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WORKSHOP ON RIVERINE WATER QUALITY MODELING

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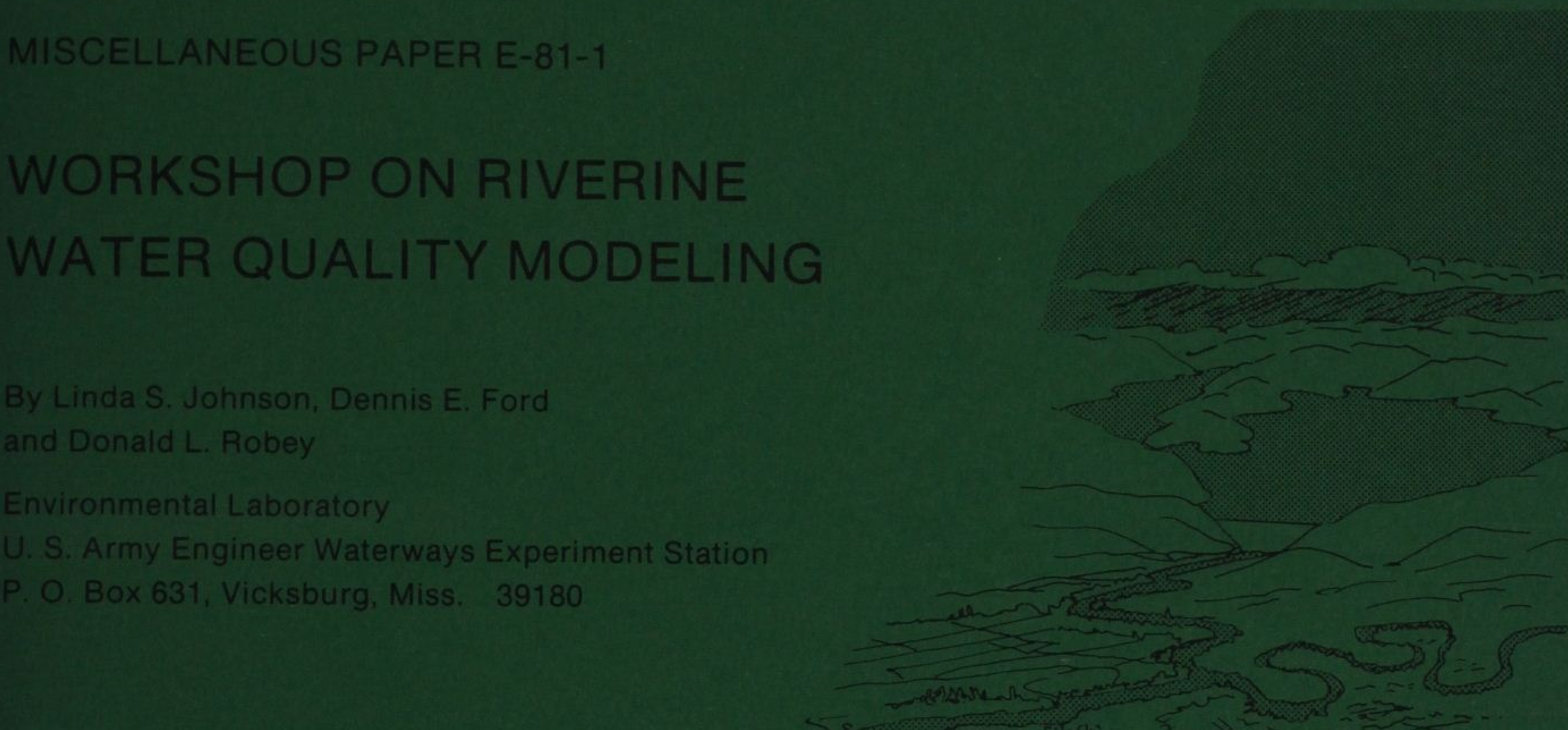

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A Riverine Water Quality Modeling Workshop was held at the U. S. Army Engineer Waterways Experiment Station (WES) on 9-10 April 1980 to address three objectives: (1) define environmental/water quality problems in large rivers encountered by Corps of Engineers (CE) Offices; (2) determine if state-of-the-art riverine models are able to address these problems; and (3) identify areas of inadequacy in the state-of-the-art models for future study and development

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in the Environmental and Water Quality Operational Studies (EWQOS) Program. To address these objectives, representatives from CE District and Division Offices, other Federal agencies, and the consulting community were invited to participate in the Workshop.

At the Workshop, problems were identified in two main areas: water quality problems and problems associated with water quality models. Major water quality problems dealt with reservoir releases and sedimentation. The modeling-related problems included the entire spectrum from new model development to model application problems (i.e. coefficient selection).

Workshop recommendations included collecting data sets for a one-dimensional unsteady flow water quality model and for a two-dimensional vertically averaged model. The development and verification of a mathematical algorithm for the transport of fine suspended sediment were also recommended.

PREFACE

This report summarizes the results of the Riverine Water Quality Modeling Workshop held 9-10 April 1980 at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. The Workshop was sponsored by the Environmental and Water Quality Operational Studies (EWQOS) Program, Task IB.3, entitled "Develop and Evaluate Improved Descriptions for Important Ecological Processes Unique to Rivers." The EWQOS Program is sponsored by the Office, Chief of Engineers, and managed by WES.

The Workshop was organized and conducted and the report prepared by Ms. L. S. Johnson under the direct supervision of Dr. D. E. Ford; and under the general supervision of Mr. D. L. Robey, Chief, Water Quality Modeling Group, Dr. R. L. Eley, Chief, Ecosystem Research and Simulation Division, and Dr. J. Harrison, Chief, Environmental Laboratory. Dr. J. L. Mahloch was the EWQOS Program Manager.

The Commander and Director of the WES during this period was COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

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Vicksburg, Mississippi

9-10 April 1980

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AGENDA

RIVERINE WATER QUALITY MODELING WORKSHOP

U. S. Army Engineer Waterways Experiment Station

Vicksburg, Mississippi

9-10 April 1980

9 April 1980

0830 Introduction/Welcome - Dr. Dennis Ford, Dr. Jerry Mahloch

0900 Workshop Objectives - Dr. Dennis Ford

0930 Model Summary - Dr. Billy Johnson

1015 Break

1030 Workshop Organization - Dr. Dennis Ford

1100 Problem Identification/Ranking - Subgroup Chairpersons

1. CE - Mr. George Strain
2. Other Federal Agencies - Mr. Marshall Jennings
3. Consultants - Dr. Dominic DiToro

1215 Lunch - WES Cafeteria

1315 Regroup - Problem Presentations by Subgroup Chairpersons

1415 Combined Problem List Ranking - Dr. Dennis Ford

1500 Break

1515 Mission Problem Statements - CE - Mr. Don Robey

General Modeling Discussion - Other Federal Agencies and Consultants - Dr. Dennis Ford

1630 Adjourn

10 April 1980

0830 State of the Art - Dr. Dennis Ford

Panel discussion by consultants of the top-ranked problems with short question and answer periods during the discussion.

1015 Break

1030 Group Problem Discussion - Dr. Dennis Ford

1215 Lunch - WES Cafeteria

1315 Workshop Summary - Dr. Dennis Ford

1400 Adjourn

WORKSHOP ON RIVERINE WATER QUALITY MODELING

PART I: INTRODUCTION

1. The objective of the Environmental and Water Quality Operational Studies (EWQOS) Program is to provide new and improved technology to solve environmental quality problems associated with Civil Works activities of the Corps of Engineers (CE) in a manner compatible with authorized project purposes. Mathematical water quality models are one form of technology currently being used to address environmental problems in existing and proposed CE projects. Numerous water quality models currently exist, but no model is capable of addressing all problems. Also, the state of the art of water quality modeling is rapidly changing.

2. A Riverine Water Quality Modeling Workshop was held at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., on 9-10 April 1980, to address riverine water quality modeling as related to CE environmental problems. The objectives of the workshop were:

- a. Define the environmental/water quality problems in large rivers encountered by CE Offices.
- b. Determine if state-of-the-art riverine models are able to address these problems.
- c. Identify areas of inadequacy in the state-of-the-art models for future study and development in EWQOS.

3. These objectives were addressed by personnel from various CE District and Division Offices, nationally recognized consultants, and representatives from other Federal agencies.

4. To meet the first objective, personnel from various CE District and Division Offices were invited to participate in the Workshop. Definition of the problems took place during the first day of the Workshop in identification and ranking sessions. Consultants attended the Workshop to address the second and third objectives. They participated in a panel discussion on the second day, during which the applicability of state-of-the-art riverine models to the identified priority problems was discussed.

5. The purpose of this report is to summarize the Workshop and present recommendations for future work in EWQOS in the area of riverine water quality modeling.

PART II: WORKSHOP ORGANIZATION

Overview

6. The Workshop was organized to obtain a large amount of information in a short period of time. The Agenda was rigorously followed to ensure all workshop objectives were addressed. Presentations were limited to welcoming comments by Dr. Jerry Mahloch, Program Manager, EWQOS, and a modeling overview by Dr. Billy Johnson, Hydraulics Laboratory, WES.

7. The purpose of the modeling overview was to ensure that all workshop participants were acquainted with models currently being used by the CE. Models summarized included a one-dimensional water quality model; a one-dimensional unsteady flow model; two-dimensional laterally averaged models; and two-dimensional vertically averaged models. Limitations of finite difference and finite element solution schemes and use of boundary fitted coordinates were also discussed. It was concluded that hydrodynamic modeling is more advanced than water quality modeling.

Attendees

8. To obtain a wide variety of input, workshop participants were selected from CE District and Division Offices, other Federal agencies, and the consulting community.

9. For selection of CE representatives, questionnaires were given to the EWQOS Field Review Group (FRG) members at the 5 December 1979 meeting at the WES. From the responses received, a tentative list of CE representatives was compiled and letters of invitation were sent out. Names of additional participants were also obtained from the EWQOS Technical Monitors, Office, Chief of Engineers.

10. Personnel from other Federal agencies were invited to the Workshop to provide input regarding their perception of CE riverine water quality problems. Representatives from these agencies were selected in coordination with the Interagency Water Quality and Ecological Modeling

Work Group of the Interagency Water Quality and Ecological Committee for Research Coordination. Agency participants included:

Dr. William R. Waldrop - Tennessee Valley Authority (TVA)
Mr. James Thomas - Water and Power Resources Service (WPRS)
Mr. Thomas O. Barnwell - U. S. Environmental Protection Agency (EPA)
Mr. Marshall E. Jennings - U. S. Geological Survey (USGS)
Dr. Harvey E. Jobson - USGS
Dr. Steve McCutcheon - USGS

11. The consulting community was represented by:

Dr. Ranjan Ariathurai (Sediment Transport)
Dr. Dominic M. DiToro (Water Quality Modeling)
Dr. James H. Duke, Jr. (Water Quality Modeling)
Dr. Thomas N. Keefer (Dispersion and Mixing)
Dr. Raul S. McQuivey (Sediment Transport)
Dr. Frank B. Tatom (Hydrodynamic Modeling)

These consultants had all performed work for the CE and other Federal agencies and were familiar with CE riverine problems. Each also had expertise in various aspects of water quality modeling and was familiar with the state-of-the-art modeling of river systems.

Problem Identification and Ranking

12. Participants were divided into three subgroups, CE, other Federal agencies, and consultants, to identify and rank water quality problems. Each subgroup selected a chairperson: CE, Mr. George Strain; other Federal agencies, Mr. Marshall Jennings; and consultants, Dr. Dominic DiToro. The participants identified water quality problems associated with riverine systems and the problems associated with the modeling of those systems. Problems were individually presented to the subgroup and recorded by the chairperson in a "round robin" fashion to allow everyone an equal opportunity in problem identification. Little or no discussion was allowed during the problem identification phase.

13. After all the problems were presented, they were assigned numbers to identify the problem and subgroup from which it originated. Each member of the subgroup then recorded his name, subgroup, and the six problems he believed to be most important on Problem Ranking Sheet No. 1

(Appendix A). The comments section on the ranking sheet was for any specific comments associated with the problem. These subgroup rankings were used as a supplement to the Combined Problem Rankings (explained below) in determining high-priority problems.

14. Each participant was then provided with a combined list of the problems identified in the three subgroups. The chairpersons presented their subgroup's problem list including a short explanation of each problem. From the combined list of problems, the participants made two separate rankings using Combined Ranking Sheets (Appendix A). First, they ranked what they considered to be the six highest priority water quality problems. Then, they ranked the top six problems associated with mathematical water quality models.

15. As the group finished their rankings, the participants from the other Federal agencies and the consultants assembled in another room for a general discussion of modeling and the need for good data bases. The CE participants were involved in preparing Mission Problem Statements for input to the OCE Research Needs System. During this time, a list of high-priority problems was generated from the combined rankings.

State-of-the-Art Determination

16. The Thursday morning session was devoted to a panel discussion by the consultants on how the high-priority problems could be addressed by state-of-the-art models. Each consultant was given the opportunity to address the major problems. The discussion included three general areas: (1) impact of unsteady flow conditions associated with hydropower operations on water quality and the stream environment, (2) water quality problems associated with sediment, and (3) data requirements for modeling. This discussion provided valuable information for the CE personnel on availability of techniques for use in solving CE problems. The discussion also identified areas for future development in riverine modeling.

PART III: RIVERINE WATER QUALITY PROBLEMS

Problems Identified

17. One of the objectives of the Workshop was to identify environmental and water quality problems associated with large rivers. The problem identification session yielded 80 problems from the three subgroups. From these problems, duplicates were eliminated and similar problems combined to leave a final list of 64 problems. The problems were divided into three main areas: water quality, modeling, and technology transfer (Appendix B).

Water quality

18. Problems associated with water quality were subdivided into three groups: reservoir release, dredging related, and general water quality problems.* The reservoir release problems include the operation of hydropower projects and associated unsteady releases, and the environmental requirements of fish and other aquatic biota downstream of reservoirs (i.e., flow, dissolved oxygen, temperature). The second group of problems was related to dredging operations. Main emphasis was on the environmental impact of dredging and the disposal of the dredged material. The remaining water quality problems made up the last group, general water quality problems.

Modeling

19. The second major problem area concerns water quality models. This area was broken down into four groups: model processes and quantification, instrumentation, models, and factors considered in model application. Model processes and quantification defines the riverine processes that existing riverine models are not capable of accurately modeling. The second group includes problems related to collection and analysis of data. The third group is composed of models and model requirements that need to be developed. (Needed models include unsteady flow models, two-dimensional models, and the coupling of hydrodynamic and

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* See Appendix B for individual listing of problems identified.

water quality models.) The last group are the factors that need to be considered when applying mathematical models, including verification, calibration, levels of analysis, computational efficiency, and model maintenance.

Technology transfer

20. Technology transfer is perhaps the most important of the three areas. The benefit of developing new techniques and models is only realized if they can be made available in a usable form to the CE District and Division Offices. This area includes guidelines for application and user manuals.

High-Priority Problems

21. The original 80 problems identified were ranked twice by Workshop participants. First, they were ranked to determine the highest priority water quality problems. They were then ranked as problems with water quality models. Tables 1 and 2 list the high-priority water quality and modeling problems and the responding subgroup. These problems are not listed by priority.

22. The high-priority water quality problems (Table 1) are related to two general areas, sediment transport and reservoir releases. The sediment transport related problems included not only the mechanics of sediment transport but also the relationships between fine suspended sediments and water quality parameters such as nutrients and contaminants. All three subgroups identified sediment transport related problems as being important. This was not the case for reservoir release problems. The representatives from other Federal agencies did not rate the reservoir release problems as high as the CE representatives and consultants. Problems associated with reservoir releases included water quality problems as well as impacts on fisheries and trade-offs between conflicting objectives.

23. The modeling related problems (Table 2) covered the entire spectrum from new model development to model application problems such as coefficient selection and inadequate model documentation. Model

improvements were tied to a more thorough understanding of the processes responsible for many of the problems identified in Table 1 (e.g. suspended sediment-toxic interactions).

Dredging Related Problems

24. Several dredging related problems were identified at the Workshop (see Appendix B). Many of these problems either have been addressed by the WES Dredged Material Research Program (DMRP) or are currently being addressed by the WES Dredging Operations Technical Support (DOTS) Program. Information on the disposal of contaminated dredged material is available from DMRP Synthesis Reports DS-78-1 through DS-78-8, DS-78-10, and DS-78-14. Assistance on specific dredging problems is available from DOTS, which is being administered by the WES Environmental Laboratory.

PART IV: STATE OF THE ART

25. The second day of the Workshop was devoted to a panel discussion by the consultants. The discussion topic was how well state-of-the-art models can address the identified priority problems. Each consultant was given the opportunity to address the major problems. Short question and answer periods occurred during the discussion. Three general topics dominated the discussion: (1) how the unsteady flow conditions associated with hydropower operations impact water quality and the stream environment, (2) what water quality problems are associated with sediment transport, and (3) what data requirements are for modeling.

Hydropower Operations

26. Hydropower operations was felt to be the most important water quality problem currently facing the CE. From a one-dimensional modeling standpoint, this problem is reasonably well understood. Considerable technology exists in the one-dimensional hydrodynamic area, and adequate dissolved constituent models exist. The hydrodynamics of unsteady flow can be modeled in one, two, and three dimensions, but water quality models are just now being developed in two dimensions. Most two-dimensional state-of-the-art models can accommodate the hydraulics of unsteady flow and one conservative species (i.e. total dissolved solids, salinity). It would be possible to add other water quality parameters to these models, but the additional data requirements are prohibitive at this time. The state of three-dimensional analysis is similar to two dimensions. The models can handle the unsteady hydraulics in three dimensions and one conservative species. However, three-dimensional analysis, because of its complexity, is only for use in small areas and/or short time periods. The largest limitation in development of two- and three-dimensional hydrodynamic models is the lack of adequate data; data are also lacking for the development of one-, two-, and three-dimensional water quality models.

Sediment Transport

27. Data are also a major concern in the sediment area. Techniques appear to be available to develop a one-dimensional model of the processes associated with sediment water quality problems, but more data are needed for that development. There seems to be a good understanding of the mechanisms associated with sand and silt, but more information is needed in the area of transport of the fine fraction (less than 0.063 mm) sediment and its impact on water quality. It was felt that modeling of sediment and water quality should be dynamically coupled to allow for their interaction. There has been work on coupling of sediment and water quality models in one dimension, but there are questions concerning whether or not the hydrodynamics are being reproduced properly. The importance of being able to model sediment accurately is exemplified by the relationship between sediment and the transport of toxic chemicals in rivers. This relationship is also one that needs to be explored, but, again, one major problem is the lack of data documenting the interaction between toxicants and suspended sediment.

Data Requirements

28. The general concensus from the discussion was that data requirements are a very important consideration when looking at models and their application to riverine water quality problems. Only in the one-dimensional hydrodynamic area does there appear to be sufficient data for verification; this is because it is assumed that there is a unique relationship between flow and stage. Water quality and sediment models lack data in all dimensions, and hydrodynamic models lack data for multidimensional analyses.

29. The type of data that should be collected was also discussed. There is a gap between the data collected routinely for historic record and the data needed for modeling. It was agreed that routine monitoring is important, but intensive surveys also need to be included to satisfy modeling data needs. When determining data requirements for an intensive

survey, a specific model should be in mind to ensure that the data collected are consistent with model requirements, especially with respect to the sensitive model parameters and water quality variables. It was also emphasized that models can and should be used in designing data collection networks. Some models are capable of determining the location of sensitive areas in a system. Another data-related concern was the lack of biological data sets (i.e., fish and benthos). These data sets are essential to the development of water quality models and the prediction of impacts on stream habitats.

Other Topics

30. Other items mentioned during the discussion included the need to determine if a relationship exists between turbidity and suspended solids and the need to identify another tracer material suitable for use in sediment studies since radionuclides require Environmental Protection Agency approval and are very difficult to use. Also, repeatedly emphasized was the need to completely identify the problem to be solved so that assumptions can be made and appropriate models can be chosen to address the problem.

Conclusions

31. The overall conclusion to be made from this discussion was that water quality problems resulting from unsteady flows from hydropower projects and sediment modeling are two areas that need to be addressed in the near future. The data question is a problem inherent in all modeling studies that also must be addressed in the near future.

PART V: DISCUSSION

32. The objective of the Workshop was to address riverine water quality modeling as related to CE environmental problems. In the following paragraphs, the problems identified at the Workshop are discussed in general terms with respect to the published results of other surveys.

Water Quality Problems

33. Before a model can be used to solve an environmental problem, the problem must first be identified and defined. The problems identified at the Workshop were not new or unique. Many of the problems were identified by other CE representatives at the EWQOS-sponsored Shallow Draft Navigation Environmental Workshop held 24-26 September 1979 at Slade, Ky. (Planning & Management Consultants, Ltd. 1980). The problems tend to be related either to water quality standards and criteria or to project purposes (e.g. navigation, recreation, etc.). The identified problems can be divided into two categories, reservoir releases and sedimentation.

Reservoir releases

34. The impoundment of rivers modifies the water quality, both within the pool and downstream of the pools from that found in the free-flowing river. Downstream water quality problems typically include minimum low flows, scour, dissolved oxygen and associated problems, and fisheries concerns. The problems have also been identified by the American Society of Civil Engineers (1978, 1980a) and Steele et al. (1980). Increased emphasis on modifying existing projects for hydropower (Seltz-Petrash 1980) will compound these problems and require more sophisticated tools for evaluating their effects on water quality.

Sedimentation

35. Sedimentation refers to any type of sediment movement. Shen (1979) identified six categories of sedimentation problems:

a. Sediment supply from watershed.

b. Variation of alluvial bed forms.

c. Sediment transport in streams.

d. Channel morphology.

e. Movement of sediment in coastal environments.

f. Relationship of sediment to other pollutants.

The American Geophysical Union (1977) and Steele et al. (1980) identified similar categories. All of these problems are of interest to the CE, but, in the Workshop, the emphasis was placed on the relationship between sediment and pollutants because nutrients, trace organics, and contaminants sorb to solids. Suspended solids, therefore, act as the major transport mechanism as well as the major mechanism for removing the constituents from solution (deposition).

Water Quality Modeling Problems

36. Natural rivers are seldom spatially homogeneous and temporally steady. A major limitation of riverine water quality modeling is the extensive use of one-dimensional steady-state models (e.g. QUAL II). Unsteady and multidimensional models are necessary to evaluate complex problems.

37. Most sediment transport models are one dimensional and were developed to study degradation and aggregation in streams (Shen 1979). The understanding of the details of the processes involved in scour and deposition is, however, poor (American Society of Civil Engineers 1980b). Little work has been done in the area of cohesive sediments, an area crucial to understanding pollutant relationships.

38. There are several problems associated with model applications: inadequate documentation, model adaptability, ease of application, and cost (Steele et al. 1980). Because of a model's limitations, the modeler is required to use professional judgment when interpreting results. It is also the responsibility of the modeler to convey the limitations and inherent assumptions to the decisionmaker so that he fully understands the reliability of the results and their utility (Thomann and Barnwell 1979).

Future Needs

39. Future needs, as identified by Steele and Stefan (1979), include development of controls for nonpoint sources of sediment and contaminants, and research in the field of transport, biomagnification, and biodegradation of toxicants. The increasing development of hydropower plants also creates areas for future development (Seltz-Petrash 1980) such as the water quality problems below hydropower plants (i.e., low dissolved oxygen) and the effects on the fisheries downstream of the plants (i.e., minimum flow requirements).

40. Future research should also include investigations of various processes that are important in determining water quality. Work needs to be done in the area of biochemical kinetics. Better understanding of these reactions and their corresponding rate coefficients will improve modeling capabilities in these areas. Another area of interest is the development of techniques to define short-term circulation and turbulent mixing at time scales equivalent to the short time scales of biochemical reactions. Research is also needed in the area of transport of cohesive sediments (i.e., from storm runoff) and its relationship to the transport of pollutants (Steele et al. 1980).

41. Future model development should be limited to extending existing models to two and three dimensions, and refining these models to make them more computationally efficient, rather than developing new models (Shen 1979). The existing models should also be evaluated for suitability under various conditions. Procedures for model calibration and verification were discussed by Shen (1979), Steele et al. (1980), and Thomann and Barnwell (1979). Shen (1979) expressed the view that data needs had to be clearly defined for calibration and verification purposes. Steele et al. (1980) also expressed this concern, but with respect to the accuracy and precision of the data collected. Thomann and Barnwell (1979) noted that the graphical comparisons used now for verification purposes are qualitative analyses that require the modeler to make a judgment on how well the predicted data fit. They suggested that quantitative verification techniques (i.e. statistical analyses)

would be useful tools in future modeling studies. Steele et al. (1980) also brought out the fact that many models, once verified, are never updated to reflect condition changes in the receiving water body. Post-audit surveys should be considered for future modeling programs to check the accuracy of model predictions beyond verification results.

42. Data collection and management are another major area of concern. Steele et al. (1980) noted that present water quality monitoring networks are very much collection oriented, when the main concern should be the data and information use. Data collection should be a balanced program between long-term routine monitoring to establish trends and intensive data surveys during critical periods. Steele et al. (1980) added that, for modeling purposes, the data should be collected with a particular model in mind so that a concentrated effort can be made on those parameters to which the model is most sensitive.

PART VI: RECOMMENDATIONS

43. Based on the results of the Riverine Water Quality Modeling Workshop and other related studies, recommendations for future research include:

a. Collect a verification data set for a one-dimensional unsteady water quality model. Several one-dimensional riverine water quality models are being evaluated in FY 80 with respect to numerical algorithms, model formulations, efficiency and cost of application, ease of application, and model documentation. An unsteady flow model will be selected for verification. This model will be capable of addressing water quality problems downstream of hydropower projects.

b. Select and evaluate a two-dimensional, vertically integrated, hydrodynamic model. This model will be used in large rivers and shallow reservoirs that do not stratify. The model will be the base for a future, two-dimensional water quality model.

c. Develop and verify a mathematical algorithm for the transport of fine suspended sediment. The algorithm when coupled with a hydrodynamic model should be able to predict the spatial and temporal distribution of fine sediments in natural systems. This type of model is required for prediction of contaminant transport.

d. Collect a two-dimensional data set to be used in conjunction with b and c. The data set should include hydrodynamic data and suspended solids data in addition to water quality parameters.

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Table 1

High-Priority Water Quality Problems

and Responding Subgroups

Problem	CE	Other Federal Agencies	Consultants
Nonpoint pollutant production from watershed	X	X	X
Transport and dispersion of toxicants in streams		X	X
Saltwater intrusion due to lock and dam operations, channel modifications, and hydropower	X		X
Impact of sediment on nitrogen and phosphorus cycles	X	X	X
Sediment transport (especially fines) as related to toxicants and toxic chemistry (adsoprtion-desorption)	X	X	X
Water quality-sediment coupling in models		X	X
Water quality impacts of unsteady flow operation downstream of hydropower projects	X		X
Inability to determine minimum flow requirements for fish and wildlife	X	X	X
Means of prioritizing downstream water quality objectives	X		X
Impact of instream disposal of dredged material (sediment, dissolved oxygen, turbidity)	X		X

Table 2

High-Priority Modeling Problems

and Responding Subgroups

Problem	CE	Other Federal Agencies	Consultants
Transport and dispersion of toxicants in streams	X	X	X
Two-dimensional lateral riverine model development	X	X	X
Need for real time water quality model for reservoir/river system and user guide	X	X	X
Measurement of benthic demand	X	X	
Model evaluation procedures including postaudit and competing predictions	X	X	X
Mixing models - when is a one-dimensional representation invalid?	X		X
Lack of technology transfer including guidelines, guidance, and manuals	X	X	X
Inability to model sediment impacts on nitrogen and phosphorus cycles		X	X
Coupling transport model with sediment (bed interaction) model	X	X	X
Coupling water quality and sediment models			X

APPENDIX A: WORKSHOP FORMS

Riverine Water Quality Modeling Workshop

9-10 April 1980

Problem Ranking Sheet No. 1

Name: ______________________

Subgroup: ______________________

Rank	Problem Number	Comments
1	____	______________________
2	____	______________________
3	____	______________________
4	____	______________________
5	____	______________________
6	____	______________________

Riverine Water Quality Modeling Workshop

9-10 April 1980

Combined Problem Ranking Sheet

Name: ______________________________

Subgroup: __________________________

Rank	Problem Number	Comments
1	_____	____
		____
		____
2	_____	____
		____
		____
3	_____	____
		____
		____
4	_____	____
		____
		____
5	_____	____
		____
		____
6	_____	____
		____
		____

APPENDIX B: PROBLEMS IDENTIFIED*

Reservoir Release Problems

Determination of water quality impacts of unsteady flow operation downstream of hydropower projects

Impact of unsteady hydropower operation on bank stability and vegetation

Inability to determine minimum flow requirements for fish and wildlife requirements

Means of prioritizing downstream water quality objectives

Quantification of water quality problems associated with pumped storage

Significance of duration of low dissolved oxygen or temperature on fish and benthos

Determination of effects of freshet reduction of anadromous fishes

Quantification of supersaturation effects on fisheries

Dredging Related Problems

Disposal of contaminated dredged material

Where and how to place dredged material in a stream to minimize maintenance

Impact of instream disposal of dredged material (sediment, dissolved oxygen, turbidity)

Interpretation of elutriate data to predict impact on a stream

Quantification procedures for water quality impacts of agitation dredging

Lack of evaluation procedures for submerged versus nonsubmerged discharge from containment area

Lack of prediction to determine whether dredged containment effluents meet mixing zone limitations

General Water Quality Problems

Nonpoint pollutant production from watersheds

Effect of increased agricultural activity on pesticide concentrations in waterways

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* These problems are not listed in order of priority.

Water quality impacts from storm sewer discharge

Effects of acid polluted releases

Quantification of turbidity versus suspended solids

Algal problems and influences on diurnal dissolved oxygen

Salinity problems in large river basins

Temperature-related impacts within and downstream of reservoirs

Effects of flood channelization on nutrient concentrations

Best management of bendway cutoffs

Water quality impact of sediment traps - modeling

Aid in siting of intakes and outfalls

Transport and dispersion of toxicants in streams

Saltwater intrusion due to lock and dam operations, channel modifications, and hydropower

Effects of reaeration through lock structure

Model Processes and Quantification

Prediction of atmospheric gas transfer on equilibration (total gas)

Ability to define mixing in river systems including wind effects, vertical diffusivity, and effects of bends, curvature, and bottom irregularities on transport

Effects of shading, bank storage, and evaporation on stream temperature models

Cohesive fine-grained resuspension, deposition, consolidation

Impact of sedimentation and resuspension on biota

Impact of sediment on nitrogen and phosphorus cycle

Sediment transport (especially fines) as related to toxicants and toxic chemistry (adsorption - desorption)

Eutrophication - plankton, periphyton, macrophyte relationships

Coupling transport model with sediment (bed interaction) model

Viscosity-density coupling in sediment models

Water quality-sediment coupling in models

Groundwater-river water quality interactions

Instrumentation

Design of monitoring and data management systems for rational assessment

Standard methods for analysis of sediments

Reaeration measurement techniques

Measurement of benthic demand

Real time inventory of conservative parameters in a reservoir

Models

Need for simplified water quality models and impact assessment

Inability to easily model hydrodynamics of unsteady flow

Two-dimensional lateral riverine model development

Development of two-dimensional vertical ecosystem model for run-of-the-river impoundments

Inability to model hydrodynamics and water quality of multiple run-of-the-river systems

Multiple water quality problems in a given reach; urban runoff, reservoir releases

Need for real time water quality model for reservoir/river system and user guide

Factors to be Considered in Model Application

Model evaluation procedures including postaudit and competing predictions

Verification of one-dimensional models using good data bases

Cost-effectiveness of modeling approach; level of analysis; trade-offs

Mixing models, when is one-dimensional representation invalid?

Matching water quality models with compatible flow models

Automatic parameter estimation for models

Efficient utilization of input-output

Computation efficiency

Code maintenance and responsibility

Technology Transfer

Lack of technology transfer including guidelines, guidance, and manuals