



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.

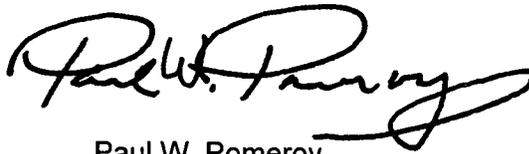
## **SUMMARY**

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,

A handwritten signature in black ink, appearing to read "Paul W. Pomeroy". The signature is fluid and cursive, with a long, sweeping underline that extends to the right.

Paul W. Pomeroy  
Chairman

