SUMMARY OF EXISTING GUIDANCE THAT MAY BE RELEVANT FOR REVIEWING PERFORMANCE ASSESSMENTS SUPPORTING DISPOSAL OF UNIQUE WASTE STREAMS

BACKGROUND

The framework for the analysis of the disposal of radioactive waste on land was developed in the 1980s for the draft (NUREG-0782) and final (NUREG-0945) environmental impact statements supporting the development of Title 10 of the *Code of Federal Regulations* (CFR) Part 61. In the development of 10 CFR Part 61, the Commission recognized the importance of protecting public health and safety over the long term and placed emphasis on the long-term performance of land disposal facilities after operations cease.

Part 61 established a waste classification scheme based on the role that the concentration and form of waste plays in the long-term performance of land disposal facilities. The classification scheme involves consideration of the concentration of both long-lived and short-lived radionuclides. The classification of short-lived radionuclides considers the impact of institutional controls, improved waste form, and deeper near-surface disposal. The impact of long-lived radionuclides is mitigated by an improved waste form, deeper near-surface disposal, and limiting the quantity and concentration disposed without consideration of institutional controls. The potential hazard of long-lived radionuclides will persist long after the short-lived radionuclide precautions cease to be effective.

The initial Part 61 analyses did not consider large quantities of depleted uranium waste because there were no commercial facilities producing large quantities of DU at that time. The NRC's initial analysis proposed concentration limits for uranium isotopes based on the waste streams that were being commercially produced at that time. But the agency's final analysis concluded that those waste streams posed an insufficient hazard to warrant establishing a concentration limit for uranium in the waste classification scheme.

In Order CLI-05-20, the Commission directed the NRC staff, "to consider whether the quantities of depleted uranium at issue in the waste stream from uranium enrichment facilities warrant amending Section 61.55(a)(6) or the Section 61.55(a) waste classification tables." In response, the staff performed an analysis and documented the results in SECY-08-0147. In that analysis, the staff concluded that the near-surface disposal of large quantities of depleted uranium may be appropriate, but not under all site conditions, and recommended modifications to 10 CFR Part 61 to ensure the safe disposal of unique waste streams, including large quantities of depleted uranium. Specifically, NRC staff noted in SECY-08-0147 that while performance of a site specific analysis is one way to satisfy the Part 61 performance objectives, licensees and applicants are free to propose alternative methods of complying with the performance objectives set out in Part 61. If this occurs, Agreement State regulators will have to confirm that the proposal complies with the requirements in Part 61. In SRM-SECY-08-0147, the Commission instructed the staff to proceed with an amendment to 10 CFR Part 61 to specify a requirement for a site-specific analysis for the disposal of unique waste streams including large quantities of depleted uranium ("unique waste streams"). Further, the Commission directed the staff to conduct a public workshop to discuss issues associated with the disposal of unique waste streams, identify potential issues to be considered in rulemaking, and identify technical

parameters of concern in the analysis so that informed decisions could be made while the rulemaking is ongoing.

The staff conducted two public workshops in September 2009 to seek input from a variety of stakeholders. A number of stakeholders expressed interest or concern with the review of performance assessments supporting disposal of unique waste streams prior to completion of the rulemaking process. This summary highlights existing guidance associated with the review of performance assessments with a focus on issues associated with the safe disposal of unique waste streams.

SUMMARY OF ISSUES

The performance objectives in 10 CFR Part 61 Subpart C are key to ensuring the safe land disposal of unique waste streams. Section 61.13 describes the specific technical analyses that must be included to demonstrate that the performance objectives of Subpart C will be met. The objectives pertaining to the long-term performance of low-level radioactive waste disposal facilities following site closure include: (i) an analysis of exposures to humans from releases of radioactivity; (ii) an analysis of the protection of individuals from inadvertent intrusion; and (iii) an analysis of long-term stability of the disposal site. The technical parameters of concern for these analyses are discussed in more detail below, and should assist Agreement States in evaluating whether a method proposed by a licensee or an applicant would meet the requirements of Part 61.

Site-Specific Analyses

Requirements for site-specific technical analyses for the disposal of low-level radioactive waste are found in 10 CFR 61.13. When the regulation and its associated standard review plan, NUREG-1200, were developed, the regulatory approach was generally prescriptive. Since then site-specific performance assessments have evolved to include more explicit representations of features, events, and processes and the associated uncertainty. In addition, the Commission in a Final Policy Statement, *Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities,* (60 FR 42622) formalized its commitment to risk-informed regulation through the use of probabilistic risk assessment methods. In SRM-SECY-98-144, the Commission advocated certain changes to the development and implementation of its regulations through the use of risk-informed and ultimately performance-based approaches.

Section 4.2 of NUREG-1854 implements a risk-informed performance-based approach that identifies generic technical review procedures for the evaluation of site-specific performance assessments. These generic technical review procedures are grouped into the following categories: system description, data sufficiency, data uncertainty, model uncertainty, and model support. In addition, Section 3.5 of Volume 2 of NUREG-1757 provides guidance on the evaluation of engineered barriers used in site decommissioning. If similar barriers are used in land disposal of low-level radioactive waste, then this guidance may be useful. NUREG-1573 may also be useful, as it provides guidance on: (1) an acceptable approach for systematically integrating site characterization, facility design, and performance modeling into a single performance assessment process; (2) five principal regulatory issues regarding interpreting and implementing Part 61 performance objectives and technical requirements integral to a low-level radioactive waste disposal facility performance assessment, and (3) implementation of NRC's performance assessment methodology. The guidance in NUREG-1573 may help ensure the consistency of different reviews. The underlying philosophy expressed throughout NRC

guidance is that the disposal system and site should consider the desired performance and the characteristics of the waste being disposed.

Intruder analyses

Section 61.13, *Technical Analyses*, requires analyses that demonstrate with reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. The need for an intruder dose assessment is not identified in the regulation because the NRC staff, in NUREG-0782 and NUREG-0945, performed an intruder dose assessment for the waste streams anticipated to be disposed of in commercial low-level radioactive waste disposal facilities. The analysis resulted in the radionuclide concentrations provided in the waste classification tables at 10 CFR 61.55. In developing the waste concentration limits, the NRC staff performed intruder analyses using an annual dose limit of 5 mSv (500 mrem).

In NUREG-0782 and NUREG-0945, inadvertent intrusion was assumed to occur at some point following the closure of a low-level radioactive waste disposal facility. The intruder was assumed to excavate and construct a residence on the disposal site (intruder–construction), or to occupy a dwelling located on the disposal site and ingest food grown in contaminated soil (intruder–agriculture). The intruder–agriculture scenario was assumed to be possible only if the waste had degraded to an unrecognizable form. The analysis also considered the exposure to radionuclides through inhalation of contaminated soil, dust and air, direct radiation, and ingestion of contaminated food and water. Additional exposed waste scenarios were considered as well as other potential exposure pathways. Additional details on the inadvertent intruder analyses are provided in Appendix G of NUREG-0782.

Since protection of an inadvertent intruder was a primary consideration in the development of the waste classification system, *it would be prudent for licensees considering the disposal of unique waste streams to perform a dose assessment for an individual inadvertent intruder.* Although there could be other ways to perform this analysis, the NRC staff believes that a site-specific analysis of the unique waste streams is the most effective way to do this. An intruder dose assessment consistent with the NRC analyses supporting the development of 10 CFR Part 61 would provide reasonable assurance that the 10 CFR 61.42 performance objective ensuring protection of individuals from inadvertent intrusion would be met. Consistent with the analyses performed by NRC staff, the analyses should consider reasonably foreseeable activities by an intruder that may result in inadvertent disruption of the disposal facility and release of radioactivity to the environment. For a site-specific intruder dose assessment, typical scenarios considered could include intruder–construction and intruder–agriculture, as well as other reasonably foreseeable scenarios. As noted previously, consistent with the analyses performed by NRC staff in NUREG-0782 and NUREG-0945 and reaffirmed in the Denial of Petition for Rulemaking, PRM-61-2, the intruder annual dose limit should be 5 mSv (500 mrem).

Climatic and environmental conditions would typically be considered in a site-specific assessment. As discussed in NUREG-1573, performance assessments should consider variability in natural conditions, processes, and events. Consideration of variability in natural conditions usually includes the selection of scenarios and pathways in the performance assessment. However, for a typical commercial low-level radioactive waste disposal facility where the hazard from the inventory remaining at 500 years is expected to be low and inventory limits on long-lived radionuclides can be set, NUREG-1573 states that unnecessary speculation about major changes to future climate (such as glacier formation) or human behavior should be

avoided because the human population would be dramatically affected by the natural process itself.

However, more gradual changes, such as climatic changes to nature, timing, and the magnitude of meteorological processes and events, should be considered in performance assessment modeling for long-lived radionuclides. For long-lived unique waste streams, these gradual changes should also be considered when evaluating impacts to inadvertent intruders. If current conditions are used to eliminate what would otherwise be considered credible disruptive land use scenarios and the waste is long-lived, the intruder dose assessment should consider expected changes to climate and environmental conditions as a result of natural cycling of the climate. Changes to the climate may make the eliminated land use scenarios more or less likely to occur in the future.

Dosimetry

The performance objective at 10 CFR 61.41 requires that concentrations of radioactive material released to the general environment "not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public." As a matter of policy, in the final rule for disposal of high-level waste at Yucca Mountain (66 FR 55752), the Commission considered 0.25 mSv (25 mrem) total effective dose equivalent (TEDE) as the appropriate dose limit within the range of potential doses represented by the older limits found in regulations, such as 10 CFR 61.41, that were published prior to the adoption of a dosimetry system that was able to account for the radio-sensitivity of the different organs.

Incidental waste determinations under the Ronald Reagan National Defense Authorization Act of Fiscal Year 2005 typically use the performance objectives specified at 10 CFR Part 61, Subpart C. In SRM-SECY-05-0073, the Commission directed the staff, in its responsibilities related to these incidental waste determinations, to use the latest science based on radiological protection requirements in the International Commission on Radiological Protection (ICRP) Publication 26 methodology instead of the older requirements in ICRP Publication 2. The ICRP-26 methodology basically uses a standard of 0.25 mSv (25 mrem) TEDE.

Period of Performance

The period of performance is not specified in 10 CFR Part 61, in part due to the site-specific and source-specific influence on the timing of projected risk from a low level radioactive waste disposal facility. The NRC staff recognizes that the lack of a specified period of performance creates uncertainty for licensees and regulators as to how to implement a site-specific performance assessment for unique waste streams. In NUREG-1573, Section 3.2.3, the staff considered a performance period of 10,000 years, which is believed to be sufficient to capture the risk from the short-lived radionuclides that comprise the bulk of the disposed activity. In general, the analyses in NUREG-1573, NUREG-0782, and NUREG-0945 recognize the need for a performance period commensurate with the persistence of the hazard, but assumed that the amount of long-lived waste disposed of as low-level waste would be limited. The Advisory Committee on Nuclear Waste expressed a similar concern in its letter to the Chairman, dated February 11, 1997. The guidance in NUREG-1573 identified specific exemptions to the expectation of limited quantities of long-lived waste including in-growth of daughter products from large inventories of uranium. For radionuclides for which projected doses are increasing at 10,000 years, the staff recommended in NUREG-1573 that the calculation be continued, assuming the same set of conditions, processes, and events considered significant over the

initial 10,000 years until the peak dose is reached regardless of when that occurs. NRC staff recommended that assessments beyond 10,000 years not be used for determining regulatory compliance with the performance objective. However, assessments beyond 10,000 years can be used as a basis for making judgments about the magnitude of the estimated dose relative to the performance objective and its time of occurrence beyond the regulatory compliance period, and may provide an important contribution to the site environmental evaluation. If, after considering the magnitude and time of the dose, and associated uncertainty, the regulatory authority decides the dose is unacceptably high, either inventory limits would have to be imposed or the waste is not suitable for disposal as low-level radioactive waste at the site.

In SECY-08-0147, NRC staff revisited the evaluation of the performance period completed in NUREG-1573 and recommended an approach for application to the assessment of depleted uranium disposal similar to that described in NUREG-1573 for typical commercial low-level radioactive waste disposal. The staff recommendation considered and attempted to be consistent with other national policy on waste disposal such as for high-level and transuranic wastes. To be consistent with SECY-08-0147 and NUREG-1573, for unique waste streams that are long-lived and where quantities are significant, *the staff recommends that licensees consider the characteristics of the waste, the analysis framework (assumed scenarios, receptors, and pathways), societal uncertainties, and uncertainty in predicting the behavior of natural systems over time*. Commission policy on period of performance for unique waste streams will be established in the rulemaking process and may differ from this staff recommendation.

Mitigation and Limitation

As discussed in SECY-08-0147, near-surface disposal of large quantities of concentrated depleted uranium may be appropriate under certain conditions. The staff evaluated the potential use of robust engineered covers and burying the waste at deeper near-surface depths as approaches that could meet the 10 CFR Part 61 performance objectives. In addition to concentration limits, an important concept of the 10 CFR Part 61 regulatory framework that may be useful for unique waste streams, after considering appropriate design considerations (e.g., depth of waste and cover performance), is inventory limits. Inventory limits are discussed in 10 CFR 61.7, Concepts. A regulatory agency may limit inventory for disposal or otherwise not permit disposal of any waste stream (including unique wastes) based on consideration of the timing and magnitude of doses and the associated uncertainty. For any type of waste, a regulatory agency can limit or prohibit the disposal of the waste if the prospective licensee has not adequately addressed the uncertainty associated with the disposal of the waste. Robust engineered barriers or other types of facility design, such as increased disposal depth, may reduce uncertainty and help mitigate impacts, such that inventory limits may be unnecessary or modified for a site. For disposal of large quantities of long-lived waste, impacts of disposal actions may be more uncertain and require more robust technical evaluation of processes not likely to impact the disposal of short-lived waste (e.g., long-term degradation of engineered barriers).

Radon

Some unique waste streams, such as concentrated depleted uranium, may have the potential to generate significant concentrations of radon gas. However, as noted above, the draft and final environmental impact statements for 10 CFR Part 61 did not envision that large quantities of material that could generate radon would be disposed of as low level radioactive waste.

NUREG-0782 assumed 17 Curies (Ci) of ^{238}U and 3 Ci of ^{235}U would be disposed of in 1 million m^3 of waste over a 20-year generic low-level radioactive waste disposal site operating life. Therefore, the performance objectives in Subpart C of 10 CFR Part 61 do not provide explicit requirements for radon. Different regulatory programs and different regulatory agencies have taken a variety of approaches to assess and ensure the impacts of radon are mitigated.

The update of the 10 CFR Part 61 impacts analysis methodology in Volume 1 of NUREG/CR-4370 explicitly addressed the effects of radon gas generation, which is important for near-surface disposal of depleted uranium. Radon was recognized as a daughter-product in some waste streams, in which case the in-growth of radon gas in buildings was expected to be included in the intruder-agriculture scenario. NUREG/CR-4370 provided approaches to calculate radon doses, and stated that the doses should be added to other impacts calculated for the intruder-agriculture scenario. Radon is also discussed in NUREG-1573, Section 3.3.5.7, as being included as part of the assessment of gaseous releases in low-level radioactive waste disposal.

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