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

August 24, 1994

The Honorable Ivan Selin
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Selin:

SUBJECT: COMMENTS ON HIGH-LEVEL RADIOACTIVE WASTE RESEARCH PROGRAMS ON VOLCANISM, NATURAL ANALOGS, AND TECTONICS

The purpose of this report is to communicate ACNW observations on three research programs of the Office of Nuclear Regulatory Research in high-level radioactive waste (HLW), namely volcanism, natural analogs, and tectonics. The Committee identified in its November 10, 1993 Program Plan the review of the HLW research program as a priority issue in its support of the Commission's responsibility to license the proposed Yucca Mountain repository. Subsequently, you asked the Committee to examine the relevancy, sufficiency, and timeliness of the HLW research program. This report is a limited review within the broader activity which we are currently conducting at your request. The Committee's review aims to determine the use of the research to the technical basis for regulatory guidance and evaluation of a license application for an underground high-level waste repository. We plan to review other areas in the HLW research program and report these findings to you.

During the past several months the Committee has been briefed by the staffs of the Office of Nuclear Regulatory Research (RES), the Office of Nuclear Material Safety and Safeguards (NMSS), the Center for Nuclear Waste Regulatory Analyses (CNWRA), the U.S. Department of Energy (DOE), and the State of Nevada on their current programs on volcanism, natural analogs, and tectonics. These three programs together receive over thirty percent of the current annual funding for NRC HLW research.

Based on our review and discussions, the Committee views the research programs on volcanism, natural analogs, and tectonics as generally relevant and supportive of the Commission's regulatory mission and sufficient for the intended purposes. Thus, research in these topics deserves continued strong support. Nonetheless, the Committee believes that volcanism and tectonics research should be focused on the application of results to performance assessment (PA) and accelerated toward usable results. The Committee believes the relevance of natural analog studies has not been firmly

established due to the lack, to date, of sufficient integration of natural analog data into PA analyses.

General Comments

As a result of the review to date, we make several comments that appear common to the research programs on volcanism, natural analogs, and tectonics.

1. Program Priorities

The manner in which RES establishes priorities for programmatic areas, as well as for specific projects within these areas, should be improved by use of a risk-based approach. Prioritization of research projects should be rooted in their relevance to the estimated frequencies and consequences and associated uncertainties of specific events or scenarios affecting the proposed repository. Performance assessment will be useful in this effort. The PA by NRC and DOE needs to be a major guiding force for bounding the scope of research issues and establishing relative priorities.

Specifically, it is not evident how PA is being used or contributes to identifying key technical uncertainties (KTUs), user needs, research activities, and those processes, parameters, and assumptions that are most critical to performance. The Committee found little evidence that the studies and associated data are directed at testing assumptions that significantly impact site performance. Making stronger connections between PA and research priorities would improve the relevance and sufficiency of the research program. For example, there are diverse volcanism research activities under way at the CNWRA involving eruption/consequence modeling, studies of volcanic centers, preparation of data bases, and development of probability models for volcanic disruption. These activities need to be prioritized, in part, by a closer linkage to the support or testing of critical assumptions in PA so as to provide timely and usable results.

We recognize quantitative results of PA have only recently become available. Nonetheless, we urge the NRC staff to factor, as quickly as possible, PA results into formulation of the KTUs before new user needs are defined. While we encourage a greater emphasis on use of PA in setting priorities, we caution the NRC staff against basing programmatic decisions solely on PA results, especially until the key PA uncertainties have been explicitly quantified.

The Committee expects to revisit the issue of research priorities and schedules once the DOE Proposed Program Approach (PPA) has been better described.

2. KTUs and User Needs

The Committee believes the NRC staff should expedite the process of fine-tuning the KTUs and clarifying user needs. The need to update user needs is extremely important, as those defined over four years ago are still the bases of current HLW research programs. The NRC staff is now in the process of using Systematic Regulatory Analysis (SRA) to develop its License Application Review Plan (LARP). As a part of the LARP development process, the staff has formulated KTUs for all relevant technical disciplines. While the SRA/LARP process is a welcomed improvement in defining user needs compared to the former, less structured approach, the NRC staff has not completed this process. Many of the KTUs have an excessively broad scope and need to be sharpened. Thus, it was difficult for the Committee to identify how research project objectives and tasks are to resolve specific KTUs.

The NRC staff has indicated that a KTU integration review will be performed in FY 1994. The Committee believes this is very important in prioritizing and refining details of the KTUs and developing new and revised user needs but is concerned that the schedule may be excessively ambitious unless near-term progress becomes evident. The Committee recommends that completion of the integration review and definition of new user needs be given high priority by NMSS. Recognizing that these activities are ongoing, the Committee sees an important opportunity for RES to examine the current relevancy of specific research tasks for both current and future activities, and refocus its research program in response to new user needs.

3. Integration of Research Activities

The interdependence or close coupling of processes under investigation at Yucca Mountain, such as volcanism and tectonics, or tectonics and hydrology, must be evaluated to assess overall repository performance. However, briefings by the NRC and CNWRA staffs did not identify mechanisms in place to bring about such integration.

The existing projects in tectonics and volcanism appear to be focused on understanding discrete processes, as opposed to the interdependency of processes and their relationship to the regional tectonic setting. While the RES staff described a project planned for the future entitled, "Modeling Mantle Dynamics," which is designed to integrate the major tasks in both volcanism and tectonics, the project plan for it will not be developed until FY 1995. We recommend that the required integration should be more rapidly and deliberately implemented.

4. Communication

The Committee has commented before on the need for improvement in communication. We recommend that the RES staff summarize more expeditiously the results of its as well as the CNWRA's research into usable products for NMSS and others. Furthermore, with a few notable exceptions, the research performed by the CNWRA is not widely distributed and generally is not subjected to close scrutiny and peer review by the knowledgeable scientific community. The Committee recommends that NMSS and RES ensure that the results of research completed by the CNWRA receive such peer attention. In addition, the Committee continues to view the communication between the NRC staff and the DOE as unsatisfactory and in need of significant improvement regarding timeliness and level of detail.

5. External Research Activities

The CNWRA and RES are urged to continue to take advantage of opportunities in the use of external personnel to conduct research that is not within the scope of expertise of in-house staff. Several examples of the use of this procedure by bringing research expertise and facilities to bear on specialized problems have shown the merits of the approach. We suggest that benefits of external involvement in HLW research, including cost effectiveness, development of innovative ideas, enhanced program flexibility, and access to research expertise and equipment, merit increased use by RES.

Specific Comments

The Committee is pleased that some research has already proven useful in the guidance of regulatory policies, as background for technical assistance to the NMSS staff, and to stimulate DOE to further its efforts in the volcanism area. The following comments are aimed at increasing the effectiveness of the research activities.

1. Volcanism--This research bears directly upon the regulatory issues of overall system performance (10 CFR 60.112) and a potentially adverse condition identified in 10 CFR 60.122(c)(15). Scenarios of concern involve both direct and indirect effects of magmas that may breach the surface or reach the near surface in the vicinity of the proposed repository at Yucca Mountain. The issues include both the probability of an igneous event in the Yucca Mountain region and the consequences.

NRC's volcanism research is aimed at gaining a better understanding of igneous processes to reduce uncertainty in estimating both the probability and consequences of magmatic

events. The results should lead to development of more reliable models that predict the probability of volcanic disruption and eruptive scenarios and consequences in terms of any eventual transport of radioactive materials to the biosphere. Although preliminary calculations suggest that the probability of volcanism at Yucca Mountain is very low over the next 10,000 years, continued research appears to be justified as the current PA results are based on limited models and data and do not incorporate coupled processes.

a. Having embarked upon a program to characterize volcanism in the Basin and Range province and to formulate volcanic models for the Yucca Mountain region, RES needs to bring critical aspects of this program to fruition. Specifically, RES needs to formulate expeditiously a set of alternative defensible volcanic and coupled tectonic models that can be used in probabilistic PA and to estimate magmatic effects. RES should continue to concentrate on those parts of the volcanic studies that achieve this goal and, if necessary, limit the overall scope of the program. For example, the Cerro Negro, Nicaragua and the Tolbachik, Russia volcanic analog studies may be of lower priority.

   In addition, the Basin and Range province project should not become mired in preparation of Geographic Information System (GIS) data bases, but data bases of an appropriate level of detail should be developed that will enable testing of models for the Yucca Mountain region. The level of detail required and how and when the data will be used should be well established. The NRC staff should have long-term plans for maintenance of and additions to the GIS data bases until they are supported by others.

b. The Field Volcanism project is wide ranging and appears to be open ended and lacks targets of application. The Committee recommends that the goals of the research, in terms of specific types and uses of data to be obtained, need to be more clearly defined, articulated and limited in the context of realistic expectations considering resources and timeliness.

c. The indirect effects of magmatism on waste canisters are of sufficient concern that the NRC staff should ensure that these effects are evaluated. The effects of magmatically driven hydrothermal circulation of solutions that may be affected by released volatiles are likely to be important. These effects appear to be readily amenable to modeling and laboratory testing. The Committee recommends that these issues be explicitly

evaluated as to their importance to the goals of the research program.

2. Natural Analogs--This research is directed at systems and processes in a field situation that are considered analogous to the Yucca Mountain geologic setting. This research takes advantage of the large scales, long time periods, and the many and complex interactions that characterize geologic systems. Such processes are difficult or impossible to duplicate in the laboratory.

   a. Relevancy of natural analog studies is difficult to ascertain because of uncertainties in the initial and boundary conditions of the analogs and complexities in interpretation due to coupled processes. This concern can be dispelled by developing research plans that are closely tied to achievement of regulatory and licensing goals. Furthermore, the data available in the natural setting are virtually infinite, and therefore care must be exercised in the choice of research parameters that are relevant to regulatory concerns. The Committee found that the direct connection between key regulatory uncertainties and data being collected at HLW natural analog sites is not obvious in all NRC projects. The Committee recommends that such nexus be specifically identified for all analog projects.

   b. Natural analog projects are often conducted and funded in cooperation with other nations. The geological setting of the projects may not be analogous to the Yucca Mountain site. While not negating the potential utility of such projects, the relevance may not be sufficient to warrant the expenditure of resources. The Committee recommends that the expectations and objectives of this type of research be better defined and used in prioritization.

   c. The use of natural analog data and interpretations in either quantitative PA or model validation needs to be carefully and precisely defined. The Committee is encouraged to learn that RES and CNWRA have recently conducted a workshop on the nexus between PA and geochemical natural analog research. The Committee recommends that this process also be applied to analogs in volcanism, tectonics, and other areas such as the results of ground water movement at the Apache Leap test site in Arizona.

3. Tectonics--This research is important in determining several potentially adverse conditions at the proposed Yucca Mountain repository site that involve seismicity, potentially signifi-

cant faults, movement of gases and surface waters, and ground water levels. In addition, the research provides an overall geologic framework needed to evaluate coupled processes and assess overall site performance.

Tectonics integrates a variety of geoscience disciplines to determine the past as well as present dynamic processes and their effect on the nature of the geologic setting. Understanding these processes requires a knowledge of the regional tectonic framework, far-field stresses and geologic events. The geologic structures resulting from the tectonic processes and the processes themselves impact the nature and integrity of a repository site in a variety of ways. Thus, this research is especially important to NRC's regulatory guidance and licensing concerns. The review of tectonics is exclusive of rock mechanics and seismic hazards.

a. The tectonics research program of the CNWRA has been in place for a relatively short period and has been largely directed toward literature review, data compilation, definition of research plans, and development and compilation of software for modeling and analysis. These preparatory tasks are completed or scheduled for completion by September 1994, at which point the program will be poised to address critical questions through data analysis and modeling. Tectonics provides the regional picture needed to evaluate other processes, and therefore the Committee recommends that RES accelerate the model development and analysis phase of the program. As a result, it may be necessary to limit the overall scope of tectonics research activities.

b. The Committee is pleased to see the tectonics research activities take on a regional viewpoint, but extension of the study area beyond the immediate structural province of the proposed Yucca Mountain repository site should only be done with clearly identified goals and strong justification which is currently not available.

c. The concerns expressed (as discussed in 1.a) regarding the appropriate level of detail, maintenance, and data types of GIS data bases are also applicable to the tectonic data bases.

d. In view of the continuing concern about the impact of faulting on the integrity of the Yucca Mountain site and about the role of faults in subsurface water movement, tectonics research needs to emphasize the understanding and effects of faults at Yucca Mountain and the nature of faults as a result of the evolution of the regional strain pattern over time. This goal was not apparent to

the Committee in the research plans. We recommend that RES ensure the relevance and sufficiency of the program by inclusion of such plans.

Summary

The Committee's major findings are summarized as follows:

- The research programs in areas of volcanism, natural analogs, and tectonics are generally relevant and supportive of the Commission's regulatory mission in HLW. The Committee supports continuation of HLW research in these areas. However, the HLW research program should be improved to make it more relevant and timely.

- RES should ensure that it has established well-defined, risk-based priorities for its programs. In addition, RES should develop a mechanism for establishing that those programs are required to support or test critical assumptions of Performance Assessments (PA) and Key Technical Uncertainties (KTUs). In particular, research efforts should be tied more closely to PA in an iterative manner so that assessing relative risk of a phenomenon becomes an explicit part of the research planning process.

- The current transition period when KTUs and user needs are being developed using Systematic Regulatory Analysis (SRA) is an excellent opportunity for RES to take a prominent leadership role in refocusing the research objectives in response to the new KTUs as well as potential changes in the DOE Yucca Mountain program.

- Integration between research projects that address discrete phenomena but are closely coupled, such as tectonics and volcanism needs to be strengthened to assess the overall performance of the proposed Yucca Mountain repository.

- More effective communication of research results within the NRC and with the larger scientific community is essential for the contemplated use of the program results.

- The benefits of research external to the CNWRA, such as cost effectiveness and availability of specialized research expertise and equipment, merit continued use of such projects by RES.

We are pleased to note that many of the points raised in this report are recognized by the parties involved in the HLW program. However, we believe action is warranted which will lead to improving the effectiveness and timeliness of the program. Future reports to the Commission will detail observations and recommenda-

tions on other specific HLW research programs that will serve to support and refine the general observations made herein.

Sincerely,

Martin J. Steindler
Chairman