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FOREIGN TRIP REPORT

ORNL/FTR-3812

DATE: November 7, 1990

SUBJECT: Joint Report of Foreign Travel of B. Gordon Blaylock, Senior Research Staff; R. H. Gardner, Senior Research Staff; and F. Owen Hoffman, Research Staff II; all of the Environmental Sciences Division

TO: Alvin W. Trivelpiece

FROM: B. Gordon Blaylock, F. Owen Hoffman, and Robert H. Gardner

Purpose: B. G. Blaylock, F. O. Hoffman, and R. H. Gardner participated in and presented papers at the BIOMOVS Symposium and Workshop on the Validity of Environmental Transfer Models, October 8-12, Stockholm, Sweden. R. H. Gardner also held discussions on model validation and comparison at the Free University of Amsterdam on October 15 and at the National Institute of Public Health and Environmental Protection in Bilthoven, The Netherlands on October 16.

SITES VISITED:

10/8-12/90	Stockholm, Sweden	G. Johansson	Blaylock, Gardner, and Hoffman
10/15/90	Free University and IVM, Amsterdam, The Netherlands	C. Lammes H. Verbruggen	Gardner
10/16/90	RIVM, Bilthoven, The Netherlands	J. P. Hettelingh L. Hordijk	Gardner

ABSTRACT:

The travelers attended the symposium and workshop for the conclusion of Phase 1 of BIOMOVS and presented papers that summarized results and suggested new approaches to the problem of estimating the long-term fate, effect, and human risk of environmental contaminants. R. H. Gardner also visited the Institute for Environmental Studies at the Free University, Amsterdam, and the National Institute of Public Health and Environmental Protection in Bilthoven, The Netherlands, to confer with scientists about the development and current use of new models and methods of performing environmental assessments.

PURPOSE:

BIOMOVS (BIOspheric MOdel Validation Study) is an international cooperative study initiated in 1985 by the Swedish National Institute of Radiation Protection to test models designed to calculate the environmental transfer and bioaccumulation of radionuclides and other trace substances. The objective of the symposium and workshop was (1) to synthesize results obtained during Phase 1 of BIOMOVS (the first five years of the study) and (2) to suggest new directions that might be pursued during Phase 2 of BIOMOVS. The travelers were an instrumental part of the development of BIOMOVS. This symposium allowed the travelers to present a review of past efforts at model validation and a synthesis of current activities and to refine ideas concerning future development of models and data for assessing the fate, effect, and human risks of environmental contaminants.

R. H. Gardner also visited the Free University, Amsterdam, and the National Institute of Public Health and Environmental Protection (RIVM) in Bilthoven to confer with scientists about current research in theoretical ecology and the use of models for estimating the transport and effect of environmental contaminants and to learn about the European efforts to map critical loads of acid deposition.

SUMMARY OF ACTIVITIES:

The BIOMOVS Symposium and Workshop, Stockholm, Sweden

The BIOMOVS Symposium and Workshop was held in Stockholm, where the BIOMOVS project was initiated in 1985. The primary objectives of BIOMOVS were to (1) test the predictions of a variety of environmental models for selected exposure scenarios, (2) explain differences in predictions as a function of the model structures and uncertainties in the data, and (3) recommend priorities for future research to improve the accuracy of model predictions.

This symposium (October 8-12, 1990) was the concluding meeting of the five-year BIOMOVS program. The symposium was organized so that most sessions started with papers that summarized the BIOMOVS scenarios and the lessons learned from these studies. The papers were usually given by individuals who had been scenario chairmen and who were responsible for the BIOMOVS technical reports. These opening papers were followed by invited and submitted papers on the same subject or on related topics. The symposium consisted of 42 papers, two of which were not presented because the Soviet scientists who wrote them were unable to attend the meeting.

Over 118 scientists from 26 countries and 58 institutions (see Appendix B) were represented at the Stockholm meetings. The papers were presented to illustrate the two different approaches used to fulfill the BIOMOVS objectives, namely (1) formulation of test scenarios with model predictions compared against a data set that was not initially available to modelers and (2) comparison of model predictions for specific scenarios by propagation of uncertainty (e.g., Monte Carlo analysis).

The assessment of model uncertainties and the comparison of models under different environmental conditions (i.e., scenarios) made the participants aware of the large uncertainties associated with model use and application compared with the traditional sources of error associated with model development and insufficient data.

The following are among the most outstanding accomplishments of Phase I of BIOMOVS. BIOMOVS is the first international organization to

- formally test and evaluate biospheric transfer models of radionuclides and other toxic substances
- use nonradioactive trace elements to test predictions of models developed for radioecological assessment,
- use data on Chernobyl fallout for model testing,
- use intercomparison of predictions and uncertainty estimates in the absence of test data for relevant assessment scenarios, and
- make uncertainty analysis a major component of model evaluation.

In his invited presentation, Owen Hoffman outlined the following conclusions from the five-year BIOMOVS Phase I study.

1. The knowledge of biological systems is sufficiently incomplete to preclude the development of true "process-level" models. Therefore, by necessity, biospheric models are empirically based.

2. BIOMOVS has revealed a high lack of confidence in predictions made for time periods far into the future. However, even for well-known exposure pathways operating over relatively short time periods, consistent accuracy to within a factor of two is beyond the capability of current assessment models.

3. Larger uncertainty estimates often reflect partial familiarity on behalf of model users with the derivation and selection of parameter values in their models. Thus, there is a continued need for assessment modelers to establish a close link with experimentalists.

4. Increased model complexity has not necessarily led to increased accuracy. To reduce uncertainty, there is a need for research efforts to better correlate critical model parameters with readily measurable environmental variables. Detailed description of a site did not improve the estimates of uncertainty when important parameters could not be correlated with site-specific information.

5. Each test scenario represents a "special case"; thus testing must be conducted over a range of sites and release conditions in order to arrive at meaningful

conclusions. Obtaining such test data is a major task and is facilitated in the BIOMOVS study only through the widespread monitoring of Chernobyl fallout.

6. Blind testing, as was conducted in the BIOMOVS 'A' Scenarios, is necessary to evaluate accuracy. In the absence of test data, as was the case in the 'B' Scenarios of BIOMOVS, model evaluation requires extensive discussion and debate. Of particular interest are the discrepancies that remain after conclusion of this discussion. These discrepancies provide incentive for additional research.

7. Differences in model results and uncertainty estimates are to be expected, depending on the nature of the assessment question and the expertise of the model user. (Within the 'A-4' Scenario of BIOMOVS, 23 computer codes were applied to scenarios described for 13 different locations. Several of these codes were actually identical in model structure and employed similar data bases. Nevertheless, large differences in results did occur. These differences were entirely the result of differences in user interpretation of the data provided for the scenarios).

8. The criterion for a successful model prediction is dependent on the purpose for which the model was developed. In some cases, large overestimation was deemed satisfactory because it confirmed intended bias of models designed not to underpredict.

Many recommendations were made within the BIOMOVS study; however, the following are among the most noteworthy.

1. Particularly important assessment tasks should be independently assigned to more than one modeling group to identify potential discrepancies in results and to provide incentive to resolve differences. This recommendation is essential for achieving credibility.

2. The BIOMOVS concept should be extended to the entire field of environmental risk assessment, which includes

   - source-term predictions;
   - transport in the atmosphere, hydrosphere, and geosphere;
   - internal dosimetry;
   - risk (from radionuclides and chemicals); and
   - cost of risk reduction or avoidance options.

It was noted that the international community involved with internal dosimetry of radionuclides within humans appears to be reluctant to engage in the application of uncertainty analysis for dosimetric models.

The symposium was concluded with two presentations. Dr. F. O. Hoffman summarized the conclusions from all the BIOMOVS scenarios. Dr. Peter Barry from the Atomic Energy of Canada, Ltd., Chalk River Labs discussed the lessons learned from the BIOMOVS

Study and how these should be applied to future studies. Dr. Barry, who has been involved in predicting the environmental transport of radionuclides for 35 years, concluded that, before he became involved in the BIOMOVS study, he was confident that he could use well-known environmental transport models to predict with 50% accuracy the concentration in cows' milk of ^{131}I from atmospheric releases. However, after being involved in BIOMOVS, he concluded that prediction within one order of magnitude of the measured values was more realistic for most models. Dr. Barry also pointed out the need for additional site-specific data for improving parameter values and for testing models, but he acknowledged the fact that support for radioecologists to obtain these data is practically nonexistent.

In a discussion with B. G. Blaylock, Dr. Asker Aarkrog (from the Riso National Laboratory of Denmark and past president of the International Union of Radioecologists) expressed concern about the European countries following the lead of the United States in not supporting radioecological studies. Support for his laboratory, which provided valuable information during the Chernobyl accident, had been reduced, and members of his staff were being assigned to other areas.

The Institute for Environmental Studies at the Free University, Amsterdam

The Institute for Environmental Studies (IVM) at the Free University was established in 1971 and is the oldest academic institute for basic and applied environmental research in The Netherlands. IVM is a nonprofit organization with over 80% of its funds provided by external sources. The Institute's primary objective is to carry out multidisciplinary and interdisciplinary research on environmental issues. The Current director of IVM is Prof. Dr. H. Verbruggen, and the Institute employs nearly 40 researchers from a variety of disciplinary backgrounds, including chemistry, ecology, hydrology, geography, geochemistry, economics, econometrics, psychology, and sociology.

R. H. Gardner met with C. Lammes and H. Verbruggen at IVM to discuss the theory and methods of assessing the uncertainties associated with environmental models. Because of the diversity of problems now being studied at IVM and the variety of computer models IVM uses to predict environmental effects, there was a great deal of interest in the techniques developed at Oak Ridge to compare different models and assess their uncertainties. It was evident from the questions and discussions following the lecture that both IVM and the Environmental Sciences Division (ESD) would benefit from exchanges of information and personnel. The staff of IVM is closely associated with the Economics Faculty of the Free University, and IVM's models and publications reflect the use of economic principles for studying environmental effects. Issues of global change are of particular concern at IVM. Staff interests focus on the development of realistic economic scenarios associated with or driven by global change. Several practical and theoretical questions arise, including the relative magnitude of uncertainties associated with different economic scenarios and the need to include this information in assessing global change effects.

The National Institute of Public Health and Environmental Protection (RIVM) in Bilthoven, The Netherlands

RIVM, located in the city of Bilthoven near Utrecht, is a national institution concerned with a wide variety of environmental problems. A new awareness of environmental issues has developed with the publication of "Zorgen voor Morgen" by RIVM. "Zorgen voor Morgen" (literal translation: "Concern or Anxiety for Tomorrow") details the important local, regional, and global environmental issues that directly affect life in The Netherlands from 1985 until 2010. Because of these environmental concerns, Leen Hordijk, Peter Janssen, and Wout Slob had invited R. H. Gardner to attend a workshop at RIVM in March of 1989 to discuss the state-of-the-art methods of assessing the uncertainties associated with predictions of environmental models. The computer program (PRISM) developed at ESD for the Monte Carlo analysis of model uncertainties is now being extensively used at RIVM. The traveler was able to return to RIVM on this trip to discuss the use of PRISM, to confer on problems of estimating prediction uncertainties, and to learn of the new techniques being developed at RIVM.

Peter Janssen has spent considerable time inspecting and modifying the PRISM program for use at RIVM. In particular, Janssen has added a suite of statistical distributions in a format that allows the user to specify inputs in a flexible fashion and has carefully analyzed different statistical methods for summarizing the results. With W. Slob and J. Rotmans, he has produced a document (in Dutch) that evaluates different approaches for performing sensitivity and uncertainty analyses.

A European center for estimating critical loads of sulfur deposition across Europe was established at RIVM in November of 1989. This activity is led by Jean-Paul Hettelingh of RIVM, with Robert Downing of the U.S. Environmental Protection Agency (EPA) also participating. Progress in the mapping exercise has been impressive, with each country providing the necessary data and several empirical and theoretical approaches used to estimate deposition levels and effects. This activity is possible because the Executive Body for the Convention on Long-Range Transboundary Air Pollution of the United Nations Economic Commission for Europe decided to establish a Working Group on Abatement Strategies. The purpose of this group is to assess abatement strategies for sulfur and nitrogen emissions and to establish a Working Group on Effects to assess environmental impacts. A final map of critical loads should be available t the Executive Body by November of 1991.

SUMMARY EVALUATION AND RECOMMENDATIONS:

The BIOMOVS study was conceived in 1985, approximately nine months before the Chernobyl accident. Because the formal structure of the organization was in place, the Chernobyl data were rapidly analyzed and inconsistences in the data were pointed out. As a result, BIOMOVS was responsible for improvements in the quality of many of the Chernobyl data bases.

Originally, the BIOMOVS project was to consist of modelers, who would make predictions, and experimentalists, who would provide data for model testing. Although there were attempts to bring experimentalists into the BIOMOVS program, most attended only one or two meetings. As a result, BIOMOVS became a program for modelers or for individuals who used models for assessment purposes. There is some danger in such programs because modelers assign parameter values to complete their predictions regardless of the data available. The overall impression is that parameter values are well documented and that there is no need for additional data. BIOMOVS has demonstrated that a primary source of uncertainty in model predictions stems from the misapplication of generic parameter values. However, the widespread availability of generic parameter values is used to justify the withdrawal of further support for laboratory and field experiments.

Validation of Assessment Model Predictions (VAMP), a program sponsored by the International Atomic Energy Agency, was established for the continuation of model testing with the use of Chernobyl data and, in many ways, is similar to BIOMOVS. Dr. F. O. Hoffman is chairman of the Multiple Pathways Section of the VAMP Program. VAMP is making an effort to keep the experimentalists involved in the program by placing emphasis on the validation of environmental processes.

It is surprising that U.S. regulatory agencies did not support the BIOMOVS program, although these agencies are using environmental transport models for regulatory purposes. It appears that the agencies are very content with their models and are not concerned about the accuracy of their predictions. However, when regulatory models were used by BIOMOVS participants, the predictions were not as accurate as many had anticipated.

During the concluding days of the workshop (October 11-12) BIOMOVS Phase 1 was finalized, and plans were proposed for BIOMOVS Phase 2. The three countries supporting BIOMOVS Phase 2 are Canada, Sweden, and Spain. At the present time, because of the lack of a sponsor, there will be no U.S. participation in BIOMOVS Phase 2.

These meetings had particular relevance to the research programs in ESD because of the similarity of many of the environmental problems faced by scientists in The Netherlands to those faced by ESD researchers, because of the desire of IVM and RIVM to make use of the ESD experience in model development and analysis, and because of the potential for the Dutch scientists to make important new contributions to these difficult issues. Therefore, the following activities seem particularly worthwhile:

1. Continue to maintain close contact with RIVM, the development of their simulation methods, and their application of uncertainty analysis. The integrated approach used at RIVM may prove to be a valuable model for our own regional assessments.

2. Exchange publications and information with the staff at IVM. Many of the environmental problems being addressed at IVM are similar to problems being studied at ESD. In addition, the IVM staff have a strong background in

economic theory and have made extensive use of economic methods to predict the social consequences of environmental effects.

3. Use contacts within ESD and at EPA to determine the U.S. involvement in the European center for determining critical loads. The research and assessments produced by this center will have a direct bearing on our assessments of critical loads in the United States.

APPENDIX A

ITINERARY

B. G. Blaylock and F. O. Hoffman

October 5-6, 1990	Travel from Oak Ridge, Tennessee, to Stockholm, Sweden
October 7, 1990	Weekend (Sunday)
October 8-12, 1990	Symposium and Workshop on the Validity of Environmental Transfer Models, Stockholm, Sweden
October 13, 1990	Return from Stockholm, Sweden, to Oak Ridge, Tennessee

R. H. Gardner

October 5-6, 1990	Travel from Oak Ridge, Tennessee, to Stockholm, Sweden
October 7, 1990	Weekend (Sunday)
October 8-12, 1990	Symposium and Workshop on the Validity of Environmental Transfer Models, Stockholm, Sweden
October 12, 1990	Travel from Stockholm, Sweden, to Amsterdam, The Netherlands
October 13-14, 1990	Weekend
October 15, 1990	Visit and discussions with H. Verbruggen and C. Lammes at IVM at the Free University
October 16, 1990	Visit and discussions at RIVM in Bilthoven with J. P. Hettelingh, L. Hordijk and associates.
October 17, 1990	Return from Amsterdam, The Netherlands, to Oak Ridge, Tennessee

APPENDIX B

SIGNIFICANT CONTACTS

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