johanson, R C et al. (1984) **Hydrological Simulation Program - FORTRAN (HSPF): Users Manual for Release 8.0** EPA-600/3-84-066, U S EPA, Athens, Ga 30613.

Lumb, A M and J L Kittle (1984) "ANNIE - An Interactive Processor for Hydrologic Models," in **Emerging Computer Technology in Stormwater and Flood Management,** American Society of Civil Engineers, New York, NY 10017, pp 352-365.

Mills, W B et al. (1982) **Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants** EPA-600/6-82-004, U S EPA, Athens, Ga 30613.

Roesner, L A, P R Gigure and D E Evenson (1981) **Computer Program Documentation for the Stream Quality Model QUAL-II** EPA-600/9-81-014, U S EPA, Athens, Ga 30613.