

# Summaries of Related Modeling Studies

This appendix summarizes five previously completed studies of model development, use, and dissemination—three conducted wholly within the United States, one from Canada, and one international assessment. The five were chosen for their currency and relevance to the issues raised in this report, and largely corroborate OTA findings regarding current modeling issues. They are:

1. "Federally-Supported Mathematical Models: Survey and Analysis, National Science Foundation (NSF), 1974.
2. "Ways to Improve Management of Federally-Funded Computerized Models, " General Accounting Office (GAO), 1976.
3. "A Study for Assessing Ways to Improve the Utility of Large-Scale Models, ' National Bureau of Standards (NBS), 1978.
4. "Survey of Environmental Management Simulation Models in Canada, ' R. D. Miller.
5. "SCOPE International Assessment Project on Groundwater Model Modeling"

## 1. "Federally-Supported Mathematical Models: Survey and Analysis" (Fromm, Hamilton, & Hamilton)

This survey was completed in 1974 by NSF. It surveyed a universe of over 650 models which addressed some aspect of social decisionmaking, and which were used by or developed for nondefense Federal agencies. Responses were received for 222 models, from over 230 project directors and 80 Federal agency monitors.

Respondents indicated that the most important constraints limiting model utility were: 1) data availability, and 2) ease of use by nontechnicians. Responses also indicated a prevailing tendency for actual use of models to fall short of intended use. Policy-related model uses appeared to have the greatest shortfall—between one-third and two-thirds of the models failed to achieve their stated purposes with respect to direct application to policy problems.

Based on survey responses, staff attributed low policy utilization rates for models primarily to lack of communication between model builders and potential policy-makers during model development, and secondarily to policy makers' limited capabilities to use models once they had been developed. The study found very little interaction between developers and users during model development— actual briefings were held in only 19 percent of the projects, and user agencies ran models and analyzed results in only 34 percent; written reports alone

were provided in over 50 percent of surveyed modeling projects. Most of the projects were supported by grants, with very infrequent specification of performance requirements or desired detail and characteristics by the funding agency.

The survey identified two dimensions to the "ease of use" problem: 1) decisionmaker understanding of models, and 2) the adequacy of developer-supplied instructions for operating the model. Both developers and agency personnel noted that policy makers frequently lack the training that would equip them to use models appropriately. On the other hand, in about 75 percent of the surveyed cases, the documentation supplied by the developer was considered inadequate to enable non-project personnel to set up and run the model. The majority of the documentation efforts failed to include user manuals, operating instructions, or computer programs. Use rates were found to be highest for models having user manuals; these tended to be produced when funding agencies specified desired model characteristics, and when funding was carried out under contracts rather than grants.

## 2. "Ways to Improve Management of Federally-Funded Computerized Models"

This 1976 survey conducted by GAO was based on responses to questionnaires regarding 519 federally funded models developed *and/or* used in the U.S. Pacific Northwest. Fifty-seven of those models costing over \$100,000 to develop were selected for detailed review—and 33 of these were described by respondents as having encountered "major problems" in development. GAO characterized these problems as being due to:

- inadequate management planning (70 percent);
- inadequate management commitment (15 percent);
- and
- inadequate management coordination (15 percent).

GAO found that model development problems tended to result in models not being used once they are developed, cost overruns for models, and prolonged development time. The reasons most frequently given for model development problems were: 1) the unreliability of model results, 2) developers' inability to obtain necessary data, and 3) users' failure to allocate enough funds to complete the model. GAO further outlined development problems stemming from deficiencies in management planning, commitment, and coordination:

- Problems attributable to inadequate management planning:

- Management did not clearly define the problem to be modeled; thus, the developer had to guess what had to be modeled.
- The developer was not able to obtain the data needed to make the model function.
- Management allocated insufficient funds to complete the model.
- Management did not make workable provisions for updating the model for future use; thus, the model soon began to produce outdated information.
- Management did not make provisions for evaluating the model.
- Management did not clarify documentation requirements for the model. As a result, only the developer understood how it worked and the relationship maintained by the variables incorporated into it.

● Problems attributable to inadequate management commitment:

- Management did not actively participate in planning of the model. Thus, the model did not clearly reflect their needs.
- Management did not understand computer modeling techniques and applications. Consequently, they could not effectively use information obtained from the models.

● Problems attributable to inadequate management coordination:

- Management did not monitor the model development effort on a continuous basis. Thus, management allowed development efforts to continue after they should have been terminated.
- Managers did not coordinate the development effort with the developer. As a result, the model was developed without reasonable assurance that it would meet user needs.

Two major solutions for these problems were proposed in the GAO report: First, the use of a phased approach to model development, requiring the funding agency to review projects and decide whether to continue development at the end of each of five stages: 1) problem definition, 2) preliminary design, 3) detail design, 4) evaluation, and 5) maintenance. This suggested procedure is seen as promoting a more thorough early investigation of the nature of the problem and of possible solution methods, as well as providing a method of controlling commitments to modeling efforts.

GAO's second proposal was that the Department of Commerce and the General Services Administration, using their respective authorities under the Brooks Act (Public Law 89-306), formulate Government-wide standards and guidance on developing and procuring

computerized models, and coordinate with other Federal agencies to obtain advice regarding such standards and guidance.

3. "A Study for Assessing Ways to Improve the Utility of Large-Scale Models"

(S. I. Gass, Z. F. Landsdowne, R. P. Harvey, and A. J. Lemonine)

This study, completed in December 1978 for NBS, surveyed a group of modelers selected for their recognized expertise and their interest in the modeling profession. Of 57 modelers who were requested to participate, 39 responded, yielding the following cross-section of affiliations and expertise:

<i>Affiliation</i>		<i>Expertise</i>	
University	8	Analytic	19
Not-for-profit	8	Simulation	12
Profit	9	Economics	9
Government	*		
Total	39	Total	~

These participants, responding to propositions and statements in 18 model improvement area categories, gave highest priority to proposals to clarify the relationship between model developer and user, and increase the interaction between them. Strongest support was voiced for such specific proposals as:

1. Model developers should specify a documentation plan in their contract, detailing the documents to be produced, the resources allocated, and personnel responsibilities.
2. The Federal Government should establish a flexible set of model documentation guidelines that can be used by model developers and sponsors to create a project's documentation plan.
3. Requests for proposals (RFPs) should indicate the ultimate user of the model, and require meetings between model developers and users to aid in designing models to meet user requirements.
4. Model developers should be required to prepare verification and validation test plans, report results of the tests, and describe their implications for future use of their models.
5. Model forums should be established by professional organizations, industrial groups, and the Federal Government.

Participants also indicated strong support for coordinated model development and data collection. They supported mandatory data availability and costing assessments prior to the issuance of an RFP for a model, and requirements for parallel data collection efforts to be specified in the "scope of work" if necessary data are not already available.

Moderate support was also expressed for: 1) requiring greater specificity in the RFP statement of work,

including explicit statements of model scope and objectives; 2) Federal exploration of phased management approaches to model development; and 3) requiring all model development contracts to address the issue of user training.

Participants strongly disapproved of centralized Government-sponsored review and analysis relating to models, specifically rejecting model clearinghouses; a model testing, verification, and validation center; and a Government modeling research center.

#### 4. “Survey of Environmental Management Simulation Models in Canada” (R. D. Miller)

Simulation modelers in Canada who were involved with developing environmental management models were requested to complete questionnaires regarding the models they had developed. Questions were directed toward five general areas:

1. purpose of the model, including the audience to which it was directed;
2. degree of success, including implementation of the model and its use in decisionmaking;
3. problems encountered during model development and implementation;
4. planning and managerial factors that might serve as predictors of success; and
5. technical details of how the simulation was carried out.

The overall results of the survey suggest that the surveyed model development projects suffered from lack of involvement and meaningful contribution by decisionmakers in the early stages of model development. A lack of user credibility accorded to the model was reported only in cases where users had not been involved in managing the project. In these cases, user credibility was cited as a problem with far greater frequency than the modeler’s willingness to help, suggesting that modelers neglect to involve decisionmakers more often than decisionmakers refuse to consider the advantages of developing models.

Specific correlations were found between:

- perceived success and attempts to involve users at early stages of development, specifically by giving system managers some voice in managing the simulation project;
- perceived success and preproject literature searches or state-of-the-art surveys;
- perceived success and intended audience. Cases where model output was to be used by technical or research staff had a significantly better success level than cases where model results were to be used by policy formulation groups, or middle- or high-level management; and

- model purpose and difficulties encountered during the project. Where models were constructed primarily for research purposes, lack of understanding of mechanisms, and lack of available data, were most often cited as problems; where models were intended for policy recommendations, lack of user credibility was the most frequently named problem.

#### 5. “SCOPE International Assessment Project on Groundwater Model Modeling”

The SCOPE project was carried out between 1975 and 1977, primarily through surveys of two groups: 1) active model developers, and 2) those active in applying models to management problems. Reports on approximately 250 models were submitted in response to the project survey.

The purpose of the assessment was to provide guidance on measures for improving the utility of models in ground water management. Four major problem areas were identified during the course of the project, and were ranked by project staff and an international steering committee in the following order of importance:

1. accessibility of models to users;
2. communications between managers and technical personnel;
3. inadequacies of data; and
4. inadequacies of modeling.

The survey found difficulties in gaining access to existing models to be the most serious impediment to effective use of models in ground water management. Major problems of accessibility revolve around the usability of model documentation, model distribution, adequate training in the use of models, and user certification. Project staff suggested that improvements in these areas would require shifts in the incentive structures of institutions, or even modifications to the institutions themselves. Their primary recommendation involved establishing public agency requirements for adequate documentation as a prerequisite for funding any model development effort.

To improve communication between managers and technical personnel, the study staff recommended measures to increase interactive participation in problem definition and model application, so that managers become directly involved in developing the models they commission. Additional recommendations included designing model outputs to be easily understandable by nontechnical personnel, and encouraging further development of management “decisionmaking” models.

Data-gathering recommendations stressed improved methods for routine data collection, storage, and retrieval, and sensitivity analysis as a method of determining the most critical data needs for modeling purposes.