Prioritization of Model Support Activities for Performance and Safety Assessments - 17111

Roger Seitz

Savannah River National Laboratory

ABSTRACT

Performance and Safety Assessments (PAs) to support disposal of radioactive waste and tank farm closure consider the performance of a wide variety of wastes, facilities and natural systems over very long time frames. Within the United States Department of Energy - Office of Environmental Management (DOE-EM), several PAs are currently being developed and similar applications are underway at numerous locations around the world. The Savannah River National Laboratory (SRNL) is providing technical support for PAs at several DOE-EM sites and developed recommendations for approaches to prioritize model support activities to help focus efforts on activities that would be expected to significantly influence decision-making.

A general approach has been developed to identify data needs for the modeling, foster integration and communication between the PA team and the groups providing model support, and document the basis for prioritization of specific model support efforts. The approach addresses development of the rationale for efforts to address key needs and also describe the rationale for not pursuing efforts that are not expected to influence the conclusions of the PA. The approach will be of use for groups conducting PAs for waste disposal and can also be applied for other modeling efforts for site restoration activities (e.g., decommissioning, environmental remediation, etc.).

INTRODUCTION

PAs are required for radioactive waste disposal and for closure of tank farms at DOE sites. The PAs provide a quantitative evaluation of the potential doses that could result from potential releases from these facilities over very long time frames. The conceptual and mathematical models used for a PA include large numbers of inputs that are required for application of computer codes. This leads to the potential for significant model support efforts (data collection, conceptual model development, etc.) to populate the inputs for the PA. There is a need to prioritize the efforts to collect data and develop conceptual models in order to better focus the scope of the model support activities. The large numbers of inputs and assumptions associated with PAs leads to challenges to address questions like: How much data are needed to support the inputs for the PAs? When are generic data sufficient for a given assumption? Which data and assumptions should be the focus of the experimental program?

When considering the extent and focus of model support activities, it is important to maintain perspective that, in general, a PA is not intended to predict exactly what will occur in the future. Rather, a PA is intended to provide information to help

decision-makers develop waste acceptance criteria and determine whether there is a reasonable expectation that a disposal facility will perform in compliance with the applicable performance objectives [1]. These are different considerations that, in turn, lead to different needs for input data. When considering uncertainty for the PA applications, the focus shifts from an intent to quantify uncertainty in the results of the modeling to that of identifying specific uncertainties which could result in a different decision regarding compliance or acceptance of a specific waste stream (i.e., Is there reasonable expectation that the dose will be less than 25 mrem/yr rather than, what will the dose be over 1,000 years or more?).

This paper describes a general approach to identify needs and prioritize the level of effort for collection of data based on the needs of the PA. Recommendations from the National Council on Radiation Protection and Measurements (NCRP) are described to highlight expectations for PA modeling and provide perspective for prioritization of model support activities. A general approach for the prioritization of data needs for the PA is then described.

NCRP RECOMMENDATIONS

NCRP Report 152 [1] provides recommendations for development of PAs for near surface disposal facilities. The NCRP report highlights the importance of, and challenges associated with, development of conceptual models and providing the input data to support those models. Fig. 1, taken from the NCRP report, illustrates the different components leading to a PA model and highlights that reviewers tend to focus more on the data and conceptual models that form the basis for the PA, which in turn emphasizes the importance of these parts of the PA process. The challenge is that there are hundreds of potential inputs for a PA that must be considered, but it is not realistic to plan to embark on detailed programs to collect site- and/or facility-specific data to support all of those inputs. Thus, the NCRP also provides recommendations for approaches to prioritize data collection and model refinements based on the specific needs for a disposal facility.

The concept of “importance analysis” is introduced in the NCRP report to highlight the use of a focused version of sensitivity and uncertainty analysis that identifies factors that are most significant in the context of the decision to be made based on the PA. NCRP Report 152 places strong emphasis on a needs-based approach to data collection:

> *“Data collection should be driven by needs of performance assessment. This view is a cornerstone of an iterative approach to performance assessment… Since data collection is costly, it is inefficient to obtain many types of site- and radionuclide-specific data at the start of the performance assessment process. In an iterative approach, results of initial modeling studies that are based on limited data are used to identify important data needs. Subsequent iterations then become more detailed in those areas of greatest concern, and they may require that additional data be collected.”*

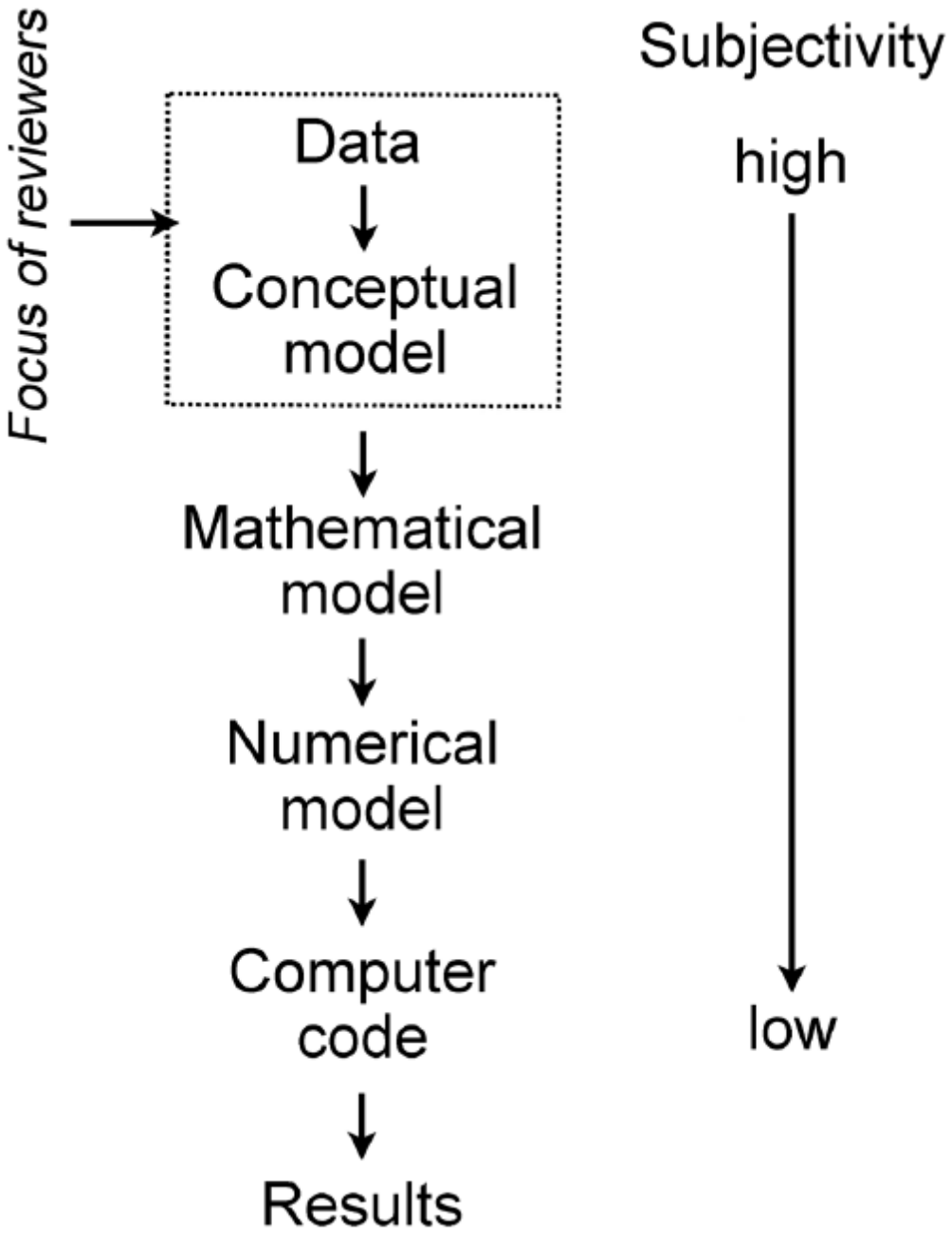

Fig. 1. Different components in the PA modeling process highlighting the focus of reviewers on assumptions about data and conceptual models [1].

The iterative approach that is applied for PAs reflects the recognition that uncertainty is an unavoidable aspect of decisions about the behavior of complex, underground waste disposal systems over very long periods of time extending hundreds and thousands of years in the future. NCRP Report 152 stresses that

> "*…over these time frames, there is no question that uncertainties exist, and that a decision maker must account for them. However, there are important questions about the nature of these uncertainties, and about how to treat them in a way that leads to reasonable decisions regarding regulatory compliance.*"

The important point is that it is not realistic to try to quantify all of the uncertainties. An approach is needed that seeks to identify and acknowledge the uncertainties and efficiently address and manage them. Use of a graded and iterative approach provides a means to start the PA process with available information and use PA modeling results to identify the key assumptions that influence a decision, and then as necessary, refine those aspects of the PA based on the potential to change a decision.

GENERAL APPROACH

Hundreds of potential inputs need to be considered for a PA. It is not realistic or efficient to assume that extensive efforts are needed to seek detailed data for every input parameter for the PA. An effective approach to prioritization needs to integrate the efforts of those providing the data and models for the PA and the team conducting the PA. The general approach described in this white paper focuses on identifying the necessary inputs, considering existing information, providing perspective on the uncertainty and importance of different inputs, and prioritizing investments in model support (data collection, conceptual understanding) based on the influence on the decision to be made. This emphasis on the decisions to be made are critical because as discussed in the previous section, priorities need to be based on whether uncertainty regarding an input can change a decision rather than just changing the model results in a manner that will not impact the decision.

Initial Perspectives

At large DOE sites, which can have multiple PAs and numerous risk assessments, there is an ability to begin, at a relatively high level, to narrow down the universe of inputs for a PA to a more manageable list with the potential to be important for the PA that may require additional model support. For example, other PAs or risk assessments at a site provide valuable insights that may be directly applicable to a PA for a new facility. Initial efforts on a PA often start from the systems view of the PA and consider best available information where site-and waste-form specific information are not available. Table I provides an example of how this first level of information could be presented.

Table I. Example categories of input data and general impressions of the availability of data and potential needs for a PA.

	Availability of Data	Level of Need
Human Exposure	Defined for other approved PAs at the site.	Very low, generally accepted approaches in place.
Natural System	Numerous modeling efforts at the site, including recently approved PAs.	Low, but there is a need for confirmation of applicability of existing information and update it based on conditions at the facility.
Engineered Features	Significant information on cover and liner systems. Some data on cementitious materials.	Low/Med, may need information on containers/barriers not considered in detail in other PAs.
Waste Forms	Limited information available for new waste forms. Specific material properties not available.	High, lack of information available for expected high inventory waste forms.

Table I provides a starting point for discussion about information that is already available and provides general perspective about areas that are likely to be of greatest need. It is not unusual that there is a need for waste form-specific information to confirm the initial assumptions. Investing some initial effort to document high-level perspective at this stage provides a starting point for potential debate about the relative need for different types of data (e.g., Is there information available that is not addressed in the table? Does everyone agree with the general statements in the table? If not, what needs to be changed?).

This approach also provides a means to identify some potential areas of interest before initial PA modeling work has been completed. The first priority will often be focused on areas where site-specific information are not available. Such testing may not be based on results of the PA that suggest a need, but based on an expectation of influence on the PA and the basic need to provide site- or waste form-specific information to confirm or replace generic assumptions. This can be a balancing act, because generic information may be sufficient for many inputs, so there is some judgment at this point about the expected influence of a given input. Use of available information provides a means to identify areas where further information is needed. The examples in this white paper reflect the state of a hypothetical process where limited modeling using available information has been conducted.

As indicated in Table I, the data collection programs often do not need to be focused on human exposure, as those assumptions are often well defined from previous PA or risk assessment efforts at the site. Likewise, if the facility in consideration is located at a site where other modeling efforts have been conducted, there will be a substantial understanding of the natural system and a sense of what is and is not important. Inevitably, there may be specific considerations at the location of the disposal facility that need to be addressed, but a number of aspects of the natural system are likely to be sufficiently understood for the purposes of the PA. Sensitivity analyses addressing the natural system from other PAs also provide perspective about the importance of different inputs.

The engineered system often includes features specific to the facility being considered, but relevant information may be available from other facilities at the site. For example, there may have been previous studies of cover performance at the site. Also, at a drier site, other PAs or risk assessments may have shown that the range of expected performance of covers is generally sufficient to meet requirements necessary for a new facility. However, assumptions related to performance of engineered systems can be more facility-specific in the context of the waste being disposed.

Waste forms can be an area where additional information is needed to confirm or update assumptions based on available information, because the form can be facility-specific. There may be similarities with other disposal facilities, but there may be high inventory, facility-specific waste forms where credit needs to be taken.

Prioritization

This section describes an approach for identification of higher priority model support activities. Fig. 2 provides a general process to identify the specific data expected to be the greatest need. The figure provides a rough concept for the flow of information and integration of the PA modeling with model support activities. PA modeling is reflected on the left side and model support activities on the right side. The center column represents the sharing of information and decision-making regarding key inputs, including specification of areas of model support for additional study and/or refinement.

The general flow starts at Box 1 with the PA team defining an initial conceptual model and seeking input to populate the data needed for those initial models. This dialogue can occur formally through written documents (e.g., model descriptions, calculations) and through formal working meetings involving PA and model support teams. Communications should also be maintained informally through routine conversations and meetings.

Box 2 is an integrating activity to identify available supporting information to populate the model in Box 1. The dashed box at the top of the column under model support represents existing information that can be used to support development and population of inputs for a conceptual model. Data packages may already be available that can be used as input for the initial stage of the PA. Some may be more generic, but can be used for the initial calculations.

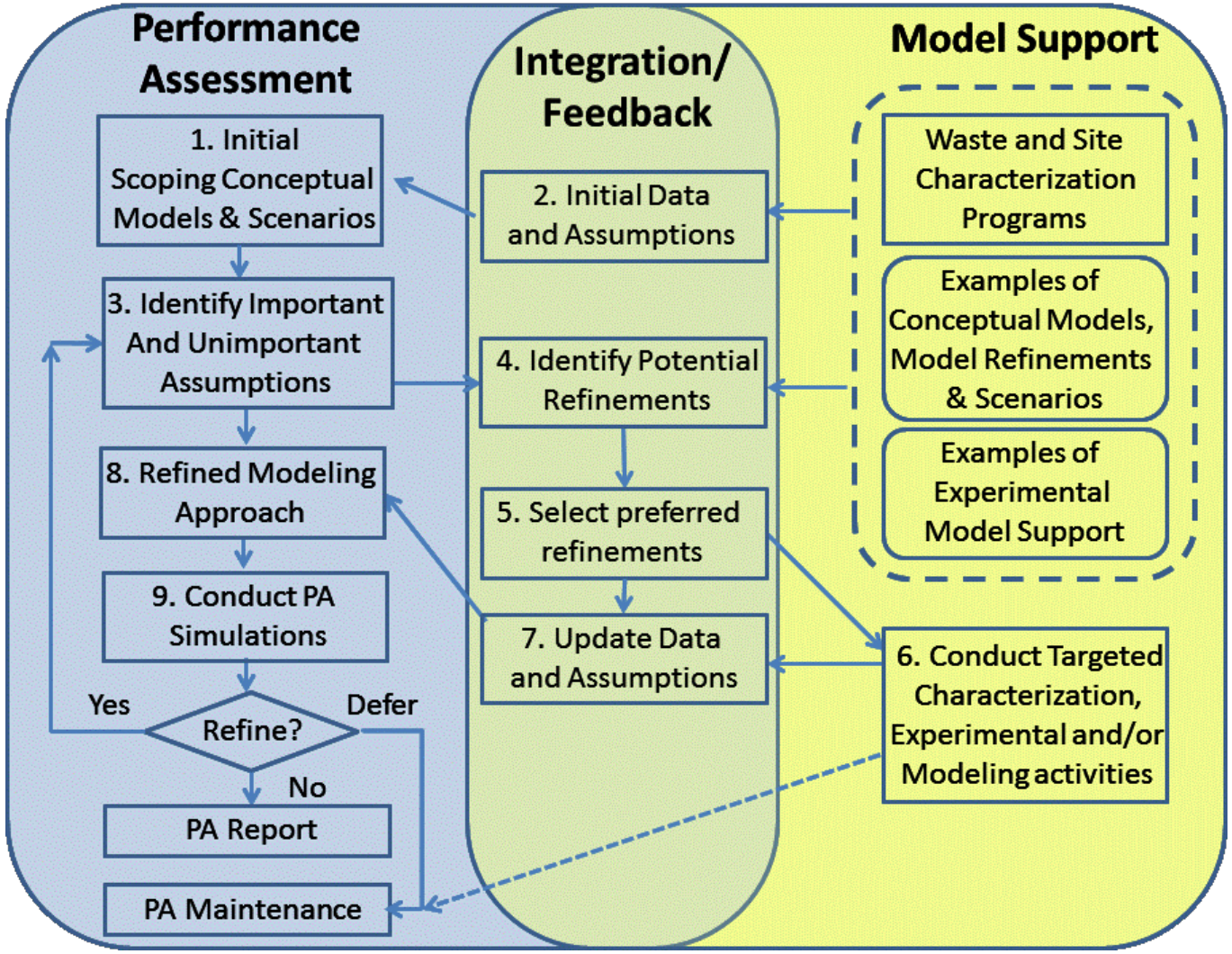

Fig. 2. Conceptual Flow Chart for Integration of PA and Model Support Activities. Note that depending on the duration and priority of activities, some refinement can occur during the development of the PA and others will occur during maintenance.

Box 3 includes the implementation of initial PA modeling with some emphasis on identification of inputs that have the greatest influence on the conclusions of the PA. Likewise, this discussion should also address inputs that are relatively unimportant for the conclusions. The initial calculations are also used to provide insights regarding inputs that have a significant influence on the release rates from a waste form (and those with minimal influence). Table II provides some generic examples of how this information may be presented and evaluated.

Table II. Examples of Assumptions and Needs for Waste Forms.

Waste Form	**Assumptions**	**Potential Data Needs**	**Vulnerabilities**
Filter Media *I-129 release is a key contributor in first iteration of PA*	Minimal credit for K_d and diffusion filter media Encapsulated in oxidized material with paste properties	Properties of clean encapsulation material, including redox Diffusion coefficients and K_d (Iodine, ?) for encapsulation	Properties not based on actual formulations Oxidizing conditions increase K_d for I-129
Ion Exchange Resin	Oxidized resin with no retention of contaminants Stabilized, waste form has properties of oxidized mortar K_d of waste form based on weighted average of K_d in waste & grout	Confirm material properties of final waste form Redox of final waste form K_d of resin and diffusion coefficients in waste form	Properties not based on actual formulations Properties potentially optimistic for unstable resin Oxidizing conditions increase K_d for I-129
Ag-mordenite *Release rates are expected to be low, even with pessimistic K_d*	K_d at low end of range based on testing with water representative of cementitious material Stabilized waste form has properties of oxidized, mortar K_d of waste form based on weighted average of K_d in waste and grout	Confirm material properties of final waste form Redox of final waste form K_d of waste	Defensibility of K_d

Note: This table focuses on vulnerabilities for defensibility. The pessimistic-bias that is built-in by some of the assumptions is not addressed, but could be addressed as needed in testing.

As discussed above, the true indication of “importance” is related to influence on the conclusions of the PA (e.g., comply or not comply). In early PA calculations, the results can provide some indication of factors controlling releases with some limited links to the overall conclusions (e.g., total dose). As the more complete simulations are conducted, the priorities can be further confirmed in context of the conclusions (i.e., an input parameter may be important to the release rate, but the release rates may all be low enough that, regardless of the input value, all of the release rates may result in an acceptable conclusion).

Box 4 is the integrated activity to identify potential refinements to model data and assumptions that are expected to be beneficial for improved decision making. Box 5 is an integrated activity to specify the key refinements that are to be considered based on availability of information and implementation considerations. This white paper provides examples of Boxes 4 and 5. This information then drives Box 6 where the model support activities for targeted characterization, experimental and or modeling refinements are conducted. Information from Box 6 is obtained in the proper form to support updated modeling assumptions in Box 7. These assumptions are implemented into the PA models in Box 8 and then the modeling simulations are conducted in Box 9. After Box 9, the need for further refinements or updates is assessed which can feed back to the earlier steps in the process or lead to a conclusion that the assessment is sufficient to support the decision.

Note that the approach described in Fig. 2 can be conducted during development of the PA and as a part of PA maintenance depending on the duration of the effort required for activities in Box 6 and specific priorities relative to the significance for the conclusions of the PA. It can be decided to make some refinements as the PA is being developed and other refinements may be deferred and addressed as part of the PA maintenance process.

SUMMARY

PAs to support disposal of radioactive waste and tank closure consider the performance of a wide variety of wastes, facilities and natural systems over very long time frames. Within DOE-EM, several PAs are currently being developed and similar applications are underway at numerous locations around the world. SRNL is providing technical support for PAs at several DOE-EM sites and has developed recommendations for approaches to prioritize model support activities to help focus efforts on activities that would be expected to significantly influence decision-making. This leads to a more efficient and cost-effective implementation of PAs that is also focused on the areas that are the greatest concern.

Hundreds of potential input parameters are considered to support the modeling that is conducted for PAs. The inputs must be defensible in the context of the PA objectives and how the model results are used. Data collection and model refinement efforts (model support) can be costly and time consuming and it is not realistic or efficient to plan to embark on detailed programs to collect site- and/or facility-specific data to support all of those inputs.

An effective approach to prioritization of model support activities needs to integrate the efforts of those providing the data and models for the PA and the team conducting the PA. The general approach described in this paper focuses on prioritizing investments in model support based on the expected influence on the decision to be made. This emphasis on the decision is critical because priorities need to be based on whether uncertainty regarding an input can change a decision rather than just changing the model results in a manner that will not impact the decision. The NCRP recommendations for PA introduced the concept of “importance analysis” to reflect this distinction.

A general approach has been developed that addresses the identification of data needs for the modeling, fostering integration and communication between the PA team and the groups providing model support, and documentation of the basis for prioritization of specific model support efforts. The approach addresses development of the rationale for efforts to address key needs and also describe the rationale for not pursuing efforts that are not expected to influence the conclusions of the PA. The approach will be of use for groups conducting PAs for waste disposal and can also be applied for other modeling efforts for site restoration activities (e.g., decommissioning, environmental remediation, etc.).

REFERENCES

1. National Council on Radiation Protection and Measurements, 2005, “Performance Assessment of Near-Surface Facilities for Disposal of Low-Level Radioactive Wastes,” NCRP Report No. 152, Bethesda, MD.