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# IEER Comments on the Nuclear Regulatory Commission's Rulemaking Regarding the "Safe Disposal of Unique Waste Streams Including Significant Quantities of Depleted Uranium"[1]

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On March 18, the Nuclear Regulatory Commission (NRC) directed its staff to proceed with a rulemaking to amend the low-level waste rule to take into account the gap in the existing rule,[2] which does not address depleted uranium waste created in large amounts, such as at uranium enrichment plants. This followed the preparation by the staff of a paper, SECY-08-147,[3] which presented the Commission with four options. The March 18, 2009, decision was to proceed with Option 2 as specified in SECY-08-147.

> Previously, in the adjudicatory proceeding for the Louisiana Enrichment Services (LES) license application, the Commission determined that depleted uranium is properly classified as low-level radioactive waste. Although the Commission stated that a literal reading of 10 CFR 61.55(a)(6) would render depleted uranium a Class A waste, it recognized that the analysis supporting this section did not address the disposal of large quantities of depleted uranium. Outside of the adjudication, the staff was tasked to evaluate this complex issue and provide specific recommendations to the Commission. SECY-08-0147 is the result of the Commission's direction and provides recommendations for a path forward.

[1] U.S. Nuclear Regulatory Commission, "Notice of Public Workshop on a Potential Rulemaking for Safe Disposal of Unique Waste Streams Including Significant Quantities of Depleted Uranium," *Federal Register* v.74, no.120 (June 24, 2009), pages 30175-30179, on the Web at http://edocket.access.gpo.gov/2009/pdf/E9-14820.pdf. Hereafter referred to as NRC FR Notice 2009. Hereafter NRC FR Notice 2009.

[2] Annette L. Vietti-Cook (Secretary [of the Commission]), Memorandum to R. W. Borchardt (Executive Director for Operations), *Staff Requirements – SECY-08-0147 – Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, Nuclear Regulatory Commission, March 18, 2009, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/srm/2008/2008-0147srm.pdf. The Commission's approval of the staff's recommendation was not unanimous. Commissioner Gregory Jaczko dissented. See below.

[3] R.W. Borchardt (Executive Director for Operations), to the Commissioners [of the NRC], *Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, Rulemaking Issue, SECY-08-0147, October 7, 2008, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2008/secy2008-0147/2008-0147scy.pdf. Hereafter referred to as SECY-08-0147 2008.

> As an initial approach to addressing this complicated issue, the Commission has approved the staff's recommended Option 2 to 1) proceed with rulemaking in 10 CFR Part 61 to specify a requirement for a site-specific analysis for the disposal of large quantities of depleted uranium (DU) and the technical requirements for such an analysis; and 2) to develop a guidance document for public comment that outlines the parameters and assumptions to be used in conducting such site-specific analyses.
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> In revising 10 CFR 61.55(a)(6) in this limited scope rulemaking, the Commission is not proposing to alter the waste classification of depleted uranium. Eventual changes to waste classification designations in the regulations must be analyzed in light of the total amount of depleted uranium being disposed of at any given site. However, the Commission is stating that for waste streams consisting of significant amounts of depleted uranium, there may be a need to place additional restrictions on the disposal of the depleted uranium at a specific site or deny such disposal based on unique site characteristics and those restrictions should be determined by a site specific analysis which satisfies the requirements of the proposed new 61.55(a)(9). This thought should be clearly indicated in the proposed rulemaking package seeking public comment. As part of this rulemaking, the staff should promptly conduct a public workshop inviting all potentially affected stakeholders, including licensees, state regulators and federal agencies. At this workshop, the staff should discuss the issues associated with the disposal of depleted uranium, the potential issues to be considered in rulemaking, and technical parameters of concern in the analysis so that informed decisions can be made in the interim period until the rulemaking is final.[4]

The first thing to note here is that the Commission is proposing only to revise 10 CFR 61.55(a)(6) and to add a new paragraph 10 CFR 61.55(a)(9), which does not now exist. Specifically, it is *not* proposing within this limited rulemaking to modify any part of 10 CFR 61 outside of 10 CFR 61.55(a). This intention is also clear from the Federal Register notice announcing the workshops.[5] The second critical thing to note is that the vote was not unanimous. Commissioner Jaczko, who has since been appointed the Chairman of the NRC, voted against Option 2, having earlier stated his preference for Option 3:

> In my original vote on SECY-08-0147, I approved Option 3 (determine classification for depleted uranium within existing classification framework) and I disapproved the staff's recommendation for Option 2 (rulemaking to specify requirement for site-specific analyses for the disposal of large quantities of depleted uranium). Since that vote, which was dated November 3, 2008, more information has come to light that I would like to address in my vote.
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> The disposal of large quantities of depleted uranium (DU) is a unique challenge because, unlike typical low-level waste, the doses increase over time rather than decrease. The technical analysis included with SECY-08-0147 indicates that

[4] Annette L. Vietti-Cook (Secretary [of the Commission]), Memorandum to R. W. Borchardt (Executive Director for Operations), *Staff Requirements – SECY-08-0147 – Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, Nuclear Regulatory Commission, March 18, 2009, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/srm/2008/2008-0147srm.pdf.

[5] NRC FR Notice 2009.

> additional requirements are likely needed for disposal of large quantities of DU in order to protect public health and safety; for example, increased waste disposal depth or robust radon barriers may be required. However, Option 2 does not explicitly change the classification of DU as presently provided for in 10 CFR 61.55 and therefore the waste would remain classified as Class A. I do not believe that it is logical to argue that that waste that requires additional requirements for disposal (similar to those required for Class C waste) can still be labeled as Class A waste.[6]

As directed by the Commission, , the NRC staff held a two day workshop in Bethesda, Maryland, in which I was an invited participant, as well as one in Salt Lake City.[7] The proceedings were transcribed. The transcript and slide presentations have been posted on the NRC's website.

I will first provide comments on the DU portion of the rulemaking and then provide briefer comments relating to other unique waste forms and the NRC's proposal for a longer term risk-informed revision of the entire low-level waste rule.

## A. SECY-08-147 Is Fundamentally Deficient in Concept

Option 2, as described in SECY-08-147, is to keep the existing designation of DU as Class A waste based on the default paragraph in the low-level waste rule 10 CFR 61.55(a)(6). This paragraph states: "If radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A." Since this was recognized as insufficient for ensuring health and safety, Option 2 proposes the addition of a new paragraph. The proposal is summed up in SECY-08-147 as follows:

> Proposed Change: Modify paragraph 61.55(a)(6) to include a statement that, for unique waste streams including, but not limited to, large quantities of depleted uranium, the requirements of § 61.55(a)(9) of this part must be met. Section 61.55(a) would then be modified to include a paragraph (a)(9), which would include a requirement that *the disposal facility licensee must perform, and the Commission must approve, a site specific analysis demonstrating that the unique waste stream, including large quantities of depleted uranium, can be disposed of at the site in conformance with the performance objectives in subpart C to Part 61.*[8]

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[6] *Commissioner Jaczko's Revised Comments on SECY-08-0147 Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, March 6, 2009, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2008/2008-0147vtr.pdf. See pdf pp. 7 and 8.

[7] The transcripts for both the Maryland (September 2 and 3, 2009) and the Utah (September 23 and 24, 2009) Workshops, the slide presentations, and background documents are available on the NRC's web page: *Unique Waste Streams*, on the Web at http://www.nrc.gov/about-nrc/regulatory/rulemaking/potential-rulemaking/uw-streams.html. Hereafter cited as NRC DU meeting transcript, September 2, 2009, and NRC DU meeting transcript September 3, 2009.

[8] SECY-08-0147 2008, p. 8. Italics, in the original, provide the text of the proposed new paragraph.

There are is a fundamental problem with this paragraph. It *assumes* that there exist sites that can comply with the performance requirements of 10 CFR 61, Subpart C. SECY-08-0147 provides no site-specific analysis to prove this in even one case. As we will see, the generic analysis of various types of sites and scenarios performed are fundamentally deficient in their assumptions and in their modeling. The NRC staff did not take into account even the possibility that no site would be found suitable under the performance requirements of Subpart C. Option 2 contains no fallback provision to examine alternative methods of managing large amounts of DU that could meet the performance requirements. Specifically, it does not consider deep disposal.

But the problem goes even deeper. The NRC staff failed even in its generic and deficient analysis to examine whether shallow land burial (at sufficient depth but less than 30 meters) could meet the performance requirements of Subpart C. So far as limiting dose to the general public are concerned, those performance requirements are specified at 10 CFR 61.41 as follows:

> Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must 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. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

SECY-08-0147 did not calculate organ doses at all despite the fact that the main radionuclides in question – uranium-238, uranium-234, thorium-230, radium-226, radon-222 (and its daughters) – have dose conversion factors for particular organs that are much greater than for the equivalent dose to the whole body. For instance, the bone surface dose due to radium-226 per unit intake by ingestion is about 44 times larger than the whole body dose equivalent. As another example, the target organ for radon-222 (and its decay products) is the lung and other organs get minimal doses. When organ dose to whole body equivalent ratios for inhalation are considered (important in case waste is uncovered by erosion, especially in dry areas), the differences can be even greater. The ratio of bone surface dose to the whole body effective dose equivalent for inhalation of medium solubility thorium-230 is more than 50.[9]

Other examples are easy to provide. For instance, the bone surface dose from drinking water contaminated with lead-210 (a decay product of radon-222) is more than 30 times bigger than the committed whole body equivalent dose.

At the Bethesda, Maryland, workshop, I asked why the performance assessment was not according to the criteria in 10 CFR 61 Subpart C. Dr. Esh, the principal author of the analysis in SECY-08-147, stated that the NRC staff had used a "modern" approach and used TEDE as the performance criterion:

> Primarily because in more recent evaluations; in particular, for waste incidental to reprocessing, we have had direction from the Commission to use more modern methods, instead of those old methods. So we followed that direction. [10]

[9] Dose conversion factors are from EPA's Federal Guidance Report 13.
[10] NRC DU meeting transcript, September 2, 2009, p. 104.

I pointed out that human beings still have organs, and 10 CFR 61 Subpart C requires organ dose calculations, so it is not a question of "modern" methods of calculation. Further, the most recent EPA method of internal dose calculation, published as Federal Guidance Report 13, allows for both organ dose and whole body effective dose equivalent calculations. So it is not even a question of "modern" methods versus obsolete methods.

Also, whether a certain method is "modern" or not or whether only whole body equivalent doses are used in other parts of the NRC's work is irrelevant. The plain language of the present DU rulemaking process requires an evaluation relative to the performance requirements of 10 CFR 61, and those requirements are in Subpart C. In turn, Subpart C requires, among other things, limitation of organ dose. Hence, in every circumstance where organ dose may exceed whole body effective dose equivalent, as is the case with DU disposal, the rule *requires the calculation dose to the critical or most exposed organ*.

As noted above, the Commission is proposing only to revise 10 CFR 61.55(a)(6) and add a new paragraph that would specify disposal requirements for DU. The Commission has not authorized modification of 10 CFR 61 Subpart C. Specifically, it has not anywhere mentioned that the organ dose requirement of 10 CFR 61.41, which is in Subpart C, is to be ignored or changed. Further, SECY-08-0147 itself states that it will examine whether compliance with 10 CFR 61 Subpart C can be achieved with shallow land burial:

> The technical analysis addressed whether amendments to § 61.55(a) are necessary to assure large quantities of DU are disposed of in a manner that meets the performance objectives in Subpart C of 10 CFR Part 61.[11]

Dr. Esh, the principal NRC staff author of SECY-08-0147, explicitly stated during the Bethesda, Maryland, workshop that the NRC was not proposing to modify Subpart C.[12]

**But SECY-08-0147 did not evaluate performance of DU disposal in shallow land facilities according to a principal element of the requirements of Subpart C. Rather SECY-08-0147 entirely ignored the organ dose calculation requirements of Subpart C as specified in 10 CFR 61.41. This is a central problem with the present proceeding without any other factor. Further, were organ doses to be calculated, even with the fundamentally deficient modeling in SECY-08-0147 (see below), that, contrary to the conclusions of the SECY-08-0147, the model may show that the performance requirements of Subpart C would not be met by shallow land disposal.**

The decision of the NRC instructing the staff to proceed with the rulemaking based on Option 2 is basically flawed since it depends centrally on the technical analysis of the NRC staff in SECY-08-0147 actually showing that it was, at least in theory, possible that some imaginable shallow land configuration could meet the performance requirements of Subpart C. But SECY-08-0147 is fundamentally incomplete since it did not even attempt to calculate organ doses, which are most important, under the circumstances, for evaluating disposal performance.

[11] SECY-08-0147 2008, p. 1.
[12] NRC DU meeting transcript, September 2, 2009, p. 105.

**Recommendation 1: Since the entire premise of proceeding is fundamentally flawed in regard to the performance requirements of Subpart C, and since the staff paper on which the NRC made its decision to proceed with this rulemaking did not even attempt to calculate organ doses, as required by Subpart C, the NRC should stop the present process immediately and begin a new rulemaking that properly specifies the parts of the rule that are being considered for revision and that provides the relevant NRC analysis to the public so that it may comment upon it.**

### B. Scientific Deficiencies in SECY-08-0147

The main technical premise on which the proposed rule change in regard to disposal of significant amounts of DU as Class A waste is that it can be shown that certain low-level waste shallow land disposal facilities would meet the performance requirements of 10 CFR 61. In this section we will leave aside the basic problem that SECY-08-147 did not evaluate the most important part of the performance requirement (dose to the critical organ) and focus on the model and the assumptions that the staff used in SECY-08-147 to analyze performance.

The following are features of the analysis of performance in SECY-08-0147:

- It considers sites in various climatic zones, but is not site specific.
- It assessed doses for one million years – the approximate period during which the decay products of U-238, the main ingredient of DU, continue to build up. This approximates a peak dose calculation.
- As radium-226 builds up over thousands of years, radon-222 emissions increase. Radon-222 doses were included in the analysis. A clay layer that would inhibit radon migration was included. Given the assumption of no erosion, this layer would essentially stay intact over a million years.
- Shallow burial (defined as less than 30 meters depth) at various depths was considered.
- Chronic intruder as well as offsite resident doses were considered.
- Various exposure pathways were considered.
- Both air and water induced erosion were assumed to be zero for one million years.
- An ad hoc model, consisting of a commercial Monte Carlo package and an in-house spreadsheet, was developed.
- The dose assessment was based on TEDE, which is Total Effective Dose Equivalent (defined as the sum of deep external dose and committed effective dose equivalent for internal dose).
- For the offsite resident a 25 millirem annual TEDE dose limit was applied as the performance objective. For the chronic intruder who builds a house above the disposal site, a 500 millirem annual dose limit (TEDE) was applied as the performance objective.[13]

[13] It should be noted that 10 CFR 61 requires assurance that an inadvertent intruder be protected after institutional control expires, but does not specify a dose limit. 10 CFR 61.42 states in its entirety: "Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal

The results of the modeling were as follows:

- Using the TEDE approach, the analysis concluded that shallow land burial, less than 3 meters deep, was not suitable for DU, except for "small quantities" defined as 1 to 10 metric tons.[14]
- Disposal of DU in large amounts at humid sites "with viable water pathways is probably not appropriate."[15]
- For disposal at 5 meters or deeper, up to 30 meters, SECY-08-0147 concluded that disposal at arid sites could meet performance criteria:

> Depleted uranium can be disposed of under arid conditions and meet the Part 61 performance objectives for 1,000 to 1 million years performance periods, if the waste disposal depth is large, or robust barriers are in place to mitigate radon.[16]

Besides the failure to evaluate doses to organs, the following limitations of the analysis should be noted (most came up during the presentations or the discussion at the Bethesda, Maryland, workshop):

1. Climate change was not considered – that is, a constant climate was assumed for one million years.
2. Changes to the chemical form of uranium over one million years were not considered.
3. Colloidal transport of radionuclides was not included.
4. The clay barrier to radon migration into a home built over or near the disposal area was assumed to stay intact over a million years (e.g., no cracks would develop that may allow more migration of radon into the house). The effects of aeolian or fluvial erosion were not considered. The assumption was that the site would be stable for one million years. (The assumption is stated as follows in SECY-08-0147: "Site stability requirements would be achieved. There will not be significant releases of waste to the environment from fluvial or aeolian erosion."[17]

Let us consider these problems one by one.

*1. Climate change*

It is scientifically unsound and contrary to the available data to assume that climate will not change for one million years. Even without the anthropogenic emissions that are currently accelerating climate change, climate has changed naturally on times scales of thousands of years. For instance, Dr. Peter Burns of the University of Notre Dame, a geochemist invited by the NRC to participate in both workshops, and who participated in both of them, noted that Death Valley

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site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed." A figure of 500 mrem per year is often used for performance assessment.

[14] SECY-08-0147 2008, Enclosure 1, p. 16.

[15] SECY-08-0147 2008, Enclosure 1, p. 16.

[16] SECY-08-0147 2008, Enclosure 1, p. 16. Emphasis in the original.

[17] SECY-08-0147 2008, Enclosure 1, p. 9.

was underwater 10,000 years ago and that climate projections could not be relied on for 10,000 or 100,000 or 1 million years.

Climate affects practically every environmental factor relevant to the performance assessment from the integrity of the cap to erosion rates to dilution of radionuclides in groundwater. As one example, the model results in SECY-08-0147 show that "[r]adon fluxes to the environment are very sensitive to the long-term moisture state of the system."[18] Since rainfall is one critical parameter to vary in climate, the radon dose results would evidently also be affected. Similarly, radon dose results would be affected if the integrity of the clay liner is damaged or destroyed by variations in rain, snow, temperature, and/or wind that are greater than those assumed in the modeling. (SECY-08-0147 assumes no erosion even from the present climate – see below).

In fact, the record of the Bethesda, Maryland, workshop shows that even the NRC staff agreed that ignoring climate change for such long periods was not appropriate. The terms "silly" and "silliness" came up in the context of trying to describe attempts to model shallow land burial for a million years, but it was suggested by the moderator, Chip Cameron, that this was perhaps not the best language to use in a regulatory context.[19] Whatever, the term used to describe the fact that the modeling ignored climate change, the essence of the matter is that there was general agreement that climate change should not be ignored for shallow land burial for periods much shorter than one million years – for instance over 10,000 years. This is not as important in the context of radionuclides with half-lives that are much shorter than 10,000 years, but in a context of DU, where the specific activity of the material is growing due to the build up of daughter products, it is essential to consider climate change.

**Recommendation 2: Future modeling for disposal of significant amounts of DU should include climate change.**

*2. Chemical changes to the form of DU*

SECY-08-0147 considered only shallow land burial, with a clay cap being put over the waste. By its very nature, the environment of the DU would be oxidizing. Elementary considerations show that there would be considerable chemical changes, especially over long periods of time in the proposed waste form, $U_3O_8$, that the NRC has accepted as suitable for disposal in its licensing process of the two uranium enrichment plants (LES and USEC) that were granted licenses in 2006 and 2007 respectively. Ignoring chemical changes in $U_3O_8$ in an oxidizing environment is not only scientifically unsound, but it also leads to potential underestimates of uranium mobilization in groundwater. Such mobilization may be enhanced by the presence of complexing compounds. The dose estimates in SECY-08-0147 may therefore be considerable underestimates, notably via the water pathway (including radon via the water pathway).

**Recommendation 3: A technical discussion of the expected changes in chemical forms in the specific environment in which disposal is proposed is essential. Specifically, the effects of an oxidizing environment on the specific waste form proposed, including $U_3O_8$, needs to be analyzed in detail.**

[18] SECY-08-0147 2008, Enclosure 1, p. 15.
[19] NRC DU meeting transcript September 2, 2009, at various places in pp. 98 to 116 and also pp. 185, 195, and 251.

*3. Colloidal transport*

In the modeling in SECY-08-0147, the principal pathways for radionuclides to reach the human environment are diffusion of radon through the clay barrier and dissolution of radionuclides in groundwater and from that various other water related pathways, such as ingestion of contaminated food irrigated with contaminated water. However, colloidal transport of radionuclides was not considered. This could be a significant pathway, especially for insoluble forms of uranium and its decay products.

**Recommendation 4: Colloidal transport needs to be included in the modeling of DU disposal.**

*4. The assumption of long-term stability*

The model assumes that the disposal site, including the clay cap, will be stable for one million years. Erosion is ignored. It is assumed that the clay liner will not crack for one million years. This is a critical factor in the performance modeling results. Cracks would provide a fast path for radon migration. Assuming that a clay liner will stay intact therefore results in spuriously low radon dose estimates. Of course, considering a thinning of the cap or a complete erosion of the cap prior to dissolution of the waste would result in very large long term doses. For instance, uncovering of the waste by aeolian erosion in a few thousand years would expose intruders to large external gamma doses from radium-226. These doses would be very small if the cap stays intact, which is the assumption in SECY-08-0147. It can be expected that large doses would result from shallow land burial even at the depths at which SECY-08-0147 derives low doses in dry climate if there any significant erosion. This has been demonstrated in straightforward modeling exercises by the Institute for Energy and Environmental Research which were introduced into testimony during the LES licensing proceedings.[20]

**Recommendation 5: A realistic modeling of the shallow land burial needs to be done that would include fluvial and aeolian erosion, the effects of compromises of the integrity of the clay cap via the development of cracks, etc.**

*5. Conclusions regarding modeling in SECY-08-0147*

Several of the modeling assumptions that play large roles in the conclusion of SECY-08-0147 that there could exist shallow land disposal sites where doses would be small (less than 25 millirem per year whole body effective dose equivalent) are scientifically unsound. A realistic

[20] Arjun Makhijani and Brice Smith, *Costs and Risks of Management and Disposal of Depleted Uranium from the National Enrichment Facility Proposed to be Built in Lea County New Mexico by LES,* Takoma Park, MD: Institute for Energy and Environmental Research, November 24, 2004. Version for public release redacted on Feb. 1, 2005, on the Web at http://www.ieer.org/reports/du/lesrpt.pdf, p. 24 (Hereafter Makhijani and Smith 2004/2005) and Arjun Makhijani and Brice Smith, "Update to *Costs and Risks of Management and Disposal of Depleted Uranium from the National Enrichment Facility Proposed to be Built in Lea County New Mexico by LES by Arjun Makhijani, PhD. and Brice Smith, Ph.D. based on information obtained since November 2004,*" Takoma Park, MD: Institute for Energy and Environmental Research, July 5, 2005. Version for public release redacted on Aug. 10, 2005, on the Web at http://www.ieer.org/reports/du/LESrptupdate.pdf, p. 16. Hereafter Makhijani and Smith 2005.

analysis that took such factors as climate, clay cap stability, and geochemical considerations into account would lead to three potential conclusions. First, there is no reliable way to estimate long term performance of DU in shallow land disposal facilities. Second, radiation doses from shallow land burial under even modestly realistic assumptions are likely to be well over the performance requirements of Subpart C. Third, the uncertainties in such dose estimates would be so high that they would be reasonably considered unreliable.

It is reasonable to conclude that a scientifically reliable assessment of DU disposal in shallow land disposal facilities cannot be made for the time periods at which peak doses from DU would be expected, or even much shorter time periods of 10,000 or more years.

**C. Period of Performance**

The Federal Register notice seeks comment on whether the period for which the performance requirements in regard to dose be limited. There is at present no limitation for period of performance in 10 CFR 61. Specifically, Subpart C has no time limitation in it. The Federal Register notice explains the situation as follows:

> NRC continues to consider 10,000 years a sufficient period, with some exceptions, to capture (i) the risk from the short-lived radionuclides, which comprise the bulk of the activity disposed; and (ii) the peak radiological doses from the more mobile long-lived radionuclides, which tend to bound the potential radiological doses at time frames greater than 10,000 years ….As part of a planned rulemaking, NRC is soliciting stakeholder views regarding a time period to evaluate the performance of near-surface disposal of unique waste streams.[21]

Neither condition that normally applies the customary period of 10,000 years for which NRC considers it suitable to estimate performance applies to significant amounts of DU. The first condition obviously does not apply since all three isotopes of uranium in DU (U-234, U-235, and U-238) are very long-lived. The second condition also does not apply. DU from enrichment plants or other similarly pure or nearly pure DU (in any common chemical form) has a specific activity that is far greater than the 100 nanocuries per gram associated with the limit for Class C waste containing transuranic alpha emitters. Under dry climatic conditions, should they persist (as is assumed in some scenarios in SECY-08-0147), the DU would not be expected to be mobile enough for most of it to migrate away from the site. This is indicated by the peak dose analyses in SECY-08-0147.

I have argued in expert testimony before the NRC that DU from enrichment plants is much like (GTCC) waste containing long-lived alpha-emitting transuranic radionuclides at concentrations greater than 100 nanocuries per gram. This conclusion finds support in a National Research Council publication as well.

> If disposal [of depleted uranium oxide] is necessary, it is not likely to be simple. The alpha activity of DU is 200 to 300 nanocuries per gram. Geological disposal is required for transuranic waste with alpha activity above 100 nanocuries per

[21] NRC FR Notice 2009, pp. 30176-30177.

> gram. If uranium were a transuranic element, it would require disposal in the Waste Isolation Pilot Plant (WIPP) based on its radioactivity. The chemical toxicity of this very large amount of material would certainly become a problem as well. One option suggested by the U.S. Nuclear Regulatory Commission (USNRC) is disposal in a mined cavity or former uranium mine. Challenges for this option would include understanding the fundamental differences between uranium ore (see Sidebar 6.1) and the bulk uranium oxide powder.[22]

The peak doses from DU disposal are expected to occur after thousands of years, hundreds of thousands of years, or even a million or more years, depending on the chemical form, disposal site characteristics, etc. Hence, the normal criteria of the NRC limiting performance evaluation to 10,000 years do not apply.

The staff's position in SECY-08-0147 regarding the period of performance is ambiguous:

> Considering the technical aspects of the problem, the performance assessment staff recommends a performance period of *10,000 years* for the analysis of *DU* disposal. However, analyses should be performed to peak impact, and if those impacts are significantly larger than the impacts realized within 10,000 years, then the longer term impacts should be included in the site environmental evaluation.[23]

It is unclear from this whether or not the staff intends for the peak dose to meet Subpart C criteria or not. However, unless Subpart C is sought to be changed, the performance assessment must be carried to the time of peak dose and the dose criteria of 10 CFR 61.41, including organ dose, must be met. But it should be noted in this context that the NRC staff itself does not consider the analysis in SECY-08-147 to be conservative.

Specifically, SECY-08-0147 and its Enclosure 1, states that the staff developed a "screening model" to do a "screening analysis" whose purpose "was to evaluate key variables such as disposal configurations (disposal depth and barriers), performance periods, institutional control periods, waste forms, site conditions, pathways, and scenarios."[24]

During the Bethesda, Maryland, workshop, I asked whether the term "screening" was being used to indicate a conservative analysis – that is, an analysis that would give an upper bound for the dose estimate, so that one could be reasonably assured that a more realistic analysis would yield a lower dose estimate. In other words, such a screening analysis would lead to an assurance that the conclusion that DU could be disposed of in shallow land burial and meet specified performance criteria was robust.

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[22] National Research Council, Board on Radioactive Waste Management, Committee on Improving the Scientific Basis for Managing Nuclear Materials and Spent Nuclear Fuel through the Environmental Management Science Program, *Improving the Scientific Basis for Managing DOE's Excess Nuclear Materials and Spent Nuclear Fuel*, National Academies Press, Washington, DC, 2003. On the Web at http://books.nap.edu/books/0309087228/html/index.html., p. 67 as quoted in Makhijani and Smith 2004/2005, pp. 7-8.

[23] SECY-08-0147 2008, Enclosure 1, p. 21. Emphasis in original.

[24] SECY-08-0147 2008, Enclosure 1, pp. 8-9.

Dr. Esh indicated that the term "screening analysis" was not used in that sense in the paper. He agreed with the suggestion that the screening model in SECY-08-0147 "wasn't conservative."[25]

**Conclusion regarding period of performance: The conclusion from the above is that if the NRC wishes to assess performance of disposal of DU in significant amounts according to Subpart C, which contains no time limits, then a limit on the period of performance to 10,000 years is entirely inappropriate. The stated goal of the proposed rulemaking exercise is to limit consideration of changes to 10 CFR 61.55(a). Therefore, a limitation on the period of performance cannot be used for disposal of significant quantities of DU within the context of the present rulemaking. An entirely new rulemaking proceeding would be needed, since restricting performance evaluation to anything short of peak dose in this case would be a de facto change in Subpart C.**

One may conclude the following by examining the transcripts of the Bethesda, Maryland, workshop (as well as the Salt Lake City workshop):

- Uncertainties become very large over periods as long as 10,000 to one million or more years,
- Modeling shallow land burial over periods as long as a million years or more quantitatively with some confidence appears infeasible, and
- The main radiological problems in dry areas, other than those that might be associated with uncovering the waste, appear over the long term (thousands of years or more), presuming the areas remain dry.

During the Bethesda, Maryland, workshop, there were several suggestions about restricting the period of performance. One was to use the period now required for mill tailings (1,000 years); another was to use the period required under 40 CFR 191 for deep geologic disposal, for instance at the Waste Isolation Pilot Plant (10,000 years). However, none of these suggestions can be legitimately considered under in the present rulemaking. If the NRC wants to consider limiting the period of performance for significant amounts of DU, then it must start a new proceeding and propose changes in Subpart C, along with the rationale for those changes.

The rationale for limiting the period of performance cannot be simply to protect the industry or provide the industry with a way to get rid of DU from enrichment plants or even that it is difficult to do a modeling exercise to the time of peak dose. Since it is the NRC's mandate to protect public health, and since public health can be much better protected with appropriate deep disposal similar to geologic disposal at WIPP, the NRC must first consider such deep disposal before it considers any relaxation of Subpart C. This would also require a different rulemaking from the one that the NRC is now embarked upon.

In the context of deep geologic disposal, where estimating performance can be done on a better scientific foundation, the NRC might consider adopting the approach taken in the French high-level waste rule. That rule recognizes that the uncertainties increase greatly beyond 10,000

[25] NRC DU meeting transcript, September 2, 2009, p. 83.

years. But instead of changing the dose performance standard, it changes the method by which the modeling is done:

- For up to 10,000 years, the uncertainties in the parameters are specified explicitly and probability distributions are provided. This gives a realistic set of estimates of what the performance would be, assuming the parameters are well characterized.
- Beyond 10,000 years the conservative, fixed values are used for parameters so as to calculate an upper limit of the dose. The same dose reference number is maintained but now we have what would be a bounding value for the long term, presuming the upper bound parameters: climate, geological, and others can be specified in a scientifically defensible way.[26]

**D. Some Other Matters**

It is important to note that SECY-08-0147 did not analyze performance of above-ground structures, such as those used at the EnergySolutions facility in Utah. Hence, any rule change would not apply to disposal at that site, unless the NRC actually develops modeling approaches for above ground structures for a million years. This would be an even more unrealistic task than the one undertaken in SECY-08-0147 to estimate performance in below ground shallow disposal.

**E. Other "Unique" Waste Forms**

Like significant amounts of DU, there are several other waste streams that do not clearly fall into the present structure of 10 CFR 61.55(a) as is recognized now by the NRC. These could include significant amounts uranium recovered during reprocessing for instance. Such uranium is typically contaminated with transuranic radionuclides and some fission products.

DU in large amounts is in many ways the best characterized and known of such potential waste streams. There should be no consideration of other waste streams within the present proposed rulemaking to revise 10 CFR 61.55(a)(6) and add a new para 10 CFR 61.55(a)(9).

**F. The Rights of Agreement States**

States that regulate civilian nuclear licensees under agreement with the NRC ("Agreement States") are required to meet a complex set of "compatibility" requirements to ensure that NRC requirements are being met. The regulation and enforcement is done at the state level in such cases. But the NRC has the responsibility to ensure that there is compliance with applicable federal regulations. The industry and state regulator sentiment is for the NRC to give the

[26] Règle Nº III.2.f (10 juin 1991) *Règles fondamentales de sûreté relatives aux installations nucléaires de base autres que reacteurs Tome III: production, contrôle et traitement des effluents et déchets. Chapitre 2: Déchets solides*, on the Web at http://www.asn.fr/index.php/Les-actions-de-l-ASN/La-reglementation/Reglementation-associee/Regles-fondamentales-de-surete-et-guides-de-l-ASN/RFS-III.2.f-abrogee-par-le-guide-de-surete-relatif-au-stockage-definitif-des-dechets-radioactifs-en-formation-geologique-profonde-du-12.02.08.

maximum possible leeway to state authorities. States can generally set more conservative standards than those at the federal level.

During the Bethesda, Maryland, workshop I expressed concerns as to whether there was adequate oversight regarding the two sites that may, in the near future, dispose of DU from enrichment plants – Utah (EnergySolutions site) and Texas (Waste Control Specialists (WCS) site). Specifically, I raised the issue of whether the NRC was adequately exercising its oversight responsibilities. I had raised the same issue during my testimony as an expert witness for the intervenors in the National Enrichment Facility licensing case.

Specifically, I found that some of the results of the modeling done in a performance assessment that underlies the EnergySolutions license contained physically impossible numbers. For instance, more uranium-238 was proposed to be disposed of per gram of Utah soil than the weight of the Earth. I was asked during the Bethesda, Maryland, workshop whether I was comfortable with the State of Texas agreeing to a DU concentration limit for the WCS site. I said that the last time I looked at the WCS issue, which was four years ago, I was not convinced that WCS was even qualified to receive radioactive waste – since, among other things, their license application at that time proposed to dispose of more U-235 as waste than had ever been mined.[27]

If the NRC and the state of Utah has failed to require a correction of such evident scientific problems, even though it has been formally put on the table, how could one be confident of the process for licensing and enforcing DU disposal regulations? Neither has the NRC responded to my comment regarding WCS during the workshop.

I also pointed out that IEER has done the only independent site specific analysis of DU disposal by shallow land burial for the WCS site and of a site with parameters corresponding to the Utah site. Our analysis had shown that doses would be exceeded at both sites by large margins in well under one million years and in most cases on times scales on the order of 10,000 years. I was told, informally, that NRC staff would look into the record of the LES proceeding. In response, I told them I would supply the IEER LES reports to the staff. IEER has sent the URLs for the reports to the moderator Chip Cameron.[28]

Expectation of IEER: We expect that before any draft rule is promulgated that the NRC will respond specifically to the above problems in regard to WCS and EnergySolutions and also make clear whether it intends to be more vigilant in regard to elementary matters of science when it comes to oversight of agreement states.

[27] See Makhijani and Smith 2005, for instance at p. 2 and p. 20.

[28] Post-workshop note: IEER sent the URLs to the moderator Chip Cameron on September 21, 2009. These are also cited in footnote 21, above.

## G. Conclusions

The present rulemaking is based on the false premise that SECY-08-0147 has demonstrated the feasibility of adequate performance relative to Subpart C of some shallow land disposal facilities. SECY-08-0147 did not actually calculate performance relative to the most important requirement of Subpart C – organ dose. It is also fundamentally flawed in its science and in its assumptions. The suggestions as to limitation of period of performance are, given the NRC's own normal criteria, entirely out of order in this proposed rulemaking.

The Federal Register Notice as well as the NRC instruction to the staff was to consider a very limited change to the low-level waste rule. Specifically, the Commission directed the staff to consider a revision of 10 CFR 61.55(a)(6) and to add a new paragraph 10 CFR 61.55(a)(9) that would specify how a site specific analysis for depleted uranium (and possibly other "unique waste streams") should be done. Associated guidance was also to be developed. The NRC did not state that performance requirements specified in 10 CFR 61 Subpart C would be modified. On the contrary, both the NRC and the NRC staff have represented that the intent is not to modify Subpart C but to assess performance with respect to the requirements of Subpart C.

The analysis of SECY-08-0147 did not assess performance according to all the requirements of Subpart C. Specifically, organ doses were not estimated. There were also explicit suggestions that the period of performance for disposal of significant quantities of DU might be limited in some way. This would also be a material change to Subpart C in the context of disposal of large amounts of DU.

The proposed rulemaking cannot change Subpart C either explicitly or implicitly – for instance by omitting organ dose calculations or limiting the period of performance. The NRC has not provided any estimate of the changes in health damage that may be expected as a result of changes in Subpart C. As a result, the public has been provided with no opportunity to comment specifically on the changes that would be made to their protection of their health aspects as a result of any explicit or implicit changes in Subpart C.

A change to Subpart C, where the core public health provisions of the low-level waste regulations are specified, would be a major change to the regulation. The Atomic Energy Act requires the NRC to have public health protection as one its primary purposes and it empowers the NRC to take action accordingly. A change to Subpart C, which is central to the health protections provided by the low-level waste rule, would therefore be a major federal action. It would violate the Administrative Procedures Act if Subpart C were to be changed in the context of the present proposed rulemaking, where no analysis for changing Subpart C has been provided. .

IEER therefore strongly recommends that:

- The present rulemaking be stopped.
- A new rulemaking that corresponds to Option 3 should be initiated for significant amounts of DU.

- The possibility that DU will fall into the Greater than Class C category of low level waste should be explicitly included.
- The option of deep geologic disposal should be considered – indeed, given the text of the low-level waste rule as it now stands, this would the normal mode of disposal of significant amounts of DU.
- Performance standards as set forth in Subpart C should be maintained.
- There should be no limit on the period of performance.
- A change in the method by which performance is evaluated could be considered along the lines that are specified in the French high-level waste rule cited above.
- The NRC should ensure that sound and defensible scientific assumptions, methods, and analytical tools are used and that input data represent conditions that might reasonably be expected, or that would put an upper limit to dose calculations.
- The NRC should exercise more oversight over agreement states to ensure that the methods, data, conclusions, analyses, computer models, and parameter values meet at least minimal tests of scientific soundness.