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

May 19, 1997

MEMO TO: John C. Hoyle
Secretary of the Commission

FROM: John T. Larkins, Executive Director
Advisory Committee on Nuclear Waste

SUBJECT: REVISION #1 TO THE SCHEDULE FOR THE ACNW MEETING WITH THE NRC COMMISSIONERS, MAY 20, 1997 - SCHEDULE/BACKGROUND INFORMATION

The ACNW will meet with the Commissioners between 2:00 and 3:30 p.m. on Tuesday, May 20, 1997. The Committee has decided to switch the order of their presentation to present issues they believe are of greatest interest to the Commission first. This switch moves the first topic on the old schedule to last place and the last topic on the old schedule into the first place. The proposed schedule would now run as follows:

Introduction - NRC Chairman	2:00 - 2:05 p.m.
Risk-Informed, Performance-Based Regulations - Dr. B. John Garrick (TAB C.2)	2:05 - 2:20 p.m.
Reference Biosphere Critical Group - Dr. B. John Garrick (TAB B.2)	2:20 - 2:35 p.m.
Flow and Radionuclide Transport/Coupled Processes - Dr. George Hornberger (TAB B.3)	2:35 - 2:50 p.m.
Igneous Activity - Dr. William Hinze (TAB C.1)	2:50 - 3:05 p.m.
Selected topics from ACNW's November 20, 1996 Priority Issues - Dr. Paul Pomeroy (TAB B.1)	3:05 - 3:20 p.m.
Closing Remarks - NRC Chairman	3:20 - 3:30 p.m.

cc: ACNW Members
ACNW Technical Staff

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

May 13, 1997

MEMO TO: John C. Hoyle
Secretary of the Commission

FROM: John T. Larkins, Executive Director
Advisory Committee on Nuclear Waste

SUBJECT: ACNW MEETING WITH THE NRC COMMISSIONERS, MAY 20, 1997 - SCHEDULE/BACKGROUND INFORMATION

The ACNW is scheduled to meet with the NRC Commissioners between 2:00 and 3:30 p.m. on Tuesday, May 20, 1997, to discuss the items listed below. Background materials related to these items are attached.

A.	Introduction - NRC Chairman		2:00 - 2:05 p.m.
B.	Completed Projects		
	B.1	Selected topics from ACNW's November 20, 1996 Priority Issues - Dr. Paul Pomeroy	2:05 - 2:20 p.m.
	B.2	Reference Biosphere Critical Group - Dr. John Garrick	2:20 - 2:35 p.m.
	B.3	Flow and radionuclide Transport/Coupled Processes - Dr. George Hornberger	2:35 - 2:50 p.m.
C.	Work In Progress		
	C.1	Igneous Activity - Dr. William Hinze	2:50 - 3:05 p.m.
	C.2	Risk-Informed, Performance-Based Regulations - Dr. John Garrick	3:05 - 3:20 p.m.
D.	Closing Remarks - NRC Chairman		3:20 - 3:30 p.m.

Attachments: As stated

cc: ACNW Members
ACNW Technical Staff

Advisory Committee on Nuclear Waste
Meeting with
U.S. Nuclear Regulatory Commission

Rockville, MD
May 20, 1997

ITEM B.1:

SELECTED TOPICS FROM ACNW'S NOVEMBER 20, 1996 - PRIORITY ISSUES

(DR. POMEROY)

Selected Topics From ACNW's

November 20, 1996 Priority Issues

Dr. Paul Pomeroy
Chairman ACNW

Criteria For ACNW Priorities

Overarching criterion for Assigning Priorities to issues is the protection of the public, workers, and the environment from any adverse effects of the management of nuclear waste, especially in regard to disposal facilities.

Other criteria applied include:

- **NRC's strategic plan, including trends and directions in regulatory practice, such as the adaptation of a risk-informed, performance-based method of regulation and decision-making**
- **The strategy and activities of licensees and applicants**
- **The scientific and technical basis of information supporting the safety and performance assessments of nuclear waste disposal facilities, including the quality and level of technical expertise involved**
- **The timeliness of the advice provided by the ACNW with respect to effective decision-making in the regulatory process**

1997 ACNW PRIORITY ISSUES

- **Regulatory Framework**
  - **Dr. Garrick - The Reference Biosphere and Critical Group**
  - **Dr. Pomeroy - Agreement States Issues**

- **Waste Containment and Isolation Strategy**
  - **Waiting for DOE's document, still some time away**

- **Viability Assessment and Site Characterization**
  - **Dr. Hinze - Igneous Activity**
  - **Dr. Hornberger - Flow and Radionuclide Transport**

- **Repository Design**
  - **Dr. Hornberger - Coupled Processes**

- **Low-level Radioactive Waste (LLW) Disposal**
  - **Believe Committee's views on this topic known to Commission**

1997 ACNW PRIORITY ISSUES (contd.)

- **Decommissioning**
  Dr. Pomeroy

- **Expert Judgment**
  Dr. Pomeroy

- **Risk-Informed and Performance-Based Regulation**
  Dr. Garrick

- **Performance Assessment**

- **Uranium Mill Tailings**

- **Interim Surface Storage Facilities for Spent Fuel**

Regulatory Framework - Agreement States Issues

- **The Criteria Used to Evaluate Adequacy and Compatibility**
  - **The direct relationship of criteria to assurance of competency as well as benefits to protection of public health and safety not proven**
  - **Criteria could include: (1) the number and severity of Incident Reports, and (2) the cost to potential licensees**
- **The State Regulations**
  - **More stringent state regulations, although legal, result in a lack of consistency that leads to public confusion**
- **Site Reviews of Low-Level Waste Facilities**
  - **A critical component in the evaluation of the state technical capability**

Decommissioning - Non-Reactor Facilities

- Placement of the scope and system of decommissioning regulations into a comprehensive strategy for all "low-level" waste leading to consolidation of regulatory controls and consistent regulatory criteria on all radioactive materials (uranium mill tailings, NORM, NARM, decommissioning waste, etc.) within a single agency, the NRC

- Development of a document that specifies the Elements of an Adequate Program

- Identification of those SDMP Sites posing the greatest Risk to the Public and the Environment and Directing Resources to those Cases

Expert Judgment

- Plays an important role in the Decision Making Process
- Concerns:
  - Incorporation of New Data and Conceptual Models
  - Communications

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

November 20, 1996

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

Dear Chairman Jackson:

SUBJECT: 1997 PRIORITY ISSUES FOR THE ADVISORY COMMITTEE ON NUCLEAR WASTE

CRITERIA FOR PRIORITIZATION

The Advisory Committee on Nuclear Waste (ACNW) has adopted and implemented criteria for assigning priorities to issues it will consider. Priorities are assigned and updated annually on the basis of the criteria presented below. Of course, priorities are subject to change at any time on the basis of the needs of the Commission and developing events.

The overarching criterion for assigning priorities to issues is the protection of the public, workers, and the environment from any adverse effects of the management of nuclear waste, especially in regard to disposal facilities.

Other criteria applied in the prioritization process are listed below:

- **NRC's strategic plan, including trends and directions in regulatory practice, such as the adoption of a risk-informed, performance-based method of regulation and decision-making**

  This criterion for establishing priorities includes the consideration of the Commission's own thinking and judgment concerning nuclear waste issues. In particular, it includes a clear understanding of the Commission's view of what the priorities are. However, the ACNW does not restrict the issues to only those of immediate concern to the Commission.

- **The strategy and activities of licensees and applicants**

  Special emphasis should be placed on the Department of Energy's (DOE's) licensing strategy and activities, including the program plan, the site characterization

program, and the performance assessment for the proposed Yucca Mountain repository. The idea is that priorities are dependent not only on the regulatory process but also on the intentions of the licensee and applicant.

- **The scientific and technical basis of information supporting the safety and performance assessments of nuclear waste disposal facilities, including the quality and level of technical expertise involved**

  The importance of an issue is clearly dependent on the quality of the supporting information, such as basic data, and the analyses performed.

- **The timeliness of the advice provided by the ACNW with respect to effective decision-making in the regulatory process**

  The licensing process involves the systematic and incremental development of information. Timely regulatory decision-making depends strongly on an effective match of information development and regulatory involvement.

The application of these criteria has resulted in the following priority issues, not listed in order of importance. It should be pointed out that not all of these issues will be considered. In the final analysis, current events will determine the course of our reviews.

PRIORITY ISSUES

1. Regulatory Framework

   The ACNW will continue to focus on the framework for high-level waste disposal. Environmental Protection Agency (EPA) standards (40 CFR Part 197) and NRC's conforming regulations are scheduled for development. The ACNW will monitor the interaction between the EPA staff and the NRC staff as they consider these standards and regulations. In 1997 DOE will provide for agency and public comment, their HLW siting regulation (10 CFR Part 960). The ACNW will review and comment on the DOE document. Subissues under this topic are the following: regulatory time of compliance, consideration of the critical group and reference biosphere, and whether consideration should be given to risk discounting as an element of a standard. We will consider the defense-in-depth philosophy, the use of subsystem requirements, and the treatment of uncertainty.

2. Waste Isolation Strategy

The ACNW will monitor and comment on DOE's final Waste Isolation Strategy and the NRC staff's response to this document, once these become available. The Waste Isolation Strategy document is expected toward the end of 1996 from the DOE. This issue will focus on the source term and will consider container design. As part of this review, we will examine the NRC staff's Key Technical Issues (KTI) effort and its interface with the DOE's Waste Isolation Strategy.

3. Viability Assessment and Site Characterization

The DOE is scheduled to complete the viability assessment (VA) of the Yucca Mountain repository site in 1998. The principal objective of the VA is to address the major unresolved technical questions and the technical and economic feasibility of constructing and operating a geologic repository at the Yucca Mountain site. The ACNW will review DOE's conclusions and the NRC staff's review of the VA. The ACNW will also be able to determine if the KTI process (the basis of the staff's review effort) will produce sound regulatory decisions. The ACNW will provide advice to the Commission and guidance to the staff on site characterization and analysis activities related to DOE's studies and NRC's KTIs.

4. Repository Design

The ACNW will continue to focus its attention on the repository design, including thermal loading issues. Additional details of the design will be developed as part of the viability assessment determination, but will not be finalized. The ACNW has unresolved concerns on coupled thermal-hydrological-mechanical-chemical processes and will continue to evaluate progress in this area. Other design elements that could affect the overall behavior of the repository, due to their effects on overall system chemistry, are concrete tunnel liners and iron from steel sets and fuel canisters. The ACNW will evaluate the adequacy of models that have been developed to predict repository behavior. Issues such as retrievability and canister design would be considered under this topic. The ACNW will examine the proposed location of the repository within Yucca Mountain and the impact that the repository "foot print" will have on the facility design.

5. Low-Level Radioactive Waste (LLW) Disposal

In December 1995, the ACNW commented on SECY-95-201 in which the NRC staff listed three options for NRC's LLW program (eliminate, reduce, or keep the status quo). In July 1996,

the ACNW produced a report titled "Elements of an Adequate LLW Program," which suggested that, as a minimum, the current program be retained. Our advice is consistent with the Commission's preliminary preferred option in Direction Setting Issue Paper 5. Agreement State programs and the progress of compacts and individual States in developing new disposal facilities remain an issue with ACNW. We remain concerned about the final disposal strategy for mixed wastes and will continue to monitor developments. The ACNW will continue its review of an NRC staff Branch Technical Position on Low-Level Waste (LLW) Performance Assessment and the related time of regulatory compliance associated with LLW disposal.

6. Decommissioning

The ACNW continues to have a strong interest in waste disposal issues related to decommissioning. In the past, the ACNW has advised the Commission on streamlining the Site Decommissioning Management Plan (SDMP) and on the lessons learned from decommissioning the Pathfinder power plant. The ACNW anticipates commenting further on the use of performance assessment in determining priorities for cleanup in SDMP sites. We have several concerns in this area, including residual levels of contamination, mixed waste, greater-than-Class C waste, and consistency of screening criteria and methodology.

7. Expert Judgment in Regulatory Decision Making

The ACNW issued a report in August 1996 on the NRC's Branch Technical Position (BTP) on Expert Elicitation in the High-Level Radioactive Waste Program. In its advice on the BTP, the ACNW identified four areas of concern: (1) the selection of subject matter experts and participation of the experts in refining the problem definition, (2) aggregation of the results, (3) interpretation of the results, and (4) application of expert elicitation. The ACNW will continue to monitor the application of the BTP to specific expert elicitations being conducted by DOE and on the generic applications of the BTP guidance.

8. Risk-Informed and Performance-Based Regulation

The ACNW expects to support an effort designed to help move the agency from deterministic regulations toward risk-informed and performance-based regulation. The goal is to link adequate assurance of safety more closely with the regulations. Our effort will consider practices in other nations that are implementing risk-informed and performance-based regulations. Efforts toward risk harmonization with the EPA will be considered.

9. Performance Assessment (PA)

The ACNW will continue to monitor DOE's total system performance assessment (TSPA) and review the staff's Iterative Performance Assessment Program including NRC's audit review of TSPA. We will continue to consider whether PA is being used to its full advantage in prioritizing issues. The ACNW will investigate the treatment of uncertainty in the use of bounding analyses. Uncertainty analyses are important in determining the adequacy of site characterization and abstracting geologic information for PA models. The ACNW will continue to monitor progress in these areas, and will comment on the advisability of the NRC staff producing a separate guidance document on the treatment of uncertainty.

10. Uranium Mill Tailings

The ACNW will review NRC regulations pertaining to uranium mill tailings. Considerations will include a determination of the risk and practical remediation methods such as the stabilization of tailings piles and groundwater protection monitoring in the vicinity of the tailings pile, as well as radon emissions control. We are interested in the impact on NRC regulations of (1) the current Congressional requirement for perpetual government custody of tailings sites and (2) the EPA standards for the cleanup of uranium and thorium mill sites after permanent closure.

11. Interim Surface Storage Facilities for Spent Fuel

The ACNW will address NRC concerns with a central interim HLW storage facility. We will identify issues that need consideration in surface HLW facilities, including handling operations, cask requirements, comparative risk of various options, and alternatives to dry storage.

We look forward to discussing this 1997 list of priority issues with you and the other Commissioners in the near future. We would welcome any comments and suggestions regarding additions, deletions, or changes in emphasis that you might wish to make.

Sincerely,

Paul W. Pomeroy
Chairman

ITEM B.2:

REFERENCE BIOSPHERE CRITICAL GROUP

(DR. GARRICK)

Reference Biosphere and Critical Group Issues and Their Application to the Proposed HLW Repository at Yucca Mountain, Nevada

Dr. B. John Garrick
Vice-Chairman ACNW

What Are The Questions?

- What is the overarching issue?
- What is the essence of the ACNW advice?
- What is the basis for the advice?

The Issue

- The issue is the exposure scenario(s) that should form the basis for demonstrating compliance of the proposed Yucca Mountain HLW repository.

- Embedded in this issue are the definitions of the reference biosphere, the critical group, and the previously defined time of compliance (June 7 letter).

The ACNW Advice

The Committee's advice takes the form of:

- **Generic definitions for the reference biosphere and the critical group.**
- **Identification of issues unlikely to be resolved by scientific evidence; resolution most likely dependent on the establishment of policy.**
- **Emphasizing the importance of taking advantage of known site characteristics and repository design features to provide increased focus and understanding of the repository performance and safety.**
- **Recommending some principles for calculating and interpreting risk measures.**

Essence of the Advice

- **Reference Biosphere: The environment in which the biota and critical group may come in contact with radionuclides.**

- **Critical Group: The population group forming the basis for calculating the radiation risk to the public and including, but is not limited to, the maximally exposed individual.**

- **Policy Requirement: The basis for defining demographics and behavior of populations at risk from the repository for the time of compliance.**

- **Site-Specificity: Use known site and design characteristics to generate regulations and guidance that will reduce technical uncertainties and increase confidence in the assessment of the safety and overall performance of the repository.**

Risk Assessment Principles: Consistency of application of risk-based methods, a critical group that includes individuals who are at greatest risk, and an indication of the regional risk.

Basis for the Advice

- Scientifically based.
- Policies only where there are scientific gaps.
- Risk-informed and performance-based.
- Consistency of application.

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

April 3, 1997

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

Dear Chairman Jackson:

SUBJECT: REFERENCE BIOSPHERE AND CRITICAL GROUP ISSUES AND THEIR APPLICATION TO THE PROPOSED HIGH-LEVEL WASTE REPOSITORY AT YUCCA MOUNTAIN, NEVADA

The purpose of this letter is to convey the observations and recommendations of the Advisory Committee on Nuclear Waste (ACNW) regarding the issues associated with defining the reference biosphere and the critical group in site-specific regulations for the proposed high-level waste (HLW) repository at Yucca Mountain. This letter supplements the ACNW letter dated June 7, 1996, subject, "Time Span for Compliance of the Proposed High-Level Waste Repository at Yucca Mountain, Nevada," in which we indicated the dependence of the time of compliance on the specification of the reference biosphere and critical population group. In that letter, the Committee indicated that it would provide additional comments on these topics after review and discussion. We believe this letter is appropriate and timely in view of the Commission's need to respond to the Environmental Protection Agency's (EPA's) efforts to develop a Yucca Mountain specific standard (40 CFR Part 197) and make appropriate modifications to the Nuclear Regulatory Commission's (NRC's) HLW regulations.

Our observations and conclusions are based on discussions during a working group meeting on "Specification of the Critical Group and Reference Biosphere" held during the 84th meeting of the ACNW on June 25, 1996, and presentations on biosphere modeling at the 90th meeting of the ACNW on March 21, 1997. During the working group sessions, both oral and written presentations were made by members of the National Academy of Sciences/National Research Council Panel that authored the report, "Technical Bases for Yucca Mountain Standards," and by representatives of the NRC staff, the EPA, the Department of Energy (DOE), the Electric Power Research Institute, and the State of Nevada.

In this letter we provide definitions and assumptions that generally apply to the issues of the biosphere and critical group, and offer suggestions on how these general considerations and definitions can be applied to the Yucca Mountain site. In the course of providing advice on the treatment of biosphere and critical group issues, as well as all other issues, the Committee has been supportive of the agency's desire to move in the direction of risk-informed, performance-

based regulations and standards. Important attributes of adopting a risk-informed approach are the focus on the health and safety of the public and the quantification of uncertainties.

THE PROBLEM

It is necessary to establish a rational basis for determining the radionuclide exposure scenario(s) for the proposed Yucca Mountain repository. Key to solving this problem is specification of a reference biosphere and a critical group. Specification of a reference biosphere sets the conditions for all pathways by which radionuclides from the repository may reach humans, including movement through the food chain as well as direct ingestion of ground water. Specification of a critical group is required because regulations will likely be based on acceptable doses to this group, a surrogate for the public. This approach is in contrast to the traditional NRC dose-based regulatory approach that considers the maximally exposed individual at a prescribed distance from the facility for determining compliance. Also, because of the long time periods involved and the desire to simplify the performance assessment wherever possible, an appropriate definition of the time of compliance is an important consideration.

The definitions for time of compliance, critical group, and reference biosphere should enable a license applicant to identify clearly the assumptions and calculations used in performance assessment. The specification of these elements should be based as much as possible on scientific and technical evidence. In the absence of such evidence, a decision based on policy will have to be made by the appropriate Government unit on the basis of current conditions and reasonably bounded uncertainties. For example, the specification of the critical group, as well as certain factors of the reference biosphere, will require decisions about appropriate estimates of future human demographics and behavior. The overall objective in defining these terms for Yucca Mountain should be protection of the public health and safety and the environment for future generations, using policies and procedures rooted in available science.

GENERAL DEFINITIONS AND ASSUMPTIONS

The following definitions and assumptions form a basis for providing guidance on the important, interconnected issues of the reference biosphere and the critical group necessary for the performance assessment of a geologic repository for radioactive waste.

1. The reference biosphere is the environment (biologic, geologic, hydrologic, and atmospheric) in the vicinity of the repository in which the biota and the critical group may come in contact with radionuclides. The biosphere defines the portion of the environment in which radionuclides can reach human populations. Exposure pathways in the biosphere include ground water, surface water, soils, plants, animals, and air.

2. The critical group is a relatively homogeneous group of people whose location in the general vicinity of the repository and whose habits are such that they include individuals expected to receive the highest doses from radionuclides discharged from the repository. Estimates of exposures to the critical group may be extended to risk through the appropriate dose-response relationship.

3. The biosphere and the critical group should be based on known site characteristics. Site characteristics include the geologic and climatic setting, engineered safety features, and demographics. The policy set forth in the standard and regulations must allow site-specific characteristics to be considered; that is, they must not be overly prescriptive in a generic sense.

4. The societal state of the region around the repository cannot be predicted with confidence for thousands of years into the future. Large uncertainties exist in the description of the societal states. Decisions regarding demographics, human behavior, and land use thousands of years into the future should be a matter of policy derived from available science. A reasonable policy is that the current societal state in the vicinity of a site will be the basis for analyzing the expected safety of the public unless there is scientific evidence to indicate that other climatic, demographic, or biological conditions are more appropriate.

These four definitions and assumptions are believed to be a reasonable foundation for addressing the issues of biospheres and critical groups for any nuclear waste repository. We now apply these definitions and assumptions to the proposed Yucca Mountain repository and the surrounding area with respect to the specific issues of the biosphere and the critical group.

APPLICATION OF THE REFERENCE BIOSPHERE AND THE CRITICAL GROUP TO THE PROPOSED YUCCA MOUNTAIN REPOSITORY

Reference Biosphere

The description of the biosphere is an important element of defining repository exposure scenarios for calculating public health risk. The primary source of risk is likely to be the ingestion of food and water. Site-specific attributes are critical to the description of transport pathways that lead to calculated exposures of the critical group. Thus, site characterization is a key source of information for describing the reference biosphere.

Future changes in the biosphere that can be reasonably characterized should be considered in this definition. For example, climatic components of the reference biosphere will change with time. Paleoclimatic and paleohydrologic studies of the Quaternary Period, and especially the Holocene, indicate (and can provide bounds on) climate change to a cooler, wetter regime associated with the onset of the next glacial cycle. The anticipated changes in climate over time can be used to refine the reference biosphere when supported by scientific evidence. For example, a potential rise in the water table as a result of a cooler, wetter climate could make ground water more accessible in the currently arid regions in the vicinity of Yucca Mountain. Should evidence to the contrary arise as a result of site characterization studies, that too should be part of the input to the definition of the reference biosphere.

Critical Group

As indicated in definition 2 above, the critical group is a relatively homogeneous group of people whose location and habits are such that they are representative of those individuals expected to receive the highest doses as a result of the discharge of radionuclides. The suggested policy

assumption of item 4 above leads to the definition of the critical group. For example, the density, distribution, and habits of the population in the Amargosa Valley could be the basis for defining the critical group. Although the definition of a Yucca Mountain specific critical group will likely be decided on the basis of policy, the need remains to develop a repository performance assessment model that is convincing, clear, and justifiable.

The purpose of this letter is not to prescribe a calculation procedure but to identify some principles that the Committee believes should guide the critical group risk calculations for the proposed Yucca Mountain site. These principles are as follows:

1. The principle of consistency should be applied in the use of probabilistic methods. The "principle of consistency" as used here is the consistent application of probabilistic methods to different aspects of the Yucca Mountain repository performance assessment, including waste container degradation, radionuclide transport, and the human exposure scenario.

2. The critical group should include those individuals who are at greatest risk.

3. The group should be relatively homogeneous in terms of the exposure of its individuals to radiation.

4. Even if the regulation prescribes a maximum acceptable dose to only the critical group, risk-based calculations should be performed that clearly display the probability and health effects to the public in the vicinity of the repository.

Calculations of the type specified in item 4 above are consistent with the adoption of a risk-informed approach to regulation. In particular, it is important to understand how the risk is distributed. Thus, calculations that indicate the likelihood that "N" or more people will receive "D" or more dose will provide a meaningful indication of the risk to the entire population being studied. Such calculations can be especially constructive in revealing site peculiarities that may result in highly localized doses. Furthermore, the results may reveal interdiction options that could turn an otherwise questionable site into an acceptable one at a fraction of the resources that might be required to consider an alternate site.

The Committee believes that the definitions, assumptions, and principles outlined herein provide a basis for the NRC staff to develop guidance on the licensing of the proposed Yucca Mountain HLW repository. We wish to emphasize an important message in this letter. Even though a policy solution is required for some of the issues associated with the Yucca Mountain site, the Committee believes that scientific evidence should prevail when it exists. For example, both the regulations and the staff should encourage the DOE to consider temporal changes, such as climate, and to utilize those changes that can be scientifically supported.

SUMMARY

Specification of the reference biosphere and the critical group is an important element in the regulation of nuclear waste disposal facilities. The ACNW proposes a set of definitions and assumptions to guide the specification of the biosphere and the critical group. For the proposed

Yucca Mountain repository, we recommend using the results of the site characterization program as the principal basis for defining the reference biosphere, the environment through which the critical group may be exposed to radionuclides. The Committee believes that specification of the critical group, a small relatively homogeneous assembly of the most highly exposed people that serve as a surrogate for the public, requires the establishment of policy. The policy suggested is that the reference biosphere and the critical group could be based on present conditions in the Amargosa Valley unless a scientific basis can be given for using other assumptions.

We believe that our proposed approach can result in a robust and defensible set of regulations.

Sincerely,

Paul W. Pomeroy
Chairman

ITEM B.3:

FLOW AND RADIONUCLIDE TRANSPORT COUPLED PROCESSES

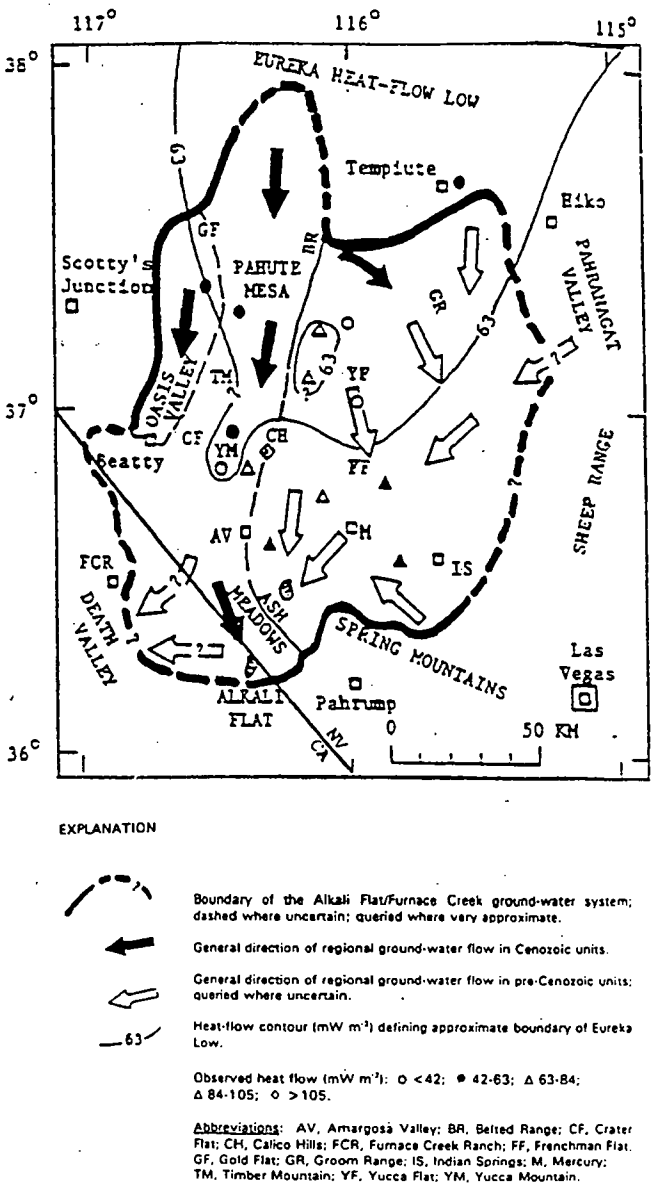
(DR. HORNBERGER)

Flow and Radionuclide Transport Issues at Yucca Mountain and Coupled Processes

Dr. George Hornberger
ACNW

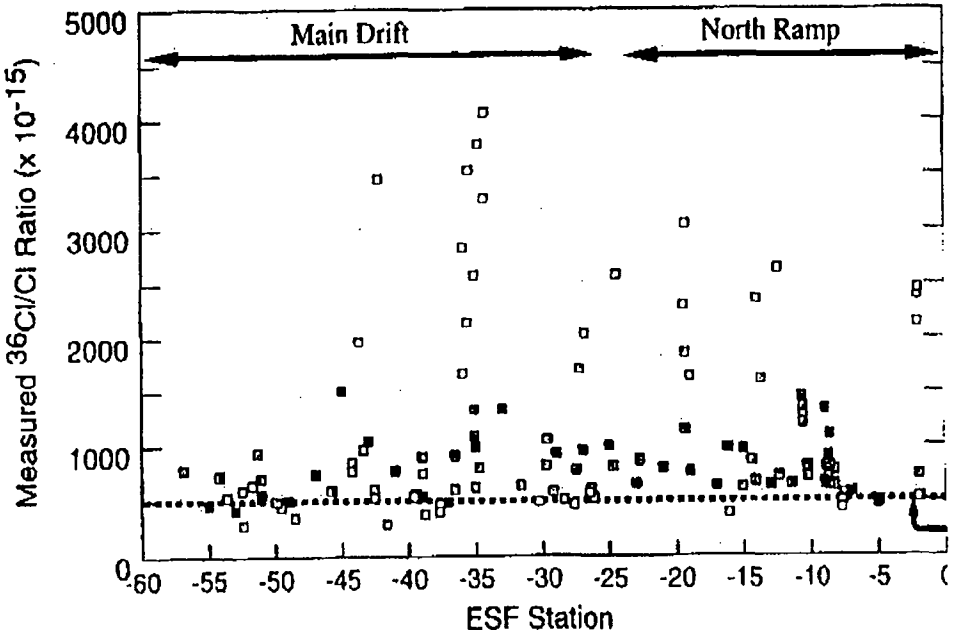
Background

- Radionuclide transport is considered a "major system attribute" in the Department of Energy's Waste Containment and Isolation Strategy.
- ACNW believes that the NRC Key Technical Issues related to water flow and radionuclide transport at Yucca Mountain are significant to repository performance.
- ACNW held a working-group meeting in September 1996.



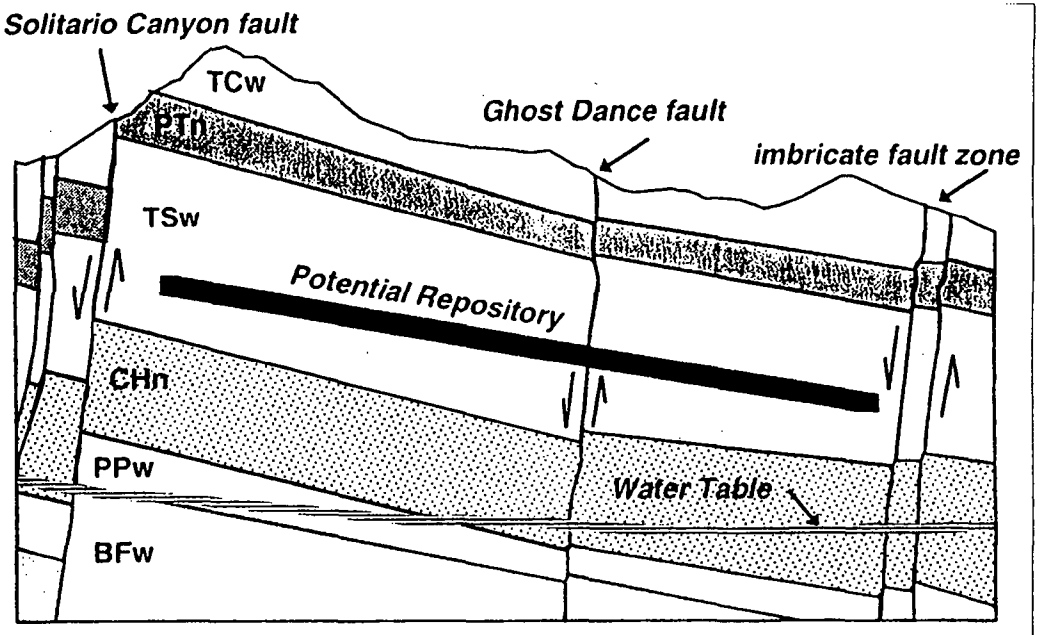
Significant Issues from Working Group Meeting

- **Exploratory Studies Facility samples show apparent "bomb-pulse" ^{36}Cl on or near some faults that are mapped at the surface. These results reinforce the notion that interconnected fractures form transport pathways for radionuclides at Yucca Mountain.**



Significant Issues from Working Group Meeting

- Although average flux values are now thought to be significantly higher (1 to 20 mm/yr) than in the past (<<1mm/yr), there appears to be a paucity of critical information on hydrological characteristics of fractures and faults and their impact on the transport of radionuclides.

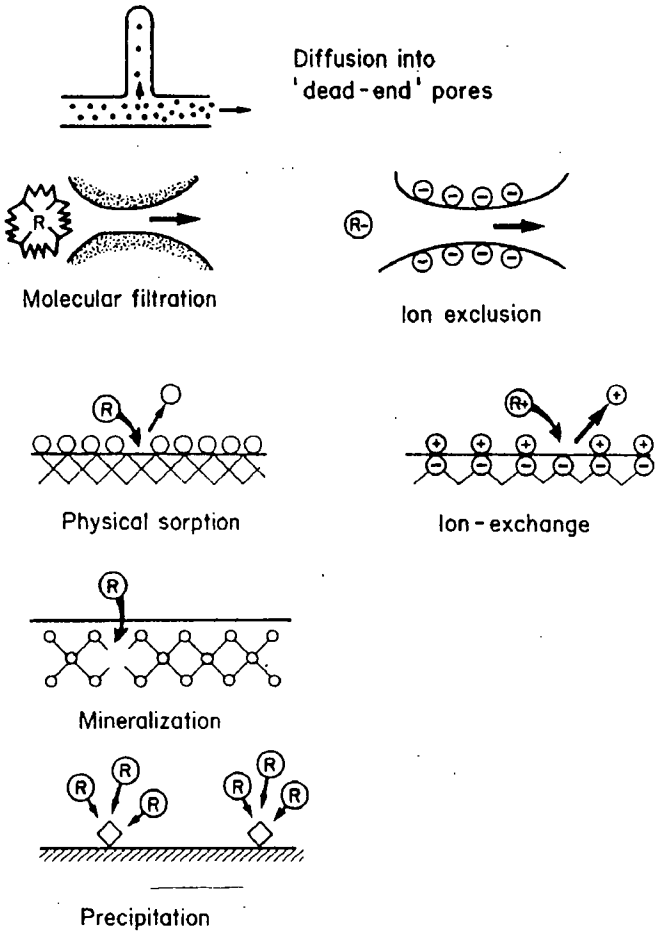


Schematic cross section of the potential Yucca Mountain repository region showing location of the repository horizon and static water table with respect to the thermal/mechanical stratigraphic units defined by Ortiz et al. (1985). TCw: Tiva Canyon welded unit; PTn: Paintbrush nonwelded unit; TSw: Topopah Spring welded unit; CHn: Calico Hills nonwelded unit; PPw: Prow Pass welded unit; BFw: Bullfrog welded unit.
Source: Wilson et al., 1994.

Significant Issues from Working Group Meeting

- It is unclear how DOE is taking into account the chemical state of the repository in its evaluation of performance.

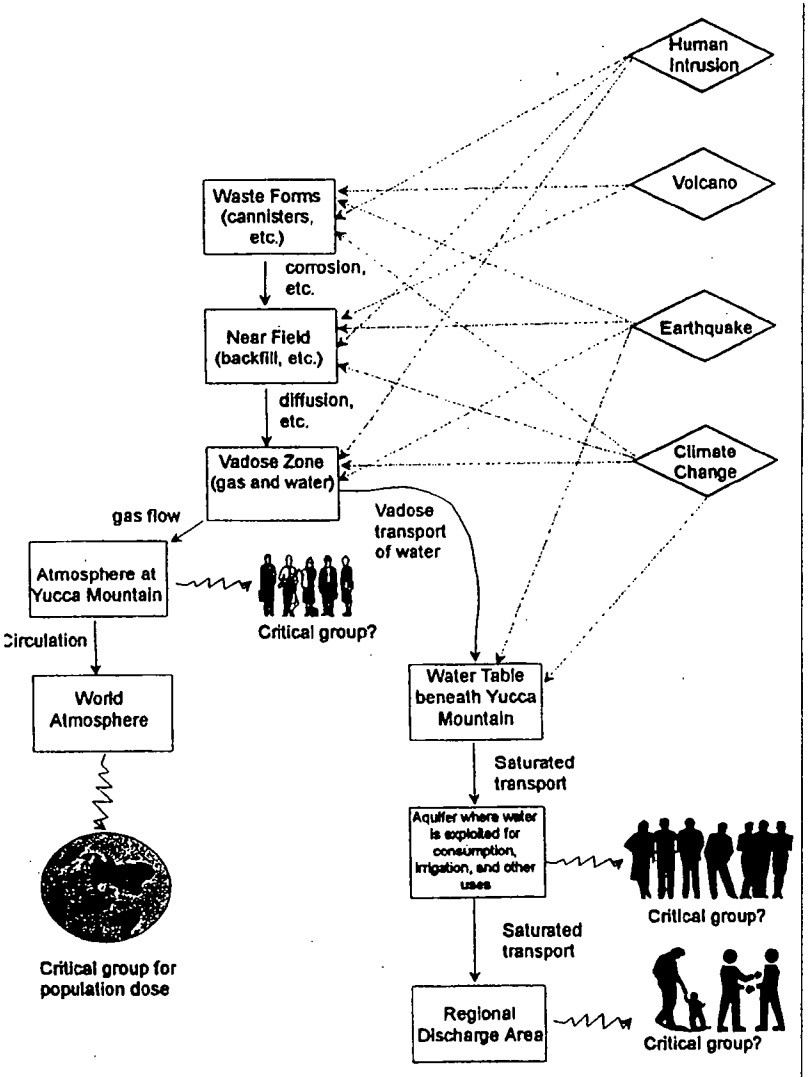
- The role of geochemistry in radionuclide transport may become crucial to demonstrating compliance:
  - Attenuation of concentrations in groundwater
  - Effects of colloids is an unresolved issue.



Concerns and Advice

- ACNW is concerned about integration in the DOE program, e.g., the transition from "science" models to "engineering" models for total system performance assessment (TSPA).

- NRC staff should follow closely the DOE expert elicitations and TSPA abstraction workshops and continue to examine available information from DOE to ensure that the abstraction from detailed models to the TSPA models is valid and transparent.



Concerns and Advice

- ACNW is concerned that the NRC staff had to eliminate radionuclide transport work at the CNWRA.
- NRC needs to maintain a critical level of expertise related to flow and radionuclide transport and should ensure the CNWRA continues to develop coupled chemical and hydrologic transport models
- NRC also should consider supporting work to observe naturally occurring colloids and possibly to introduce colloidal "tracers" at the ALRS to generate data useful for bounding calculations at Yucca Mountain.

COUPLED PROCESSES

- Anticipate increased use of PA to prioritize coupled process studies
- Greater emphasis needed on data acquisition versus development of models and codes
- Greater emphasis needed on near field chemistry
- Staff activities limited by resource constraints; commitment to increase use of PA to guide priorities and conduct sensitivity studies this year

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

February 13, 1997

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

Dear Chairman Jackson:

SUBJECT: COMMENTS ON FLOW AND RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN

Evaluation of the strategy for dealing with disposal of high-level radioactive wastes will require a license applicant to demonstrate convincingly that a site has hydrogeological characteristics that are appropriate for mitigating releases of radionuclides to the biosphere. Consequently, the Advisory Committee on Nuclear Waste (ACNW) continues to hold as a high priority the evaluation of NRC Key Technical Issues that relate to flow of water and the transport of radionuclides at Yucca Mountain. The ACNW held a working group on flow and radionuclide transport on September 26, 1996. The Committee heard from representatives of the Los Alamos National Laboratory, the Lawrence Livermore National Laboratory, the Lawrence Berkeley Laboratory, the Electric Power Research Institute, the Department of Energy (DOE) Yucca Mountain Project Office, and the University of Arizona.

Following the presentations at the working group, and on the basis of other experience as well, the ACNW has several recommendations that reflect our continuing interest in the important issue of transport of radionuclides at the site.

- Because of the importance of radionuclide transport and the effects of sorptive processes on radionuclide concentrations in groundwater, as recognized in the DOE Waste Containment and Isolation Strategy, the NRC should maintain a critical level of expertise within its staff and at the Center for Nuclear Waste Regulatory Analyses (CNWRA) related to flow and radionuclide transport.

- The NRC staff should examine available information from DOE to ensure that the abstraction from detailed models to the total system performance assessment (TSPA) models are valid and transparent and that the details of individual models are clear. As part of this examination, the NRC should

follow closely the appropriate DOE expert elicitations and TSPA abstraction workshops.

- It is not clear that DOE is developing a comprehensive chemistry model for the site for analyzing transport processes. Accordingly, the staff should ensure that the CNWRA continues to levelop coupled chemical and hydrologic transport models to determine whether these coupled processes are important to demonstrating compliance with a risk- (or dose-) based standard. As part of this model development, the staff should continue to support the work at the CNWRA to determine the potential importance of "foreign" materials (such as concrete and steel) in the performance of the repository.

- The Apache Leap Research Site (ALRS) could be used as a location to collect important data on colloid migration through a fractured unsaturated tuff. The NRC should consider supporting work to observe naturally occurring colloids and possibly to introduce colloidal "tracers" at the ALRS to generate data useful for bounding calculations at Yucca Mountain.

DETAILED COMMENTS

Total System Performance Assessment Issues

Radionuclide transport by subsurface water at the Yucca Mountain site is thought to be the most significant pathway in terms of risk to the critical group. The evaluation of risk will be accomplished through TSPA. It is necessary to establish the important processes and mechanisms for retaining and retarding the release and transport of radionuclides from the repository. These processes attenuate radionuclide concentrations in the ground water and thus reduce the calculated dose to a member of the critical group. To be effective in evaluating of the expected license application for Yucca Mountain, the NRC staff will have to be able to understand and critically evaluate the work of DOE and its contractors on transport phenomena. The ACNW is concerned that the NRC staff had to eliminate radionuclide transport work at the CNWRA. The issue remains critical to assessment of the repository, and we encourage reinstatement of CNWRA activities in this area.

An evaluation of the Yucca Mountain site with respect to standards will require the framework of a risk assessment. The ACNW is not convinced that the DOE program is strongly integrated. We are concerned that the transition from models developed in somewhat isolated "science" programs of DOE contractors to those required for practical, "engineering" system-level performance assessment may be opaque. It is essential that the NRC staff fully understand the abstraction process. Currently, DOE is planning and conducting a series of expert elicitations related to the performance assessment resource

base. The NRC staff needs to continue evaluating these activities, as well as the DOE abstraction workshops.

Flow and Transport in the Vadose Zone and the Saturated Zone

Samples recovered from the Yucca Mountain Exploratory Studies Facility (ESF) show apparent "bomb-pulse" ^{36}Cl on or near some faults that are mapped at the surface[1]. The isotopic data, which provide important insights into transport processes, reinforce the notion that an interconnected set of fractures forms a transport pathway for radionuclides at Yucca Mountain. DOE models for flow and transport in the vadose zone must employ flow along faults and fractures and diffusion from the fractures into the matrix as important processes. There appears to be a paucity of critical information on hydrological characteristics of fractures and faults and their impact on the transport of radionuclides.

Models for the vadose zone employed by DOE necessarily rely on integrated average values of percolation fluxes of water through the repository horizon. The generally accepted average flux values have crept upward over the past years, covering a range between 1 and 20 mm/yr. In the saturated zone, models use "dual continuum" methods to approximate flow in fractures and diffusion into the surrounding rock matrix. The available data related to hydrological characteristics of rocks in the saturated zone may not be adequate to constrain models in a credible way. The NRC and CNWRA staffs need to maintain their efforts in flow and transport modeling in the vadose zone and the saturated zone, and on the use of data to determine parameters in the models, to ensure that they will have the capability to conduct an assessment at the time of license application.

The Role of Chemistry in Evaluating Risk

In February 1995, a group of DOE and contractor scientists prepared a "white paper" outlining the needs for quantifying chemical reactions at Yucca Mountain.[2] The report notes that "the key performance issue for the Yucca Mountain site is radionuclide transport. Transport, in turn, consists of the coupling of flow (hydrology) and retardation (geochemistry)." This report describes how chemical studies involving concrete, waste canisters, and other "foreign" materials in the near field are essential ingredients of a program. In such a program, solubility, speciation, and sorption must all be adequately quantified in the near and far fields. We could not determine from material presented to us at the working group the extent to which DOE is taking into account the effect that these "foreign" materials have on reactions and speciation of important nuclides (e.g., Np, Tc, U, Pu, I, and perhaps Se). The chemical state of the repository needs to be evaluated to

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[1] Fabryka-Martin, J.T., Dixon, P.R., Levy, S., Liu, B., Turin, H.J., and A.V. Wolfsberg. 1996. Systematic sampling for chlorine-36 in the Exploratory Studies Facility. Draft material presented to the ACNW.

[2] Simmons, A.M., Nelson, S.T., Cloke, P.L., Crump, T.R., Duffy, C.J., Glassley, W.E., Peterman, Z.E., Siegel, M.D., Stahl, D., Steinkampf, W.C., and B.E. Viani. 1995. The Critical Role of Geochemistry in the Program Approach. Unpublished paper.

determine whether these materials exercise a significant buffering effect on the chemical environment in terms of the calculated consequences.

The role of geochemistry in radionuclide transport has become crucial to demonstrating compliance. The understanding of the hydrologic system at Yucca Mountain has evolved from a model based primarily upon fluid flow through the rock matrix, with very slow transport pathways, to a model that includes, and may be dominated by, fluid flow through an interconnected network of fractures, with relatively fast pathways. What is needed is a comprehensive chemical model for the site. The NRC staff should evaluate DOE's efforts in this area and determine the advisability of DOE's developing a site chemistry model. We are concerned that DOE may be relying too much on laboratory-scale experiments. We urge the NRC staff to investigate the appropriate use of data from intermediate-scale field tests and from natural analogs to build confidence in modeling results.

Colloids and Radionuclide Transport

The transport of colloids through unsaturated rocks is a poorly understood phenomenon. We received no information at our working group to counter the 1995 conclusion of Manaktala, et al[3]: "Based on reports in the available literature, it may be possible for colloids to form in the Yucca Mountain environment, but the extent to which they could contribute to overall radionuclide transport remains unclear." We do not know whether colloid migration could be an important consideration in either enhancing or inhibiting radionuclide transport at Yucca Mountain. We believe that it is important to deal with the colloid issue in a direct fashion. The importance of colloid transport may be negligible, but an initiative must be taken to assess whether this is true.

The ALRS is in a fractured tuff but has an annual rainfall of more than twice that at Yucca Mountain. In a sense, the ALRS is an "analog" for Yucca Mountain under pluvial conditions, which are anticipated to occur within the time frame of a few tens of thousands of years. Because the ALRS is wetter than Yucca Mountain, it should be possible to collect water samples of flow through fractures in the vadose zone and determine colloid concentrations. Because there is a known connection along a fracture to a surface expression in a stream channel, it should also be possible to introduce colloidal "tracers" at the surface and monitor samples at depth to quantify transport. Data from the ALRS should prove to be very valuable in performing bounding calculations for Yucca Mountain that may resolve the colloid issue.

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[3] Manaktala, H., Turner, D.,Ahn, T. Colten-Bradley, V., and E. Bonano. 1995. Potential Implications of Colloids on the Long-Term Performance of a High-Level Radioactive Waste Repository, CNWRA 95-015.

We trust that our comments and suggestions will be helpful in assessing the potential risks associated with the proposed high-level waste repository at Yucca Mountain.

Sincerely,

Paul W. Pomeroy,
Chairman

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

November 8, 1996

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

Dear Chairman Jackson:

Subject: COMMENTS ON COUPLED PROCESSES IN THE NRC HIGH-LEVEL WASTE PRELICENSING PROGRAM

SUMMARY

The Advisory Committee on Nuclear Waste (ACNW) is impressed by the progress that the NRC staff and the Center for Nuclear Waste Regulatory Analyses (CNWRA) have made in developing a strong program to study potential coupled processes at the site of the proposed repository at Yucca Mountain, Nevada. Furthermore, we are pleased with the plans for integrating coupled processes among the vertical slice investigations of key technical issues (KTIs). The Committee has provided observations and suggestions to strengthen NRC's approach to coupled processes.

We want to emphasize the following recommendations:

(1) Performance assessment needs to have a more prominent role in guiding the prioritization of coupled processes studies.

(2) The NRC should revise its decision to not participate in DECOVALEX, a multidisciplinary international program dedicated to the Development of Coupled Models and their Validation against Experiments.

(3) The coupled processes studies are "data starved." Changes are needed in the program to rectify this situation.

(4) The modeling studies in thermal-hydrological (TH) processes need to be expanded.

(5) Greater attention is needed on near-field chemistry, with particular emphasis on thermal-hydrological-chemical (T-H-C) processes that affect contaminant release and transport.

INTRODUCTION

In February 1996, we communicated our recommendations and suggestions on the "Revised Prelicensing Program Strategy for the U.S. Nuclear Regulatory Commission High-Level Waste Repository Program ('Vertical Slice Approach')" and the NRC staff's plans for resolving KTIs dealing with the proposed high-level waste (HLW) geologic repository at Yucca Mountain, Nevada. In that letter, we made suggestions for improving the strategy and investigation of the KTIs, but we were, and continue to be, supportive of the work of the NRC staff in this regard. We see this program as an excellent response to maintaining a prelicensing program focused on critical issues in the face of limited resources. In our February 1996 letter we expressed our concern that within the specified strategy and program, it was unclear if the issue of in situ thermal-mechanical-hydrological-chemical (T-M-H-C) coupled processes was moving toward resolution. This letter provides further comments on that concern.

Construction of the proposed repository will perturb the stress pattern in Yucca Mountain, thus resulting in mechanical deformation of the surrounding rock and the emplaced HLW will cause a significant heat pulse to the rock. The resulting thermal and mechanical effects are interrelated and may significantly affect the movement of water and the nature of related hydrologic properties, as well as the chemical processes acting on the waste, canisters, and surrounding engineered and natural materials of the repository. These coupled processes may have an important impact on the performance of the repository over the course of its history. The algorithms used in modeling the performance of the repository system are influenced strongly by the analytical descriptions of the various coupled relationships among physical and chemical phenomena. The Committee is concerned that the "vertical slice" approach to the KTIs could lead to neglect of interaction of phenomena and their resulting modifications of parameters and processes. To evaluate the current validity of this concern, the ACNW reviewed the status of the investigation of coupled processes by the NRC staff and the integration of these activities among and within KTIs through a working group on T-M-H-C coupled processes at the 85th meeting of the Committee. Comments were made by representatives of the NRC staff, the CNWRA, Lawrence Berkeley Laboratory, the U.S. Geological Survey, the Department of Energy (DOE), academia, and private industry.

The Committee learned of the significant progress in the T-M-H-C coupled processes investigations and was impressed by studies being performed by the NRC and CNWRA. Effort has been put into the related KTI investigations and the integration of elements of the coupled processes among the KTIs. Below are our observations and suggestions regarding coupled processes, which should focus future activities on the potentially most critical elements.

TECHNICAL OBSERVATIONS AND SUGGESTIONS

I. General

(1) The NRC staff, with the support of the CNWRA, has developed a strong program for studying the impact of selected coupled processes on the performance of the potential repository at Yucca Mountain. This is especially true in T-H coupled processes, which have been ranked consistently as high priority in reviews of both the NRC's and the DOE's programs.

(2) A key to coupled processes studies and the development of supporting data is understanding their overall importance to repository performance. The Committee is pleased to see the increasing role of performance assessment (PA) in this regard. It is critical that the PA activity be used to provide the necessary insights and understanding of physical processes to maximize the return on investment of investigative resources. The Committee looks forward to the increased use of PA to guide the scope of analysis and research activities.

(3) We understand the continued need to reassess the allocation of HLW funding in the face of shrinking resources. However, the Committee is concerned about NRC's withdrawal from Phase II of the multidisciplinary international program DECOVALEX. The Committee sees the results of the DECOVALEX project to date as meaningful to the NRC HLW program. The testing of mathematical models and computer codes for predicting the effects of coupled processes, which is the aim of the project, is a most critical aspect of the study of coupled processes. In the tasks outlined for the continuing project, a variety of models and codes, developed largely independently by investigators in several countries, will be tested against each other and against experimental results from international nuclear waste test facilities. Although these test sites will not duplicate exactly the proposed unsaturated-tuff geologic repository at Yucca Mountain, the results should be useful in the NRC scoping studies and testing of models and codes. For these reasons, the Committee urges the staff to reverse its decision to withdraw from the DECOVALEX project.

(4) The coupled processes studies of the NRC and the CNWRA appear to be "data starved." The primary emphasis of the studies has been on developing models and related codes. This is an important element of the program but is only one of the necessary ingredients to bringing the program to fruition. The termination of the HLW research program in this topic apparently has reduced access to experimental and geologic analog information useful in validating the models and codes and in providing bounding data. This is true over a range of processes but is especially important to thermal processes and their effect on properties and other processes. In the face

of this problem, both the NRC and the CNWRA should make specific efforts to obtain all relevant data from the DOE and its contractors. Further, the Committee believes that there is important information to be gained from studies of current and ancient geologic regions, with thermal anomalies for which data are available. For example, existing data from the Nevada Test Site operations may be useful. Also, the Committee has learned of recent studies on the properties, chemistry (mineralogy), and mechanical characteristics of rocks similar to those at Yucca Mountain surrounding an igneous intrusion in the Nevada Test Site. This and similar analogs are potentially a valuable source of T-H-M-C information.

Limitations on data from thermal testing are exacerbated by the current timing of the thermal tests being conducted and organized by the DOE at Yucca Mountain. The high thermal inertia of the rock precludes significant acceleration of the studies. Currently, the single heater test in the Exploration Study Facility and the large block test will provide thermal input before the DOE's Viability Assessment (VA), but these tests will not give the bulk properties of Yucca Mountain. The plan is to obtain these properties from the drift scale thermal tests, but data from this test will not be available in time for the VA decisions. Furthermore, it is unclear how the results of these tests will be used to evaluate alternative models for describing thermally induced phenomena in highly fractured rock. The NRC should consider how these data limitations will affect their response to the DOE's VA.

II. Specific

(1) The Committee concurs with the emphasis placed by the NRC staff on the T-H coupled processes, but we note that in the CNWRA's assessment of the importance of post-closure processes, the combination of T-H processes on chemical processes is deemed most important. We agree with this conclusion because of the potential effect on release, transport, and retardation of radionuclides. However, we note only limited, albeit important, attention directed to the chemical portion of the coupled processes equation. Studies are largely limited to model and code development using simplified matrix mineralogy (chemistry). We believe greater attention is warranted on near-field, contaminant-related chemistry, for example, the effect of temperature on the chemistry of glasses, of sorption of radionuclides by zeolites and other minerals, of redox changes, and so on. We encourage scoping studies to determine the potential impact of temperature and hydrology on chemistry as this will affect NRC decisions that have to be made in the near term related to the VA. For example, mineral precipitation and dissolution may

profoundly alter the rock permeability in the near-field region. The required thermodynamic data at elevated temperatures currently are inadequately known and the effects of such attributes as grain size and fracture filling on chemical reactions need clarification.

(2) The NRC and the CNWRA note potential shortcomings in the Equivalent Continuum Model (ECM), which is the current focus of T-H studies. Of critical concern is the effectiveness of the ECM in predicting flow through fractured rock and the possible development of the "heat pipe" associated with the thermal pulse caused by the decaying HLW. The DOE Peer Review Team on Thermohydrologic Testing and Modeling also identifies potential shortcomings. The Executive Summary of the DOE report states that the ECM quantitative predictions, particularly where they impact design of the underground structures, should be accepted with a great deal of caution. The Executive Summary also states the following:

> The main computational codes. . .have undergone extensive development and verification. The next step in their use, however, should involve investigations, primarily in underground tests, where the efficacy of ECM can be carefully examined. Given the apparent limitations of the ECM, further application of these models would appear to be inappropriate without such confirmation.

We encourage the CNWRA to expand its studies of T-H to include testing the ECM models and codes through studies of current and ancient geothermal regions. These geologic analogs, at a minimum, should identify the effects and relative importance of the principal processes.

(3) We encourage studies of T-H-C processes between the repository and the location of the critical group. We understand that a study has been initiated at the CNWRA to study hydrological chemical (H-C) effects in the Calico Hills formation, which is rich in cation exchange minerals. We believe this and related studies are warranted. The staff needs to be aware of nonreversible processes in the near field, such as thermal effects on permeability, and their impact upon far-field processes.

(4) The program to study the effect of natural disruptive processes, for example, igneous activity, was not the subject of our current review. Nonetheless, we were pleased to learn that the study of the effect of natural disruption of the repository is included in future plans for coupled processes investigations by the NRC.

(5) We believe it is important to conduct scoping studies to aid in the assessment of the potential effects from coupled

processes that are not deemed important on the basis of literature review. Specifically, we suggest that scoping calculations be performed to address the concerns regarding "indirect flow" processes or "Onsager processes."

(6) We believe the mechanical aspects of the T-H-M-C processes are less problematic than the other components, and, thus, at this time, related studies can be minimized or eliminated.

III. Related Issues

(1) Our original concerns about the investigation of coupled processes in the "vertical-slice" approach to key issues during the prelicensing studies by NRC were focused on the integration among the various processes. We are pleased that the NRC management has proceeded beyond the KTI dealing with Total Systems Performance Assessment and Integration by developing a management integration task force. We congratulate the staff on this action, which goes a long way toward alleviating our concern. This "top-down" approach has many advantages. Nonetheless, we encourage the staff at all levels to be sensitive to the need to communicate across discipline and KTI boundaries and thus to implement integration meaningfully and in a timely manner. In addition, we encourage management to continue support of the Integration Task Force in the important studies leading to decisions at the time DOE completes its VA process and in the years beyond the VA in the prelicensing and licensing periods.

(2) We have referred to many of the coupled processes investigations as "data starved." Resource limitations mandate limited opportunity for experimentation and field studies, and, thus, this lack of data is likely to remain unremedied, without special efforts on the part of management. We believe joint programs with other nations that have parallel interests are a worthwhile investment. In addition, every effort must be made to apply the considerable data collected by DOE and its contractors to the NRC programs. Furthermore, we suggest that important data on critical coupled processes problems exist in peer-reviewed journals and industrial and government literature. Management should work toward developing a climate that fosters using these low-cost data in the NRC program.

(3) The Staff is encouraged to be sensitive to the developing DOE strategy for waste emplacement in the repository so that the potential effects on thermal loading are included in scoping and sensitivity studies as part of the coupled processes program. Because of limited thermal testing at the time of the VA, the NRC should evaluate the impact of these studies at that time and develop strategies for minimizing their impact. Limitations imposed by an incomplete understanding of thermal

properties and processes because of restricted in situ testing even in the post-VA period remains a possibility that needs to be considered by the NRC.

We believe the NRC staff has a strong program to examine the importance of coupled processes and trust that these suggestions will be helpful in further focusing the program.

Sincerely,

Paul W. Pomeroy
Chairman

ITEM C.1:

IGNEOUS ACTIVITY

(DR. HINZE)

Igneous Activity

Dr. William J. Hinze
ACNW

THE ISSUE

- Potential Risk from Igneous Activity identified as important site characterization issue based on:
  - Geologically modern volcanism in the proximity of Yucca Mountain (likelihood of activity)
  - Entrainment of waste in eruptions could bring waste to surface (consequences)
- Historically a contentious issue:
  - DOE, NRC, and State of Nevada have had a major activities to study igneous activity at Yucca Mountain
  - Science of assessing likelihood and consequences is not well developed
  - Limited experience in prediction and number of igneous events at Yucca Mountain mandates a statistical approach

ACNW ACTIVITIES

- Monitored progress of NRC Igneous Activity program
- Supported need for strong NRC program
- Convened a full day meeting in April to examine status of Igneous Activity KIT
- ACNW concludes the topic is nearing completion and should be brought to an orderly close within approximately one year

STATUS

- DOE has closed out its volcanism site characterization program with PVHA, but synthesis report will not be available until later in the year

- DOE and NRC disagree on approach to estimate probability of an igneous event and precise probability value

- NRC has performed consequence estimates; DOE is in planning stages and will do analysis as part of TSPA-VA

- NRC continues to conduct limited field and modeling studies to constrain uncertainty and test conceptual models

RESULTS

- NRC tentative estimates are:
  - probability: 10 E-7 to 10 E-8 events/year
  - consequences: 500 mrem/year
  - risk: 0.5 mrem/year in 10,000 years
  - DOE estimates probability of 1.5 x 10 E-8 (10 E-7 to 10 E-10 bounds) events per year from PVHA

ACNW'S CONCLUSIONS

- NRC has a strong technical program that provides excellent confirmatory expertise
- Probability and consequence activities of NRC need to be prioritized and brought to an orderly conclusion within a year
  - Probability studies need to be summarized and potential igneous event sites nearby Yucca Mountain investigated
  - Consequence studies need to consider range of scenarios in sensitivity studies
- Greater reliance on PA is needed to establish relative risk of Igneous Activity and other KIT's and to establish priority activities
- Maintain expertise in Igneous Activity to monitor and evaluate continuing scientific progress in predicting igneous events

ITEM C.2:

RISK-INFORMED, PERFORMANCE-BASED REGULATIONS

(DR. GARRICK)

Risk - Informed, Performance - Based Regulation in the Nuclear Waste Field

B. John Garrick, Vice Chairman

Advisory Committee on Nuclear Waste

Factors Favoring RIPB Regulation in the Nuclear Waste Field

- Compliance demonstration already rooted in meeting performance requirements.
- The regulatory standard at least for high-level waste is in fact probabilistic.
- Regulations covering HLW are evolving with the anticipated first license application for a HLW repository, thus timing favors transition to RIPB.
- PRA policy statement and PRA implementation plan sets framework for staff uses of PA and PRA.

Factors to be Overcome to Implement RIPB Regulation in the Nuclear Waste Field

- Risk assessment experience of NRC principally in the nuclear power field.
- Facility differences are extensive and thus compromise the relevancy of the nuclear power experience.
- Engineered systems involving active equipment and hardware have been the principal target for the development of the analytical methods of risk assessment.
- PRA started as a risk-based discipline, PA did not. Probabilistic features have been evolving in PA.

Question

- **How can PRA approaches, methodologies, and techniques be brought to bear on PAs?**

The Basics

- **Both PRA and PA must answer the same set of risk questions.**

  1. **What can go wrong?**
  2. **How likely is it?**
  3. **What are the consequences?**

Comparisons of Nuclear Power PRAs and Nuclear Waste Repository PAs

- **Similarities:**
- **Both scenario-based.**
- **Scenarios of both require definitions of initial states and end states.**
- **Both have ultimate risk measures that involve health effects from radiation.**
- **Both involve the philosophy of defense-in-depth.**

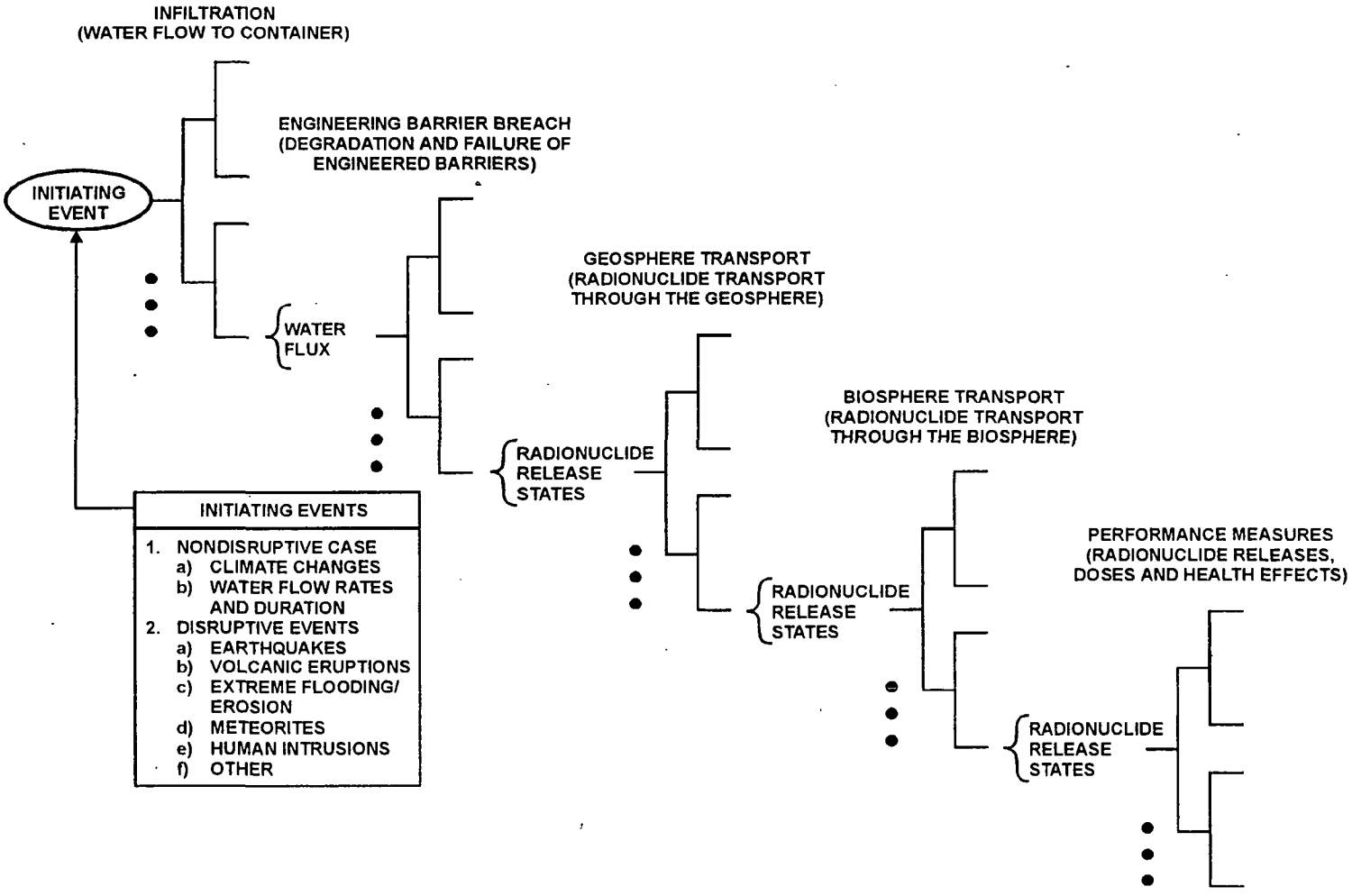
Dissimilarities of PAs and PRAs

- Roles of active and passive systems.
- Accidents versus performance.
- Time constraints.
- Safety goals versus no safety goals.
- Unconditional risk versus conditional risk.
- Degradation rates versus failure rates.

PRA Experience That Can Enhance PAs

- Segmenting of the analysis into logical pinch points.
- Data processing and the form of the results.
- The adoption of multiple risk (performance) measures.
- Importance ranking by scenarios, initial states, and FEPs.
- Modeling analogs:
  - Plant model versus infiltration model.
  - Containment model versus engineered barrier model (source term).
  - Site model versus biosphere model.

A Conceptual Model for Probabilistic Performance Assessment



Risk Measures