



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

November 6, 1995

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

Dear Chairman Jackson:

SUBJECT: COMMENTS ON THE HIGH-LEVEL RADIOACTIVE WASTE RESEARCH PROGRAM IN
HYDROLOGY

This letter report communicates the results of the Advisory Committee on Nuclear Waste (ACNW) review of the Office of Nuclear Regulatory Research's (RES) high-level radioactive waste (HLW) research program in hydrology. The Commission requested the Committee to examine and report on the relevancy, sufficiency, and timeliness of the HLW research program. The Committee previously reported on its review of volcanism, natural analogs, tectonics, and engineered barrier system research in the HLW program. The purpose of the Committee's review is to determine the role of hydrology research in the development of technical basis for regulatory guidance and evaluation of a license application for the proposed repository at Yucca Mountain, Nevada.

The Committee finds ample justification for the HLW hydrology research program and has important observations and recommendations to improve the relevance, sufficiency, and timeliness of the program. Our major findings are: (1) the risk significance of some of the ongoing work at the Center for Nuclear Waste Regulatory Analyses (CNWRA or Center) has not been demonstrated, (2) the Committee recommends that the staff emphasize the use of Performance Assessment (PA) to justify the basis of research projects, (3) RES needs to ensure that the projects and schedules of the hydrology research program are aligned with current needs of the licensing program and the impending changes in the Environmental Protection Agency's (EPA's) standards for the Yucca Mountain repository as a result of the National Research Council's technical bases findings (Ref. 1). For example, the longer time frame and risk-based standard recommended by the National Research Council panel may place greater emphasis on the dilution potential of the saturated zone, and (4) overall greater emphasis is needed on bringing projects to closure and packaging project results in usable formats for transfer to the licensing staff. These findings and others are discussed in more detail in the body of this report, and are later summarized at the end.

During 1995, the Committee devoted attention to the hydrologic aspects of site characterization at Yucca Mountain and related NRC preparations to evaluate a possible license application for a repository at Yucca Mountain. Of particular interest has been the guidance provided by NRC to the Department of Energy (DOE) on the interpretation and application of the subsystem requirements of 10 CFR Part 60 dealing with minimum groundwater travel time from the disturbed zone of

the repository to the accessible environment. Our comments on that subject were transmitted to you in our report of May 25, 1995. A logical followup to our evaluation of NRC's preparations for guidance on groundwater travel time is a review of the HLW hydrology research program. The DOE program schedule for site characterization, the implication of a new EPA standard for the potential Yucca Mountain repository, and possible changes in 10 CFR Part 60 add to the timeliness of our review. At our 77th meeting on September 20, 1995, the Committee was briefed on this topic by RES, the Office of Nuclear Material Safety and Safeguards (NMSS), the CNWRA, and the principal investigators of the NRC-sponsored HLW hydrology programs at the Apache Leap Research Site of the University of Arizona. This report is derived from the Committee's evaluation of the results of that briefing and subsequent deliberations.

Groundwater is the most likely agent to cause degradation of waste package containment, radioactive release from the engineered barrier system, and transport to the accessible environment. Hydrology research is a high-priority issue at NRC and has a prominent role in the draft HLW Research Program Plan (Ref. 2). Critical issues in hydrology include infiltration, conceptual models for fracture/matrix flow, parameter estimation, and radionuclide transport in both liquid and vapor phases. The hydrology research programs at the CNWRA and the University of Arizona receive approximately 15 percent of NRC's current annual funding for HLW research.

General Comments

In our report of August 24, 1994, to Chairman Selin regarding the HLW research program on volcanism, natural analogs, and tectonics, the Committee identified several general concerns that are also appropriate to the HLW hydrology research program. We note improvement in some other areas; for example, the effective technical communications between the NRC and DOE in matters related to the hydrology of the proposed Yucca Mountain repository site. Further, we are impressed with the advantages accrued to the hydrology research program as a result of the participation of external experts from the University of Arizona. Our general concerns are as follows:

1. Program Priorities

The selection and prioritization of specific research topics in hydrology can be improved by use of a risk-based approach. Prioritization should be rooted in the relevance of the research to estimated consequences and uncertainties. As a result, PA should have a prominent role in selecting research topics, bounding their scope, and establishing relative priorities. We see little evidence of the role of PA in the prioritization of current hydrology research topics or how hydrology research results will be used in Iterative Performance Assessment (IPA).

2. Key Technical Uncertainties (KTUs) and User Needs

In the Committee's report regarding research in volcanism, natural analogs and tectonics, we supported the ongoing activities of NMSS to fine-tune the KTUs and clarify user needs. We reemphasize the importance of this effort and urge a

timely closure on this project. In our previous report, we stated ". . . it was difficult for the Committee to identify how research project objectives and tasks are used to resolve specific KTUs." In our review of hydrology research, a direct connection is not obvious between specific projects and the needs of the licensing staff as specified by the key technical issues (KTIs) and KTUs. The rapidly evolving licensing procedures require the synchronization of hydrology research with changing NRC guidance and licensing concerns.

3. Integration of Research Activities

The hydrology at Yucca Mountain should be closely coupled with other disciplines such as tectonics, volcanism, and geochemistry in evaluating overall repository performance. However, as in the case of previous briefings by the NRC staff and principal investigators of research projects, hydrology research reports fail to identify general mechanisms to bring about needed integration. The focus is on discrete processes, and integration appears to be an ad hoc procedure relegated to the actions of individual investigators. The Committee recommends a more visible integration of discrete research elements.

4. Communications

The Committee is pleased to note the extensive technical communications among the various components of NRC involved in hydrology research and their counterparts at DOE. As a result, there is a sharper focus to the NRC research activities and broadening use of the results of the research by both NRC and DOE. We specifically recognize the quantity and quality of peer-reviewed journal publications by the principal investigators of the NRC-sponsored research at the University of Arizona. However, a concern we raised in our report of August 24, 1994, also is appropriate to the hydrology research. In that report, we recommended, and we continue to do so, that the RES staff convert the results of research at both the CNWRA and the University of Arizona into usable products for NMSS and others. This recommendation is especially applicable to the results from studies by the University of Arizona because of limitations in the principal investigators' views of regulatory concerns.

5. Role of NRC in Hydrology Research

In evaluating hydrology research, the Committee failed to obtain a clear-cut view of the criteria used by RES to identify its research projects. This is an especially critical concern in the current climate of decreasing resources. RES needs to clearly justify the NRC research program in hydrology as well as in other HLW topics.

The Committee believes there are valid reasons for the NRC to conduct research in hydrology related to the proposed Yucca Mountain repository site. Characterization and predictive modeling of fluid flow and transport in unsaturated fractured rock such as that encountered at Yucca Mountain is a relatively new, rapidly evolving science. There is little experience or understanding of governing processes and the behavior of fluids in fractures and faults, and few field demonstrations or standardized methodologies for obtaining parameter values necessary for modeling. The NRC staff is establishing

independent methods, approaches, and data bases, which will enable them to conduct confirmatory checks on DOE's models, modeling procedures, and data. Further, the NRC research is designed to develop and validate methodologies and data bases. Although of primary use to the NRC in the licensing process, this information can be influential in optimizing the hydrology site characterization process. NRC research is providing the NRC staff with valuable experience and insight into the sensitivity of various assumptions, methodologies, and approaches on evaluating site performance. These dividends provide the staff with needed confidence and increased credibility in evaluating DOE methods, models and approaches. Thus, we endorse hydrology research at NRC, but we recommend that these studies be used to better understand critical processes and to develop and validate scoping data and methodologies.

Specific Comments on Hydrology Research

The Committee recognizes the high quality of the research activities in hydrology being carried out for the NRC by the CNWRA and the University of Arizona and of the personnel involved in conducting and directing these studies. Further, we are pleased that to date some of the results of the hydrology research have proven useful in the guidance of regulatory policies and as background for technical assistance and have played a role in improving the site characterization at Yucca Mountain. Nonetheless, the Committee believes that significant improvements are possible and warranted in HLW hydrology research from the regulatory viewpoint. The following comments are intended to increase the overall effectiveness of the NRC HLW hydrology research program.

1. Relevance

CNWRA - The CNWRA is conducting research on regional and subregional hydrology of the Yucca Mountain site, including modeling of the high-hydraulic gradient north of the site and flow channeling in tuff, development of a methodology to evaluate the importance of spatially nonuniform infiltration on the flow of water in the unsaturated zone, and the origin and importance of perched water. The relevance of many of these studies is not apparent because they have not been shown to be significant from a risk perspective. However, an important contribution of the CNWRA research in hydrology is the sharpening of the staff's capability to evaluate and gain insights into conceptual and numerical models and analyses that are anticipated in the licensing process.

The goal of the Center's hydrology research projects is to understand existing site conditions rather than those critical conditions or processes that are potentially a problem from a performance or compliance perspective. For example, the Center is attempting to identify the "correct" model to explain the high-hydraulic gradient upslope from the proposed repository. We suggest that this program element be refocused to design and test bounding models and to perform preliminary analyses of their potential impact on repository performance. Resources would be better utilized by determining if the worst-case scenarios lead to failure to comply with the HLW standards and regulations than by attempting to define the "correct" model that explains the gradient. Although there is a need to better understand governing processes in subsurface hydrology

to develop reliable models and bounding conditions, the Center needs to ensure that these processes are risk significant before they are extensively researched.

University of Arizona - The continuing hydrology research of the University of Arizona at its Apache Leap Research Site is directed to understanding governing processes and modeling flow and transport, with emphasis on field methodologies and model testing at field and laboratory scales. The program addresses many potentially relevant issues such as conceptual models, spatial variability, model uncertainty, model abstraction, model validation and testing, and scaling properties. The Apache Leap Program is also making significant progress at integrating hydrology and geochemistry in designing experiments and interpreting results.

The geology and hydrology of the Apache Leap site are, to a first order, similar to the Yucca Mountain site in that both are in unsaturated, fractured tuff. However, other conditions are dissimilar, such as climate, hydrologic setting, and tectonic conditions. These differences lead to concern about the relevancy of the Apache Leap site as an analog to Yucca Mountain and the validity of the transfer of results from studies at Apache Leap to Yucca Mountain. Experience has shown that considerable care must be exercised in transferring lessons learned from one site to another. This caution is ameliorated by the focus of the research on the general understanding of the nature and relative importance of matrix/fracture flow in tuff rock in an unsaturated environment, field-scale demonstrations, and methodology development, all of which can lend credibility and confidence to NRC's regulatory decisions.

The University of Arizona studies are leading to fundamental understanding of flow and transport processes in unsaturated, dual-continuum volcanic rocks. This understanding will lead to better interpretation and evaluation within the regulatory framework of hydrologic data from Yucca Mountain and to more credible PA. Of particular note are the hydraulic, pneumatic, and tracer tests being used to test alternative models and to evaluate the stochastic continuum approach for defining flow and transport in rocks with both matrix and fracture permeability. However, for the NRC to obtain maximum use of the results of the Apache Leap studies, RES and NMSS should, on a regular basis, interpret and translate the results into meaningful guidance.

2. Sufficiency

NRC's licensing needs are evolving. We anticipate that new research issues will emerge with, for example, the NMSS staff's identification of long-term and short-term research needs for the specific elements of the vertical slice approach. RES must be ready to modify the priorities of its research program, including hydrology research projects. For example, current research projects should place greater emphasis on the role of fault zones on flow and transport in unsaturated tuff rock. This approach recognizes that faults, as identified by the NMSS staff in their presentations to us, are a critical but poorly known hydrologic element of the vertical slice, "Hydrologic Characterization of Structural Features That Affect Water and Vapor Movements."

The Committee was puzzled that none of the projects appear to have been aimed at providing information pertinent to groundwater travel time. Although the importance of this current subsystem provision of Part 60 may change as the result of incorporation of the report by the National Research Council on Yucca Mountain standards, this regulation is pertinent to the behavior of water in the environment of the repository. The difficulties in the establishment of the travel time, made evident in reviews of this matter by the Committee, point to the need to identify research programs that will enable the NRC staff to evaluate this hydrologic characteristic.

The Committee is also concerned about insufficient research at the interface of specific research elements. We have already noted the apparent deficiencies in mechanisms for integrating research activities. Research on the coupling of hydrology of Yucca Mountain with, for example, volcanism and tectonics appears to be deficient in the current program. Briefings on the hydrology research program also failed to show how the two projects at the CNWRA on regional and subregional hydrology are integrated with each other, with related work at the Center, and with the research being performed at the Apache Leap Research Site.

3. Timeliness

No clear evidence has been made available to the Committee that timeliness of the hydrology research is a compelling factor in prioritizing, designing, or conducting the program. We realize that the time line for evaluating the technical site suitability of Yucca Mountain and other prelicensing and licensing issues has been modified recently. However, the NRC staff must be sensitive to those modified deadlines, such as the one requiring the Commission's comments on the high-level findings, and assure the Commission that research results are available on a timely basis.

Summary

The Committee's major findings are summarized as follows:

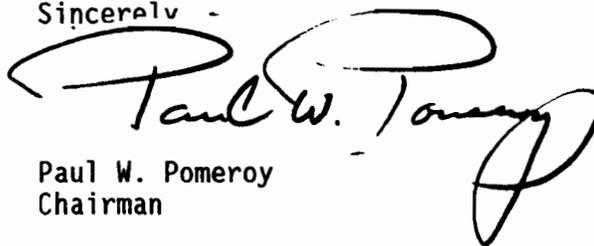
- RES and NMSS staffs should be commended for the effective communications that exist between NRC and DOE.
- RES needs to place greater emphasis on establishing well-defined, risk-based priorities for its programs and ensuring that the results of hydrology research are fed back into IPA analyses. Greater emphasis needs to be placed on using PA to integrate results from all research disciplines and in turn establishing research priorities and guiding further research.
- RES should pay particular attention to new research needs that may result from the National Research Council's technical bases recommendations, and ensure that it can deliver useful products in the needed time frame. NRC should continue to place high priority on updating its current research program and schedules to meet the evolving needs of the licensing program, which continues to change in response to reduced resources and the changing regulatory environment.

- The CNWRA research program in hydrology provides the NRC staff with valuable experience and insight into the sensitivity of assumptions, methodologies, and approaches in evaluating the performance of the Yucca Mountain site. However, the relevance of this work has not been clearly established from a risk perspective.
- The NRC research at the Apache Leap site should focus on answering regulatory questions and should become more results-oriented with respect to specific application to licensing products and activities. Although the Apache Leap site itself is not an exact analog to Yucca Mountain, the research is leading to a fundamental understanding of flow and transport processes in unsaturated, fractured, volcanic rock, which, in turn leads to greater credibility and confidence in NRC's independent review of a license application.
- Close coupling is missing between this hydrology research and IPA and other closely related disciplines, including thermal studies, geochemical transport, coupled processes, and tectonics. Also lacking is a strong link between the research at the CNWRA and the University of Arizona.
- The Committee believes there are important reasons for the NRC to conduct hydrology research in the HLW program. For example, flow and transport in unsaturated fractured rock, such as encountered at Yucca Mountain, is poorly understood and requires further elaboration to assist in PA. We endorse this research program, but recommend a greater emphasis on understanding significant processes and developing and validating data and methodologies.

Conclusion

The Committee supports the HLW hydrology research program and believes that the research results will enhance the NRC staff's capability to license an HLW repository. However, the NRC staff needs to ensure that the program is relevant to the licensing evaluation of the performance of the repository, that the research priorities reflect resource and changes in regulatory needs, and that research results are available in a timely manner.

Sincerely -



Paul W. Pomeroy
Chairman

References:

1. National Research Council, "Technical Bases for Yucca Mountain Standards," 1995
2. U. S. Nuclear Regulatory Commission, draft NUREG-1406, "NRC High-Level Radioactive Waste Research Program Plan," February 28, 1992

