

March 22, 2002

The Honorable Richard A. Meserve  
Chairman  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

**SUBJECT: REVIEW AND EVALUATION OF THE U.S. NUCLEAR REGULATORY  
COMMISSION'S WASTE SAFETY RESEARCH PROGRAM**

Dear Chairman Meserve:

The Advisory Committee on Nuclear Waste (ACNW) reviews the activities of the U.S. Nuclear Regulatory Commission (NRC) in the Nuclear Waste Safety Arena, as they relate to safety research and high-level waste (HLW) technical assistance. In this letter, we present our assessment of the quality of the research being conducted under NRC sponsorship, evaluate the methods for prioritizing research activities, and highlight a few observations from an ACNW-sponsored workshop on research needs.

### **Introduction**

During several meetings of the ACNW between July 2001 and March 2002, we discussed the NRC's waste safety research and technical assistance programs. In preparing this letter report, the ACNW drew upon a number of sources of information. These included presentations by investigators on research sponsored by the Office of Nuclear Regulatory Research (RES); the findings of the expert panel chaired by Dr. Kenneth Rogers; meetings with the Office of Nuclear Material Safety and Safeguards (NMSS) and RES staffs; and discussions with the Center for Nuclear Waste Analysis (CNWRA) staff during a visit to the CNWRA on August 23–24, 2001. We also sponsored a workshop on research needs on November 27–28, 2001, during the 130<sup>th</sup> ACNW meeting. This workshop involved participation by the NRC staff and benefitted from presentations by and discussions with internationally recognized experts in geoscience, chemistry, hydrology, decision analysis, health physics, and policy and regulatory analyses.

### **Conclusions**

- RES has a limited budget; however, the research it supports continues to involve the use of qualified scientists and is of very high quality.
- The technical assistance sponsored by NMSS and conducted by the CNWRA continues to be well managed, of very high quality, focused on important issues, and a substantial contributor to NRC's mission.

- The NMSS users' needs memorandum of October 31, 2001, provides a list of useful projects but ones that, for the most part, do not address an anticipatory research agenda.
- The external peer review associated with the publication of CNWRA work in peer-reviewed journals or presentations at technical meetings adds significant value to this work and should be encouraged.

### **Recommendations**

- The allocation of funds between nuclear reactor safety and nuclear waste safety research and between anticipatory research and technical assistance should be considered a policy matter to be decided by the Commission.
- We recommend that RES incorporate a decision analysis framework into its prioritization of waste-related research. RES should consider the approaches that were discussed at the ACNW workshop including the use of expert panels.
- We recommend that RES continue to develop collaborative arrangements with other government organizations, such as those outlined in the RES memorandum of understanding (MOU) on multimedia environmental models. Additional collaboration with other organizations, including industry organizations and organizations based in foreign countries, is important.
- We continue to recommend that the NRC expand its HLW programs to have a long-term anticipatory research component.
- We also recommend that RES consider the following suggestions made by experts at the ACNW workshop:
  - RES should identify existing waste sites, an examination of which could provide useful information. RES should develop cooperative agreements with interested organizations and the owners of the identified sites to obtain field data from those sites to refine and test conceptual models.
  - The development of improved sampling and monitoring techniques and the testing of sensors and related instrumentation could be performed at the identified sites.
  - RES should explore the use of outside experts to address specific technical issues associated with the design and prioritization of its anticipatory research program.

## **Assessment of Current Programs**

### **(1) *RES-Sponsored Research Related to Waste Safety***

On several occasions, the ACNW reviewed reports from scientists involved in waste safety research sponsored by RES. This research addressed alternative conceptual models for flow and transport in groundwater aquifers, vadose-zone hydrology, and evaluation of surface complexation modeling at a field site in Colorado. We judge this work to be of very high quality.

### **(2) *Work Performed at the CNWRA***

The HLW work carried out at CNWRA is focused on resolving problems specific to the proposed Yucca Mountain repository. Although this work is categorized as technical assistance, the ACNW has been reviewing it within the framework of its annual review of NRC-sponsored research.

From our reviews, we conclude that the work at CNWRA is well managed, of very high quality, focused on important issues, and a valuable contribution to the NRC's effective review of the proposed Yucca Mountain repository. The expertise of the CNWRA staff complements the technical capabilities of the NMSS staff. The level of funding supports a group of experts with a range of technical expertise and experimental facilities that can be used to address key technical issues associated with the proposed Yucca Mountain repository.

The results of work performed at CNWRA are frequently published in peer-reviewed journals and presented at technical meetings. The ACNW believes that external peer review adds significant value to this work and should be encouraged.

In our report to the Commission on research and technical assistance dated February 5, 2001, we stated that the HLW program needed to be expanded to have a modest, long-term anticipatory research component, perhaps through collaboration between NMSS and RES. We continue to believe that work of this type is important to prepare the NRC to effectively carry out its regulatory responsibilities, including those involving future issues.

## **Prioritization**

### **(1) *RES-Sponsored Research Related to Waste Safety***

In our report to the Commission on research and technical assistance dated February 5, 2001, we expressed the following observation concerning the Analytical Hierarchy Process (AHP):

The Analytical Hierarchy Process devised for RES favors research projects on reactor safety. The process should be revised to reflect the importance of waste-related research.

The Committee has been briefed on the methods for prioritizing RES activities and the changes that have been made in the program plan for research on radionuclide transport. The Committee also discussed research prioritization with a variety of experts during our November 2001 workshop. Our concern regarding the process for prioritizing nuclear waste-related research has not been satisfied.

We are convinced that decisions about how to divide the limited resources between nuclear reactor safety and nuclear waste safety must be a Commission-level policy decision. We also have concerns about how projects are prioritized within waste-related research. In our last report to the Commission, we observed the following:

The RES waste-related program is not large enough to support the full spectrum of NRC needs. The RES staff should develop a comprehensive plan, including realistic budget estimates, to support the case for either increasing the size of the program and/or refocusing the program.

In response to this observation, RES has issued a draft program plan for research on radionuclide transport. That plan contains a comprehensive discussion of research projects relevant to the NRC's needs and a plan for obtaining input from within the NRC and from external stakeholders. This is a positive step toward developing a coherent program. The scope of the research described in the draft program plan is beyond what can reasonably be addressed with available funding. RES recognizes this and is developing partnerships to support this effort and is using stakeholder input to help focus the program. RES has recently reissued the plan and will brief the ACNW during its meeting on April 16–18, 2002.

As noted above, RES uses an AHP-based tool to assist in making relatively high-level decisions about priorities. This is not a tool that is readily adapted to make decisions about projects within the waste field. Rather, the identification and prioritization of research projects within the waste field is best achieved through a documented process involving input from both NRC and other experts. Formalized methods for making decisions and metrics can provide a useful framework for discussion. We recommend that the NRC incorporate a decision analysis framework into its prioritization of research. RES should consider the approaches that were discussed at the ACNW workshop.

Another issue is the selection of sponsored work that is arguably "research," rather than "technical assistance." In conjunction with its comments on the RES draft radionuclide transport program plan, NMSS provided a user needs memorandum dated October 31, 2001, regarding waste management research. Funding the work requested in this memorandum would consume a significant portion of the RES resources allocated to waste-related safety research. More to the point, although the needs expressed in this memorandum appear to be reasonable, they are really needs for technical assistance. For example, many of the needs are for the upgrading of methods (e.g., a stochastic version of the RESRAD code). We do not judge such work to be in the spirit of anticipatory research, but we make no judgment regarding the relative value of anticipatory research versus technical assistance to the agency. The policy decision as to the allocation of RES funds between anticipatory research and technical assistance should be made by the Commission.

**(2) Work Performed at the CNWRA**

NMSS identifies and prioritizes tasks with the assistance of the CNWRA managers, using the following factors:

- contribution to risk
- sensitivity of repository performance to the issue under study
- level of model conservatism and uncertainty
- degree of agreement between DOE and NRC as to the treatment of the issue and the likelihood that the issue will be contentious in the hearing process
- factors related to legislative, regulatory, or other programmatic requirements

This process appears to be working well to define the most critical research and technical assistance that needs to be done at CNWRA.

**Key Comments from the Research Workshop**

Participants in the ACNW workshop provided valuable insights and identified a number of ways that research can be used to improve the understanding of waste safety issues (see Appendix). Of the observations that were emphasized by the workshop participants, the ACNW believes the following are particularly worthy of consideration by RES:

- A useful way to focus the NRC's research program might be to develop a clear understanding of lessons from past waste decontamination and decommissioning (D&D) activities using closed facilities and D&D facilities as "laboratories" and using environmental monitoring at closed sites to enhance modeling credibility.
- The NRC's research should be prioritized with full knowledge about work being done by others and with aggressive action to leverage research support through collaborative arrangements with other organizations. Active participation of the NRC staff in scientific activities associated with the disciplines important to the evaluation of waste management and disposal should be encouraged.
- The use of external peer-review panels is essential to ensure that work selected for sponsorship is indeed of the highest possible quality.

Sincerely,

**/RA/**

George M. Hornberger  
Chairman

**APPENDIX****HIGHLIGHTS FROM THE ACNW WORKSHOP ON NOVEMBER 27—28, 2001**

The Advisory Committee on Nuclear Waste (ACNW) sponsored a workshop on November 27—28, 2001, during which the NRC's future waste-related research needs were discussed. The workshop objectives were as follows:

- Develop insights regarding the information and technical tools that will be needed for future regulatory decisions.
- Explore the views of workshop participants as to what new knowledge and technical tools will be needed for these decisions.
- Discuss how research can be used to develop the new knowledge and technical tools.
- Explore processes for the effective prioritization of research.

The invited speakers in order of appearance included the following recognized experts on geoscience, chemistry, hydrology, decision analysis, health physics, and policy and regulatory analysis.

- |                     |                                |
|---------------------|--------------------------------|
| • Ashok Thadani     | NRC-RES                        |
| • Martin Virgilio   | NRC-NMSS                       |
| • Kenneth Rogers    | Consultant                     |
| • Malcom Knapp      | Consultant                     |
| • John Kessler      | EPRI                           |
| • Wes Patrick       | SWRI-CNWRA                     |
| • Michael Ryan      | Charleston Southern University |
| • William Hinze     | ACNW Consultant                |
| • Timothy McCartin  | NRC-NMSS                       |
| • William Ott       | NRC-RES                        |
| • Jane Long         | Mackay School of Mines         |
| • David Kocher      | SENES Oak Ridge                |
| • D. Kirk Nordstrom | U.S. Geological Survey         |
| • John Wilson       | New Mexico Tech.               |
| • Jack Rosenthal    | NRC-RES                        |
| • Warner North      | Stanford                       |
| • Steven Rattien    | RAND                           |

The workshop participants identified the following areas as involving challenges that could be addressed through research:

- transmutation of wastes
- new high-level waste (HLW) management options
- more cost-effective methods for packaging and stabilizing low-level waste (LLW)
- design implications of sabotage
- improved techniques and instrumentation for environmental monitoring
- risk-significance of "greater-than-Class C" waste
- improved evaluations of assured LLW isolation facilities
- durability of institutional controls for decommissioned sites
- development of strategies for evaluating the physical conditions of entombed structures
- use of safety goals in site decommissioning
- evaluation of advances in health physics for decommissioning
- evaluation of test methods for HLW packages and additional evaluation of cask integrity
- improved evaluation of slow geologic and radionuclide release processes
- identification of performance indicators for long-term disposal
- use of remote sensory techniques to verify safeguards information
- issues associated with the management of spent fuel associated with high-burnup fuel and fuel from advanced reactors
- technical issues associated with license extensions for independent spent fuel storage facilities
- performance of engineered barriers
- performance of spent fuel pool storage facilities from a risk-informed perspective
- improved capability to conduct realistic performance assessments
- development of a performance confirmation program for the Yucca Mountain repository if a decision is made to go forward with site construction

The ACNW members held extensive discussions with the workshop participants as to what is needed in the way of new information and tools and to how research could be used to develop this new information. The highlights of these discussions are as follows:

- The meeting participants generally agreed about the importance of obtaining field data. Possible sources include work being performed for activities other than radionuclide waste disposal, from applicable natural analogs, and from existing waste sites. Inverse modeling was judged to be a valuable tool for developing model improvements.
- Additional model development is generally believed to be necessary. Particular improvements include the development of more realistic conceptual models, use of experience and data to create simple and credible models for individual complex sites, and the development of an accepted process for using the information obtained from multiple competing conceptual models in regulatory decisions.
- The meeting participants generally argued that realistic assessments are preferred, with conservatism being added at the end to correctly account for uncertainty. This type of process will provide the best assessment of a system and the importance of its system components, and can be used to identify needed research. The participants also noted that the piecewise elimination of conservatism does not necessarily introduce more

realism in the analysis. Risk information, research results, and experience should be used in a systematic, system-based manner to provide the basis for eliminating inappropriate conservatism.

- It is important to design research to provide a better understanding of the effect of heterogenous structure on flow (for example, fracture-matrix interaction).
- The participants strongly encouraged using the resource embodied by the existing expertise and information in the scientific community. The participants also suggested that the use of panels of non-NRC experts would provide a cost-effective way to access state-of-the-art information.
- The participants encouraged cooperative work and the use of applicable information obtained from work done for purposes other than nuclear waste safety, as well as active participation of the NRC staff in scientific activities associated with the disciplines important to the evaluation of waste management and disposal.
- It is important to design research to provide a better understanding of the integrity of engineered barrier systems and the associated chemistry.
- Coupled processes are complex, can lead to unexpected results, and need to be better understood.
- An important purpose is to examine system assessments for significant flaws. The NRC's research program should be designed to help the agency discover and deal with the unexpected.
- Performance assessment can yield valuable information about where research is needed and what level of understanding is required for a regulatory decision. The participants noted that scientific research can have different objectives than research to provide information for a regulatory decision. Potential licensee and NRC research needs can also be different.
- The participants emphasized the need to base regulatory decisions on a clear, well-founded safety case. Research should be used to test this safety case. The participants also noted that the "safety-case" has many elements, and even an exceptionally complete and accurate performance assessment will not provide the complete basis for a safety case.
- The participants recognized the need to thoroughly understand and use existing work to avoid making incorrect assumptions about the performance of a site. The discovery of Chlorine-36 at the Yucca Mountain site and water in the tunnels at the Waste Isolation Pilot Plant site were cited as examples.
- Identified weaknesses in the basic health physics models are very important and there are areas where improvements are much needed. The linear-no-threshold dose health effects model was cited as an example.

- The inherent heterogeneity of sites and the need to preserve site integrity limit site characterization. Improved approaches to site measurement and improved instrumentation need to be developed.
- “Blind” model validations are useful for understanding and using conceptual models. The participants noted that the type and amount of data provided must be carefully evaluated to ensure meaningful results.
- It is a worthwhile strategy to design research in a way that could attract the interest of other research organizations, with the intent of those organizations funding the completion of the work. NRC involvement in outside scientific activities would promote this type of cooperation.

The last workshop discussion session addressed research prioritization. It is recognized that the NRC has a limited research/technical support budget with which to address a variety of regulatory needs. It is also recognized that NRR and NMSS needs for technical support must be met in order for the NRC to satisfy its licensing responsibilities.

The workshop participants generally believe that a research program must have a logical framework that provides clear measures of both relevance and importance and identifies a proper basis for research prioritization. The framework should ensure both the identification of all useful research and the performance of work that will provide the greatest benefit to the NRC. The AHP, as used by RES, was judged to be a worthwhile innovation but in need of improvement.

The workshop participants generally believe that the identification and prioritization is best achieved using quantitative means. Metrics, such as those used in the AHP, can provide a useful framework for discussion. External peer review provides cost-effective access to the resources of the scientific and technical community and increases the credibility of the result. The workshop participants generally believe that external peer review should be used and the NRC staff should be more active in external scientific and technical activities. The participants also stated that there will always be issues that need to be resolved by high-level policy decisions. Examples are the partitioning of research funds between reactor, materials, and waste safety, and the partitioning of research funds between anticipatory research and support of NRR and NMSS user needs.

Performance assessment and probabilistic risk analysis were judged to be valuable in identifying and prioritizing research projects. Cooperative work was judged to be an effective way of leveraging the NRC's resources, and it deserves a higher priority for this reason. Other suggested metrics were the expected impact on a regulatory decision, sunk costs, total cost and expected cost/benefit, and the likelihood of success.