NRC Position on Optimization for a Potential Geologic Repository

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Dr. Brittain E. Hill
Senior Advisor for Repository Science
Office of Nuclear Materials Safety and Safeguards
United States Nuclear Regulatory Commission

This afternoon, I would like to focus on the regulatory framework that the U.S. Nuclear Regulatory Commission (NRC) is using to review the U.S. Department of Energy's (DOE) license application for a geologic repository at Yucca Mountain, Nevada, U.S.A. NRC will evaluate this application using regulatory criteria that protect public health and safety, the environment, and common defense and security. Regulations governing the potential repository at Yucca Mountain are contained in 10 CFR Part 63, which covers both the preclosure operational period and the period of time following closure of the repository.

I must note that, in response to a successful legal challenge in 2005, the safety standards for Yucca Mountain must be extended from 10,000 yr to 1,000,000 yr following closure of the potential repository. The 10,000 year requirements that previously were established remain essentially unchanged. By law, the U.S. Environmental Protection Agency (EPA) establishes the safety standards for Yucca Mountain. The NRC, in turn, must make its regulations consistent with EPA standards. EPA issued revised standards for the 10,000 to 1,000,000 yr performance period in October, 2008 (40 CFR Part 197). Following a public comment period on the proposed revisions, NRC is currently updating its regulations to be consistent with the revised EPA standards for the 10,000 yr to 1,000,000 yr post-closure period. In this talk, when I need to refer to safety standards after 10,000 yr, I will necessarily speak to the revised EPA standards.

One of the requirements in Part 63 for the preclosure operational period is to meet the applicable requirements in 10 CFR Part 20 for radiation protection. Part 20 contains requirements for a program to reduce radiation exposures to As Low As Reasonably Achievable (10 CFR 20.1101) during the operational phase of the potential repository. Having a good ALARA program isn't the only requirement for safety during the preclosure phase of operations. DOE also must produce an appropriately detailed safety analysis, which considers event sequences that have likelihoods as low as 1 in 10,000 of occurring during the approximately 100 year preclosure period (i.e., annual frequencies of occurrence $>10^{-6}$). For event sequences that have annual frequencies of $>= 10^{-2}$, DOE must show that these event sequences would produce a dose of no more than 50 mSv/yr [5,000 mrem/yr] to a radiation worker, no more than 1 mSv/yr [100 mrem/yr] to any on-site person who is not a radiation worker, and no more than 0.15 mSv/yr [15 mrem/yr] to any real member of the public located on or beyond the facility boundaries. Any event sequence that has an annual frequency of 10^{-2} to 10^{-6} must be shown in the preclosure safety analysis to give doses of <50 mSv/yr [<5,000 mrem/yr] to a person located on or beyond the boundaries of the facility.

For the period following permanent closure of the repository, NRC has numerous regulatory requirements to protect public health and safety, the environment, and common defense and security. These requirements represent an optimized approach that ensures our regulations are

appropriately protective and provide a transparent basis to judge the safety of the proposed repository far into the future.

The first post-closure requirement is that the repository system must be constructed so that there is a system of both natural and engineered barriers. The applicant must demonstrate an understanding of the capability of these barriers in the total-system performance assessment, which is an integral part of the safety analysis report. An understanding of barrier performance is important to gaining confidence that the safety standards will be met by the proposed repository system.

A total-system performance assessment also must be used to demonstrate compliance with safety standards. This assessment must include appropriate uncertainties in both models and data, and propagate these uncertainties through the performance assessment. Performance assessment must consider events with annual likelihoods of occurrence as low as 1 in 100 million, if such events would affect the timing or magnitude of radionuclide release significantly. At the Yucca Mountain site, such events include very infrequent earthquakes and the potential eruption of a small-volume basaltic volcano.

For Yucca Mountain, uncertainties about future changes in human society or key biosphere components, which cannot be constrained by current scientific understanding, have been addressed through rulemaking. In the performance assessment, expected doses are calculated for a stylized individual, called the “reasonably maximally exposed individual” (RMEI), who represents a small group of people that are most likely to receive a maximum dose. The RMEI lives above, and withdraws water from, the center of the plume of contamination, and has the habits and lifestyles of individuals currently living in the accessible environment near Yucca Mountain. In addition to using water withdrawn from the plume of contamination for crop irrigation, the RMEI drinks 2 liters of this water each day. Thus, the RMEI approach for performance assessment avoids undue speculation about long-term changes in future societies or biosphere characteristics, while still allowing consideration of biosphere uncertainties in the performance assessment.

The numerical standard for the performance assessment is a probability-weighted expected annual dose to the RMEI. Thus, the likelihood of the RMEI receiving a dose from an event is factored into the conditional dose associated with the event. The performance assessment analyzes the uncertainties associated with data and models, and calculates a range of probability-weighted annual doses. The mean of those calculated doses to the RMEI is used to assess compliance with the post-closure dose standard.

For the post-closure period up to 10,000 years, expected annual doses to the RMEI cannot exceed 0.15 mSv/yr [15 mrem/yr]. EPA has recently specified that doses to the RMEI cannot exceed 1 mSv/yr [100 mrem/yr] from 10,000 yr to 1,000,000 yr post closure. NRC is in the process of updating its 10 CFR Part 63 regulations to conform to the EPA post-10,000 yr standard for individual protection.

In addition to the individual protection standard, for the first 10,000 yr following repository closure, a groundwater protection standard limits doses to the RMEI to less than 0.04 mSv/yr (4 mrem/yr) and sets some concentration limits for radium and some alpha emitters. The groundwater protection analysis, however, only needs to consider events that have a greater than 1 in 10 chance of occurring during the 10,000 yr period. Human intrusion is evaluated using a stylized scenario in which a driller penetrates a waste package and forms a pathway to the water table. This stylized event is evaluated for a future time when the waste package has

degraded to the extent that a driller wouldn't recognize a drill bit has hit an engineered barrier. Doses to the RMEI that result from this stylized scenario cannot exceed 0.15 mSv/yr [15 mrem/yr] in the first 10,000 years, or 1 mSv/yr [100 mrem/yr] after 10,000 years.

Confidence that the geologic repository is optimized to protect public health and safety and the environment also is achieved through a performance confirmation program. If NRC grants DOE an authorization to construct the repository, DOE must conduct a series of investigation to confirm that site characteristics encountered during construction are within the range of conditions considered in the license application. In addition, DOE must conduct additional investigations to confirm that barriers important to waste isolation are functioning as intended.

Repository oversight must continue following permanent closure. In order to close the repository permanently, DOE must have a program in place to continue monitoring the repository system, establish permanent land-use controls, construct permanent markers over the repository site, and preserve all applicable records of the repository and its contents.

NRC concludes that the regulatory requirements I've outlined provide a rigorous basis to determine if the proposed geologic repository at Yucca Mountain will be safe. Compliance with these requirements is sufficient, and appropriately optimized, to ensure public health and safety. The ALARA principle, while appropriate for preclosure and decommissioning operations, does not apply to post-closure. If the repository system is shown to be safe, further design modifications incur additional costs with values that are difficult to judge against speculative changes in future societies and economies. As an additional consideration, deep geologic disposal, by its very nature, already is viewed as ALARA. There are few technological alternatives in repository design (10 CFR Part 63). Thus, NRC concludes that its post-closure regulatory requirements represent a sufficiently optimized approach to protecting safety.

In summary, safety of the potential geologic repository at Yucca Mountain will be evaluated by considerably more that compliance with a numerical dose standard. NRC concludes that the current U.S. regulatory framework provides sufficient and optimized protection of public health and safety, the environment, and common defense and security. The principal of optimized protection (i.e., ALARA) is being applied for preclosure operations and decommissioning of the potential repository. However, long-term safety is optimized through compliance with the post-closure regulatory requirements.

References

U.S. Code of Federal Regulations, "Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada," Part 63, Chapter 1, Title 10, "Energy."

U.S. Code of Federal Regulations, "Standards for Protection Against Radiation. Code of Federal Regulations," Part 20, Chapter 1, Title 10, "Energy."

U.S. Environmental Protection Agency, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada (40 CFR Part 197)," *Federal Register,* Vol. 73, No. 200, October 15, 2008, pp. 61256–61289.