A SECOND NEA WORKSHOP ON SYSTEM PERFORMANCE ASSESSMENTS FOR RADIOACTIVE WASTE DISPOSAL

Paris, France October 22 - 24, 1985

Trip Report by Robert Cranwell

The Second Nuclear Energy Agency (NEA) Workshop on System Performance Assessments for Radioactive Waste Disposal was held at the Organization for Economic Cooperation and Development (OECD) offices in Paris, France from October 22 - 24. Chairman for the workshop was Dr. R. B. Lyon of the AECL, Canada, and secretariat was Stefan Carlyle of the Division of Radiation Protection and Waste Management, NEA. The focus of the workshop centered around the various links involved in carrying out a system performance assessment. The three principal links discussed were (1) the links between output from performance assessments and the needs of regulators, (2) the link between various predictive mathematical models used in performance assessments, and (3) the link between model development and field/laboratory observations. The NEA's perception of how these three links fit into an overall system performance assessment is shown in the enclosed figure.

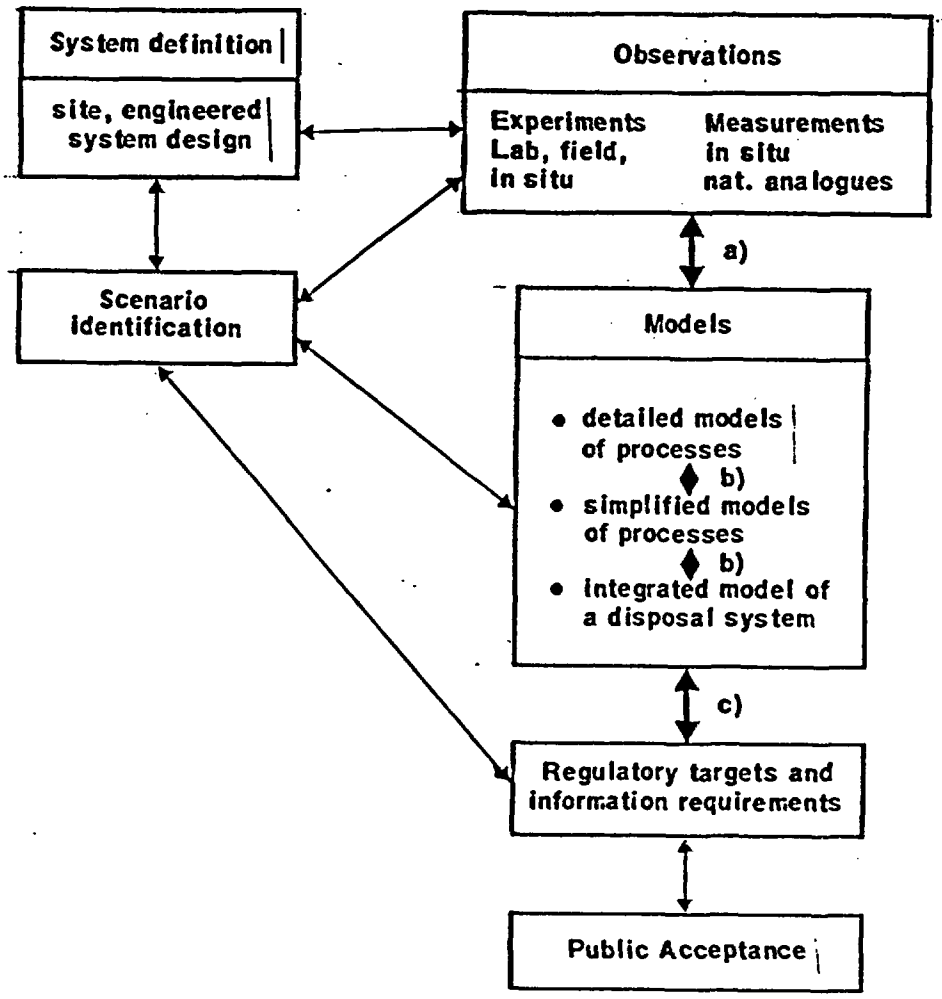
There were four sessions during the first two days of the workshop; three sessions on the above mentioned links and a fourth session on the Current Status and Development Needs in System Performance Assessments. The morning of the third day involved a plenary session devoted to reviewing the main findings of the workshop and preparing conclusions and recommendations for future needs. A copy of the final program is enclosed.

First day: October 22

A general introduction and welcome was given by Mr. K. Stadie, NEA, followed by an introduction to Session I: "The Current State and Development needs in System Performance Assessments," by Stefan Carlyle, NEA Secretariat. Mr. Carlyle gave a short presentation on why the emphasis of the workshop was on the importance of linkages in post-closure system performance assessment. The topics for the workshop resulted from a group of consultants* working with the NEA Secretariat to identify

* Participants in the NEA consultant group on System Performance Assessments: Dr. P. D. Johnston (DOE, UK), Dr. R. B. Lyon (AECL, Canada), and Dr. T. Papp (SKB, Sweden). Also invited were Dr. N. Cadelli (CEC) and Dr. R. Cranwell (Sandia, USA), but they were not able to attend the first group meeting.

LINKAGES IN SYSTEM PERFORMANCE ASSESSMENTS



a) Link between the development of models and observations (validation)
b) Link between detailed models and simple models and Link between separate models and an integrated system model
c) Link between the output of performance assessments and regulatory requirements.

key issues that have arisen and developments that have taken place since the first NEA workshop held in November of 1982. It was felt that there exists one particular problem which requires resolution; that is, how to rationalize all the various elements that combine together in carrying out performance assessments. It was concluded by the consultant group that fundamental to this rationalization is an awareness and understanding of the various links between each component of the waste disposal system. Different types of linkage exist such as the ones between those utilizing and those carrying out performance assessments, between those acquiring and those utilizing data, and between the way individual component models may be coupled together. It was considered by the consultant group that such linkages are a weak point in current performance assessments for a wide range of wastes and disposal options. By examining these links it should be possible to identify areas requiring greater attention and further work. Therefore, the objective of the workshop would be to examine the main links between particular elements of system performance assessments for radioactive waste disposal facilities, to identify areas where improvements can be made, and suggest ways of carrying these out.

Dr. C. McCombie, NAGRA (Switzerland) gave the next presentation on "The Present Status and Current Challenges in System Performance Assessments." He concluded that the current challenges for Performance Assessment were:

1) Improve detailed process models in certain areas - e.g., in the near-field.

2) More model validation.

3) Improve uncertainty treatment - especially in scenario analyses.

4) Explain the procedure and document the results more transparently.

5) Provide more input for guiding field-work.

6) Complete more system assessments giving quantitative predictions of expected performance.

He felt that scenario analysis was still probably the biggest problem; specifically, (1) the completeness of scenarios, (2) the data associated with scenarios, and (3) the analysis of scenarios.

In the afternoon, Robert Lyon introduced Session II; "The Link between Performance Assessments and Regulatory Requirements." The first presenter for this session was Dr. Peter Johnston,

DOE (United Kingdom) who spoke on "The Link Between General Performance Objectives and Performance Assessments." The thrust of the presentation was on the implications of setting general objectives for the conduct of performance assessments and for the presentation of the results of these assessments. Particular attention was given to regulatory developments in the European countries and Canada and to the procedures adopted within the CEC PAGIS project. Two issues of continuing concern where identified in the linkage between general risk limits and performance assessments. These were (1) the practical methods of calculating risks, and (2) the assurance of completeness in risk assessment. Under practical methods of calculating risk, a distinction was made between scenarios leading to long-term contamination of the environment, but low-levels of radiation exposure, and low-probability scenarios leading to higher levels of short-term radiation exposure. In each category, determination of risk was calculated differently. Under the assurance of completeness in risk assessment the problem was considered as two-fold; (1) scenario identification (i.e., completeness), and (2) selection and sampling of modeling parameters. So-called "best estimate" assessments and parameter sampling assessments were discussed.

The second presentation in Session II dealt with "The Link Between the Performance Assessments of the U.S. DOE Projects and Regulatory Requirements of NRC and EPA," by A. Van Luik, Battelle PNL (U.S.). Mr. Luik highlighted the requirements, standards, and criteria of the U.S. which included (1) The Nuclear Waste Policy Act of 1982 (NWPA), (2) The Mission Plan for the Civilian Radioactive Waste Management Program, (3) The EPA Standard (40CFR191), (4) The NRC's Requirements and Criteria (10CFR60), and (5) The Engineered Barrier System and the Multiple Barrier System Requirement. The DOE performance assessment strategy was also highlighted and an illustrative approach to calculating compliance with the EPA standard and NRC criteria was given. Mr. Luik completed his presentation by pointing out similarities and differences between regulatory requirements in the U.S. and other OECD-member nations. Controlling the exposure risk to present and future generations was felt to be the common goal of the U.S. programs and other OECD-member nations while differences were due largely to (1) the requirement to show cumulative releases to the accessible environment rather than doses to individuals or populations, (2) the 10,000 year regulatory period, compared with an undefined, and therefore indefinite period in other countries, and (3) the engineered barrier release rate limit, which as yet finds no parallel in the regulations of other nations. The containment period requirement of 300 to 1000 years is not dissimilar, at 1000 years, from preliminary goals being discussed in some national programs (e.g., Switzerland, Canada and Austria), but is much less than goals apparently being pursued by others (e.g., Sweden). It was felt that, on the

whole, the U.S. program may be more focused on the engineered barrier system than are its counterparts in other nations.

Second day: October 23

The topic of the second day of the workshop was "Linkages Between models in System Performance Assessments." The first presentation was by Bob Lyon, AECL (Canada) on "The Link between Detailed Process Models and Simplified Models." Mr. Lyon started out by indicating that models for performance assessment generally fall into four categories:

(1) Engineered Waste Package
(2) Subsurface Geological Environment
(3) Near-Surface and Surface-Environment
(4) Radiation Dose

He felt that if results of research programs are to be incorporated in the safety assessment through the use of mathematical models, the models must have the following characteristics:

(1) Interface well with experiments and experimenters
(2) Interface with other models used in assessment
(3) Have easily changed input and be economical to run
(4) Be understandable

However, no single model could satisfy all the above requirements. Therefore, we develop what are called Research Interface Models (RIMS) and Assessment Interface Models (AIMS). A RIM is developed with little thought to satisfying requirements 2, 3, and 4, but is developed primarily to interface effectively with field and laboratory experiments. A AIM is developed primarily to act effectively as a submodel in an overall safety assessment, with particular attention to requirements 2, 3, and 4. In general, the procedure for producing an assessment is to develop and validate a RIM to analyze a range of problems to be considered in the assessment. The results of these analyses are used to develop an AIM, which produces results compatible with those of the RIM over the sets of conditions required for the assessment. This ensures that extrapolations beyond actual experience are made with a model (AIM) that has been shown to give similar results for representative sets of conditions as a model (RIM) that has been shown capable of valid predictions by comparison with experiments. The AIM, which in general cannot be compared directly with experimental observation, is used only to interpolate within the range for which it has been compared with the RIM. This validation procedure is concerned only with the analysis of the particular subsystem to which the AIM is applied. It does not validate the interfaces between the AIM and models, or the other subsystems.

A couple of examples were presented of the development of AIM's for use in various assessments. One involving transport through the geosphere is as follows:

As part of the International Fuel Cycle Evaluation, an analysis was done of the potential release from a hypothetical geologic radioactive waste vault in hard rock. The AIM in this case was a variation of the GETOUT model which was used to calculate the migration of radionuclides through the geosphere. The actual system to which the assessment is to apply is fractured rock. The water moves through a complex network of fractures and networks of channels within those fractures. It is driven primarily by head gradients caused by variable topography and heat from the vault.

To relate the complex behavior of the actual system to the simplified picture in the AIM, a finite-element, three-dimensional, groundwater-flow computer code, FE3DGW (a RIM) was applied to some data taken from an actual field site. The model assumed that flow through the fractured rock could be described by treating the rock as a heterogeneous porous medium. Variability of hydrogeological properties with depth was taken into account by assigning different values of permeability and porosity to elements at different depths. Large-scale subvertical linear features (faults) observed at the field site were treated by modelling them with narrow elements that could be given permeabilities and porosities different from the surrounding rock. The driving force generated by the topographic gradient was produced by using head distributions on the upper boundary, derived from a topographic map of the field area. Hydrogeological parameters in the model were varied to determine sensitivity of the model to the parameters.

The average groundwater transit times from the hypothetical vault to the surface and the average path lengths calculated by the RIM, FE3DGW, were used in the AIM. The validity of the RIM was not fully established in this case by comparison with observations at the actual field site.

In this example, a RIM was used to provide input values to a preconceived AIM. However, the belief was that, in general, it should not be assumed that a particular AIM is capable of assimilating information from particular field or laboratory observations into an assessment. A more general procedure for progressing from experimental observation to an assessment model is to develop and validate a RIM based on observation, and then to conceptualize an AIM that calculates the important aspects of the physical system in a way that gives results in agreement with those of the RIM over the required range.

The next presenter was A. Saltelli of the Commission of the European Communities (CEC), Ispra (Italy), who spoke on the Integration of Simplified Models in Probabilistic Assessments." The emphasis of Mr. Saltelli's talk was on (1) integrated system models for use in probalistic performance assessment calculations, (2) the testing of integrated system models, and (3) the role of parameter correlation in integrated system models.

Three codes were discussed as examples of codes that could be used for integrated system modelling. These were the NUTRAN code, the SYVAC code, and the LISA code. Mention was also made of the "Monte Carlo Methodology" work being done at Sandia for the NRC.

Both in SYVAC and in LISA the assessment of the contaminant flow impact is done stochastically. Each simulation is composed of a number of runs (or scenarios in the SYVAC terminology). In turn, each run is uniquely determined by the set of sampled values of its input, i.e. by the input vector. Concerning testing of the integrated system model, the following was recommended:

i) Each module has to be tested as a "stand alone" before inserting it in the code.

ii) The test must involve the same wide range of input parameters which the module is expected to receive in the code.

iii) If the module is a mass transfer one (e.g. buffer, geosphere, etc.), it must be extensively tested for mass balance.

A good software quality assessment program, as well as code intercomparison programs such as INTRACOIN and HYDROCOIN were also recommended.

Several methods for accounting for parameter correlation were discussed. One approach is to correlate the input variables. In particular, a number of variables might be naturally correlated by making them dependent upon a set of "basic parameters." Such an approach is presently being considered for the SYVAC-3 vault submodel, where, for instance, pH, electrochemical potential, temperature and ionic strength could be taken as basic parameters. In this approach it is assumed that these parameters contain the uncertainties associated with corrosion, dissolution, etc., then these parameters, together with suitably defined probability distributions, become SYVAC's randomly selected parameters. The second step in this approach requires the provision of functional expressions which relate, for example, penetration time (container lifetime) to the basic

set of parameters. The net effect would be to select parameters for the vault which display the required degrees of correlation. Similar approaches might also be useful for the geosphere and the biosphere submodels, possibly using different sets of basic parameters and probability distributions.

Another way of correlating variables is by explicitly imposing the desired correlation coefficient between two or more variables. In SYVAC-2 a parameter with normal or log-normal distribution can be defined as correlating with another parameter having one of these distribution types. In this procedure, only the independent parameter is sampled, and the dependent one is computed. This procedure is likely to be somehow too rigid to be extensively employed. As an alternative, joint distributions might be used for the variables to be correlated, but such an approach has not yet been taken in performance assessment codes.

Another possibility is given by the technique developed by Iman and Conover and presently implemented in LISA. With this technique any combination of parameters can be correlated in LISA at the desired level (expressed by a rank correlation coefficient), regardless of the type of individual distribution. The characteristics of this technique are the following:

i) All the correlated parameters are sampled.

ii) The ranks of the sampled values conform with the requested ones.

iii) The individual (marginal) distribution of the variables is not changed by the correlation.

The advantage of this method is that it is quite general and easy to use. It can also be used to purge spurious correlations between the input variables, when this is desired. A criticism which is addressed to the use of this technique for eliminating unwanted correlations is that spurious correlations do occur in nature.

The next presenter was J. Lewi, ANDRA (France) who spoke on the "Integration of Detailed Models (French Experience)." The approach adopted in France by the CEA-IPSN is considered "deterministic" and depends on the development of a global model which will progressively take into account different phenomena, after sensitivity studies have demonstrated their influence. This model,called MELODIE, in development since mid-1984, will perform calculations for the three kinds of geological formations being considered in France: granite, salt and clay.

Different stages are foreseen in the development of the MELODIE model.

1) The first stage, currently in progress, consists of the setting up of a version which will provide the best estimate of the transfer of radionuclides in an environment defined by a set of initial data without any time variation of these data. This version associates:

   - a source model, called CONDIMENT.

   - a geosphere model (hydrological and radionuclides transport), called METIS.

   - a biosphere model, called ABRICOT.

The METIS geosphere model, modified for granite formations, has been involved in the INTRACOIN and HYDROCOIN programs.

b) The second stage foresees the addition of a parameter sensitivity studies algorithm using Latin hypercube sampling.

c) The third stage in the MELODIE development will allow for taking into account the geosphere evolution (modifications of the site's geometry, the medium characteristics, such as the fissuration or the permeability, and the boundary conditions, such as the surface hydraulic head).

A short presentation was given by R. Storck, Federal Republic of Germany, on the "Integration of Detailed Models (FRG Experience)." Three codes are used in the performance assessment for salt dome repositories in Germany. These are (1) EMOS (compartmental model) for release from repository, (2) SWIFT, for migration through geosphere, and (3) ECOSYS (compartmental model), for migration through biosphere. The compartments in EMOS are (1) waste package, (2) sealed boreholes, (3) backfilled and sealed chambers, and (4) backfilled galleries. The phenomena modelled are are (1) container failure, (2) leaching from waste matrix, (3) creep of rock, (4) forced convection in networks, (5) natural convection (6) nuclide retention by sorption and precipitation, (7) nuclide transport by forced and natural convection and diffusion, and (8) decay of radionuclides.

Session IV of the second day was on "The Link between Model Development and Field/Laboratory Observations." The first presenter was C. Cole, Battelle PNL, who spoke on the "Linkage between Laboratory/Field Observations and Models." Mr. Cole described the linkage between model development and field/laboratory observations as "an iterative program of site and system characterization for development of an observational-confirmatory data base." This data base is

designed to develop, improve, and support conceptual models for site and system behavior. The program consists of data gathering and experiments to demonstrate understanding at various spatial and time scales and degrees of complexity. Understanding and accounting for the decreasing characterization certainty that arises with increasing space and time scales is an important aspect of the link between models and observations. The performance allocation process for setting performance goals and confidence levels, coupled with a performance assessment approach that provides these performance and confidence estimates, will determine when sufficient characterization has been achieved. At each iteration, performance allocation goals are reviewed and revised as necessary. The updated data base and appropriate performance assessment tools and approaches are utilized to identify and design additional tests and data needs necessary to meet current performance allocation goals.

The second presentation in Session IV was on the "Prospects for Model Validation Against Field/Laboratory Observations," by K. Andersson, SKI (Sweden). The concept of model validation was defined as:

> A conceptual model and the computer code derived from it are "validated" when it is confirmed that the conceptual model and the derived computer code provide a good presentation of the actual processes occuring in the real system. Validation is thus carried out by comparison of calculations with field observations and experimental measurements.

It was concluded that in the context of waste disposal it is clear that "full validation" of performance assessment models in the meaning of complete confirmation of used theories and parameter values can never be achieved. It is more a matter of a process to gain confidence in the models with the aim of achieving reasonable assurance that they give a good representation of real processes. This can be done by using information from well defined laboratory and field experiments in short time scales and from natural analogues which give information in long scales but usually with less well defined initial and boundary conditions. International benchmarking programs such as INTRACOIN and HYDROCOIN were also thought to be valuable in gaining confidence in models.

Third day: October 24

The morning of the third day was devoted to a plenary session with four rapporteurs summarizing the main findings of the workshop. Since I served as rapporteur for Session IV, I have included my writeup of the main findings of this session. I have also included brief summaries of the main findings of

Sessions II and III, plus recommendations made to the NEA for future activities.

Session II - Linkage Between Performance Assessments and Regulatory Requirements

Arising from consideration of the link between regulatory requirements and performance assessments, it was agreed that performance objectives can formulated in a number of different ways and that these govern the way performance assessments are carried out. Despite a number of differences between Member countries on regulatory criteria, performance assessment procedures appear to be developing in a similar way. There is a universal awareness of the need for uncertainty analysis, and an increasing use of probabilistic systems assessment techniques. It was also considered that there is a need for transparency in performance assessment procedures and a need to validate models wherever practicable. The following specific topics were highlighted as meriting further attention.

i) The identification and screening of disposal scenarios.

ii) Assignment of probabilities to scenarios and or probability distributions to modelling parameters.

iii) Quality assurance procedures - including peer review and independent (comparison) assessments.

iv) Increased co-operation between assessment groups and regulatory authorities.

Session III - Linkage between models in System Performance Assessments

The consideration of the linkages between models in system performance assessments was divided between (a) the link between detailed process models and simplified models and (b) the link between individual process (simplified) models and integrated models of a system. It was apparent from discussions on the links between models that the various methodologies being used and developed for performance assessments are well understood, but that certain specific developmental problems remain to be overcome. In particular, the relationship between detailed models arising from laboratory or field research and simplified models used in assessments was found to be well understood. However, three problems areas were identified:

i) Research models can be of low quality leading to uncertainty which has to be taken into account in site design.

ii) Many methods of simplification exist which may give rise to problems with interchange and intercomparison of results and quality assurance.

iii) Simplification of biosphere models requires more consideration.

Examination of the link between individual process models and integrated models concentrated on probabilistic assessment and deterministic assessment codes. No clear consensus was reached on the relative role of deterministic and probabilistic methodologies, other than each has a particular role to play in assessments. It was clear from discussions that the linkages are well understood in that the current capabilities and problem areas were well defined. Problems highlighted included:

i) Analysis of boundary conditions between sub models needs to take into account in-built errors.

ii) Testing of codes and quality assurance needs to be developed.

iii) Deciding on model complexity, to suit specific tasks.

iv) The role of correlations between parameters needs to be considered further.

v) Optimization of calculations should be sought to limit computer time.

Recommended Future Activities of the NEA

- The NEA should be encouraged to examine ways to provide for international peer review of performance assessment activities, ranging from overall assessments (such as the review of KBS-3) to specific components (such as that provided by the Users Group for SYVAC-like Codes).

- The NEA can play a valuable role in the area of code development by providing an exchange facility via a model (code) library established at the NEA Data Bank.

- The intercomparison of codes was endorsed by the group as being necessary for their verification. NEA should be encouraged to play a role in the co-ordination of such activities. A suggested new activity was the establishment of a group to compare near field (engineered barrier) codes.

- The NEA's active role in the development of long term radiological criteria was endorsed.

- The NEA should be encouraged to host a workshop on uncertainties in performance assessments. This endorsed the recent activities of the RWMC in this area, where a consultant group has produced a report on Handling Uncertainties in System Performance Assessments.

- The NEA should be encouraged to host a workshop or establish an expert group to develop an agreed international methodology for scenario identification. Particular emphasis should be given to (a) the screening of scenarios, (b) the assignment of probabilities to scenarios, and (c) assignment of probability distributions to modelling parameters. A specific topic to be addressed would be the identification of scenarios covering biosphere evolution in performance assessments.

- The NEA should consider the continuation of the topical workshop on performance assessments. A possible topic for the next workshop is "Strategies for Confidence Building," which would cover validation, peer review, public consultation and communication, quality assurance, etc.

Finally, several participants at the workshop recommended that the NEA consider establishing a standard group on performance assessments (e.g. a Performance Assessment Advisory Group), composed of experts from countries active in this field, which would meet approximately once a year to:

i) Improve information exchange through periodic reviews of the state-of-the-art.

ii) Identify initiatives for co-operation.

iii) Provide a forum for the organization of peer reviews.

iv) Advise the RWMC on technical aspects of systems performance assessments.

v) Help co-ordinate NEA activities in the area of systems performance assessment.

SUMMARY OF SESSION ON THE LINK BETWEEN MODEL DEVELOPMENT AND FIELD/LABORATORY OBSERVATIONS

It was generally agreed that the ultimate goal of performance assessment models is their use in evaluating the safety of proposed disposal facilities for radioactive wastes. To achieve this predictive capability will require sufficient understanding of the processes involved, characterization of the system being modeled, a sound theory that relates understanding and characterization together, and a data base for use in supporting experimental evidence. Some of the key issues which surfaced in terms of understanding of the linkage between model development and field/laboratory observations were (1) the ability to make reliable predictions of future behavior, (2) understanding and accounting for increasing uncertainty in site characterization which arises with increasing space and time scales and degrees of complexity, and (3) a determination when sufficient characterization has been achieved.

The linkage between model development and field/laboratory observations was felt to be an interative process of site and system characterization. We start with available system characterization data, then develop preliminary models for use in setting initial performance allocation goals and designing and directing further experiments to improve the site characterization data base and alter, if necessary, our conceptual models. Ultimately, the goal becomes one of developing an observational data base that supports the validity of our detailed subsystem models for the range of conditions that are important to our performance assessment needs, and of determining when we have achieved our performance goals.

Problem Areas

In the discussion, several problem areas surfaced as important to the link between model development and field/laboratory observations. These problem areas centered around (1) model validation, (2) data availability, acquisition and use, and (3) uncertainty analysis.

Model Validation - The problem here arises from the fact that "full validation," in the context of complete confirmation of used theories and parameter values, can never be achieved. Attempts to validate a model generally encompasses one or more of the following procedures:

- Laboratory experiments
- Field tracer experiments
- Natural analogues.

It was felt that laboratory and field experiments, if properly conducted and carefully designed, were of use in model validation, particularly for short time scales. However, several problem areas associated with laboratory and field experiments were identified. These were (1) sampling procedure can alter properties of sample, (2) time and spatial scales for experiments are short compared to time and spatial scales involved with repository performance assessment, (3) difficulty in simulating properties of system at repository depths, (4) lack of laboratory data from test sites, and (5) uncertainties concerning flow situation.

Information from natural analogues was also felt to be useful in model validation, especially with respect to long time scales. Problems with natural analogues, however, arise from the lack of good analogues in the time range of 1000 to 100,000 years and in defining initial boundary conditions. Also, almost all useful information which can be obtained from natural analogues relates to chemical processes and is of little use in ground-water flow modelling.

Data - Concerns about performance assessment data can best be classified as (1) availability of data, (2) acquisition of data, and (3) use of data. Problems with the availability of data arise from the degree to which data will be available for model development (for example, fracture data for use in a dual-porosity model) and the bias injected by overlooking the original purpose of previous data collection efforts. For example, oil well exploration data provides a convenient source of existing data on deep systems but the drill stem testing techniques commonly used to measure hydraulic properties have the potential for routinely excluding any of the higher permeability measurements because of the limitations of the technique. Identification of bias is important to both the use of existing data in models and the design of new data collection efforts.

Problems with data acquisition can arise from sample size of data, frequency of sample (spatial variation), tools and instruments used to collect data, and interpretation and extrapolation of data. For example, observations and measurements of parameters are made at "points" within the system. However, characterization of the variability of these parameters in space and time is typically required to model and make performance assessment predictions. Thus, the "point" information needs to be extrapolated over the spatial and time domains. A more complicated situation arises for parameters that cannot be measured directly (e.g., permeability and dispersivity), but must be determined indirectly through inverse modeling techniques.

Problems with use of data can arise from the misuse of previously collected data, (as discussed above), use of

so-called "lumped" parameters (e.g., distribution coefficients), and use of homogeneous data in a heterogeneous system.

Uncertainty - Several sources of uncertainty in performance assessment were identified. These included (1) data, (2) models, (3) human error, (4) future events, (5) time and spatial scale effects, and (6) understanding basic physics and chemistry. It was felt that a major effort in developing confidence in our performance assessment predictions would be in reducing, quantifying, or bounding the uncertainties associated with all important components involved in making performance assessment predictions.

Possible Solutions/Research and Development Requirements

Model Validation - Since full validation was felt to be impossible, one approach suggested was to develop an international consensus on a strategy for validation work with the objective being to reach some agreement on the range of applicability of different modeling approaches and reasonable assurance that the models provide a good representation of the processes occurring. The degree of validation would be different for different models depending on their role in performance assessment. The need for more carefully designed experiments for the purpose of model validation was also suggested. It was felt that to achieve this, there was a need for close collaboration between field and laboratory experimentalists, geologists and modellers. The use of natural analogues, despite their shortcomings, were felt to be useful in answering some of the important questions regarding long term assessment of processes in the natural environment. Further investigation into the use of natural analogues was recommended. Finally, international benchmarking programs such as INTRACOIN AND HYDROCOIN were felt to be extremely useful programs for addressing the problems of model validation. The benchmarking program INTRAVAL will also be very useful in the model validation effort.

Data - Careful use of data, improved measurement techniques, close collaboration between experimentalists and modellers, and well-defined data acquisition programs were all suggested as possible solutions to the performance assessment data problem. Issues that need to be considered and addressed when field data are used and when planning and designing data acquisition programs were suggested. They include:

- How should small-sample data be averaged to obtain equivalent large-sample estimates for our performance assessment models? Is it necessary, and is it appropriate?

- What effect does variability in sample size have on our ability to obtain estimates for the spatial distribution of the data set, and what effect will this have on our estimates of spatial correlation lengths?

- How important is it that many of the parameter interpretation theories were developed for a homogeneous world and the real world is heterogeneous?

- For inversely determined parameters in a heterogeneous world, what is the appropriate relationship between:
  - the perturbation stimulus
  - kind, number, locations, and sampling size of response observations
  - model used for test interpretation
  - the sampling size of the test
  - the band width of spatial frequencies the test can detect.

Other issues also felt to be important when using data and when planning data acquisition programs were:

- purpose of the assessment and stage of the assessment program
- conceptual model or models for the system
- performance assessment approach (e.g., detailed or bounding) and the theory associated with this approach
- scale or sampling size and frequency of sampling in both space and time
- kinds of tools or instruments used to gather the data or make observations
- methods used to interpret and extrapolate these measurements or data.

Uncertainty - Uncertainty analysis should be an integral part of any performance assessment methodology, regardless of the performance objective required by the regulatory agency. Several techniques for performing uncertainty analysis currently exist. Some of the more commonly used are (1) the classical "Monte Carlo" simulations, (2) differential analysis techniques, and (3) experimental design methods. Other more recent approaches are (1) the development of stochastic models, (2) geostatistical methods such as kriging, and (3) so-called statistical inverse methods. Additional work in this area needs to be encouraged such as that proposed in the Level 3 HYDROCOIN program and international workshops on uncertainty analysis. The recent activities of the NEA in the formation of a consultant group on uncertainty analysis is a step in the right direction.

A [illegible] NEA WORKSHOP ON SYSTEM PER[illegible]E
A[illegible]TS FOR RADIOACTIVE WASTE [illegible]

FINAL PROGRAMME

Chairman: R.B. Lyon (Canada)

First day: 22nd October 1985

10.00 1. General Introduction and Welcome: Mr. K. Stadie, NEA

SESSION I THE CURRENT STATE AND DEVELOPMENT NEEDS IN SYSTEM PERFORMANCE ASSESSMENTS

10.15 2. Review of the Conclusions of the Consultants Group; The Importance of Linkages in Post-Closure System Performance Assessments - NEA Secretariat

10.40 Coffee

11.00 3. The Present Status and Current Challenges In System Performance Assessment - C. McCombie, NAGRA (Switzerland)

Covering recent assessments for a range of waste types and disposal concepts

11.45 General Discussion

12.30 Lunch

SESSION II THE LINKAGE BETWEEN PERFORMANCE ASSESSMENTS AND REGULATORY REQUIREMENTS

14.00 4. The Link Between General Performance Objectives and Performance Assessments - P.D. Johnston, DOE (United Kingdom)

Covering presentation of information in PAGIS and European regulatory requirements

15.00 Coffee

15.20 5. A Prescriptive Approach; The Link Between the Performance Assessments of the US DOE Projects and Regulatory Requirements of NRC and EPA - A. Van Luik, Battelle PNL (United States)

16.20 General Discussion and Presentations

SESSION IV THE LINK BETWEEN MODEL DEVELOPMENT AND FIELD/LABORATORY OBSERVATIONS

14.15 8. Linkage Between Laboratory/Field Observations and Models - C. Cole, Battelle PNL (United States)

- Use of field data in models
- Planning data acquisition programmes
- Adapting models to data availability

15.30 Coffee

15.50 9. Prospects for Model Validation Against Field/laboratory Observations - K. Andersson, SKI (Sweden)

- Review of methods used and lessons learnt in HYDROCOIN, INTRACOIN
- Use of natural analogues

16.50 General Discussion and Presentation

Third day: 24th October, 1985

09.30 PLENARY SESSION

Review main findings of the workshop and prepare conclusions and recommendations

12.00 Concluding remarks (R.B. Lyon)

12.30 Close of meeting.

NOTE:

For those making presentations, slide and overhead projectors will be available

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October 1985

A SECOND NEA WORKSHOP ON SYSTEM PERFORMANCE ASSESSMENT FOR RADIOACTIVE WASTE DISPOSAL

DEUXIEME REUNION DE TRAVAIL DE L'AEN SUR L'EVALUATION DES PERFORMANCES DES SYSTEMES D'EVACUATION DES DECHETS RADIOACTIFS

Final List of Participants

Belgium

Dr. J. MARIVOET
Centre d'Etude de l'Energie Nucléaire
(S.C.K./C.E.N.)
Boeretang 200,
B-2400 Mol
Tel.: (014)311801 (Ext.3911)
Tlx.: 31922

Canada

Dr. A.W. ASHBROOK
Director, Environment and Technology
Eldorado Resources Limited
255 Albert Street, Suite 400
Ottawa, Ontario K1P 6A9
Tel.: (613)2385222
Tlx.: 0533382

Mr. G.C. JACK
Manager, Waste Management Division
Atomic Energy Control Board
270 Albert Street
P.O. Box 1046
Ottawa, Ontario, K1P 5S9
Tel.: (613)9954055
Tlx.: 0533771

Dr. R.G. JARVIS
Atomic Energy of Canada Limited
Chalk River Nuclear Laboratories (CRNL)
Chalk River, Ontario, K0J 1J0
Tel.: (613)5843311
Tlx.: 05334555

Mr. R.B. LYON
Acting Director,
Waste Management Division
Atomic Energy of Canada Limited
Whiteshell Nuclear Research Establishment
Pinawa, Manitoba, R0E 1L0
Tel.: (204)7532311
Tlx.: 0757553

Finland

Mr. E.K. PELTONEN
Lic. Tech.
Industrial Power Company Ltd.
Fredrikinkatu 51-53 B
SF-00100 Helsinki
Tel.: (358-0)-605022
Tlx.: 122065 tvo sf

Mr. E.J. RUOKOLA
M.sc.(eng.)
Section Head,
Finnish Centre for Radiation and
Nuclear Safety
Department of Nuclear Safety
P.O. Box 268
SF-00101 Helsinki
Tel.: (358-0)61671
Tlx.: 122691 STUK SF

Dr. S.J.V. VUORI
Technical Research Centre of Finland
Nuclear Engineering Laboratory
P.O. Box 169
SF-00181 Helsinki
Tel.: (358-0)648931
Tlx.: 122972 vttha sf

France

Mr. M. DURIN
Commissariat à l'Energie Atomique
Centre d'Etudes Nucléaires de Saclay
DEMT/SMTS/TTMF/Bâtiment 91
F-91191 Gif-sur-Yvette Cédex
Tel.: 9084472/9084563
Tel.: 690641 ENERGAT F

Mr. J. LEWI
Chef de la SAED
Commissariat à l'Energie Atomique
IPSN/DAS/SASICC/SAED
B.P. N° 6
F-92260 Fontenay-aux-Roses
Tel.: 6547999
Tlx.: 270049 SURIN F

Mr. J.P. MANGIN
Commissariat à l'Energie Atomique
Centre d'Etudes Nucléaires de
Fontenay-aux-Roses
DRDD/SESD
B.P. N° 6
F-92265 Fontenay-aux-Roses
Tel.: 6547394
Tlx.: 270898 ENERGAT F

Federal Republic of Germany

Dr. W. HILD
Gesellschaft für Strahlen- und Umweltforschung m.b.H.
Institut für Tieflagerung
Abteilung Endlagersicherheit
Theodor-Heuss-Str. 4
D-3300 Braunschweig
Tel.: 0531/18012292
Tlx.: 952865 iffta d

Dr. R. STORCK
Gesellschaft für Strahlen- und Umweltforschung mbH München
Institut für Tieflagerung
Theodor-Heuss-Strasse 4
D-3300 Braunschweig
Tel.: (0531) 8012205
Tlx.: 952865 iftta

Italy

Dr. F. GERA
ISMES S.p.A.
Via dei Crociferi, 44
I-00187 Roma
Tel.: (06)6781800
Tlx.: 622242 BPB for ISMES

Japan

Mr. T. MATSUNAGA
Department of Environmental Safety Research
Japan Atomic Energy Research Institute
Tokai-mura,
Naka-gun
Ibaraki-ken, 319-11
Tel.: 0292 825246
Tlx.: 3632340 JTOKAI

Netherlands

Dr. B.F.M. BOSNJAKOVIC
Ministry of Housing, Physical Planning and Environment
P.O. Box 450
2260 MB Leidschendam
Tel.: 70/209367
Tlx.: 32362

Mr. P. GLASBERGEN
RIVM
P.O. Box 150
2260 AD Leidschendam
Tel.: 31.70/694251
Tlx.: 33604

Mr. R.M. KORTHOF
Ministry of Economic Affairs
P.O. Box 20101
2500 EC The Hague
Tel.: 070/797849
Tlx.: 31099 ECZA

Mr. J. PRIJ
Netherlands Energy Research Foundation (ECN)
Westerduinweg 3
1755 ZG Petten
Tel.: 02246/4429
Tlx.: 57211 REACP NL

Sweden

Dr. K. ANDERSSON
Swedish Nuclear Power
Inspectorate (SKI)
Box 27106
S-102 52 Stockholm
Tel.: 8-635560
Tlx.: 11961 SWEATOM S

Mr. R. BOGE
National Institute of Radiation
Protection
Box 60204
S-104 01 Stockholm
Tel.: 8-244080
Tlx.: 11771 SAFERAD S

Mr. T. PAPP
Swedish Nuclear Fuel and
Waste Management Company (SKB)
Box 5864
S-102 48 Stockholm
Tel.: 8-652832
Tlx.: 13108 SKB S

Switzerland

Dr. J. HADERMANN
Swiss Federal Institute
for Reactor Research
CH-5303 Würenlingen
Tel.: 56/992415
Tlx.: 53714 eir ch

Dr. P. HUFSCHMIED
Société Coopérative Nationale pour
l'Entreposage de Déchets Radioactifs
NAGRA
Parkstrasse 23
CH-5401 Baden
Tel.: 056/205511
Tlx.: 57333 Nagr CH

Dr. C. McCOMBIE
Société Coopérative Nationale pour
l'Entreposage de Déchets Radioactifs
NAGRA
Parkstrasse 23
CH-5401 Baden
Tel.: 056/205111
Tlx.: 57333 nagr CH

Dr. F. VAN DORP
Société Coopérative Nationale pour
l'Entreposage de Déchets Radioactifs
NAGRA
Parkstrasse 23
CH-5401 Baden
Tel.: 056/205511
Tlx.: 57333 nagr CH

Dr. A. ZURKINDEN
Nuclear Safety Department
Federal Office of Energy
CH-5303 Würenlingen
Tel.: 056/982853
Tlx.: 59058

United Kingdom

Mr. P.D. GRIMWOOD
Safety and Medical Services, BNFplc,
Sellafield Works,
Sellafield, Cumbria
Tel.: 0940/28333
Tlx.: 64237

Dr. P.D. JOHNSTON
Department of the Environment
Romney House
Room A.518,
43 Marsham Street
London, SW1P 3PY
Tel.: 01/212 5676
Tlx.: 22221 DOEMAR

Dr. P.C. ROBINSON
Theoretical Physics Division
Bldg. 424 4, AERE
Harwell,
Didcot, Oxon OX11 ORA
Tel.: Abingdon 24141 (Ext.2885)
Tlx.: 83135

Mr. G.M. SMITH
National Radiological Protection Board
NRPB
Chilton, Didcot,
Oxfordshire, OX11 ORQ
Tel.: Abingdon (0235)831600
Tlx.: 837124 RADPRO

United States

Mr. C. COLE
Battelle Pacific Northwest Laboratory
Battelle Boulevard
P.O. Box 999
Richland, Washington 99352
Tel.: (509)3768451
Tlx.: 152874

Dr. R.M. CRANWELL
Supervisor,
Waste Management Systems
Division 6431
Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico 87185
Tel.: (505) 8448368
Tlx.: 9109891600

Ms. C. DEFIGH-PRICE
(DOE Defense Waste; proj. Mg'r of
Environmental Analysis)
Rockwell Hanford Operations
P.O. Box 800
Richland, Wa. 99352
Tel.: (509)3739112
Tlx.:

Mr. J.D. RANDALL
Office of Nuclear Regulatory Research
United States Nuclear Regulatory Commission
Mail Stop 1130SS
Washington, DC 20555
Tel.: 1 301 4274633
1 301 4274403
Tlx.:

Mr. A. E. VAN LUIK
Battelle Pacific Northwest Laboratory
Battelle Boulevard
P.O. Box 999
Richland, Washington 99352
Tel.: (509)3768433
Tlx.: 152874

CEC

Mr. N. CADELLI
Commission of the European Communities
200, rue de la Loi
B-1049 Brussels
Belgium
Tel.: 02/2351522
Tlx.: 21877 COMEU B

Dr. A. SALTELLI
Commission of the European Communities
Joint Research Centre of Ispra
I-21020 Ispra (Varese)
Italy
Tel.:332 789686
Tlx.: 43-380042 EUR I

NEA Secretariat

Mr. K. STADIE
Deputy Director,
Safety and Regulation
OECD/Nuclear Energy Agency
38 Bd. Suchet
F-75016 Paris
Tel.: 45249654
Tlx. 630668 AENEA F

Mr. J.-P. OLIVIER
Head, Division of Radiation Protection
and Waste Management
38, Boulevard Suchet
F-75016 Paris
Tel.: 45249695
Tlx.: 630668 AENEA

Mr. S.G. CARLYLE
Division of Radiation Protection
and Waste Management
OECD/Nuclear Energy Agency
38 Boulevard Suchet
F-75016 Paris
France
Tel.: 45249627
Tlx.: 630668 AENEA

Mr. K. BRAGG
Division of Radiation Protection
and Waste Management
OECD/Nuclear Energy Agency
38 Boulevard Suchet
F-75016 Paris
France
Tel.: 45249659
Tlx.: 630558 AENEA

Mr. P. NAGEL
NEA Data Bank
Bâtiment 45
F-91191 Gif-sur-Yvette
Tel.: 49086092
Tlx.: 690920 NEA DATA

Mr. P. DIAZ MUNOZ
NEA Data Bank
Bâtiment 45
F-91191 Gif-sur-Yvette
Tel.: 49086093
Tlx.: 690920 NEA DATA