UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, DC 20555 - 0001

November 3, 2004

The Honorable Nils J. Diaz
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

SUBJECT: WORKING GROUP ON THE EVALUATION OF IGNEOUS ACTIVITY AND ITS CONSEQUENCES FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA

Dear Chairman Diaz:

During its 153rd meeting on September 22-23, 2003, the Advisory Committee on Nuclear Waste (ACNW) had a working group meeting (WGM) on the evaluation of igneous activity and its consequences for the potential Yucca Mountain high-level waste repository. The WGM included panel discussions by eight renowned scientists from academia, research institutions, and private enterprise in the fields of volcanism, risk assessment, and health physics[1]. Presentations to the Committee were made by the Nuclear Regulatory Commission (NRC) staff, staff from the Center for Nuclear Waste Regulatory Analyses (CNWRA), the Electric Power Research Institute (EPRI), ACNW staff, LANL, SNL, ORNL, the University of Utah, and ABS Consulting, Inc. Stakeholders and members of the public were given opportunities to comment on the discussions. Representatives from DOE's Yucca Mountain Project Office and the State of Nevada were invited to give presentations but declined.

The purposes of the WGM were to (1) increase the ACNW's technical knowledge of staff plans to evaluate the likelihood and consequences of disruptive igneous events at the proposed Yucca Mountain repository; (2) better understand NRC staff expectations regarding the DOE's consequence analyses; (3) identify aspects of those analyses that may need further study; and (4) complement previous working group meetings on performance assessments of Yucca Mountain. In addition, there were discussions regarding (1) the technical bases (measurements, analyses, and interpretations) necessary to conduct dose assessments, (2) the role of risk insights in the development of technical bases, and (3) the impact of outstanding technical issues on the resolution of agreements. The expert panel offered a number of suggestions and observations regarding the assessments and evaluations that will support the

[1]Drs. Bruce Crowe (the Los Alamos National Laboratory – LANL), William Hinze (Purdue University), Bruce Marsh (Johns Hopkins University), William Melson (Smithsonian Institution), Robert Budnitz [Lawrence Livermore National Laboratory, on detail to the U.S. Department of Energy (DOE)], Fred Harper (the Sandia National Laboratories – SNL), Lynn Anspaugh (University of Utah), Keith Eckerman (the Oak Ridge National Laboratory – ORNL), and ABS Consulting, Inc. (Irvine, California).

volcanism-related dose calculations. The calculations must be included in a DOE license application to meet the requirements of 10 CFR Part 63.

The WGM covered three areas of interest: (1) probability that future basaltic dikes will intersect a potential repository; (2) the manner in which a volcanic event intersects a waste disposal drift and mobilizes radioactive material from waste packages; and (3) the dosimetric consequences of subsequent dispersal of radioactive material.

To prepare for the WGM, ACNW staff and consultants attended an Appendix 7 meeting on September 21, 2004, between the NRC and DOE, where there was a presentation on the preliminary results of a recent aeromagnetic survey in the region, designed to detect possible additional buried basaltic features. Additionally, staff learned that DOE is reconvening an expert panel on volcanic hazards to examine new data that have become available since the previous 1996 expert elicitation.

Based on the information presented at the WGM, the Committee has concluded that it was not clear or transparent how the staff's work on igneous activity is risk informed. The Committee makes the following recommendations as a result of this WGM:

1. Instead of using a fixed value of 10^{-7} per year in performance assessments to represent the dike intersection frequency, it would be better to use an appropriate range, such as 10^{-8} to 10^{-7} per year, as suggested by Dr. Crowe, one of the WGM panelists. A similar range was derived in a recent ACNW staff paper (Coleman et al., 2004). This range is consistent with the Committee's previous conclusion in 2002. "The range of estimated probabilities, ~10^{-9} to ~10^{-7} per year, of an igneous intrusion into the repository used by DOE in its performance assessment is reasonable." Such a range is consistent with the volcanic history of the Yucca Mountain region.

2. The staff should give high priority to examining the realism in models for evaluating the potential interaction of magma with repository drifts and waste packages. The staff assumes that all of the radioactive material in a waste package becomes available after interaction with intrusive magma. The Committee heard an alternative view from EPRI. EPRI scientists presented an analysis of a postulated magma intrusion scenario, and contended that there is a "reasonable expectation" that no waste packages will fail during a postulated intrusive igneous event. The Committee believes that additional evaluation of waste package/magma interactions would improve the risk insights regarding the quantities of radioactive materials that could be mobilized. Recommendations provided by both EPRI (2004) and the DOE-sponsored Igneous Consequences Peer Review (ICPR) Group can offer insights on how to improve this modeling.

3. Based on the presentations, the Committee believes the staff should reassess the apparent conservatisms in the consequence and dose estimates from airborne transport of contaminated volcanic ash. Examples include wind direction, mass loading, and other parameters used in calculating dose to the reasonably maximally exposed individual (RMEI). A more transparent calculation would show how these assessments are risk informed.

Probability that future volcanism will intersect a potential repository

The most recent system-level performance assessment by the NRC staff (Mohanty et al., 2004) used a constant value of 10^{-7} per year for igneous intrusion rather than a range of probabilities. A new analysis of probability has been performed by the ACNW staff and its consultant and NRC's Office of Nuclear Research staff. This work (Coleman et al., 2004), which has been accepted for publication in the journal *Geophysical Research Letters*, suggests that an appropriate range for the likelihood of igneous intrusion into the repository is 10^{-8} to 10^{-7} per year. This range is identical to that reported in a paper by the NRC and CNWRA staff (Connor et al., 2000). These are two examples of a number of published evaluations of the likelihood of igneous events in the Yucca Mountain region. The Committee believes that a thorough, documented review of these and related evaluations will be useful in making staff analyses more transparent.

Volcanic event intersects a waste disposal drift and mobilizes radionuclides from waste packages

The NRC staff currently assumes in its modeling that the entire radioactive content of a waste package intercepted by intruding magma is available for airborne transport during a volcanic eruption. Representatives from EPRI discussed the impacts of potential igneous activity on waste packages. Their simulations suggested that under assumed conditions the waste packages would not be breached. Erosive effects of flowing magma were reported to be unlikely and waste packages did not fail from simulated overpressure effects or creep failure. EPRI representatives concluded there is "reasonable expectation" that no waste packages will fail during a postulated igneous event. EPRI only considered a scenario where the waste package had not been breached prior to magma intrusion into the repository. This may be reasonable, based on NRC staff analyses that show mean dose arising from extrusive igneous activity is much greater if the intrusion occurs in the first 500 years after postulated waste emplacement (Mohanty et al., 2004). In addition, the Committee heard presentations regarding the water content of magma which is important to its physical properties such as viscosity and explosivity (Nicholis and Rutherford, 2004). In November 2003, at its 147th meeting, the Committee was briefed on the DOE-sponsored ICPR Group recommendations (Detournay et al., 2003a and b). The ICPR was tasked to critically review the technical bases used by DOE to analyze the consequences of igneous events that might impact a repository, and to make recommendations on additional tasks that would significantly strengthen that program. Both EPRI's (2004) and the ICPR Group's recommendations offer insights on how to improve the consequence modeling. The Committee believes that it would be beneficial for the staff to consider these works in further evaluations of igneous intrusion scenarios.

Estimation of potential doses from igneous activity

The Committee heard presentations from NRC staff, the CNWRA, and other experts on the behavior of aerosols generated during explosive events involving metals and ceramics, resuspension modeling, internal dosimetry modeling and an independent comprehensive assessment of the consequence scenario. The Committee concluded from these presentations that the staff's assumptions and consequence modeling of an igneous event could be overly conservative in several ways:

1. It is unclear what fraction of the radioactive material could be involved in an eruption to which the RMEI is ultimately exposed. Further, an analysis of the range of values associated with release, transport, and exposure of radioactive material would improve the risk insights. For example, particle sizes up to 100 microns are included in the dose assessment, although 10 microns is typically considered the upper limit of the respirable range. The Committee heard during an expert presentation that in explosions designed to disperse metals and ceramics, typically less than 10 percent of the mass of particulate matter is smaller than 10 microns in diameter. The remainder of the particulate matter is larger and settles out quickly.

2. The current staff analysis assumes the wind blows towards the RMEI at all times. Always placing the receptor directly downwind artificially and incorrectly increases the estimated dose. The staff reported that this conservatism in transport and exposure modeling was being addressed, though results were not available. The re-analysis will consider a distribution of wind directions based on weather data from the Yucca Mountain region.

3. Assumed dust loadings are quite high and resuspension is modeled to continue for years. An expert panel member reported that resuspension is a phenomenon that is generally important for days after a release, rather than years. This conclusion was based on data from work at the Nevada Test Site during above-ground nuclear weapons testing.

These are examples of apparent conservatisms that result from fixed value assumptions. It is difficult for the Committee to see this as a realistic assessment. A systematic evaluation of ranges of parameters may provide more transparent risk insights in the ultimate calculation of dose to the RMEI.

Sincerely,

/RA/

Michael T. Ryan
Chairman

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