UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 17, 1997

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: APPLICATION OF PROBABILISTIC RISK ASSESSMENT METHODS TO PERFORMANCE ASSESSMENT IN THE NRC HIGH-LEVEL WASTE PROGRAM

Dear Dr. Garrick:

I am responding to your letter of October 31, 1997, to the Chairman, providing the Advisory Committee on Nuclear Waste's (hereafter the Committee's) observations and recommendations on the application of probabilistic risk assessment (PRA) methods to performance assessment (PA) in the High-Level Waste (HLW) program. The Committee's letter, in part, expands on recommendations made in a prior letter to the Chairman (dated October 8, 1997) reporting on the evaluation of the Nuclear Regulatory Commission's PA capability in the HLW program area.

The staff shares the Committee's stated goal for PA in the HLW area -- that there be transparency and clarity in the analysis to support fully the decision-making process. Further, we agree that PA provides the tools to understand the system, so that significant resources are focused on reducing uncertainties that have a significant impact on meeting the compliance measure rather than on reducing uncertainties of small import. The staff is, in fact, implementing this in its day-to-day activities related to identifying and resolving key technical issues. I address the Committee's specific recommendations in detail below.

- The Committee recommends that, to as great an extent as possible, realistic models and parameters be used so that the results of the PAs represent the full range of values that can realistically be supported by the data. In principle, the staff agrees with the Committee's recommendation. However, the level of realism incorporated into abstracted models of any PA code is a function of the data available on site and design features as well as the resources available to carry out the PA. For example, before the discovery of elevated chlorine-36 levels at repository depths in the exploratory studies facilities at Yucca Mountain, the Department of Energy (DOE) used a substantially lower range of values for fluxes through the repository in its PAs than it now uses. At that time, DOE considered that range to be a realistic parameter range although NRC disagreed and used a range with substantially higher values in its Phase 2 assessment (significantly closer to the range DOE now believes is realistic for flux through the repository). Similarly, NRC could ensure that the models in the Total-system Performance Assessment (TPA) 3.1 code more "realistically" depict the hydrologic characteristics of the site (e.g., incorporate 3-dimensional flow and transport models vs. 1-dimensional models). However, because NRC has fewer resources than DOE and because the intended purpose of NRC's code is the review of DOE's PA, some practical simplifications that are consistent with existing data are incorporated into the staff's PAs.

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Although these simplifications tend to move abstracted models toward less realism and more conservatism for selected capabilities, they do not necessarily result in ultraconservative analyses. Moreover, the simplifications are a reflection of NRC's goals for PA in the HLW area. Specifically, PA is used: 1) as a mechanism for developing an understanding of the site so as to facilitate prioritization of staff's work and 2) as a tool to perform an independent, albeit limited, evaluation of DOE's PAs. Regarding the first goal, if the staff finds areas of conservatism that need to be addressed because of the significance to performance, the staff will either reallocate resources to perform the necessary work or advise DOE of the need to address this issue. To accomplish the second goal, the staff has adopted the traditional regulatory approach by having an analysis that is conservative but is realistic enough to evaluate the validity of the licensee's analysis.

- The Committee also recommends that bounding and worst-case calculations be used primarily to screen out issues of little or no concern. The staff believes it is implementing this recommendation in its ongoing PA activities. As noted in the staff's response to the Committee's October 8, 1997, letter, in the development of its TPA 3.1 code, the staff has avoided, to the extent practicable, the use of bounding or worst-case models or parameter values and, instead, relies on models and assumptions that it considers to be technically defensible based on existing data. Simplifications that are prudently conservative are used to address: 1) those instances where narrowing the uncertainty associated with an aspect of repository performance (e.g., long-term performance of spent fuel cladding) may not be necessary to satisfactorily demonstrate compliance; and 2) those instances where schedules and resources do not permit reduction of the conservatism. Nevertheless, the staff intends to reevaluate the assumptions, models, and distributions of parameter values used in its PAs, iteratively, in the normal course of sensitivity studies and code revisions.

- The third recommendation asks that the TPA 3.1 code be reviewed for unrealistic results arising from bounding calculations embedded in the code. The Committee further recommends that ultraconservative models, assumptions, and parameter values be replaced by more realistic assumptions and probability distributions. The staff is implementing the first part of this recommendation in its ongoing PA activities. Specifically, the staff is continuing to implement an iterative process of examining the key assumptions, models, and distributions of parameter values in its analysis to assess: 1) their relative importance to the analysis as tied to the results, and 2) the appropriate levels of conservatism and/or optimism to be used. For example, the preliminary results from ongoing sensitivity studies at the process level suggest that further refinements are needed to provide greater confidence that the results reasonably reflect the performance of the site and reference design for a Yucca Mountain repository. Therefore, NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) staff are now working on refinements to the code before the initiation of system-level sensitivity studies.

  Regarding the second part of the Committee's recommendation, in the existing TPA 3.1 code, the staff incorporated assumptions, models, and distributions of parameter values that reflect the complexity associated with modeling the Yucca Mountain site, the variability of site parameters, and the uncertainty associated with the definition of the

conceptual models and parameter values. The staff has consciously attempted to use models, assumptions, and parameter values that can be technically defended.

- The Committee's fourth recommendation is that an event tree or similar approach for evaluating the TPA-3 model results should be developed and applied. The staff is aware of Dr. Garrick's longstanding interest in applying risk methods to aid in unraveling the results of the PA. The staff agrees and is in the initial stage of evaluating various methodologies that will permit the systematic evaluation of results and the identification of specific contributors to performance. Some of this work is related to importance analysis (see next bullet) and some is progressing in association with the staff's development of a risk-informed implementing rule for HLW. After defining an acceptable approach to identifying specific contributions to performance, it is anticipated that the need for DOE to perform such an analysis will be identified in either the site-specific high-level waste disposal implementing rule or accompanying guidance.
- The Committee's fifth recommendation suggests that appropriate importance measures be developed. As the Committee notes, NRC and CNWRA staffs are currently working on this task.
- The sixth and final recommendation of the Committee is that subsystem performance measures at specific pinch points in the analysis be defined. The staff, in the development of the Issue Resolution Status Report on Total System Performance Assessment, is in the process of defining "pinch points" (i.e., intermediate results from the PA analysis) that could be used as performance indicators at the subsystem level. These "pinch points" will take advantage of the existing model subsystem outputs as the Committee recommends and would, when provided, result in an additional benefit of providing additional transparency to the analysis.

The staff appreciates the Committee's observations and recommendations on the application of PRA methods to PA in the HLW program. The staff is already implementing the recommendations in its day-to-day PA activities and, therefore, believes that its PA activities will achieve the Committee's goal for PA in the HLW area.

Sincerely,

Original signed by L. Joseph Callan

L. Joseph Callan
Executive Director
for Operations

cc: Chairman Jackson
Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
SECY
CIO
CFO

Distribution: See Page 4

* See previous concurrence DOC: S:\DWM\PAHL\KIM\G970782 CP/PROOFED/DECEMBER 1, 1997

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NAME	KMcConnell/kv		TMcCartin		NEisenberg		EKraus by fax		MBell	
DATE	11/24/97		11/24/97		11/26/97		11/23/97		11/25/97	
OFC	DWM*		NMSS*		DEDR		EDO			
NAME	JGreeves		CJPaperiello		HLThompson		LJCallan			
DATE	11/29 /97		12/4/97		12/ 12 /97		12/12/ /97			

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SECY (CRC-97-1066)

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SECY

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L. Joseph Callan
Executive Director
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Commissioner McGaffigan
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NAME	KMcConnell/kv		TMcCartin		NEisenberg		EKraus by fax		MBell	
DATE	11/03/97		11/03/97		11/03/97		11/03/97		11/03/97	
OFC	DWM		NMSS		DEDR		EDO			
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DATE	11/12/97		11/ /97		11/ /97		11/ /97		11/ /97	

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 17, 1997

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: APPLICATION OF PROBABILISTIC RISK ASSESSMENT METHODS TO PERFORMANCE ASSESSMENT IN THE NRC HIGH-LEVEL WASTE PROGRAM

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Hugh L. Thompson Jr.

L. Joseph Callan
Executive Director
for Operations

cc: Chairman Jackson
Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
SECY
CIO
CFO

ACTION

EDO Principal Correspondence Control

FROM: DUE: 12/04/97 EDO CONTROL: G970782
DOC DT: 10/31/97
FINAL REPLY:

B. John Garrick
ACNW

TO:

Chairman Jackson

FOR SIGNATURE OF : ** GRN ** CRC NO: 97-1066

Callan, EDO

DESC:

APPLICATION OF PROBABILISTIC RISK ASSESSMENT METHODS TO PERFORMANCE ASSESSMENT IN THE NRC HIGH-LEVEL WASTE PROGRAM

DATE: 11/05/97

ASSIGNED TO: CONTACT:

NMSS Paperiello

SPECIAL INSTRUCTIONS OR REMARKS:

Prepare response to ACNW for EDO signature. Add Commissioners and SECY as cc's.

USE SUBJECT LINE IN RESPONSE.

ROUTING:

Callan
Thadani
Thompson
Norry
Blaha
Burns
Knapp, RES
Collins, NRR
Martin, AEOD
Cyr, OGC
Mitchell, OEDO
ACNW File

Tim/Keith work out with Norm who should respond

ACTION: Bell (Eisenberg)
Due to DWM
Director's Office: 11/24/97

cc: Greeves
Fedoline

DWM Action
Due to NMSS Director's Office
By 12/1/97
rec'd 11/6/97

rec'd 11/6 KU

11/6
11/6

OFFICE OF THE SECRETARY
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AUTHOR: B JOHN GARRICK
AFFILIATION: ADVISORY COMMITTEE ON NUCLEAR WASTE

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555

October 31 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Jackson:

SUBJECT: Application of Probabilistic Risk Assessment Methods to Performance Assessment in the NRC High-Level Waste Program

This letter provides the Commission with the Advisory Committee on Nuclear Waste's (ACNW's) observations and recommendations on the application of probabilistic risk assessment (PRA) methods to performance assessment (PA) in the High-Level Radioactive Waste (HLW) Program. We believe our recommendations enhance the Commission's policy of increasing the use of risk-informed, performance-based approaches in waste management. The Committee considers this issue a high-priority item because of the need for transparency and clarity[1] in the decision-making process, not only for the NRC's prelicensing and licensing activities for the proposed HLW repository at Yucca Mountain, but also for other waste-related activities, such as decommissioning, low-level waste management, and management of uranium mill tailings. The complexity of the proposed repository system at Yucca Mountain and the models that are intended to represent its performance over time necessitates some method for presenting the results that clearly indicates to the decision makers and to the public what the expected performance will be and what the main subsystem components are that contribute to that performance. The Committee firmly believes that certain PRA approaches can be successfully applied to the PA results for waste management.

Summary and Recommendations

In general, the Committee is impressed with the methods employed by both the NRC and the Department of Energy (DOE) in their work on PA. Analytically characterizing the performance of the proposed Yucca Mountain repository involves an unprecedented application of physical process modeling and probability methods. The progress in abstracting site characterization and facility design information into probabilistic PA (PPA) models has been extensive.

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[1] By "transparency" we mean the ability to see through the entire process, to understand the process; by "clarity" we mean the ability to discern the key elements in the analyses.

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Despite this considerable progress, the Committee does have some concerns about the staff's PA program. These concerns center around two primary issues. The Committee believes that PAs should follow the intent and spirit of the risk-assessment philosophy of developing realistic models with uncertainties included, as opposed to developing bounding or worst-case calculations. We also believe the assessments should enable unraveling the results into rank-ordered contributors to the overall risk or to the performance of the repository. The latter provides a solid basis for developing confidence in the design and meaningful risk-management practices.

Therefore, we recommend the following:

- To as great an extent as possible, realistic models and parameters should be used so that the results of the PAs represent the full range of values (i.e., upper and lower bounds, central tendency parameters, and the values in between) that realistically can be supported by the evidence.

- Bounding analysis and worst-case calculations should be used primarily to screen out issues of little or no concern, i.e., to scope the analysis, but not to be the basis for generating results that are clearly out of context with reality and, thus, that do not produce a framework for judging reality.

- The NRC Total Performance Assessment code, version 3.1 (TPA-3), should be reviewed for unrealistic results that arise from bounding calculations embedded in the code. Ultraconservative model assumptions and parameter values should be replaced with more realistic assumptions and probability distributions.

- An event tree or a similar approach for evaluating the TPA-3 model results emphasizing the systematic and efficient unraveling of results into specific contributors to performance should be developed and applied.

- Appropriate importance measures should be developed. We understand that staff from both the NRC and the Center for Nuclear Waste Regulatory Analyses (CNWRA) are currently working on this issue. The Committee encourages the continuation of this effort.

- Subsystem performance measures at specific pinch points[2] in the analysis, such as the flux of radionuclides released from the repository into the geosphere, should be defined. These performance measures might include the integrated release of radionuclides over time, or the release rate as a function of time. Both the NRC and DOE have indicated that their respective models are capable of providing intermediate results (e.g., source term output to the geosphere). Hence, the approach can take advantage of the existing model subsystem output capabilities.

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[2] Pinch points occur where outputs (material, energy, or information flow) from one module of the total system model become the inputs to another module.

Background

The comments in this letter have been developed, in part, on the basis of a working group meeting on the application of PRA methods to PA during the 93rd ACNW Meeting at the CNWRA in San Antonio, Texas, on July 24, 1997. Participants included representatives from: the PRA field; the Electric Power Research Institute; the DOE's Yucca Mountain Project; the Waste Isolation Pilot Plant PA Project; and the NRC staff. The Committee benefited from detailed NRC staff presentations on the HLW PA program and the NRC's TPA-3 code during the previous day's ACNW meeting on HLW PA capability. The Committee members and staff also observed the NRC/DOE technical exchange on DOE's Total System Performance Assessment activities and NRC's iterative performance assessment (IPA) efforts on July 21-22.

Accomplishments

The NRC staff's work on the revised TPA-3 code represents a pivotal effort. The staff has made longstanding, extraordinary efforts to ensure that appropriate site characterization information is collected and to understand the processes that ultimately may determine the performance of an HLW repository at Yucca Mountain. As part of the IPA program, the staff has developed approaches for abstracting site and design information and process models that have been incorporated into the TPA-3 model. The Committee commends this effort and notes that the recommendations previously presented are aimed primarily at developing more realistic models, mainly with respect to assumptions and scope, and improvements in processing the information that is the current output of the TPA-3 model. In particular, the Committee is not suggesting basic changes in the model but is encouraging more realistic assumptions and improvements in the methods for analyzing the results of the PAs.

Realistic Models

Probabilistic concepts have their greatest value in communicating confidence in the outcome of an event or process. They provide the tool for analysts to express their full state of knowledge about how likely an event or process is. The introduction of probabilistic analysis does not replace the deterministic models; rather, it allows a richer interpretation of results. Of course, the probabilities must be supported with appropriate evidence, and to the extent that the evidence is weak, the uncertainties are greater. Such communication is the essence of probabilistic analysis. Thus, the aim of PPA should be to "tell it like it is" on the basis of all the evidence available. The result is what the experts and, with public participation, society believes is likely to happen. A logical framework then exists to make decisions as conservative as desired, but within a framework that defines the level of conservatism.

Interpretation of the Results

Although there are clear differences between nuclear power plant PRAs and waste system PAs (which have been discussed with the Commission by both the NRC staff and the ACNW), a number of key similarities makes it possible to consider the use of PRA methods, such as the top-down event tree approach, to facilitate interpretation of PA results. Both PRAs and PAs

begin with a set of initial conditions (in PRAs these are called initiating events). In PAs, the initial conditions may consist of such phenomena as climate conditions, volcanic events, seismic events, or human intrusion. Both PRA and PAs use a modular approach to the analysis (in PRAs, this includes level-I, -II, and -III analyses; in PAs this includes analyses for infiltration, engineered barriers, source term, geosphere transport, biosphere uptake, and dose to the critical group). Both methodologies can be decomposed into logical pinch points for which specific performance measures can be developed (such as core damage for PRA and integrated release of radionuclides into the geosphere for PA). The goal is to develop a systematic and efficient method for identifying different inputs and outputs of the various modules that make up the full PA model in terms of their individual contribution to the overall performance of the repository. To do this may require a different approach in the way that scenarios are structured for PA.

At our workshop, candidate methods were presented for systematically and efficiently interpreting the results from PAs using a post-processing tool, such as an event tree approach. The postprocessor could make the results more transparent and sharpen our understanding of the total system model. The Committee believes that these techniques should be explored for TPA-3.

An important benefit of the proposed approach to interpreting PA results should be with respect to the program for evaluating key technical issues (KTIs). The postprocessor should greatly facilitate the task of determining the importance of individual KTIs to the overall performance of the repository. This will allow staff to allocate already scarce resources to the KTI program so that the focus is on the most important KTIs and subissue areas. The approach will also prove useful in determining where uncertainties are important to demonstrating compliance and where they do not really matter, even if they are large. Sometimes there is a tendency to focus only on the relative magnitude of the uncertainty in a model or parameter (large uncertainty is considered bad and small uncertainty is considered good), rather than on whether that uncertainty makes any significant difference to the bottom-line result, which is ultimately the health and safety of the public. The goal in the near term would be to avoid spending large resources on trying to reduce uncertainties that do not matter to the result. In the longer term, the goal is to be able to defend in a licensing hearing the specific staff positions in the safety evaluation report vis-a-vis the magnitudes of the uncertainties for different subsystems and for total system performance.

The Committee looks forward to following the staff's program in PA, and we are particularly interested in its progress on the two issues of transparency of results and the use of realistic models.

Sincerely,

B. John Garrick
Chairman