DEVELOPMENT OF REGULATORY GUIDANCE FOR PERFORMANCE ASSESSMENT OF LOW-LEVEL RADIOACTIVE WASTE SITES

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ABSTRACT

The United States Nuclear Regulatory Commission (NRC) is carrying out a program to improve staff capability and develop regulatory guidance for performance assessments (PAs) of low-level waste disposal facilities currently being developed in the United States. The program's primary goals are: 1) to enhance NRC staff capability to review and evaluate a license applicant's PA, and 2) to develop specific regulatory guidance for PAs. The plan is divided into two phases. Phase I focuses on enhancing in-house PA capability and developing regulatory guidance. Phase II focuses on augmenting this core capability with a more comprehensive and advanced ability. The initial program is concentrating on conducting a PA of a hypothetical disposal facility and environs using real site characterization and inventory data and a hypothetical engineered facility. The test case simulations are being done using an existing performance assessment methodology developed by Sandia National Laboratories for NRC. This approach is allowing NRC to evaluate a basic set of models used in PAs, while building on the staff's capability to use an array of codes in different modeling areas. This work is forming the core of knowledge and experience necessary to provide guidance on conducting PAs.

INTRODUCTION

The Code of Federal Regulations, Title 10, Chapter 1, Part 61 (10 CFR Part 61) specifies performance objectives for low-level waste (LLW) disposal facilities (1). Low-level waste performance assessments (LLWPAs) are an essential component of the licensing process, to provide reasonable assurance that the long-term performance objectives are met, and that the public health and safety and the environment are protected. Because of the uncertainties inherent in analyzing natural and engineered systems, performance assessment (PA) modeling can not reasonably be expected to be an exact representation of an actual disposal system or provide a precise prediction of dose. Rather, PA modeling is a site-specific tool for investigating whether it is likely that the performance objectives will be met given the assumptions and conditions used in the model(s) of the disposal facility and environment. The Nuclear Regulatory Commission's (NRC's) strategy is to invoke a reasonably conservative approach to PA modeling such that the relevant behavior of the system is bounded by the calculations (2,3). Excessively conservative or "worst case" scenarios are not recommended because they do not provide any meaningful insight into the behavior of the facility. Given the large number of variables and their associated uncertainties in a PA model, the NRC is developing regulatory guidance for conducting PAs of LLW disposal facilities. This guidance will address some important technical issues in PA modeling and will provide a framework and technical basis for conducting and evaluating PAs of LLW disposal facilities.

PERFORMANCE ASSESSMENT PROGRAM PLAN

The program plan for enhancing staff capability and providing regulatory guidance has been developed through the Performance Assessment Working Group (PAWG) at NRC. PAWG is composed of staff from both the Office of Nuclear Material Safety and Safeguards, Low-Level Waste Management Branch (NMSS/LLWM) and the Office of Nuclear Regulatory Research, Waste Management Branch (RES/WMB). The plan is broadly divided into two areas: 1) the improvement of staff capability to develop, conduct, and evaluate PAs, and 2) the development of guidance on LLWPAs. These interrelated activities are being conducted by NRC staff with the assistance of outside contractors. The program plan has been presented to the NRC Commissioners in a policy issue (information) paper and is available to the public (4).

The program will be carried out in two phases. Phase I (FY92-FY93) will involve developing regulatory guidance based on staff work and research programs, improving staff experience in conducting integrated LLWPAs, identifying areas requiring further work, and providing technical assistance to States. Work in FY92 focuses on improving staff capability, developing a draft branch technical position (BTP) on LLWPA, and revising Section 6 of the Standard Review Plan (SRP) (5). Phase I will continue, in FY93, with further improvement of this capability and development of a draft Regulatory Guide on LLWPA.

The Phase I activities will not fully address all the technical issues in LLWPA. For example, results from current research projects in concrete performance, source term analyses, and stochastic modeling will not be fully completed until Phase II (although intermediate results are available now). In addition, general progress in PA-related fields of study will likely permit some of the more difficult issues to be more fully resolved in Phase II.

Phase II, which will begin in FY94, will aim to *maintain* staff capability and continue to provide technical assistance, as required. It will also provide more detailed and extensive analyses of problem areas identified in Phase I, upgrade and improve models and codes from the research program, and factor new developments in LLWPA into the performance assessment methodology (PAM). Phase II will also include revisions of the guidance documents developed in Phase I, to include new developments and research results.

TEST-CASE MODELING

The approach for enhancing staff capability involves conducting test-case simulations using, to the extent possible, real site characterization and inventory data, and a hypothetical

engineered facility design similar to those being considered in some regional compacts and States. This work will assist staff in: 1.) understanding significant processes in LLWPAs; 2.) developing conceptual models; 3.) selecting and using appropriate computer codes; 4.) integrating sub-model input/output; 5.) evaluating uncertainty and sensitivity; and 6.) identifying technical issues and developing strategies for resolving them.

In the Phase I test-case, the staff is following the PAM developed by Sandia National laboratory (SNL) (2). Work elements for the simulations correspond directly to the structure of the PAM. By using existing methodologies and codes, the staff will acquire the basic knowledge and experience necessary for conducting LLWPA modeling and will also gain insight into the uncertainties and sensitivities of the various models currently used in LLWPA. This work is generating within the staff, a better knowledge of the usefulness and limitations of different approaches and the range of issues that a particular type of model can deal with. This modeling experience thus provides the basis for resolving technical issues in LLWPA and also for developing regulatory positions applicable to LLWPAs.

PERFORMANCE ASSESSMENT METHODOLOGY

The NRC formulated a PA strategy in 1987, that promotes a modular approach to LLW facility systems modeling (3). The goal is to quantify the potential release and transport of radionuclides through significant environmental pathways. The PAM, which is based upon this strategy, embodies a generalized conceptual model of a LLW disposal facility and environs for doing PA analyses. The PAM is broken into individual sub-modeling components including: a.) infiltration; b.) source term; c.) engineered barriers; d.) transport via groundwater, surface water, and air; and e.) dose (see Fig. 1). The modular approach allows a mix of both complex and simple models to be used in the overall LLWPA. The appropriate degree of modeling complexity within a module is determined by the availability of suitable data and its associated uncertainty.

In identifying and assessing appropriate sub-models for LLWPA, SNL noted that models for analyzing several important areas (e.g., infiltration into cover systems, concrete barrier degradation, and waste leaching) required improvement (6). The NRC continues to support research in these and other LLWPA areas (discussed below). The NRC also is supporting further SNL improvement of the PAM. Where sub-model uncertainty is large, a combination of bounding conditions, realistically conservative assumptions, and heightened attention to quantifying overall uncertainties is a suitable approach.

The computational elements of the PAM are comprised of conceptual models that are generally incorporated in computer codes. The NRC and its contractors have identified, developed, and tested a variety of computer codes suitable for LLWPA analyses. The SRP, NUREG 1200 (5), requires that codes used for LLWPA must be sufficiently documented, verified, and evaluated according to a quality assurance plan (7,8). The NRC recognizes that the choice of a particular code for modeling is governed not only by site specific issues, but also by the continual evolution and improvement of models and codes. Therefore, the NRC does not sanction specific codes for LLWPA.

GUIDANCE DEVELOPMENT

NRC documents that currently provide some guidance about LLWPA related issues include: the Standard Format and Content Guide, NUREG-1199 (9); the SRP, NUREG-1200 (5); and the Environmental Standard Review Plan, NUREG-1300 (10). The most significant of these documents, in terms of its applicability to PA, is the SRP. However, it provides only general guidance on LLWPA and does not address many specific issues or recommend means for resolving them. The SRP is currently being revised and Section 6, which deals with PA, is scheduled to be completed by the end of FY92. The development of a draft BTP on LLWPA is being coordinated with the SRP revisions.

The development of a BTP on LLWPA will provide acceptable approaches and technical bases for evaluating the performance of proposed LLW disposal facilities. This information will be used by NRC in evaluations of license applications. The BTP may also serve as a reference document for States and license applicants in determining issues and approaches that need to be considered in a PA. The BTP will address specific technical and methodological issues in PA modeling and provide guidance for resolving those issues. PAWG identified a number of LLWPA issues (discussed below) that need to be addressed by specific guidance, supported by sound technical analysis. As discussed in the program plan (4), this guidance is being developed both from NRC's supporting LLW research program and from staff experience with PA modeling. The BTP will form the foundation for developing a regulatory guide on LLWPA.

RESEARCH PROGRAM

The fields of study that form the technical and scientific basis for PA are continually evolving and improving. The NRC LLW research program, which is described in NUREG-1380 (11), is supporting work that is making significant contributions to PA-related fields. Table I lists the LLWPA research projects that NRC is funding. An important goal of the LLWPA program plan is to incorporate recent and on-going developments, for example in infiltration and source term modeling, into the existing PAM and also into improved regulatory guidance.

Another important area of research is the performance of engineered structures in LLW facilities. Much of the design work done since the publication of 10 CFR Part 61 involves engineered structures, such as concrete vaults and complex covers, to help isolate waste from the accessible environment. An important goal of the LLWPA program is to better account for these engineered features in the PAM, and to develop specific guidance for evaluating their performance.

KEY TECHNICAL ISSUES

Identification of key technical issues in LLWPA and the NRC staff's approach for resolving them will be incorporated into a BTP on Performance Assessment. Some of the categories of technical issues to be addressed include the following:

a. understanding the complete disposal system and developing conceptual model(s);

b. determining the source term (waste characterization and release processes);

c. treatment of engineered barriers and effects of aging;

d. geochemical parameters affecting transport;

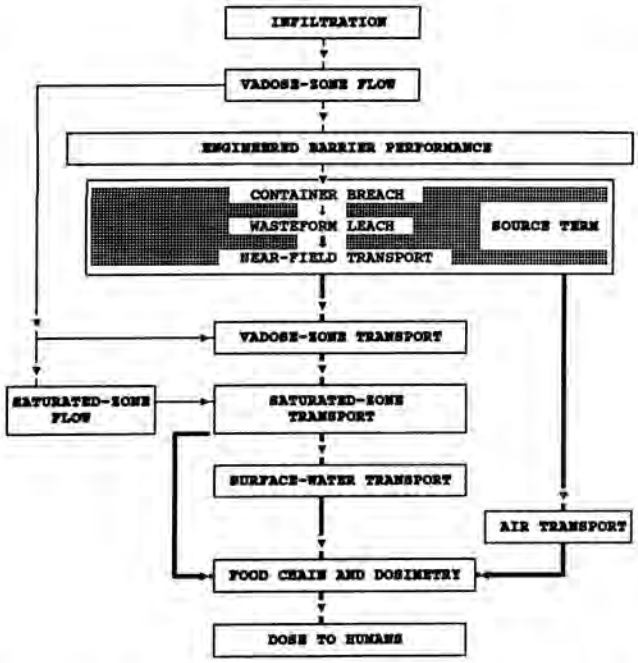

Fig. 1. Modular conceptual model of processes in low-level waste performance assessment (modified from Ref. 2). Single lines correspond to water flow pathways, double lines correspond to radionuclide transport pathways, and the stippled region corresponds to the disposal cell(s).

e. identifying significant transport pathways (e.g., groundwater, surface water, and air);

f. exposure-pathways, uptake models, and dose calculations;

g. performing sensitivity and uncertainty analyses;

h. evolution of natural processes;

i. identifying processes and events requiring analysis;

j. time frame for PA analyses.

Some of these issues are directed toward an overall understanding of the system being modeled and of the modeling process. Others are the subjects of ongoing research and presently may not have explicit solutions. In addition, some are related to site-specific conditions and, hence, generic solutions that are applicable to all sites under all conditions are not feasible. Given these caveats, staff's approach, in developing guidance for issues where explicit solutions are not presently feasible, will be to provide strategies for resolving these issues in the context of doing a PA.

COOPERATIVE LLWPA PROJECTS

NRC is participating in a variety of national and international cooperative projects to share information and gain the benefit of other LLWPA programs. NRC is coordinating LLWPA activities with the U.S. Department of Energy (DOE) by participating in DOE's Performance Assessment Task Team (PATT), which is involved in PA for management of defense waste generated at DOE laboratories. Another way NRC interacts with DOE, is through the National LLW Management Program Office, operated by EG&G at the Idaho National Engineering Laboratory (INEL), for DOE. The

TABLE I

NRC Contractors & LLWPA Research Programs

Sandia National Laboratory
- Performance Assessment Methodology
Pacific Northwest Laboratory (PNL)
- Infiltration Evaluation Methodology (IEM)
- Low-Level Waste Performance Assessment
Idaho National Engineering Laboratory
- Engineered Barriers
- Waste Form Leaching Studies
- Covers
Brookhaven National Laboratory
- Source Term Model
National Institute of Standards and Technology
- Concrete Structures
- Covers
Massachusetts Institute of Technology
- Stochastic Modeling and Site Characterization
New Mexico State University
- Las Cruces Trench Study (validation)
University of Arizona
- Las Cruces Trench Study (with NMSU)
- IEM (with PNL)
University of California - Berkeley
- Covers

EG&G group at INEL provides technical assistance on commercial LLW disposal to the States under the 1985 Low-Level Radioactive Waste Policy Amendments Act. NRC has also established regular cooperative discussions about LLWPA issues with DOE Headquarters.

In the international arena, NRC is presently involved in the International Cooperative Study for Validating Geosphere Transport Models (INTRAVAL) project. NRC also participated in earlier groundwater modeling projects such as the International Cooperative Study of Transport Codes (INTRACOIN) and the International Cooperative Study of Hydrogeologic Flow Models (HYDROCOIN). In addition, NRC staff is actively participating in cooperative exchange programs with several other countries, as well as with the Nuclear Energy Agency of the Organization of Economic Cooperation and Development (NEA/OECD).

SUMMARY

In summary, NRC has developed and implemented an LLWPA Program Plan. The goals of this phased program are: 1) to enhance NRC capability to evaluate and conduct LLWPAs, and 2) to develop more specific regulatory guidance for LLWPA. Phase I (FY92 - FY93) aims to increase staff PA capability through a series of test-case simulations, to produce a draft branch technical position on LLWPA in FY92, and to produce a draft regulatory guide on LLWPA in FY93. Phase II (FY94 and beyond) aims to supplement staff experience gained in Phase I with more detailed and extensive analyses of problem areas, to incorporate results from the

research program into the PAM, and to revise LLWPA guidance, as needed. This program will substantially increase NRC's ability to provide technically correct and credible answers to difficult questions and issues concerning LLW disposal facilities and to provide LLWPA technical assistance to States.

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