As seen in the Spring 2023 issue of **Rad**waste Solutions

New Generic Repository

Draft Recommendations from ANS

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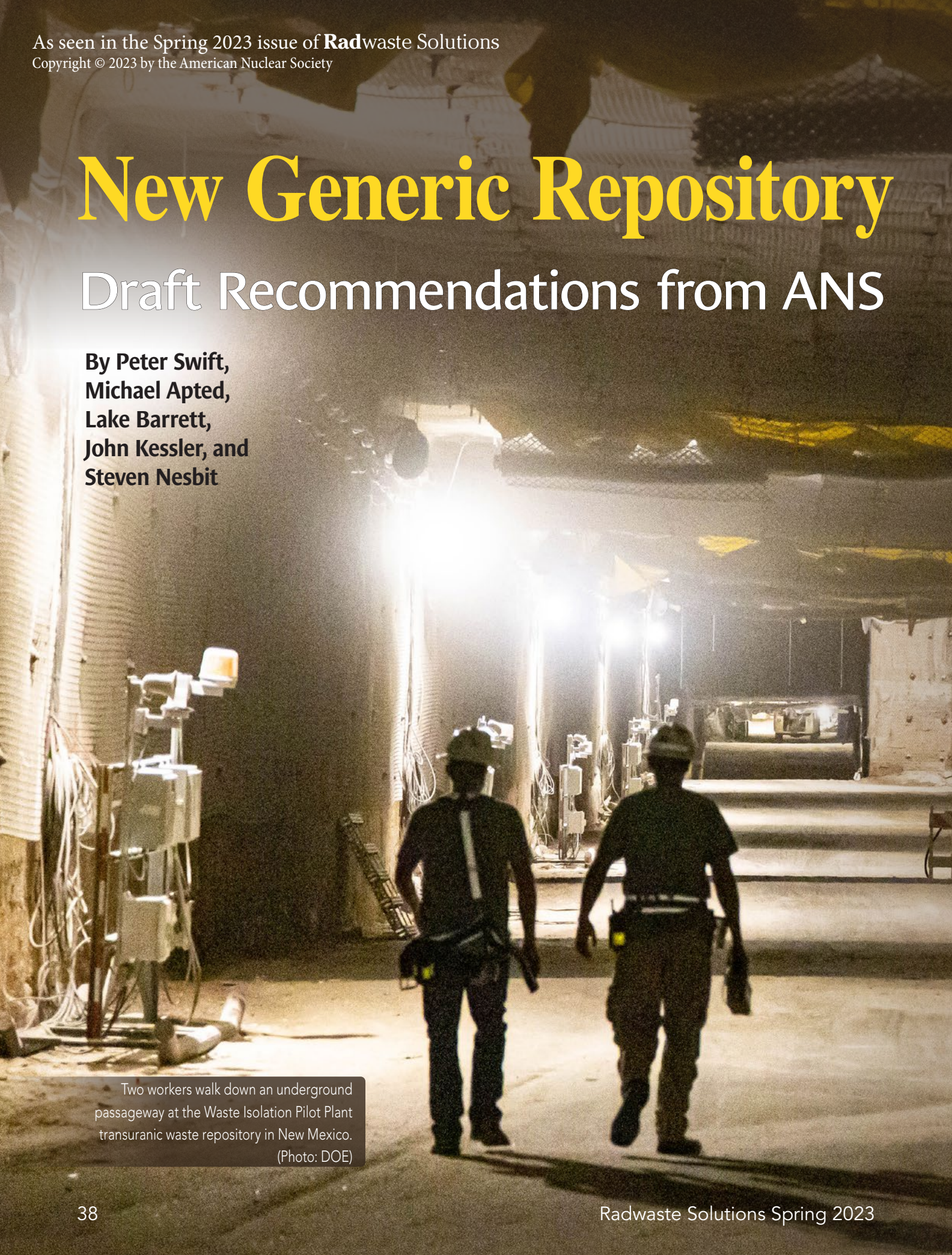

Two workers walk down an underground passageway at the Waste Isolation Pilot Plant transuranic waste repository in New Mexico. (Photo: DOE)

Environmental Standards:

Used nuclear fuel and high-level radioactive wastes are by-products of nuclear energy production and other applications of nuclear technology, and the consensus approach to disposing of those wastes safely is to encapsulate them and emplace them in stable geologic formations (geologic repositories) where they will be isolated from people and the environment for very long periods of time. The federal government has established environmental standards for waste isolation that any proposed geologic repository must meet.

In July 2021, the American Nuclear Society established a special committee to consider possibilities for revised generic environmental standards for disposal of spent nuclear fuel and high-level radioactive waste in the United States. The committee developed a number of recommendations, which are contained in a draft report that was to be issued in February for review and comment by stakeholders. The draft report can be found on the ANS website, at ans.org/policy/repositorystandard/.

The committee's draft recommendations are based on two underlying assumptions. First, that the relevant legislative framework for regulation defined in the Nuclear Waste Policy Act (NWPA) remains unchanged. Specifically, it is assumed that the Environmental Protection Agency will be charged with promulgating environmental standards for disposal and that the Nuclear Regulatory Commission will be charged with reviewing applications for disposal facilities using licensing requirements and criteria consistent with the EPA standards. Second, that existing generic disposal standards will be updated or replaced.

This second assumption is consistent with recommendations from the 2012 Blue Ribbon Commission on America's Nuclear Future [1], other review groups, and with past commitments from the NRC staff itself [2]. In its report, the committee strongly concurs with the conclusion that existing generic disposal standards should be replaced. While the current generic standards in Title 40, Part 191 of the *Code of Federal Regulations* are appropriately protective for the Waste Isolation Pilot Plant (WIPP) in New Mexico, those standards are dated with respect to the current international state of the practice. In addition, it is difficult for a layperson to discern the connection between the release limits in 40 CFR 191 and public health and safety.

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Background

At present, two sets of disposal standards and licensing requirements are in effect in the United States. The first set of disposal regulations, the EPA's 40 CFR 191 and the NRC's 10 CFR Part 60, predate Congress's 1987 decision to focus solely on the proposed Yucca Mountain repository site.

While 40 CFR 191 contains the standards under which the EPA certified WIPP for disposal of transuranic waste, 10 CFR 60 has not been implemented by the NRC for any site. In the absence of new rulemaking, both regulations would still apply in principle to any disposal site other than Yucca Mountain.

The second set of disposal regulations, the EPA's 40 CFR 197 and the NRC's 10 CFR 63, were written in the last 25 years specifically for Yucca Mountain. Without new rulemaking, the Yucca Mountain regulations could not apply to any other disposal site.

Although both sets of regulations are protective of future human health and the environment, there are significant differences in how they ensure those goals. For multiple reasons, the ANS committee concluded that the newer set of regulations, despite having been drafted specifically for the proposed Yucca Mountain repository, provide a more useful starting point for the development of a modern set of generic standards.

Nuclear Regulatory Commission staff visit the Yucca Mountain project site in 2007. (Photo: NRC)

Adopting current regulations as a starting point

It is the conclusion of the ANS committee that the regulatory standards developed for Yucca Mountain in both 40 CFR 197 and 10 CFR 63 provide an appropriate starting point for the development of generic standards.

As discussed for specific examples in the following sections, there is much in both the EPA and NRC Yucca Mountain rules that the committee agrees with and that could be adapted with relatively little modification to be applicable to generic sites.

■ *Retain the individual protection standard as the primary quantitative metric.*

The committee agrees with the approach taken by the EPA in 40 CFR 197 of adopting an individual protection standard expressed in terms of dose as the primary quantitative metric to be used in licensing a repository. Specifically, this approach, which provides a clear link to individual health consequences, is considered preferable to the approach taken in the containment requirements of 40 CFR 191, where limits are placed on the probability that cumulative releases to the accessible environment during the regulatory period will exceed specified amounts. The approach taken in the individual protection standard of setting limits on estimated annual dose, rather than on cumulative releases, is consistent with international practice and provides greater clarity than the approach taken in 40 CFR 191 to quantifying probabilistic releases. Both observations may help instill public confidence in the effectiveness of regulatory oversight.

Basing compliance on estimated future doses to a single representative individual is also preferable to setting limits on total doses to a population of individuals, either regional or global. The committee notes that the approach taken in the individual protection standard was thoroughly evaluated by the EPA during the development of 40 CFR 197 and is consistent with international practices. Furthermore, it has withstood court challenges specific to its application for the Yucca Mountain site.

■ *Retain the concepts of reasonable expectation and risk-informed decision making.*

The committee agrees with the EPA's and NRC's recognition that "proof of the future performance of a disposal system is not to be had in the ordinary sense of the word" (40 CFR 191.13(b), restated by the NRC at 10 CFR 63.201(a)(2)).

The EPA codified this observation for the Yucca Mountain site in the definition of "reasonable expectation" at 40 CFR 197.14(a), which states that reasonable expectation "requires less than absolute proof because absolute proof is impossible to attain for disposal due to the uncertainty of projecting long-term performance."

This straightforward observation provides the basis for the EPA's specifications for the treatment of uncertainty in the probabilistic performance assessment required to evaluate compliance with quantitative post-closure standards.

The committee also concurs with the NRC's risk-informed approach to regulatory decision making [3], as embodied for Yucca Mountain in 10 CFR 63. This approach is consistent with the EPA's concept of reasonable expectation that underlies 40 CFR 197, and which has been adopted more broadly by the NRC with the increasing incorporation of probabilistic risk assessment methods in the oversight of nuclear power plants.

> Reasonable expectation 'requires less than absolute proof because absolute proof is impossible to attain for disposal due to the uncertainty of projecting long-term performance.' 40 CFR 197.14(a)

■ *Continue to base the characteristics of the potentially exposed individuals on current practices.*

The committee agrees with the approach taken by the EPA in 40 CFR 197.21 regarding the characteristics of potentially exposed future individuals. Specifically, the regulation states that the "reasonably maximally exposed individual ... has a diet and living style representative of the people who now reside" in the vicinity of the repository. This approach is considered both reasonable, in that it provides implementable specificity to a topic that would otherwise be subject to unbounded speculation, and conservative, because it focuses on that portion of the almost limitless range of future human conditions that would result in the greatest potential for exposure to radioactive releases from the repository.

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While this approach bases human characteristics and behaviors on current practices, it takes no credit for currently available technology to detect and mitigate radiological hazards in the environment.

In general, the committee agrees with the approach taken in multiple places in 40 CFR 197 to providing direction about how the current characteristics of the biosphere should be determined and what future changes to the biosphere and the geologic environment must be considered. Specificity on these points is essential to limiting boundless speculation, particularly regarding possible effects of future human actions.

It is noted that regulatory direction regarding some characteristics of the biosphere unavoidably will need to be site-specific. This was not a concern for the EPA in 40 CFR 197, which is specific only to Yucca Mountain, but can be addressed in generic standards by removing site-specific requirements from the generic standard and requiring the NRC to provide requirements regarding the selection of site-specific biosphere characteristics once a site has been selected. For example, the generic definition of the "controlled area" provided in 40 CFR 191 could be brought forward into a new standard to replace the Yucca Mountain-specific definition in 40 CFR 197.

Not all such requirements, however, can as readily be made fully generic. For example, regulatory direction contained in 40 CFR 197 for Yucca Mountain includes the location of the reasonably maximally exposed individual, the specification of the representative volume of water to be considered in performance assessments, and methods to be used by the applicant in estimating concentrations of contaminants with the representative volume. Implementation of such requirements could be accomplished by the license applicant proposing appropriate values, consistent with NRC requirements and subject to approval by the NRC.

■ *Retain the requirements for the identification and screening of potentially relevant features, events, and processes.*

The committee agrees that the general approach taken by the EPA in both 40 CFR 191 and 40 CFR 197 to the identification of potentially relevant features, events, and processes is sound and should be maintained. Similarly, the criteria provided for determining which of these features, events, and processes must be included in the quantitative performance assessment are appropriate.

Specifically, experience with both WIPP and Yucca Mountain [4, 5] has demonstrated the value of allowing the applicant to omit features, events, and processes from the quantitative performance assessment that are shown to be either very unlikely to occur or to result in insignificant changes to the results of the performance assessment.

This approach, as presented for the Yucca Mountain site at 40 CFR 197.36(a)(1), provides important limits to boundless speculation while maintaining a focus on the protection of public health, safety, and the environment, and is consistent with the concept of risk-informed regulation.

■ *Base the human intrusion standard on consideration of a single stylized intrusion event.*

It is recognized that the human intrusion standard specified by the EPA for Yucca Mountain in 40 CFR 197.25 and 197.26 is site-specific and cannot be adopted as-is for a generic site. Likewise, the committee considers the approach specified by the EPA in 40 CFR 191 and implemented for WIPP inappropriate for a generally applicable standard.

As seen in the compliance certification analyses done for WIPP [4], requiring inadvertent human intrusion to be included in probabilistic evaluations of the natural evolution of the site can create a situation where licensing decisions may be dominated by irreducible uncertainty regarding human actions far in the future, rather than on the merits of the site and repository design.

The committee concludes that the general approach specified in 40 CFR 197 requiring analysis of the consequences of a stylized human intrusion scenario consisting of subsurface groundwater releases from a single inadvertent and undetected drilling event that penetrates a single waste package, regardless of the probability of its occurrence, is preferable to the approach taken in 40 CFR 191. This approach will appropriately emphasize the merits of the site geology and repository design while removing speculation about future human actions.

The committee recommends specifying a separate standard for human intrusion using the approach taken for Yucca Mountain in 40 CFR 197, modified to be generally applicable to generic sites. Specifically, human intrusion could be specified to be the result of exploratory drilling for natural resources of any type

(rather than groundwater, which was the only resource considered at Yucca Mountain), and the intrusion borehole should be assumed to provide connections to both overlying and underlying aquifers (rather than just the underlying aquifer specified for Yucca Mountain). It is recommended that the EPA retain the requirement at 40 CFR 197.26(c) that "drillers use common techniques and practices that are currently employed." To require otherwise would lead to unbounded speculation about future technologies.

It is suggested that the time of the intrusion event could be specified to be either the "earliest time after disposal that the waste package would degrade sufficiently that a human intrusion … could occur without recognition by the drillers," as specified at 40 CFR 197.25(a) for Yucca Mountain, or 1,000 years after repository closure, whichever comes first.

Specifying the time for the event would remove speculation about future drilling practices and would be consistent with the recognition that the standard relies on a stylized, rather than realistic, event. An intrusion at 1,000 years provides time for the effects on the rest of the disposal system to be manifested in quantitative comparisons with the dose rate limit and represents a conservative estimate for the earliest time of undetected intrusion for many engineered barrier designs for disposal systems.

The committee agrees with the position taken by the EPA in promulgating 40 CFR 197 that including releases to the land surface during drilling would not provide useful information regarding the resilience of the disposal system following human intrusion. It is also noted that all proposed repositories with similar waste emplacement designs and configurations would show similar releases to the surface following intrusion, and that including those releases in the regulatory standard would not provide useful information for comparing multiple sites or repository concepts. Consistent with these observations, retaining the specification that analysis should be limited to releases through groundwater pathways is recommended.

Consistent with the recommendation below regarding the regulatory time period for quantitative standards, the committee recommends limiting the time period for quantitative consideration of the consequences of human intrusion to 10,000 years.

The Yucca Mountain mine portal. (Photo: Energy Commerce)

The committee recommends limiting the period for quantitative consideration of the consequences of human intrusion to 10,000 years.

Modifying Yucca Mountain regulations

The previous recommendations notwithstanding, there are several technical issues for which the committee believes generic standards could be significantly improved by modification of the approach taken for Yucca Mountain. The following sections discuss these topics and others in more detail.

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NRC staff tour the Yucca Mountain site. (Photo: NRC)

■ ***Limit the regulatory time period for quantitative standards.***

The committee recommends limiting the period for quantitative standards to 10,000 years following disposal. It is noted that the primary quantitative metric applied to post-closure performance of repositories is the estimated annual radiation dose to future humans, and that this dose depends in large part on the behavior of the exposed individuals. As discussed, the committee agrees with the position taken by the EPA in text accompanying the initial promulgation of 40 CFR 197 that using the behavior of the individuals currently living in the region of the repository is a reasonable and conservative basis for limiting speculation about future behavior.

Projections, however, become less valuable to decision making when extended over periods longer than recorded human civilization. Although computational models can be constructed that project behavior of natural and engineered systems for very long periods, the capabilities of those models to cope with complex coupling of time-dependent boundary conditions remain problematic.

The committee maintains that the 10,000-year standard provided in 40 CFR 191 provides a more reasonable and defensible period during which quantitative estimates of the protection to humans can be meaningfully assessed than does the 1 million-year period adopted for the Yucca Mountain site in 40 CFR 197. It is further held that basing regulatory decisions on quantitative estimates of health risks to humans beyond 10,000 years introduces a false precision into a decision-making process that can be better informed by considering multiple lines of evidence, including alternative safety indicators.

This recommendation is not intended to preclude the use of simplified, quantitative modeling over longer times by either the implementor or the regulator where appropriate. Rather it is intended to avoid creating unrealistic expectations about the interpretation of such model results by requiring their comparison to a quantitative dose standard.

There is widespread recognition in the international community that safety standards should recognize the uncertainties inherent in time-dependent factors, notably associated with human behavior [6]. For example, the International Atomic Energy Agency (IAEA) notes that over longer periods, safety should be assessed through "simplified estimates and qualitative arguments rather than through the application of quantitative safety criteria." [7]

Similarly, the International Commission on Radiological Protection (ICRP) notes that "the scientific basis for assessments of detriment to health at very long times into the future therefore becomes uncertain, and the strict application of numerical criteria

may be inappropriate" and the results of any dose or risk assessments need to be interpreted in a qualitative way at long time scales [8].

There is also precedent in EPA regulations for the use of a 10,000-year period for projecting the performance of the isolation of hazardous material. Subpart C of 40 CFR 148, "Hazardous Waste Injection Restrictions," sets forth requirements that must be satisfied in a petition to allow the injection of a restricted hazardous waste into an injection well or wells. In that instance, the EPA established a period of 10,000 years for projections of retention of hazardous waste. Obviously, hazardous waste does not become harmless at year 10,001, but the EPA recognized the practical limitations associated with modeling geologic performance into the far future quantitatively for the purpose of direct comparison to a health limit. The committee also recognizes those limits on the utility of quantitative compliance requirements, but believes it is important to assess geologic repository performance during periods longer than 10,000 years.

■ *Introduce a separate standard for performance beyond 10,000 years based on multiple lines of evidence.*

As an alternative to basing regulatory compliance on quantitative system-level dose assessments for 1 million years, the committee recommends that the EPA require a demonstration that there is a reasonable expectation that the disposal system will continue to function as intended during the period between 10,000 years and 1 million years following disposal. This could be accomplished, in part, by continuing the consideration of potentially relevant features, events, and processes over a 1-million-year period.

The applicant should identify and evaluate features, events, and processes, if any, that have the potential to initiate scenarios having significantly different (and detrimental) impacts on the safety functions of the disposal system after 10,000 years. Those evaluations, and the full range of evidence used to develop them, should be considered by the NRC in the licensing process. Rather than specifying quantitative limits that would, in effect, require a full quantitative dose assessment for 1 million years, the burden would fall on the applicant to provide a sufficient analysis using qualitative or, where appropriate, quantitative, methods to demonstrate that features, events, or processes that might operate differently after 10,000 years would not significantly degrade the overall performance of the repository. This is akin to using probabilistic risk analysis to identify "cliff edge" effects in reactor safety analysis [9].

Examples of methods and metrics used by the applicant in evaluating safety functions of the disposal system after 10,000 years could include qualitative observations based on current understanding (e.g., many geologic processes can reasonably be assumed to continue to function in the future as they do today. Process-specific observations and modeling (e.g., estimates of regional rates of uplift and erosion could be compared directly to the depth of the repository), and estimates of repository-derived radionuclide concentrations in groundwater could be compared to naturally occurring concentrations.

The proposed post-10,000-year standard would not preclude the use of long-term dose estimates in evaluating the impact of potential degradation of disposal system safety functions. Rather, the proposed standard would encourage consideration of multiple lines of evidence while avoiding the sole reliance on the precision of dose estimates over a period that far exceeds human history.

■ *Replace the term "period of geologic stability" with "1 million years."*

It is recommended that the EPA remove the term "period of geologic stability" from the regulation and replace it with a generally applicable specification of 1 million years. "Period of geologic stability" was derived from the report of the National Academies Committee on the technical bases for a standard specific to Yucca Mountain [10] and is not generally applicable to generic sites.

Geologic stability is defined in the Yucca Mountain standards to be synonymous with 1 million years and would likely prove difficult to define using scientific criteria. Furthermore, it is an unsuitable concept for a generic standard because some sites might reasonably be argued to be geologically stable for shorter or longer periods of time than others under consideration. Retaining the term in the regulatory standard and applying it literally to generic sites could have the unintended and counterintuitive effect of incentivizing sites with a potential for geologic instability, however that might be defined, at earlier times.

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One million years is more than two orders of magnitude longer than recorded human history, and the ANS committee believes that it is a sufficient and conservative period to consider the possible impacts of the behavior of geologic systems on human health.

■ *Adopt requirements for multiple barriers based on the approach taken in 40 CFR 191.*

The committee agrees with the approach taken in 40 CFR 191.14(d) to require both engineered and natural barriers. This is also consistent with the NRC implementing regulations for the Yucca Mountain site (10 CFR 63.102(h), 10 CFR 63.113(a), and 10 CFR 63.115). It is recommended that the EPA adopt this approach in its standards. Specifically, the requirements at 10 CFR 63.115 to identify the barriers, describe their capabilities, and to provide the technical basis for those capabilities, consistent with the technical basis for the overall performance assessment, will result in a sound basis for the evaluation of the defense in depth provided by the repository.

Furthermore, this approach is preferable to the quantitative subsystem limits specified in 10 CFR 60 for the performance of selected components of the barrier system, as that approach carries the potential to encourage subsystem engineering solutions that may not correspond to improvements in overall disposal system performance.

It is noted that the approach is consistent with the requirements of the NWPA (Sec. 121(b)(1)(B)) "to provide for the use of a system of multiple barriers in the design of the repository," and that NRC staff completed a thorough analysis of the requirements during the promulgation of 10 CFR 63. The approach is also consistent with international practice regarding the treatment of "safety functions" in repository performance [6] and has withstood court challenges specific to its application for Yucca Mountain.

■ *Adopt requirements for retrievability consistent with the NWPA Section 122.*

The committee agrees with the approach to regulating the retrievability of waste prescribed in the NWPA. Specifically, Section 122 of the NWPA states that "any repository constructed on a site approved under this subtitle shall be designed and constructed to permit the retrieval of any spent nuclear fuel placed in such repository, during an appropriate period of operation of the facility."

In 40 CFR 191.14(f), the EPA states, "Disposal systems shall be selected so that removal of most of the wastes is not precluded for a reasonable period of time after disposal." Specific to the proposed Yucca Mountain repository, the NRC required at 10 CFR 63.111(e) that "the geologic repository operations area must be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the [NRC]."

The committee is recommending that the EPA adopt this approach in its generic standards, while leaving details of the implementation (e.g., providing further guidance on what constitutes "an appropriate period of operation" or "a reasonable period of time after disposal") to be determined by the NRC. As discussed further in a following section, deep borehole disposal concepts with operational periods for disposal that are inherently far shorter than those needed for mined repositories warrant different considerations for a "reasonable schedule" for retrievability, consistent with the NWPA.

The committee also notes that requirements and expectations regarding retrievability vary widely internationally and that the approach recommended here is consistent with those adopted in many other national programs [6].

Deep borehole disposal concepts with operational periods that are inherently far shorter than those needed for mined repositories warrant different considerations for a 'reasonable schedule' for retrievability, consistent with the NWPA.

■ *Make generic standards applicable to deep borehole disposal concepts.*

It is recommended that the EPA make generic disposal standards applicable to deep borehole disposal concepts as well as the mined repositories that have been the only application of the existing regulations. In this regard, the committee agrees with the intent of the EPA in promulgating 40 CFR 191 in 1985; "Although disposal of these materials in mined geologic repositories has received the most attention, the disposal standards apply to disposal by any means, except disposal directly into the oceans or ocean sediments."

There have been significant advances in drilling technology since the initial promulgation of 40 CFR 191, including directional drilling techniques that allow for horizontal, as well as vertical, boreholes of sufficient length to function as repositories. All potential types of borehole disposal should be covered by a new generic repository standard.

It is recognized that there are multiple ways in which borehole disposal systems could raise different regulatory issues than those posed by mined repositories. For example, the choice of whether to define the disposal system to be a single borehole or an array of multiple boreholes could impact many aspects of the compliance evaluation, ranging from the calculation of the estimated annual dose to definition of the controlled area and the location of the accessible environment boundary.

The committee believes most such issues could be appropriately addressed in a straightforward manner by the NRC in site-specific implementing criteria for a repository after the basic disposal concept had been established. Three topics, however, appear to rise to the level of potentially requiring being addressed in the generic standards.

First, it is recommended that the EPA define a borehole repository to be the full array of boreholes at a single site. This would allow applying quantitative limits to the full disposal inventory, rather than applying them to single boreholes one at a time, and it would provide a logical basis for defining the boundaries of the accessible environment and the location of the reasonably maximally exposed individual using the same approach taken for mined repositories. The requirement should be written, however, to allow flexibility for the NRC in its specification of phased licensing operations as individual disposal boreholes are characterized, constructed, and sealed.

Second, it is recommended that the EPA provide the opportunity for the NRC to address human intrusion, taking into account site-specific design and geometry considerations for deep borehole disposal systems.

Third, as noted earlier, it is recommended that the EPA allow specifically for consideration of a period of retrievability that is appropriately consistent with the operational periods likely for borehole disposal systems. This would be consistent with the requirements for retrievability provided by the NWPA.

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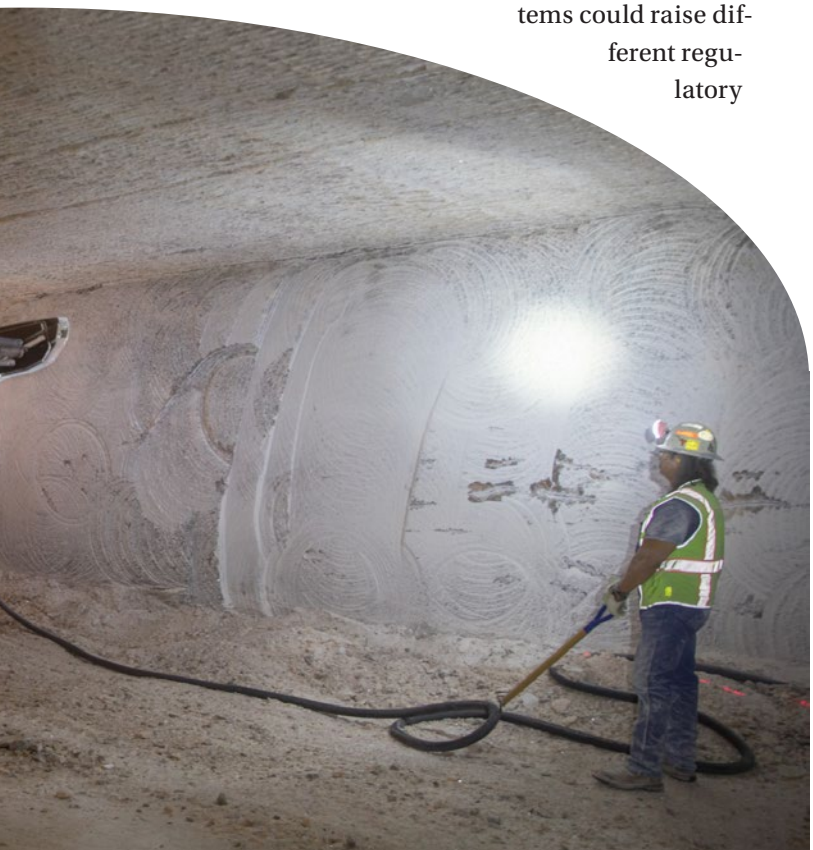

An electric continuous miner machine cuts out a waste-emplacement panel at the Waste Isolation Pilot Plant salt repository in New Mexico.
(Photo: DOE)

■ *Adopt the definition of controlled area from 40 CFR 191.*

The 40 CFR 197 definition of "controlled area" is specific to the Yucca Mountain site and is clearly not appropriate for a generic repository. The committee recommends the use of the definition from 40 CFR 191: ". . . no more than 100 square kilometers [extending] horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive wastes in a disposal system." The controlled area for a specific site would be determined by the implementing organization based on the characteristics of that site and would be subject to approval of the NRC.

The controlled area concept is well understood for a mined geological repository like WIPP or Yucca Mountain but has yet to be implemented for a borehole repository. The committee sees the concept as being fairly straightforward for a deep vertical borehole repository, including one with an array of boreholes. However, a horizontal borehole repository with boreholes projecting in multiple directions presents a potentially more complicated situation that would be addressed as described above.

■ *Remove specificity regarding the implementing organization.*

It is recommended that the new standards refer throughout simply to the "implementing organization" or the "implementor" rather than to the Department of Energy. Existing language in 40 CFR 197 speaks specifically about the DOE and its responsibilities. That is understandable, given that the NWPA specifies the DOE as the implementing agency for a repository at Yucca Mountain or other sites developed under the provisions of the NWPA. The EPA's generic regulation, however, should be general where possible, and need not presuppose that the DOE will be the only implementing organization for all U.S. geologic repositories for all time.

Other topics

The following sections provide an overview of topics that the committee believes may benefit from further consideration in the development of generic standards, regardless of whether changes result in the final rules.

■ *Consider updating guidance and requirements for radiation dose assessments to be consistent with the most recent recommendations of the ICRP.*

In some instances, the approaches specified in existing regulations for determining health consequences from radiation exposures are out of date with respect to current international practice. The most recent recommendations on dose conversion methodology from the ICRP (ICRP 2007, 2012, 2013) are an appropriate starting point for the EPA to consider.

It is noted that 40 CFR 197, Appendix A, used older ICRP dose conversion factors brought forward from 40 CFR 191, but left open the door for the DOE to use updated radiation weighting factors if NRC allows. A future EPA disposal standard could be updated to bring itself into alignment with international practice. Given the multigenerational operational lifetime anticipated for many deep geologic repository concepts, continued updating of the dose conversion methodology by either the EPA or the NRC should be expected and welcomed.

■ *Consider removing the groundwater protection standard.*

The committee recognizes that this topic was the subject of extensive comment and deliberation in the late 1990s during the drafting and promulgation of 40 CFR 197, and that it may be unlikely that further recommendations at this point will be constructive.

With that said, the committee concurs with the comments made by the NRC staff in 1999 specific to the EPA's proposed groundwater protection standard [11]. Consistent with NRC's required "all-pathways" safety assessment requirement, the committee recommends having overall quantitative standards for protection of human health in place; the imposition of additional groundwater protection standards based on treated drinking water systems, as is the case with current U.S. repository standards, is unnecessary and counterproductive. Specifically, the committee believes that the groundwater standard as implemented in 40 CFR 197 adds no additional protection to the standards for human health, safety, or the environment beyond that already provided by the individual protection requirements.

The committee also shares the NRC's concern expressed in 1999 that the allowable levels of radium,

gross alpha activity, and combined beta and photon emitters specified in 40 CFR 197 were intended for application to treated sources of community drinking water (see 40 CFR 141.66) and are inappropriately and inconsistently applied to untreated groundwater in 40 CFR 197. If promulgated as part of a generic standard, applying drinking water standards to untreated groundwater has the potential for incentivizing the selection of sites with otherwise pristine groundwater because sites with higher background levels of radium or other sources of radioactivity would present greater challenges in meeting a standard that was never intended to be applied in this manner.

Applying drinking water standards to untreated groundwater has the potential for incentivizing the selection of sites with otherwise pristine groundwater because sites with higher background levels of radium or other sources of radioactivity would present greater challenges in meeting a standard that was never intended to be applied in this manner.

■ *Establishing the level of protection.*

The committee makes no specific recommendation on the regulatory limit for annual dose to an individual living near a proposed repository. The individual protection dose limits in 40 CFR 191 and 40 CFR 197 are set at 0.15 millisieverts per year (15 millirem per year) for the first 10,000 years after repository closure. In addition, 40 CFR 197 applies a limit of 1 mSv per year (100 mrem per year) during the period of 10,000 years to 1 million years after permanent closure.

The committee expects that the EPA will establish an annual limit on projected individual dose due to a geologic repository in the range of 0.15-1 mSv per year (15-100 mrem per year). The committee considers a limit in that range to be appropriately conservative for a public health and safety standard, with the lower end of the range being quite restrictive relative to many current U.S. and international practices.

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Conclusions expressed in this article should be interpreted as draft recommendations subject to change on further review and are strictly the opinions of the individual authors. As such, they do not represent policy recommendations of the American Nuclear Society.