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RE: ANS Report

These are Nevada's comments on the American Nuclear Society's report: Recommendations on Post closure Aspects of Generic Standards for the Permanent Disposal of Spent Nuclear Fuel and High-Level and Transuranic Radioactive Wastes in the United States ANS Disposal Standards Report Draft for Comment. We appreciate the opportunity to comment on this important topic.

Please contact me for any additional information: fdilger@anp.nv.gov.

Sincere regards,

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CC:
Nevada Congressional Delegation
Senator Richard Bryan
Nevada Commission on Nuclear Projects

State of Nevada's Comments on the American Nuclear Society's Draft Recommendations on Postclosure Aspects of Generic Standards for the Permanent Disposal of Spent Nuclear Fuel and High-Level and Transuranic Radioactive Wastes in the United States

(Submitted on April 14, 2023)

The following Summary and Comments reflect the State of Nevada's commitment to the task of helping to set the stage for promulgation of sound, generic standards for the permanent disposal of spent nuclear fuel (SNF) and high-level (HLW) and Transuranic (TRU) radioactive wastes in the United States consistent with health-based standards and appropriate levels of protection for public health and safety. It may be useful to note in the history discussion (ANS at p. 30), the policy that the federal government should ultimately bear responsibility for disposing of high-level radioactive waste pre-dates the Nuclear Waste Policy Act of 1982. The Atomic Energy Commission announced that policy in 1970. *See*, 35 Fed. Reg. 17530, November 14, 1970.

Summary

See, separate attachment.

Comments

1) **General Comments**

(a) Key Topics Not Addressed in the Draft Recommendations:

- It is first important to recognize that these Draft Recommendations address only the compliance of a specific repository design in a specific geological context with the proposed regulatory standard. They say nothing as to how designs and sites should be compared. Consequently, they do not address issues related to site and design selection or optimization of design. This is an appropriately limited objective but leaves open what regulatory guidance should be provided on these wider topics.

- The ANS Draft Recommendations address only potential impacts on human health due to releases of radionuclides from a repository. Impacts on human health from releases of non-radioactive materials, *e.g.*, lead, cadmium and chromium, are not addressed. It is assumed that the intent is that these impacts should be addressed in a different regulatory context, possibly through a broader environmental impact analysis, but this could usefully be stated.

- In addition, the Draft Recommendations do not address impacts of releases of radionuclides into, and their impacts on, the environment. This is understandable, because there is limited guidance from international organizations or overseas on this topic with respect to repositories for solid radioactive wastes. However, the broader topic of impacts on non-human biota due to releases of radionuclides in routine and accidental contexts has been extensively addressed and guidance is available from the IAEA and ICRP (IAEA, 2012; IAEA, 2014; ICRP, 2008; ICRP, 2009; ICRP, 2014; ICRP, 2017). Also, techniques and software, such as the ERICA Tool (https://erica-tool.com/) and RESRAD-BIOTA (https://resrad.evs.anl.gov/codes/resrad-biota/) are available to perform such assessments. Therefore, if the recommendations are to be robust in relation to ongoing developments, it would be prudent to include specific discussion of this topic.

2) Statutory and Legislative Issues

The ANS states that it "assumes that the relevant legislative framework for regulation defined in the 1982 Nuclear Waste Policy Act, as amended (NWPA), remains unchanged" (ANS at p. 8). However, as explained below, certain aspects of the ANS' draft recommended standards are inconsistent with current law.

The Atomic Energy Act of 1954, as amended (AEA), requires that any statutory standard applicable to the licensing of repositories must prohibit any "unreasonable risk to the health and safety of the public (AEA § 57 c ((2)). Any generic repository standards issued under the NWPA must also provide for "protection of the general environment from offsite releases" (NWPA § 121(b)). These provisions and others have been authoritatively construed to prohibit any consideration of and reliance on non-safety factors (such as costs versus benefits) in defining and assuring a minimum level of protection (*Union of Concerned Scientists v. NRC*, 824 F. 2d 108 (D.C. Cir. 1987). Accordingly, under current law, generic repository standards must provide a minimum level of protection that reflects a judgment of what is an acceptable risk to the public. Such standards are commonly referred to as health based.

The recommendation that dose standards should be limited to 10,000 years is not health based. Is the ANS recommending changes in the statutory basis for repository standards? Nevada notes in this regard that public acceptance of a proposed repository is difficult even when the applicable standards are health based. If the fundamental standards are not health based, then members of the public cannot be assured that public safety will not be endangered. As a result, public acceptance will not be, and should not be, achievable.

3) The ANS Standards Are Not Health Based

The ANS' recommended standards do not include any dose limit or other limit to the risk associated with repository releases after 10,000 years, notwithstanding that releases after 10,000 years are both reasonably foreseeable and reasonably likely to impose a significant risk to the health and safety of the public. Instead, ANS recommends that features, events, or processes (FEPs) that might operate differently after 10,000 years should not "significantly degrade the overall performance of the repository" (ANS at p. 17). But, significant degradation is not defined, leaving open the real possibility that degradation deemed "insignificant" in the subjective judgment of the reviewers would nevertheless cause unacceptable health effects on future generations. This is not a health-based standard.

The comparison to the NRC's treatment of "cliff-edged" effects in reactor safety analyses (ANS at p.17) is less than helpful. Such treatment can entail the use of cost-benefit analyses under the NRC's backfit rule (10 CFR 50.109), which would be inconsistent with a heath-based standard (*see e.g.*, *NRC Staff Guidance- Regulatory Decision-Making for Reevaluated Flooding and Seismic Hazards for Operating Nuclear Power Plants*, ADAMS Accession No. ML16237A114, September 21, 2016, at p. 8). In this regard, while the ANS states that "it is generally accepted that the current generation has a responsibility to deal with its own waste products in a manner that will protect not only themselves but future generations" (ANS at p. 57), ANS provides no discussion of how the absence of a risk standard after 10,000 years is consistent with this principle. The ethical duty this generation of humans, who generated the waste, owes to distant future generations who will bear the risks of disposal, has (at least in the United States), been defined as, at the very minimum, assuring that future generations will not bear a risk to health and safety which will adversely affect their quality of life or that today's generation would consider unacceptable (*see, e.g,* the preamble to 40 FR Part 197, 73 Fed. Reg. 61256 at 61274). The complete absence of any health-based limit to human risk after 10,000 years is utterly inconsistent with this ethical duty.

It is true, as ANS notes, that there is widespread recognition that safety standards should acknowledge the irreducible uncertainties inherent in time-dependent factors associated with human behavior (ANS at p. 16). But that problem is addressed and eliminated by another ANS recommendation to "[r]etain the concept of basing the characteristics of the reasonably maximally exposed individual on current practice in the vicinity of the disposal site, and retain regulatory specificity regarding characteristics of and future changes to the biosphere" (ANS at p. v). ANS cannot rely on uncertainties in predicting future human societies, behavior, and knowledge in justifying one of its recommendations (no health-based standard after 10,000 years) when those same uncertainties are eliminated by another one. In any event, there is no scientific basis for choosing 10,000 years. It's not as though time-dependent factors associated with human behavior suddenly become unknowable at 10,000 years. Moreover, given that the standards are generic ones, potentially applicable to multiple different repository geologies and license applications, there is no basis for choosing 10,000 years as the point beyond which quantitative estimates or repository performance always become unreliable.

Finally, any discussion of what constitutes a health-based standard must include consideration of what constitutes the appropriate burden of proof, for even the most stringent standard will fail to provide adequate protection in actual practice if the burden of proof is too lax. This subject is discussed in some detail below, but for now, it is sufficient to focus on ANS' statement that "proof of the future performance of a disposal system is not to be had in the ordinary sense of the word" (ANS at p. 10). It is not at all clear what this statement means because complicated and disputed scientific issues are regularly addressed and resolved in legal proceedings without excessive hand-wringing about impossible burdens of proof. But the statement could be understood to say that if "proof" means that the amount and quality of evidence that reasonably well-informed decisionmakers would consider sufficient to prove a proposition in other scientific fields, then proof that a repository is safe is impossible. If that is what ANS means here, then the inevitable question arises: Should nuclear reactors be allowed to operate at all if safe disposal of the resulting wastes cannot be established "in the ordinary sense of the word?"

4) The Standards

The ANS recommends (for 10,000 years) that values in the range of 0.15–1 mSv (15–100 mrem) pe year are appropriately conservative for a public health and safety standard (ANS at p. vi). But ANS omits to mention that the U.S. Environmental Protection Agency (EPA) has, in the past, rejected values as low as 0.25 mSv (25 millirem) as insufficiently protective (*See* 2001 EPA Comment Response Document, EPA-HQ-OAR-2005-0083-0043, at 4-5 (rejecting proposed standards of 70 and 25 millirems per year)). The ANS should also explain how standards as lax as 1 mSv from a single source would compare with values of acceptable risk applied to other EPA-regulated activities hazardous to human health and, if necessary, justify less stringent standards applied to repositories. Comparisons to natural background or variations in natural background (ANS at p. 24) are useless because risks do not become acceptable merely because they are naturally occurring, as evidenced by the fact that people often take protective actions to minimize naturally-occurring risks (*e.g*., building tornado shelters).

5) Separate standards for Yucca Mountain

The Draft Recommendations are clear in recommending that the Yucca Mountain standards should be used as a basis for developing new, generic standards (*See,* ANS at p. iv). However, for generic application, modifications to those standards are recommended. Nevertheless, for Yucca Mountain, ANS states that 40 CFR Part 197 should continue to be applied. This is illogical. Presumably, the objective here is to provide a 'level playing field' for all proposed sites and repository designs. If this is the case, it would be preferable to bring Yucca Mountain into the generic standards, particularly if those standards are subject to future revision and are truly consistent with public health-based standards.

6) Reasonable Expectation

ANS recommends the use of "reasonable expectation" as the standard of proof in geologic repository licensing reviews and proceedings (ANS at pp. 10-12). According to

ANS, “proof of the future performance of a disposal system is not to be had in the ordinary sense of the word” (ANS at p. 10), but 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,” (ANS at p. 10). Additionally, ANS argues that reasonable expectation is consistent with “NRC’s risk-informed and performance-based approach to regulatory decision-making as embodied in 10 CFR 63” applicable to Yucca Mountain (ANS at p. 11). This recommendation is not well supported, fails to take into account NRC practice and precedent, and should be rejected.

The standard of proof that is and always has been applied in NRC licensing reviews and proceedings is “reasonable assurance.” The NRC has long explained that “[r]easonable assurance is not quantified as equivalent to a 95% (or any other percent) confidence level, but is based on sound technical judgment of the particulars of a case and on compliance with our regulations” (*AmerGen Energy Co., LLC (Oyster Creek Nuclear Generating Station*), CLI-09.07, 69 NRC 235 (2008)). Moreover, the NRC applied a “reasonable assurance” standard of proof to the licensing of geologic repositories when it found that “one or more mined geologic repositories for commercial high-level radioactive waste and spent fuel will be available by the years 2007—2009” (79 Fed. Reg. 56238, 56240 (September 19, 2014)). Finally, the NRC has explained that “there is no meaningful difference between ‘reasonable assurance’ and ‘reasonable expectation.’” ((*See,* letter NRC General Counsel to M. Malsch, May 18, 2007 ML071520180)

Therefore, the ANS is incorrect when it attempts to justify the “reasonable expectation” standard of proof on the basis that absolute proof would otherwise be required. Moreover, contrary to what ANS implies, “reasonable expectation” is not required by NRC’s risk informed and performance-based approach to licensing of geologic repositories. In fact, adopting a “reasonable expectation” standard of proof would suggest a false distinction between “reasonable assurance” and “reasonable expectation” because, as the NRC has explained, there is no meaningful distinction between the two.

7) <u>Probabilistic uncertainty analysis</u>

The requirement to undertake a probabilistic uncertainty analysis is welcome, as is the use of a dose (or risk) based compliance standard. The use of an individual-based standard is appropriate and in line with international practice, and there is not a strong distinction between using a standard based on risk and one based on the expectation value of dose. The Draft Recommendations argue that a dose-based standard is more robust than a risk-based standard because of potential changes in the dose-response relationship. Although arguably true, it should be noted that the effective dose used as a basis could, itself, be subject to revision, *e.g.,* through changes in tissue and radiation weighting factors.

8) <u>Multiple Barriers</u>

The ANS recommends that the standards include a requirement for multiple barriers, consistent with the approaches taken in 40 CFR 191.14(d) and implemented by the NRC for Yucca Mountain in 10 CFR Part 63, to ensure defense in depth (ANS at p. v). Further, the ANS concludes that "the requirements in 10 CFR 63.115—to identify the barriers, describe their capabilities, and 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 (ANS at p. 19). But there is no explanation how mere descriptions and analyses of multiple barriers will add anything to defense in depth. If a cardboard box were the only engineered barrier, would it qualify as one of the multiple barriers that contributes to defense in depth simply because the applicant described its capabilities and provided the technical basis for those capabilities consistent with the technical basis for the overall performance assessment?

Moreover, the ANS is somewhat misleading when it suggests that merely identifying the barriers, describing their capabilities, and providing the technical basis for those capabilities are consistent with the technical bases for the overall performance assessment, is in accord with the NRC's implementation of 10 CFR Part 63. In fact, important issues regarding multiple barriers and defense in depth remain unresolved. Among other things, there is a question about how to apply the NRC Staff's understanding that, while the regulations did not include any quantitative measure for what constitutes defense-in-depth, there will inevitably be a subjective decision to be made. It would be reasonable to consider the capabilities of the barriers for a proposed facility and then it would be in the judgment of the NRC staff to determine whether there is adequate defense-in-depth." (ML15191A096 at p. 251). And, as the ANS acknowledges, the IAEA recommends that "[t]he overall performance of the disposal system shall not be unduly dependent on a single safety function" (ANS at p. 52). The ANS seems to endorse this IAEA recommendation, but it does not explain how undue dependence is avoided by mere descriptions and analyses.

As noted above, the emphasis on including multiple barriers characterized by their safety functions is in line with international practice. However, the relevance of adopting multiple barriers should be demonstrated in safety analyses. This can be done by modelling a set of 'What if' scenarios in which non-compliance of the system with one or more of the safety functions is demonstrated to result in only a limited degree of degradation of system performance. It may be useful to include some guidance on the need to demonstrate a structured approach to scenario selection, distinguishing, for example, reference, variant and 'What if?' scenarios.

Nevada's one experience with the application of ANS' approach to defense in depth makes the rule ineffective in practice. DOE's repository design and schedule requires drip shields as part of the engineered barrier system and requires that the drip shields will be installed in the final 10 years of repository operation after all the waste is emplaced, but before a license amendment for permanent closure of the repository is issued at 100 years after first waste emplacement. Nevada's analysis of DOE's license application data and assumptions indicate that without the presence of drip shields, the

EPA Standard for individual doses from released radionuclides could be violated in less than 1,000 years after closure, thus indicating that repository performance is dependent on a single engineered barrier – the drip shield. But notwithstanding this dependence, DOE relied on the theory, endorsed in the draft standard, that accurate and complete descriptions of the drip shields and their role in the total systems performance assessments was all that was necessary. Any analysis of this possible undue dependence, or the ramifications associated with DOE's possible inability to successfully procure and install the drip shields, was deemed unnecessary. This approach essentially ignored the basic concept of defense in depth.

While the drip shield installation is required in DOE's Safety Assessment, circumstances are easily envisioned that would result in foregoing installation. For example, the 11,500 drip shields planned would cost billions of dollars (in today's dollars) for materials (titanium) and fabrication after decades of expenditure from the Nuclear Waste Fund to construct and operate the repository. The likelihood that the Nuclear Waste Fund will be near or at exhaustion when billions of dollars are needed for drip shield fabrication and installation is a real and necessary consideration that could result in Congress refusing to appropriate the requested additional funds. With no other option, DOE could amend the safety assessment to attempt to show through performance assessment that the drip shield is not needed to assure performance. This only-one-of-its-kind example of failure of defense in depth in regulatory practice strongly suggests the need for quantitative review and standards for the effectiveness of multiple barrier safety protection. Yet, there has been no analysis of whether uncertainties in drip shield installation or performance makes reliance on them "undue" because DOE adopted the theory, endorsed by ANS, that mere descriptions and analyses of drip shield performance is sufficient.

9) <u>Characteristics of Potentially Exposed Individuals</u>

The Draft Recommendations argue (*see,* Appendix C) for a near-present-day community context for selecting the potentially exposed individuals to be considered in dose estimation. However, this seems to be intended to relate to people who now reside in the vicinity of the repository (Section III.1.3). The Draft Recommendations are silent on how potential changes in climate and landscape might affect that community. Such changes could markedly affect community characteristics, even if the technological capabilities and social characteristics of society remain unaltered. The implications of climate and landscape change for repository safety have been addressed extensively by the IAEA (*see*, *e.g*. IAEA, 2020).

10) <u>Timescale for quantitative assessment</u>

The Draft Recommendations argue for a limit of 10,000 years on the time period for application of quantitative standards. They note that although computational models can be constructed that predict the behavior of natural and engineered systems for longer time periods, the capabilities of those models to cope with the complex coupling of time-dependent boundary conditions remain problematic. However, this argument neglects the consideration that such coupling is far more challenging in some contexts than others. It is particularly challenging at Yucca Mountain where water percolation through the repository regime is highly dynamic and strongly controlled by surface conditions, and reliance is placed on complex engineered barriers to achieve safety. It is a far lesser issue in a deep clay formation (as considered by ANDRA, see https://international.andra.fr/solutions-long-lived-waste/cigeo), where radionuclide diffusion through the clay has a characteristic timescale of the order of millions of years. It is also less of an issue in deep vertical borehole disposal because such boreholes penetrate to depths where groundwater movement is typically very limited (different considerations may apply in shallower, highly deviated boreholes). Although the Draft Recommendations do not address design and site comparisons, it would be helpful to have quantitative standards that extend for a long enough period to discriminate between the options. Rather than abandoning quantitative calculations beyond 10,000 years, it would be better to specify a quantitative standard that extends out to the time of peak dose (or risk), and require explicit evaluation of uncertainties in the calculations out to that time (these uncertainties being limited to those of the engineering and geology aspects of the design and site), recognizing that the surface environment and human community are much more uncertain and are imposed as a 'measuring instrument' to convert radionuclide fluxes from the geosphere into a common measure of impact. Time to peak dose is preferred over a fixed value of one million years to reflect the consideration that some geological regimes (*e.g*., ancient basement rock or thick clay strata) are stable on much longer timescales, whereas others, such as salt domes, may only be mechanically stable on somewhat shorter timescales. For general purposes, the regulatory period could be set at the one million year mark unless there is a credible showing of peak dose occurring beyond the one million year threshold.

The quantitative assessment must, at a minimum, include the time at which peak dose from repository releases are projected to occur. In the Yucca Mountain example, the timing of peak dose is directly related to the degradation of the waste packages and the attendant uncertainties. In other geologic settings, other factors may have a greater role in the time of peak dose.

With a focus on natural stability of the site, there is no basis for a radiation protection standard to permit bifurcation of the allowable dose at an arbitrary time within the regulatory period. Returning again to the Yucca Mountain example, there is no reasonable rationale for bifurcating the dose standard in EPA's 40 CFR Part 197 standard for Yucca Mountain.

11) Controlled area

At Section III.2.6, it is accepted that the definition of a controlled area in 40 CFR Part 197 is not appropriate. However, the preferred definition from 40 CFR Part 191 makes no mention of the timescale for which the controlled area is assumed to be present. In most national disposal programs, it is recognized that control cannot be maintained indefinitely. Typically, closure of the repository is followed by a period of no more than a few hundred years for which control is maintained by the implementing organization or its successors. Thereafter, free access is assumed, with implications both for potential intrusion and for groundwater exploitation.

12) Intrusion

The proposal to use a single, stylized human intrusion scenario is welcomed. However, it seems unduly restrictive to limit the assessment of impacts to effects on the groundwater pathway. For example, in a geological environment where a permeable host rock (*e.g*. limestone) is overlain by an impermeable cap rock (*e.g*., mudstone) a penetration through the cap rock could lead to a pulse release of gas (*e.g*., resulting from corrosion in the repository). It is suggested that the study of the stylized human intrusion scenario should address all identified, potentially relevant pathways. Often, but not always, this will result in only the groundwater pathway being addressed quantitatively.

13) Groundwater protection

The State of Nevada and many others consider the protection of groundwater to be of critical importance. While groundwater protection, as currently implemented in regulation, provides little protection beyond that provided by individual protection standards (Section III.3.2), Nevada believes it is an important feature of any regulatory regime going forward. In Europe, for example, groundwater protection has been increasingly debated over recent years (e.g. in relation to the Groundwater Protection Directive of the European Union, see http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF). The context is that multiple potential sources of pollution should not be allowed to degrade groundwater quality.

While Nevada believes that retention of a groundwater standard is critical, it should apply cumulatively both to radionuclides present in the groundwater and to those likely to be added through discharges from a nuclear waste repository. The draft regulation seems to suggest that the groundwater protection standard might provide an incentive to site a repository in areas with “pristine” groundwater resources that serve as community water supplies where this standard and the identical radiation protection standard of the Safe Drinking Water Act would apply. This suggested modification could conceivably result in nearly doubling the radiation exposure to individuals consuming the water. By retaining the standard as is, the incentive in site selection would be to avoid the potential for otherwise prohibited (under the SDWA) radiation exposure to users of a community water supply. Other sections of the Draft retain the use of current environmental and human characteristics in repository performance assessment. Site selection should not encourage a known deviation from this important performance parameter.

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