October 16, 2001

Dr. George M. Hornberger, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: REVIEW OF CHEMISTRY ISSUES AND RELATED NRC STAFF CAPABILITY FOR THE PROPOSED HLW REPOSITORY AT YUCCA MOUNTAIN

Dear Dr. Hornberger:

The Advisory Committee on Nuclear Waste (ACNW) issued a letter on August 13, 2001 to the Chairman, regarding chemistry and related staff capability for the proposed high-level waste repository at Yucca Mountain, Nevada. The letter, based on a review of the report by ACNW's Working Group on Chemistry Issues and Related NRC Capability for the Proposed High-Level Waste Repository at Yucca Mountain (Report attached), presents recommendations stemming from specific observations. The Working Group focused on waste package (WP) and drip shield corrosion, near-field (i.e., inside the drifts) and in-package chemistry, radionuclide mobilization and transport, and coupled thermal-hydrologic-chemical (THC) processes.

Three overarching issues are raised in the ACNW letter. These are 1) the adequacy of process-level modeling to address specific chemical issues, and abstractions of process models in the U.S. Department of Energy's (DOE's) Total System Performance Assessment (TSPA), 2) the potential effect of conservative assumptions on the credibility of analyses of the near-field and natural environments; and 3) the U.S. Nuclear Regulatory Commission's (NRC's) preparedness to address contingencies, such as changes in design or safety-case strategy.

Responses to these general issues are:

1) The staff shares the ACNW's concerns regarding the modeling of specific chemical issues, and notes that aspects of these concerns have been discussed by the staff in: (1) the Issue Resolution Status Reports for the Container Life and Source Term, Evolution of the Near-Field Environment, and Radionuclide Transport Key Technical Issues (KTIs); and (2) recent technical exchanges regarding Total System Performance Assessment and Integration KTI, on May 15 through 17, and August 6 through 9, 2001.

2) Regarding the comment on DOE's inconsistent use of conservative assumptions, the staff agrees with ACNW's concerns. DOE's documentation of its TSPA uses the word "conservatism" for a variety of reasons (e.g., basis for excluding a specific process in the TSPA, justification for the selection of a boundary condition for a model). The staff will continue to communicate with DOE on the need to clearly explain the TSPA and the associated technical support. Any claims that approaches are conservative should also be carefully explained and justified. The staff would like to point out that its review of the DOE's TSPA considers the technical support for the models, parameters, and assumptions.

3) Regarding NRC's preparedness to address contingencies, the staff envisions continuing its analyses of chemical issues, including those that might result from design changes. The ACNW indicates that the staff seems to be well-positioned to deal with impacts of evolution of design changes. For example, if an alternative repository design includes backfill, from its evaluation of previous repository designs which included backfill, the staff would be prepared to evaluate the effects on repository thermal behavior, near-field chemistry, mass transport, rockfall, and criticality. Finally, in response to changes in DOE's safety-case strategy, the staff has continued to develop realistic chemistry models such as radionuclide release/source-term models and in-package chemistry models. These efforts are used to improve our understanding of chemical conditions and processes important to performance, enabling our technical reviews of the DOE's site characterization and performance to be risk informed.

Responses to Recommendations

The ACNW letter included seven recommendations. Staff responses to the paraphrased ACNW recommendations are provided below.

Recommendation 1 The staff should continue exploring chemical issues associated with major design changes (e.g., a hot versus a cold repository, or use of backfill).

The staff plans continuing its analyses of chemical issues, including those that might result from design changes. The staff will continue to conduct NRC's Total-system Performance Assessment (TPA) exercises, with appropriate additional modeling, covering a wider range of repository temperatures. The additional modeling may include non-equilibrium localized chemistry for in-package and near-field. The staff will call on the knowledge which was obtained from analyses of the previous designs for future performance assessments (PAs) of backfill.

In the Technical Exchange on "Range of Thermal Operating Modes," held on September 18 through 19, 2001, the staff discussed with DOE, the option of a hot or cold repository, and also, the concerns ACNW identified regarding the modeling of specific chemical issues, and the inconsistent use of conservative assumptions. As a result of that meeting, NRC-DOE agreements were reached to resolve issues.

Recommendation 2 The staff should continue to be supported and encouraged in its efforts (1) to conduct independent analyses, (2) to evaluate DOE's TSPA, process models, and data, and (3) to establish independent computer code capability.

The staff agrees that completing an objective review of DOE's data, process models, and TSPA includes performing independent analyses. Examples of ongoing independent analyses that span a variety of levels in the hierarchical process of TSPA model development (e.g. data, process models, model abstractions for the TSPA, and the TSPA model itself) include: (1) experimentation at the CNWRA to address chemical data and process issues, (2) continued development and improvement to MULTIFLO and corrosion models, and (3) revision to the TPA code (version 5.0 is currently planned for FY02). Independent analyses allow the staff to identify issues and provide the staff with the expertise to accept or reject the DOE's compliance assessment. They verify DOE's positions for various chemical issues and provide additional knowledge bases for objective and universal evaluations of the DOE's positions. In addition, in

order to efficiently translate independent analyses into the review of DOE's data, process models, and TSPA, the staff has taken a proactive approach. Quite a few staff members have already completed a GoldSim Training Course held at NRC headquarters and the staff has requested the TOUGHREACT code used by DOE in the modeling of near-field chemistry. GoldSim is the computational platform that DOE has used to develop their PA models. NRC's alternative conceptual models based on independent data may be tested partly using GoldSim, TOUGHREACT, or TSPA. This will enable the staff to evaluate the impact of the alternative models and data on the DOE's compliance assessment.

The Computerized Risk Assessment and Data Analysis Lab (CRADAL) in NMSS has been responsive to the staff needs for sufficient computational resources to develop the staff's own TSPA models (e.g. TPA) and to evaluate the DOE's TSPA which uses the GoldSim software package. The DOE's current TSPA model requires large computational resources to execute probabilistic simulations. The NRC's computational resources are sufficient to allow evaluation of DOE's TSPA model and results, but they are somewhat limited to allow multiple probabilistic simulations. The projected execution time would be quite long. Staff will continue to work with CRADAL to improve computational resources.

Recommendation 3 The staff should continue developing a better understanding of the corrosion mechanisms of Alloy 22 and other engineered barrier materials.

The staff continues to gain a better understanding of corrosion mechanisms by conducting appropriate experiments and modeling. The staff is actively evaluating the up-to-date knowledge available on corrosion, from DOE's and the U.S. Nuclear Waste Technical Review Board's WP expert panels. Independently, the staff is studying natural, archaeological, and industry analogues of Alloy 22 and other engineered barrier materials, to improve confidence in the modeling of long-term behavior of WP and engineered barrier materials.

Recommendation 4 The staff should continue evaluations of coupled THC processes.

The complexity of near-field processes and conditions, in the strongly driven system, makes characterizing this environment extremely challenging. The staff will continue to use the coupled code MULTIFLO to characterize near-field chemical conditions. With the low temperature design alternative, additional scenarios will be evaluated to determine effects on performance.

Recommendation 5 The staff needs to more fully address in-package chemistry issues.

The staff agrees with the ACNW assessment of the status of in-package chemistry issues. Conditions in the WP control the release of radionuclides and their form (e.g., dissolved species, or colloids and particulates). By a KTI-related agreement with DOE, in-package chemistry models will be validated and documented in an updated DOE Analysis and Model Report. The staff will review that report and conduct independent analyses, as appropriate.

Recommendation 6 The staff should continue to develop an appropriate source-term model.

The staff continues to develop realistic source-term models. The current model for spent-fuel dissolution has been derived from corroborated data obtained from the tests in various aqueous solutions. This model will be further modified to incorporate more appropriately the effect of secondary minerals and to represent more rigorously the pH effect, as appropriate data become available. Additionally the diffusional release model will be implemented in the TPA.

Recommendation 7 NRC and the Center for Nuclear Waste Regulatory Analyses (CNWRA) should continue efforts to gain better insights into the radionuclide transport and attenuation processes in the TSPA.

The staff agrees that a mechanistic understanding of processes affecting radionuclide transport results in improved predictions, and plans to continue its efforts in this direction. For example, next year, the staff will continue its experimental study of neptunium sorption on calcite and its molecular dynamics simulation of uranium sorption. The staff will be working on a Nuclear Energy Agency Sorption Project to apply process modeling approaches to sorption test cases. This work will be used to risk inform our approach for reviewing the DOE's TSPA.

Sincerely,

/RA/

William D. Travers
Executive Director for Operations

cc: Chairman Meserve
Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
SECY

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