UTAH DIVISION OF RADIATION CONTROL

DENISON MINES (USA) CORP'S WHITE MESA RECLAMATION PLAN, REV. 5.0

INTERROGATORIES – ROUND 1

MARCH 2012

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ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
BMF	Berggren Model Formula
Cc	Coefficient of Consolidation, cubic centimeter
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLSM	Controlled low strength material (grout)
cm	centimeter
CQA	Construction Quality Assurance (officer)
Cv	Coefficient of Compression
DOE	U.S. Department of Energy
DUSA	Denison Mines (USA) Corp
D_{15}, D_{50}, D_{85}, etc.	Diameter of soil particle below which 15%, 50%, 85%, etc. of the mass of a sample is comprised of this or smaller sized particles
EPA	U.S. Environmental Protection Agency
ET	Evapotranspiration
F	Fahrenheit
ft	foot
g	gram; gravitational acceleration (32.2 ft/sec^2
IBC	International Building Code
ICTM	Infiltration and Contaminant Transport Modeling
km	kilometer; 1000 meters
m	meter
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site and Investigation Manual
MCE	Maximum Credible Earthquake
mg/l	milligram per liter
mi	mile
mm	millimeter
MUSLE	Modified Universal Soil Loss Equation
NRC	U.S. Nuclear Regulatory Commission

NRCS	Natural Resources Conservation Service
NUREG	Label denoting a collection of documents published by the US Nuclear Regulatory Commission
pcf	pounds per cubic foot
pCi	picocurie; 10^{-12} curie
PGA	Peak ground acceleration
PMP	Probable Maximum Precipitation (event)
psf	pounds per square foot
QA/QC	Quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
Rev.	Revision
RG, RegGuide	Regulatory Guide (NRC)
sec	second, Section
SPT	Standard Penetration Test
TEDE	Total Effective Dose Equivalent
T.O.C.	Table of Contents
UAC	Utah Administrative Code
USGS	United States Geologic Survey
Vs30	average shear-velocity down to 30 m
5h:1v/10v:1h	five/ten horizontal units (5h/10h) to one vertical unit (1v); represents slope or steepness

INTERROGATORY WHITEMESA RECPLAN REV 5.0; R313-24-4; 10CFR40.31(H); INT 01/1: RESPONSES TO RECLAMATION PLAN REV. 4.0 INTERROGATORIES

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40.31(h): An application for a license to receive, possess, and use source material for uranium or thorium milling or byproduct material, as defined in 10CFR40, at sites formerly associated with such milling shall contain proposed written specifications relating to milling operations and the disposition of the byproduct material to achieve the requirements and objectives set forth in appendix A of 10CFR40. Each application must clearly demonstrate how the requirements and objectives set forth in appendix A of 10CFR40 have been addressed. Failure to clearly demonstrate how the requirements and objectives in Appendix A have been addressed shall be grounds for refusing to accept an application.

INTERROGATORY STATEMENT:

The Division has reviewed the responses to Reclamation Plan 4.0 and is not asking for additional information at this time; however, the Division reserves the right and may submit comments and/or additional interrogatories following completion of review of the Denison Mines (USA) Corp (DUSA) response document dated December 28, 2011 (DUSA 2011).

BASIS FOR INTERROGATORY:

The State transmitted Interrogatory Round 1 following its review and evaluation of Reclamation Plan Rev. 4.0 (o/a September 10, 2010). A meeting was held on October 5, 2010 with DUSA personnel regarding Denison's plan to prepare and submit a Reclamation Plan Rev. 5.0 incorporating an evapotranspiration cover system. The State prepared and issued Interrogatory Round 1A for the purpose of giving guidance to DUSA on topics that it must address in Reclamation Plan Rev. 5.0 for matters relating to the evapotranspiration cover system. A complete review of DUSA's December 28, 2011 response to the Round 1 and Round 1A must be performed to ensure that all issues that are still relevant have been adequately addressed.

The Division received a letter from Denison Mines (USA) Corp (DUSA) dated December 28, 2011 (DUSA 2011) that provided responses) to: (i) Round 1 and Round 1A interrogatories that were submitted to DUSA on Rev. 4.0 of the Reclamation Plan Rev. (DUSA 2009) in 2010 (Division 2010); and (ii) Round 1A interrogatories that were submitted to DUSA in 2011 (Division 2011) regarding an alternative cover system design that was proposed by DUSA in 2010 (see DUSA letter dated October 6, 2010 [DUSA 2010]. The December 28, 2011 response document was forwarded to URS Corporation on February 23, 2012 and is currently under review.

REFERENCES:

Denison Mines (USA) Corp. 2009. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 4.0, November 2009.

Denison Mines (USA) Corp. 2011. Responses to Supplemental Interrogatories – Round 1A for Reclamation Plan, Revision 4.0, November 2009. December 28, 2011.

Division (Utah Division of Radiation Control) 2010. Denison Mines (USA) Corporation Reclamation Plan, Revision 4.0, November 2009: Interrogatories – Round 1. September 2010

Division (Utah Division of Radiation Control) 2011. Denison Mines (USA) Corporation Reclamation Plan, Revision 4.0, November 2009: Supplemental Interrogatories – Round 1A. April 2011.

INTERROGATORY WHITEMESA RECPLAN REV 5.0; R313-24-4; 10CFR40, APPENDIX A, CRITERION 4; INT 02/1: ENGINEERING DRAWINGS

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 4: "The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade:

… (c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Executive Secretary will consider relaxing this requirement for extremely gentle slopes such as those which may exist on the top of the pile.

….Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed must be well protected with substantial rock cover (rip rap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain must be evaluated to assure that there are not ongoing or potential processes, such as gully erosion, which would lead to impoundment instability."

NUREG-1620, Section 2.5.3: The assessment of the disposal cell cover design and engineering parameters will be acceptable if it meets the following criteria:

(3) Details are presented (including sketches) of the disposal cell cover termination at boundaries, with any considerations for safely accommodating subsurface water flows.

(4) A schematic diagram displaying various disposal cell layers and thicknesses is provided. The particle size gradation of the disposal cell bedding layer and the rock layer are established to ensure stability against particle migration during the period of regulatory interest (NRC 1982).

INTERROGATORY STATEMENT:

Drawing REC-1: Provide design details for Discharge Channel.

Drawing REC-3: Provide design details for Discharge Channel. Identify the limits of the proposed Sedimentation Pond.

Establish and indicate on the appropriate drawing(s) the location of the main drainage channel. Demonstrate that the Cell 1 embankment and appurtenant apron are designed to remain stable under PMP conditions.

Drawing TRC-2: Correct the location shown by green dashes for the "Approximate limit of compacted cover,"

Drawing TRC-4: State where "Filter Layer" is defined. Link Rock Apron A and Rock Apron B to characteristics presented in the table at Detail 1/8.

Drawing TRC-5: In Sections A/3 and B/3, indicate the cover thickness to be 9 feet ***minimum****. State the maximum tailings elevation on the North end of each section.*

Drawing TRC-6: Please explain why the Compacted Cover cannot continue through the entire sections rather that terminating as "wedges".

Drawing TRC-7: Please explain why the Compacted Cover cannot continue through the entire sections rather that terminating as "wedges". State maximum slope on transitional slopes in Section A/3, B/3, and C/3 to be 5:1. State maximum tailings elevations in each section.

Drawing TRC-8: Revise both the Plan and the Elevation of Detail 1/8 to refer to the table provided below rather than stating D50 = 7.4" min. State where "Filter Layer" is defined. Show the "Riprap Filter Layer" on the side slopes of Details 3/5, Detail 4/8, and Detail 5/8 or otherwise resolve the conflict involving "Riprap Filter Layer" that exists between Detail 1/8 and the details cited. State where "Clay Liner" called out in Detail 4/8 is defined. Justify terminating the "Clay Liner" shown in Detail 4/8 at the exterior extreme (of top) of the "Radon Attenuation and Grading Layer". State the cover thickness shown in Detail 4/8 to be 9 feet minimum. Show the correct maximum tailings elevations in Details 6/8 (presently incorrectly stated) and 7/8 (presently not stated).

BASIS FOR INTERROGATORY:

The Licensee should resolve conflicts, clarify ambiguities, and provide missing information to properly document the proposed designs.

Upstream of the discharge channel, it appears that drainage from precipitation events would likely create a random main drainage channel location in Cell 1. It is not desirable for this drainage channel to have the northern toe of the Cell 1 dike as a channel wall. Controlling the location of drainage channeling in Cell 1 appears to be important. Without establishing the location of the main drainage channel location, the Cell 1 embankment and appurtenant apron would need to be designed to be stable under PMP drainage channel wall depth and velocities. Note: Drawing TRC-4 shows topsoil and vegetation east of the riprap rock in Cell 1 and bedrock to the west.

REFERENCES:

NRC 1992. "Preparation of Environmental Reports for Uranium Mills," Regulatory Guide 3.8, October, 1992.

NRC 2003. Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978. Washington DC, June 2003.

NRC 2008. "Standard Format and Content Of License Applications for Conventional Uranium Mills," Draft Regulatory Guide DG-3024, Ma, 2008.

INTERROGATORY WHITEMESA RECPLAN REV. 5.0; R313-24-4; 10CFR40 APPENDIX A CRITERIA 1 AND 4; INT 03/1: CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN, COVER CONSTRUCTABILITY, AND FILTER AND ROCK RIP RAP LAYER CRITERIA AND PLACEMENT

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 1: " The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific siting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6)…

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 4: "The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade:

… (c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Executive Secretary will consider relaxing this requirement for extremely gentle slopes such as those which may exist on the top of the pile.

….Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed must be well protected with substantial rock cover (rip rap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain must be evaluated to assure that there are not ongoing or potential processes, such as gully erosion, which would lead to impoundment instability."

INTERROGATORY STATEMENT:

Refer to Section 5 of Attachment B, Construction Quality Assurance/Quality Control Plan, to the Reclamation Plan, Rev. 5.0: *Please provide the following:*

1. *In Sections 5.3 and 5.4, clarify the nature and characteristics of wastes that would be placed into the reclaimed Cell 1 footprint area within which the 1-foot-thick compacted clay liner would first be installed. Verify whether and state consistently throughout the CQA/CQC Plan whether any uranium mill tailings materials would be placed into the clay-lined Cell 1 footprint area. If no tailings will be placed in the Cell 1 area, then change the name ("Cell 1 Tailings Area") given in the T.O.C., and Sections 1.1, 5.3, 5.4.2, and 5.6 of the CQA/CQA Plan to "Cell 1 Contaminated Soil and Demolition Debris Disposal Area" or other name as appropriate, and revise the descriptions of waste materials to be placed into the clay-lined Cell 1 area as needed throughout the CQA/CQC Plan to be consistent with the proposed disposal plan.*
2. *In Sections 5.6.4 and 5.6.5, provide a detailed justification to support the technical appropriateness and the constructability of the proposed topslope areas of the proposed cover system having such extremely flat slopes (e.g. 0.1 to 0.82 %). Provide information demonstrating that such topslope areas of the cover could be constructed with such shallow inclinations maintained continuously over the long distances that are required based on the currently proposed over design drawings such that no areas of runoff concentration or areas where ponding or could occur would result. Provide information justifying that appropriate required tolerances specified for final grades for ensuring conformance to the proposed extremely flat slope inclinations can be maintained and measured in the field with sufficient accuracy to ensure compliance with the specified slope requirements.*
3. *In Section 5.7.1.2, described material sampling frequency and filter gradation and filter permeability calculations (with associated acceptance criteria) that will be performed for the granular materials used in constructing the granular filter layer beneath the riprap layer on the sideslopes, to ensure that all applicable filter acceptance criteria will be achieved between the granular filter layer and each topslope cover layer component.*
4. *In Section 5.7.1, specify the minimum required thickness of the rock riprap layer on the sideslopes – equal to 1.5 times the D_{50} of the rock rip diameter of 7.4 inches, or the D_{100} of the rock rip rap materials, whichever is greater, as per NUREG-1623 (NRC 2002) – for clarity and transparency in the CQA/CQC process.*
5. *In Sections 5.7.2, 5.7.4, and 5.7.5 provide additional details regarding the minimum thickness for placed riprap layer material and requirements for using specialized equipment or rearranging of rocks by hand, as needed, in accordance with the specified minimum required final thickness of the rock rip rap layer. Also provide additional details and requirements regarding procedures to be used to verify proper in-place rock*

riprap layer thickness and procedures for gradation testing in a completed initial riprap layer section, and for visual observations of the test section by field personnel. Provide criteria and procedures for testing additional test sections where observations suggest rock placement appears to be inadequate or where difficulties are experienced during rock place activities.

BASIS FOR INTERROGATORY:

In Section 5.4.4 of the CQA.CQC it states that backfill materials placed around placed demolition debris might include stockpiled soils, contaminated soils, ***tailings and or other approved materials*** *[as approved by the Construction Manager and CQA officer]; however, in other sections of the CQA/CQAC Plan and in the Reclamation Plan it is indicated that no tailings placement would occur in the Cell 1 area.*

The ability to accurately construct the extremely flat topslope areas with a uniform slope to the proposed specified grades and within the associated allowable tolerances, and the ability to accurately verify that these flat slopes have been constructed uniformly and without the occurrence of areas of flow concentrations or areas where ponding of water could occur has not been adequately demonstrated.

It has not been adequately demonstrated that all applicable filter layer criteria have been met for all interfaces that would occur between the sideslope filter layer and topslope cover components.

NUREG-1623 (NRC 2002), Section 2.1.2 recommends that the minimum required thickness of a rock riprap layer be no less than 1.5 times the D_{50} of the rock riprap materials, or the D_{100} of the rock rip rap materials, whichever is greater.

NUREG-1623 (NRC 2002), Appendix F provides specific recommendations regarding rock rip placement procedures and procedures for conducting testing and visual observations during rock rip rap placement that should be adhered to during construction and that should be addressed in the CQA/CQC Plan.

REFERENCES:

NRC 2002. U.S. Nuclear Regulatory Commission, "Design of Erosion Protection for Long-Term Stability", NUREG-1623, September 2002.

INTERROGATORY WHITEMESA RECPLAN REV5.0; R313-24-4; 10CFR40, APPENDIX A, CRITERION 4; INT 04/1: VOID SPACE CRITERIA AND DEBRIS, RUBBLE PLACEMENT AND SOIL/BACKFILL REQUIREMENTS

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 4: "The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade:

…(c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Executive Secretary will consider relaxing this requirement for extremely gentle slopes such as those which may exist on the top of the pile.

…Rock covering of slopes may be unnecessary where top covers are very thick (or less); bulk cover materials have inherently favorable erosion resistance characteristics; and, there is negligible drainage catchment area upstream of the pile and good wind protection as described in points (a) and (b) of this criterion.

Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed must be well protected with substantial rock cover (rip rap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain must be evaluated to assure that there are not ongoing or potential processes, such as gully erosion, which would lead to impoundment instability.

INTERROGATORY STATEMENT:

1. ***Refer to Section 6.0 of Appendix G and Section 7.0 of Attachment A (Technical Specifications) of the Reclamation Plan, Rev. 5.0:***

   a. *Please define and justify a maximum void space percentage that will be allowed when disposing of demolition and decommissioning debris fragments and rubble in Cell 1. Describe, in detail, construction practices that will enable satisfying this specified limit.*

b. *Please provide detailed procedures that will be used to control residual voids to meet the specified maximum allowable void space percentage(s) and a description of the specific construction quality assurance / quality control and verification procedures to be used to demonstrate that the void space criteria will be achieved.*

c. *Demonstrate how the percentage of allowable void space relates to the settlement analyses performed to evaluate the effectiveness of the procedures for placing debris fragments and rubble, placement of backfill in/around/under debris items, and compaction of the debris/backfill materials, for precluding the potential for slope reversal in the Cell1 cover system. Please also refer to "INTERROGATORY WHITEMESA RECPLAN REV. 5.0; R313-24-4; 10CFR40 APPENDIX A; INT 07/1: TECHNICAL ANALYSIS - SETTLEMENT AND POTENTIAL FOR COVER SLOPE REVERSAL AND/OR COVER LAYER CRACKING".*

d. *Please further define the characteristics of, and estimate the percentage of organic materials (including, for example, wood, branches, roots, paper, and plastic), expected to be disposed of. Provide specifications and procedures for disposing of organic materials such that long-term biodegradation of the disposed organic materials will not compromise the integrity and stability of the cover system.*

e. *Please provide detailed specifications for segmenting and placing metallic waste materials in layers so that structural shapes or other large pieces will not lie across or on top of each other. Please indicate that placement of metallic materials will allow large voids to be minimized and filled with soil. Please address special handling and disposal procedures for oversized and/or odd-shaped steel materials, including cutting or trimming dimensions before positioning for burial, and placement procedures to ensure that no large "slip planes" will occur within the disposal mass. Specify maximum allowable lift thickness for such material placement. Please also describe shredding, cutting or trimming procedures required to ensure that such materials following shredding, cutting or trimming can be placed within the specified allowable layer thickness.*

f. *Provide additional details of type of materials and placement practices, including specific dimensions of all demolition debris expected to be disposed of in Cell 1. Please justify that items needing to be size-reduced prior to disposal will in fact be size reduced. Provide additional information to justify that a maximum allowable size of dismantled or cut materials of 20 feet in the longest dimension (as proposed) and a maximum volume of 30 cubic feet are acceptable criteria for placement of such objects in a disposal cell.*

g. *Please provide a contingency plan to address the situation in which an insufficient quantity of demolition debris and rubble and contaminated soil would be available to fill the Cell 1 footprint area to a sufficiently high final waste grading configuration to provide a smooth, continuous transition between the completed Cell 1 cover system and the Cell 2 cover system, with no sudden, abrupt changes in slope between the two cover systems. Discuss means and methods that will be used, regardless of achieved final debris/rubble/contaminated soil placement grades, for ensuring that a smooth cover slope transition will occur between these two cell area cover systems.*

h. *Clearly and consistently define procedures/specifications for backfilling of interior void spaces inside debris objects (e.g., backfill of insides of smaller segmented pipe sections). Rectify apparent current inconsistencies between descriptions of backfill* *materials proposed for such use as described in Attachment A (e.g., controlled low-strength materials [CLSM] or flowable fill) and backfill materials for this use as described in Appendix (random fill materials). Provide rationale for selecting preferred backfill materials (e.g., CLSM) for different types and/or sizes of internal void space, as appropriate. For CLSM/ flowable fill, etc… used, provide information on the minimum required compressible strength of the material.*

i. *Describe how the compressive strength requirement for CLSM or other grout backfill, in conjunction with the void space backfilling requirements and ultimate allowable void space and organic waste percentages relate to the design objectives for minimizing settlement of the backfilled Cell 1 area debris/rubble/backfill mass to preclude the possibility for long-term cover slope reversals.*

BASIS FOR INTERROGATORY:

The placement of debris materials in the reclaimed tailings embankment has the potential to create voids or areas of insufficient compaction. The presence of excessive voids in the final reclaimed waste disposal embankment following waste placement and construction of the final closure cover could lead to unacceptable amounts of long-term total or differential settlement in the reclaimed embankment. Excessive amounts of such settlement could impact the integrity of the final closure cover system, and, if sufficient in extent, result in localized slope change(s) and/or slope reversal(s) in the final slopes of the reclaimed embankment. A slope reversal would create an opportunity for localized ponding of moisture or water which could result in increased infiltration rates through the embankment. To address/mitigate potential concerns relating to settlement following waste placement, procedures for placing and compacting soil and debris wastes should incorporate several requirements, including specifying a method or methods for filling of larger-sized void spaces (e.g., with CLSM/flowable fill or other grout, etc…) that cannot be readily accessed by standard construction equipment for backfilling with soil or tailings.

Appendix G to the Reclamation Plan Rev. 5.0 states "Contaminated soils will be disposed of in last active tailings cell or Cell 1. Contaminated soils will be placed in the last active cell or Cell 1 as random fill material (material used to fill voids within mill material, achieve desired cover system slopes, and provide a firm base for construction of the cover system)". In contrast, Attachment A to the Reclamation Plan Rev. 5.0 states "…The voids on the inside of the item shall be filled with sand or grout (controlled low-strength material, flowable fill, etc.)". Clarification needs to be made on which method/methods will be used for filling larger-sized void spaces.

It is recommended that if the void space resulting from placement of such large concrete monoliths is greater than approximately 5%, then an acceptable cement grout or flowable fill such as controlled low-strength material be placed between the monoliths, or alternativelythat monoliths be placed far enough apart to allow proper equipment access to compact as necessary.

Attachment A to the Reclamation Plan Rev. 5 states that "the maximum size of dismantled or cut materials shall not exceed 20 feet in the longest dimension and a maximum volume of 30 cubic feet for placement in the cells". Additional justification needs to be provided to demonstrate that these dimensions will be adequate for disposal with respect to minimizing potential for *differential settlement occurring within the disposal cell. For other similar projects (e.g., DOE 1995; DOE 2000), based on experience gained at several uranium mill demolition debris and rubble disposal projects, specified the following procedures for placing and compacting soil and debris and rubble wastes into tailings repositories to address/mitigate potential concerns relating to settlement:*

- *Limiting the maximum dimension of larger-sized debris items to a maximum allowable length (e.g., 10 ft) in longest dimension;*
- *Limiting at least one dimension of larger-sized debris items to no more than a maximum allowable width (e.g., 10 to 12 inches for pipes); and*
- *Specifying a method or methods for filling of larger-sized void spaces (e.g., with flowable fill or grout) that cannot be readily accessed by standard construction equipment for backfilling with soil or tailings.*

To accomplish the above objectives, it was specified that larger sized items be placed as flatly as possible rather than in a tangled mass that could result in "nesting", i.e., result in a compressible mass that would be subject to excessive compression as additional fill is placed and compacted. For these projects, individual loads of larger sized items were also specified to be spread out as necessary to ensure proper filling of any open voids with contaminated soil or tailings and so that contaminated soil or tailings backfill materials and the debris items could be adequately compacted.

Additionally, these projects included specifications that window frames, siding, and roofing material be placed and compacted, at a minimum, as pieces or stacks of such materials (e.g., bundles of siding) in an 18-inch lift, occasionally increased to 24 inches for taller bundles of wood pieces; that placement be accomplished in a compact, dense layer with bundles placed next to each other to the extent possible, that voids between bundles be reduced to the minimum achievable, and that bundles that are broken be separated into stacks 12 inches or less in height; and that contaminated soil or tailings then be spread and compacted over the layer not exceeding 12-inches in loose lift thickness.

Similar sets of detailed specifications were developed and used on the above-described projects for size-reduction and controlled placement of pipe sections, concrete rubble, monoliths, and large rock fragments, and associated backfill placement, and compaction of debris/rubble and soil mixtures.

The applicability and benefit of employing these specifications or similarly detailed specifications, should be evaluated, and implemented for this project as warranted.

REFERENCES:

Denison Mines (USA) Corporation. 2011. Reclamation Plan, Revision5.0, White Mesa Mill, Blanding, Utah: September 2011

Denison Mines (USA) Corporation. 2009a. Reclamation Plan, Revision 4.0, White Mesa Mill, Blanding, Utah, Exhibit C: November 2009

Exhibit C: Probable Maximum Precipitation (PMP) Event Computation, White Mesa Mill - Cell 4B, Blanding , Utah". September 10, 2009. Letter to Dane Finerfrock, dated September 11, 2009.

DOE (U.S. Department of Energy). 1989. Technical Approach Document, Revision II. UMTRA-DOE/AL 050425.0002.

DOE 1995. Uranium Mill Tailings Remedial Action Project, Slick Rock, Colorado Subcontract Documents. U.S. Department of Energy, Albuquerque, New Mexico. October 1, 1995. DOE/AL/62350—21F-Rev. 1-Attachment.

DOE 2000. WSSRAP Disposal Facility Technical Specifications, Section 2300: Waste Removal, Handling, and Placement. WP-437, Disposal Cell Construction. May 15, 2000.

EPA (U.S. Environmental Protection Agency). 1989a. Final Covers on Hazardous Waste Landfills and Surface Impoundments, Technical Guidance Document, EPA/530-SW-89-047, Office of Solid Waste and Emergency Response, Washington, D.C. URL: http://webcache.googleusercontent.com/search?q=cache:VEVCaJfyPDQJ:nepis.epa.gov/Exe/ZyPURL.cgi%3FDockey%3D100019HC.txt+site:epa.gov+EPA+Final+Covers+Guidance&cd=4&hl=en&ct=clnk&gl=us.

EPA 1991. Seminar Publication, Design and Construction of RCRA/CERCLA Final Covers. EPA/625/4-91/025.May 1991, 208 pp.

EPA 2004. (Draft) Technical Guidance for RCRA/CERCLA Final Covers. U.S EPA 540-R-04-007, OSWER 9283.1-26. April 2004, 421 pp. URL: nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10074PP.txt.

Gilbert, P.A., and Murphy, W.M. 1987. Prediction/Mitigation of Subsidence Damage to Hazardous Waste Landfill Covers.EPA/600/2-87/025, March 1987, 81 pp. NTIS PB-175386.

Nelson, J.D., Abt, S.R., Volpe, R.L, van Zyl, D., Hinkle, N.E., and Staub, W.P. 1986. Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments.Prepared for Nuclear Regulatory Commission, Washington, DC.NUREG/CR-4620, ORNL/TM-10067.June 1986, 151 pp.

NRC 2002. U.S. Nuclear Regulatory Commission, "Design of Erosion Protection for Long-Term Stability", NUREG-1623, September 2002.

NRC 2003. Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978. Washington DC, June 2003.

INTERROGATORY WHITEMESA RECPLAN REV. 5.0 R313-24-4, 10 CFR 40 APPENDIX A; INT 05/1: SEISMIC HAZARD EVALUATION

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 1: " The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific siting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6).

Refer to R313-24-4, 10 CFR 40 Appendix A, Criterion 4 (e): The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term "capable fault" has the same meaning as defined in section III(g) of Appendix A of 10 CFR Part 100. The term "maximum credible earthquake" means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material.

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 6(1): "In disposing of waste byproduct material, licensees shall place an earthen cover (or approved alternative) over tailings or wastes at the end of milling operations and shall close the waste disposal area in accordance with a design which provides reasonable assurance of control of radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (ii) limit releases of radon-222 from uranium byproduct materials, and radon-220 from thorium byproduct materials, to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second (pCi/m^2s) to the extent practicable throughout the effective design life determined pursuant to (1)(i) of this criterion. In computing required tailings cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances may not be considered. Direct gamma exposure from the tailings or wastes should be reduced to background levels. The effects of any thin synthetic layer may not be taken into account in determining the calculated radon exhalation level. If non-soil materials are proposed as cover materials, it must be demonstrated that these materials will not crack or degrade by differential settlement, weathering, or other mechanism, over long-term intervals."

NUREG-1620 specifies that "Reasonable assurance [shall be] provided that the requirements of 10 CFR Part 40, Appendix A, Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, have been met."

INTERROGATORY STATEMENT:

Refer to Appendix E and Attachment E.1 to Appendix E to Appendix D, Updated Tailings Cover Design Report of the Reclamation Plan, Rev. 5: *Please provide the following:*

1. *Please further clarify the rationale for selecting the annual probability of exceedance of hazard for the facility.*

2. *Adjust the cited USGS National Hazard Map PGA (peak ground acceleration) value of 0.15 g for the site Vs30 as appropriate.*

3. *Explain why the calculated hazard for the background earthquake PGA of 0.24 g was estimated but ignored in the recommendations provided in Appendix E.*

4. *Provide information to justify the use of 15 km distance for a background earthquake Mw 6.3 event.*

5. *Perform and report results of a site-specific probabilistic seismic analysis in lieu of using the USGS National Hazard Maps for developing site-specific seismic design parameters.*

BASIS FOR INTERROGATORY:

The rationale for selecting the annual probability of exceedance of hazard for the facility needs to be clarified. Appendix E to the Appendix D of the Reclamation Plan Rev. 5 states that the "10,000 year return period (1 in 10,000 annual probability) is adopted for evaluating the long-term stability of the facility". However, in the following sentences, the report states that a return period of 2,500 years (1 in 2500 annual probability) is appropriate for the operational conditions of the facility. It needs to be clarified if or how the facility is being evaluated for the two annual probabilities. Is so, further details would need to be provided.

It is unclear how the 0.15 g PGA is "reasonable for the White Mesa site". Appendix E cites the USGS National Hazard Maps and a PGA of 0.15 g for a 10,000 year return period. This value is for a Vs30 of 760 m/sec. The report continues by stating that the Vs30 for the site is 586 m/sec. The 0.15 g value cited in this regard needs to be adjusted for the site Vs30.

Appendix E describes background earthquakes and adopts an Mw 6.3 event at a distance of 15 km. Additional justification needs to be provided for the use of the 15 km distance.

A single ground motion prediction model should not be used in hazard analysis because the epistemic uncertainty in ground motion prediction is being ignored. Currently, there are five Next Generation Attenuation (NGA) ground motion models, including an update of Campbell and Bozorgnia (2007), which should be used in the deterministic calculation for the PGAs in Table 1, Peak Ground Accelerations for White Mesa, in Attachment E.1 of Appendix E.

The USGS National Hazard Maps should not be used for developing site-specific seismic design parameters (Personal Communication between Dr. Mark Petersen, Chief, National Seismic Hazard Mapping Project, and Ivan Wong of URS Corporation 2010) for critical and important facilities. For such types of facilities, a site-specific probabilistic seismic hazard analysis is recommended.

REFERENCES:

Campbell, K.W. and Bozorgnia, Y., 2007, Campbell-Bozorgnia NGA Ground motion relations for the geometric mean horizontal component of PGA, PGV, PGD and 5% Damped Linear Elastic Response Spectra for Periods Ranging from 0.01 to 10 s: Earthquake Spectra 24, pp. 139-171. 2008

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011.

INTERROGATORY WHITEMESA RECPLAN REV5.0; R313-24-4; 10CFR40 APPENDIX A, CRITERION 1; INT 06/1: SLOPE STABILITY

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40 Appendix A, Criterion 1: The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific siting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6). . . .

Refer also to INTERROGATORY WHITEMESA RECPLAN Rev. 5.0 R313-24-4, 10 CFR 40 APPENDIX A; INT 05/1: SEISMIC HAZARD EVALUATION above.

Slope Stability

***NUREG-1620, Section 2.2.3**: The analysis of slope stability will be acceptable if it meets the following criteria:*

(1) Slope characteristics are properly evaluated.

(a) Cross sections and profiles of natural and cut slopes whose instability would directly or indirectly affect the control of radioactive materials are presented in sufficient number and detail to enable the reviewer to select the cross sections for detailed stability evaluation.

(b) Slope steepness is a minimum of five horizontal units (5h) to one vertical unit (1v) or less. The use of slopes steeper than 5h:1v is considered an alternative to the requirements in 10 CFR Part 40, Appendix A, Criterion 4(c). When slopes steeper than 5h:1v are proposed, a technical justification should be offered as to why a 5h:1v or flatter slope would be impractical and compensating factors and conditions are incorporated in the slope design for assuring long-term stability.

(c) Locations selected for slope stability analysis are determined considering the location of maximum slope angle, slope height, weak foundation, piezometric level(s), the extent of rock mass fracturing (for an excavated slope in rock), and the potential for local erosion.

(2) An appropriate design static analysis is presented.

(a) The analysis includes calculations with appropriate assumptions and methods of analysis (NRC, 1977). The effect of the assumptions and limitations of the methods used is discussed and accounted for in the analysis. Acceptable methods for slope stability analysis include various limit equilibrium analysis or numerical modeling methods.

(b) The uncertainties and variability in the shape of the slope, the boundaries and parameters of the several types of soils and rocks within and beneath the slope, the material properties of soil and rock within and beneath the slope, the forces acting on the slope, and the pore pressures acting within and beneath the slope are considered.

(c) Appropriate failure modes during and after construction and the failure surface corresponding to the lowest factor of safety are determined. The analysis takes into account the failure surfaces within the slopes, including through the foundation, if any.

(d) Adverse conditions such as high water levels from severe rain and the probable maximum flood are evaluated.

(e) The effects of toe erosion, incision at the base of the slope, and other deleterious effects of surface runoff are assessed.

(f) The resulting safety factors for slopes analyzed are comparable to the minimum acceptable values of safety factors for slope stability analysis given in NRC Regulatory Guide 3.11 . . . .

(3) Appropriate analyses considering the effect of seismic ground motions on slope stability are presented.

(a) Evaluation of overall seismic stability, using pseudostatic analysis or dynamic analysis, as appropriate (U.S. Army Corps of Engineers, 1977; NRC, 1977). Alternatively, a dynamic analysis following Newmark (1965) can be carried out to establish that the permanent deformation of the disposal cell from the design seismic event will not be detrimental to the disposal cell. The reviewer should verify that the yield acceleration or pseudostatic horizontal yield coefficient necessary to reduce the factor of safety against slippage of a potential sliding mass to 1.0 in a "Newmark-type" analysis has been adequately estimated (Seed and Bonaparte, 1992).

(b) An appropriate analytical method has been used. A number of different methods of analysis are available (e.g., slip circle method, method of slices, and wedge analysis) with several variants of each (Lambe and Whitman, 1979; U.S. Army Corps of Engineers, 1970b; NRC, 1977; Bromhead, 1992). Limit-equilibrium analysis methods do not provide information regarding the variation of strain within the slope and along the slip surface. Consequently, there is no assurance that the peak strength values used in the analysis can be mobilized simultaneously along the entire slip surface unless the material shows ductile behavior (Duncan, 1992). Residual strength values should be evaluated if mobilized shear strength at some points is less than the peak strength. The reviewer should ensure that appropriate conservatism has been incorporated in the analysis using the limit equilibrium methods. The limit equilibrium analysis methodologies may be replaced by other techniques, such as finite element or finite difference methods. If any important interaction effects cannot be included in an analysis, the reviewer must determine that such effects have been treated in an approximate but conservative fashion. The engineering judgment of the reviewer should be used in assessing the adequacy of the resulting safety factors (NRC, 1983a,b).

(c) For dynamic loads, the dynamic analysis includes calculations with appropriate assumptions and methods (NRC, 1977; Seed, 1967; Lowe, 1967; Department of the Navy, 1982a,b,c; U.S. Army Corps of Engineers, 1970a,b, 1971, 1972; Bureau of Reclamation, 1968). The effect of the assumptions and limitations of the methods used is discussed and accounted for in the analysis.

(d) For dynamic loads, a pseudostatic analysis is acceptable in lieu of dynamic analysis if the strength parameters used in the analysis are conservative, the materials are not subject to significant loss of strength and development of high pore pressures under dynamic loads, the design seismic coefficient is 0.20 or less, and the resulting minimum factor of safety suggests an adequate margin, as provided in NRC Regulatory Guide 3.11 (NRC, 1977).

(e) For pseudostatic analysis of slopes subjected to earthquake loads, an assumption is made that the earthquake imparts additional horizontal force acting in the direction of the potential failure (U.S. Army Corps of Engineers, 1970b, 1977; Goodman, 1989). The critical failure surface obtained in the static analysis is used in this analysis with the added driving force. Minimum acceptable values for safety factors of slope stability analysis are given in Regulatory Guide 3.11 (NRC, 1977).

(f) The assessment of the dynamic stability considers an appropriate design level seismic event and/or strong ground motion acceleration, consistent with that identified in Chapter 1 of this review plan. Influence of local site conditions on the ground motions associated with the design level event is evaluated. The design seismic coefficient to be used in the pseudostatic analysis is either 67 percent of the peak ground acceleration at the foundation level of the tailings piles for the site or 0.1g, whichever is greater.

(g) If the design seismic coefficient is greater than 0.20g, then the dynamic stability investigation (Newmark, 1965) should be augmented by other appropriate methods (i.e., finite element method), depending on specific site conditions.

(h) In assessing the effects of seismic loads on slope stability, the effect of dynamic stresses of the design earthquake on soil strength parameters is accounted for. As in a static analysis, the parameters such as geometry, soil strength, and hydrodynamic and pore pressure forces are varied in the analysis to show that there is an adequate margin of safety.

(i) Seismically induced displacement is calculated and documented. There is no universally accepted magnitude of seismically induced displacement for determining acceptable performance of the disposal cell (Seed and Bonaparte, 1992; Goodman and Seed, 1966). Surveys of five major geotechnical consulting firms by Seed and Bonaparte (1992) indicate that the acceptable displacement is from 15 to 30 cm [6 to 12 in.] for tailings piles. The reviewer should ensure that this criterion is also augmented by provisions for periodic maintenance of the slope(s).

(j) Where there is potential for liquefaction, changes in pore pressure from cyclic loading are considered in the analysis to assess the effect of pore pressure increase on the stress-strain characteristics of the soil and the post-earthquake stability of the slopes. Liquefaction potential is reviewed using Section 2.4 of this review plan. Evaluations of dynamic properties and shear strengths for the tailings, underlying foundation material, radon barrier cover, and base liner system are based on representative materials properties obtained through appropriate field and laboratory tests (NRC, 1978, 1979).

(k) The applicant has demonstrated that impoundments will not be located near a capable fault on which a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand might occur.

(4) Provision is made to establish a vegetative cover, or other erosion prevention, to include the following considerations:

(a) The vegetative cover and its primary functions are described in detail. This determination should be made with respect to any effect the vegetative cover may have on reducing slope erosion and should be coordinated with the reviewer of standard review plan Chapter 3. If strength enhancement from the vegetative cover is taken into account, the methodology should be appropriate (Wu, 1984).

(b) In arid and semi-arid regions, where a vegetative cover is deemed not self-sustaining, a rock cover is employed on slopes of the mill tailings. If credit is taken for strength enhancement from rock cover, the reviewer should confirm that appropriate methodology has been presented. The design of a rock cover, where a self-sustaining vegetative cover is not practical, is based on standard engineering practice. Standard review plan Chapter 3 discusses this item in detail.

(5) Any dams meet the requirements of the dam safety program if the application demonstrates the following:

(a) The dam is correctly categorized as a low hazard potential or a high hazard potential structure using the definition of the U.S. Federal Emergency Management Agency;(b) If the dam is ranked as a high hazard potential, an acceptable emergency action plan consistent with the Federal Emergency Management Agency guide (U.S. Federal Emergency Management Agency, 1998) has been developed.

(6) The use of steeper slopes as an alternative to the requirements in 10 CFR, Part 40, Appendix A, will be found acceptable if the following are met:

(a) An equivalent level of stabilization and containment and protection of public health, safety, and the environment is achieved.

(b) A site-specific need for the alternate slopes is demonstrated.

INTERROGATORY STATEMENT:

1. *Demonstrate slope stability for the tailings impoundment and new cover system using shear strength parameters and other soil properties assigned to the various components (cover, embankment/dike, tailings, and foundation) consistent with soil type, degree of compaction, and anticipated degree of variability. Justify selection of values for soil parameters.*
2. *In evaluating slope stability, address and report the effects of shallow and non-circular failure surfaces, in addition to circular and/or deeper ones.*
3. *Demonstrate that assumed drainage conditions are appropriate, are at least consistent with, or are conservative compared with drainage/seepage results, projected immediately at closure and at the end of the impoundment design life (i.e., 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years).*
4. *Assess the slope stability of Cell 1 adjacent to Cell 2 where mill debris and contaminated soils are to be placed and covered.*
5. *Explain and justify the selection of the pseudo-static coefficient used in the assessment of seismic stability. If the selected value of the pseudo-static coefficient cannot be justified, revise the value of the coefficient used in stability analyses and revise and report the results of stability analyses.*

BASIS FOR INTERROGATORY:

The slope stability analyses presented by the Licensee uses the same shear strength parameters (phi=26 degrees, c=900 psf) for the reclamation cover, impoundment dikes, and the foundation soils above the bedrock. These properties were derived from limited triaxial testing of very stiff / very dense material recovered from apparently in-situ soil. Given that the different soil zones in *the cover system are to be placed with varying degrees of compaction (some being quite loose) and that the density of the dikes may vary from that of the foundation, the use of singular soil properties throughout the analyses is inappropriate. Shear strength parameters and other soil properties such as unit weight should be assigned to the various earthen components consistent with soil type, degree of compaction, and anticipated degree of variability. The selection of strength parameters should also be explained and justified. Because of the relatively loose state proposed for some of the cover soils, the Licensee's stated approach (i.e., "circular failure surface analyses were conducted by targeting deeper, full-slope failures as opposed to shallower, superficial failures.") may miss truly critical failure surfaces. Shallow surfaces as well as non-circular ones should be considered.*

The slope stability analyses performed by the Licensee assume that the tailings impoundment cells behave fully drained, thus phreatic surfaces were not included in the analyses. The Licensee should demonstrate that such assumptions are appropriate (i.e., are at least consistent with, if not conservatively interpreted) based on the results of drainage/seepage analyses representing conditions immediately at closure as well as at the end of the design storage life of the facility. Such analyses should reflect the variations in the tailings properties and drainage systems (slimes dewatering systems) particular to each tailings management cell (e.g., approximately 600-ft by 400-ft area containing slimes "burrito drain" array in each of Cell 2 and Cell 3 vs. area blanket sand layer and slimes drain piping system in Cells 4A and 4B;). Tailings properties will vary in response to variations in historic (and future) milling processes as well as deposition history (and future) and discharge –related distribution within each cell. The soil shear strength parameters (particularly those of the tailings) used in the slope stability analyses should be consistent with the drainage conditions thus demonstrated.

As described in the Basis for Interrogatory section of "INTERROGATORY WHITEMESA RECPLAN REV. 5.0 R313-24-4; 10CFR40 APPENDIX A, CRITERION 4; INT 07/1: TECHNICAL ANALYSIS - SETTLEMENT AND POTENTIAL FOR COVER SLOPE REVERSAL AND/OR COVER LAYER CRACKING", the tailings dewatering analyses presented in Appendix H to the Updated Tailings Cover Design Report, do not adequately represent (i.e., account for) potential variations in the tailings properties, nor their potential distribution within the various tailings management cells. As requested in the interrogatory cross-referenced above, the tailings dewatering analyses should be revisited or at least clarified and better substantiated, and the Licensee should test actual tailings specimens from the site. The number of specimens involved should be commensurate with anticipated variability of the tailings conditions in the containment cells.

The slope stability analyses presented by the Licensee are based on a selected cross-section in Cell 4A apparently intended to represent the greatest height of an otherwise uniformly designed embankment. However, different conditions exist in Cell 1 adjacent to Cell 2 where mill debris and contaminated soils are to be placed and covered. The slope stability of this section should be analyzed.

To aid future review, the shading applied to the slices of the failure mass should be removed (thus enabling the profile lines of the underlying soil type to be seen). It is also suggested that contours for the factor of safety be added to the search grid as well as definitions of the search radii.

The explanation and justification for the factor applied to the PGA to establish the pseudo-static coefficient provided by the Licensee appears to be flawed. The Licensee's report reads thusly:

> *"The seismic coefficient represents an inertial force due to strong ground motions during the design earthquake, and is represented as a fraction of the PGA at the site (typically at the base of the structure). Tetra Tech (2010) recommended using a value of 0.1 g for the seismic coefficient in accordance with IBC (2006) recommendations to multiply the PGA by 0.667 to determine a design acceleration value. The strategy of representing the seismic coefficient as a fraction of the PGA has been adopted in review of uranium tailings facility design and documented in DOE (1989). A value of 0.667 typically represents post-reclamation conditions. Based on this guidance and the recommendations in Tetra Tech (2010), the seismic coefficient used for the pseudo-static stability analysis was 0.1 g."*

The 2006 International Building Code (IBC) does not contain such a recommendation (it does not discuss pseudo-static slope analysis). The code does use a factor of 2/3 to convert MCE ground accelerations to design accelerations for structural components, but this is an issue separate from and not related to the seismic coefficient used for slope stability. Explain why reference is made to the IBC since that document is for the design of buildings and not earthen tailings impoundments, or revise the discussion accordingly to more clearly state the justification for use of the selected seismic coefficient.

Assessment of slope stability under seismic conditions is dependent upon the Licensee's seismic hazard analysis. Any revisions to the seismic hazard analysis may necessitate revisions to this assessment.

NUREG-1620 (NRC 2003), Section 2.2.3 specifies that: "The analysis of slope stability will be acceptable if it meets the following criteria:

(1) Slope characteristics are properly evaluated.

(a) Cross sections and profiles of natural and cut slopes whose instability would directly or indirectly affect the control of radioactive materials are presented in sufficient number and detail to enable the reviewer to select the cross sections for detailed stability evaluation.

(b) Slope steepness is a minimum of five horizontal units (5h) to one vertical unit (1v) or less. The use of slopes steeper than 5h:1v is considered an alternative to the requirements in 10 CFR Part 40, Appendix A, Criterion 4(c). When slopes steeper than 5h:1v are proposed, a technical justification should be offered as to why a 5h:1v or flatter slope would be impractical and compensating factors and conditions are incorporated in the slope design for assuring long-term stability.

(c) Locations selected for slope stability analysis are determined considering the location of maximum slope angle, slope height, weak foundation, piezometric level(s), the extent of rock mass fracturing (for an excavated slope in rock), and the potential for local erosion.

(2) An appropriate design static analysis is presented.

(a) The analysis includes calculations with appropriate assumptions and methods of analysis (NRC, 1977). The effect of the assumptions and limitations of the methods used is discussed and accounted for in the analysis. Acceptable methods for slope stability analysis include various limit equilibrium analysis or numerical modeling methods.

(b) The uncertainties and variability in the shape of the slope, the boundaries and parameters of the several types of soils and rocks within and beneath the slope, the material properties of soil and rock within and beneath the slope, the forces acting on the slope, and the pore pressures acting within and beneath the slope are considered.

(c) Appropriate failure modes during and after construction and the failure surface corresponding to the lowest factor of safety are determined. The analysis takes into account the failure surfaces within the slopes, including through the foundation, if any.

(d) Adverse conditions such as high water levels from severe rain and the probable maximum flood are evaluated.

(e) The effects of toe erosion, incision at the base of the slope, and other deleterious effects of surface runoff are assessed.

(f) The resulting safety factors for slopes analyzed are comparable to the minimum acceptable values of safety factors for slope stability analysis given in NRC Regulatory Guide 3.11 . . . .

(3) Appropriate analyses considering the effect of seismic ground motions on slope stability are presented.

(a) Evaluation of overall seismic stability, using pseudostatic analysis or dynamic analysis, as appropriate (U.S. Army Corps of Engineers, 1977; NRC, 1977). Alternatively, a dynamic analysis following Newmark (1965) can be carried out to establish that the permanent deformation of the disposal cell from the design seismic event will not be detrimental to the disposal cell. The reviewer should verify that the yield acceleration or pseudostatic horizontal yield coefficient necessary to reduce the factor of safety against slippage of a potential sliding mass to 1.0 in a "Newmark-type" analysis has been adequately estimated (Seed and Bonaparte, 1992).

b) An appropriate analytical method has been used. A number of different methods of analysis are available (e.g., slip circle method, method of slices, and wedge analysis) with several variants of each (Lambe and Whitman, 1979; U.S. Army Corps of Engineers, 1970b; NRC, 1977; Bromhead, 1992). Limit-equilibrium analysis methods do not provide information regarding the variation of strain within the slope and along the slip surface. Consequently, there is no assurance that the peak strength values used in the analysis can be mobilized simultaneously along the entire slip surface unless the material shows ductile behavior (Duncan, 1992). Residual strength values should be evaluated if mobilized shear strength at some points is less than the peak strength. The reviewer should ensure that appropriate conservatism has been incorporated in the analysis using the limit equilibrium methods. The limit equilibrium analysis methodologies may be replaced by other techniques, such as finite element or finite difference methods. If any important interaction effects cannot be included in an analysis, the reviewer must determine that such effects have been treated *in an approximate but conservative fashion. The engineering judgment of the reviewer should be used in assessing the adequacy of the resulting safety factors (NRC, 1983a,b).*

(c) For dynamic loads, the dynamic analysis includes calculations with appropriate assumptions and methods (NRC, 1977; Seed, 1967; Lowe, 1967; Department of the Navy, 1982a,b,c; U.S. Army Corps of Engineers, 1970a,b, 1971, 1972; Bureau of Reclamation, 1968). The effect of the assumptions and limitations of the methods used is discussed and accounted for in the analysis.

(d) For dynamic loads, a pseudostatic analysis is acceptable in lieu of dynamic analysis if the strength parameters used in the analysis are conservative, the materials are not subject to significant loss of strength and development of high pore pressures under dynamic loads, the design seismic coefficient is 0.20 or less, and the resulting minimum factor of safety suggests an adequate margin, as provided in NRC Regulatory Guide 3.11 (NRC, 1977).

(e) For pseudostatic analysis of slopes subjected to earthquake loads, an assumption is made that the earthquake imparts additional horizontal force acting in the direction of the potential failure (U.S. Army Corps of Engineers, 1970b, 1977; Goodman, 1989). The critical failure surface obtained in the static analysis is used in this analysis with the added driving force. Minimum acceptable values for safety factors of slope stability analysis are given in Regulatory Guide 3.11 (NRC, 1977).

(f) The assessment of the dynamic stability considers an appropriate design level seismic event and/or strong ground motion acceleration, consistent with that identified in Chapter 1 of this review plan. Influence of local site conditions on the ground motions associated with the design level event is evaluated. The design seismic coefficient to be used in the pseudostatic analysis is either 67 percent of the peak ground acceleration at the foundation level of the tailings piles for the site or 0.1g, whichever is greater.

(g) If the design seismic coefficient is greater than 0.20g, then the dynamic stability investigation (Newmark, 1965) should be augmented by other appropriate methods (i.e., finite element method), depending on specific site conditions.

h) In assessing the effects of seismic loads on slope stability, the effect of dynamic stresses of the design earthquake on soil strength parameters is accounted for. As in a static analysis, the parameters such as geometry, soil strength, and hydrodynamic and pore pressure forces are varied in the analysis to show that there is an adequate margin of safety.

(i) Seismically induced displacement is calculated and documented. There is no universally accepted magnitude of seismically induced displacement for determining acceptable performance of the disposal cell (Seed and Bonaparte, 1992; Goodman and Seed, 1966). Surveys of five major geotechnical consulting firms by Seed and Bonaparte (1992) indicate that the acceptable displacement is from 15 to 30 cm [6 to 12 in.] for tailings piles. The reviewer should ensure that this criterion is also augmented by provisions for periodic maintenance of the slope(s).

REFERENCES

International Building Code 2006. International Code Council, Inc.

MWH Americas 2011. Appendix E – Slope Stability Analysis, contained in Appendix D, Updated Tailings Cover Design Report, White Mesa Mill, September 2011 to the Reclamation Plan, White Mesa Mill, Rev. 5.0, September 2011.

Tetra Tech, Inc. (Tetra Tech) 2010. "White Mesa Uranium Facility Seismic Study Update for a Proposed Cell," Technical Memorandum to Denison Mines, February 3.

U.S. Department of Energy (DOE) 1989. Technical Approach Document, Revision II, UMTRADOE/AL 050425.0002, Uranium Mill Tailings Remedial Action Project, Albuquerque, New Mexico.

NRC 1982. U.S. Nuclear Regulatory Commission, "Regulatory Guide 3.8; Preparation of Environmental Reports for Uranium Mills", Washington DC, Rev. 2, October 1982.

NRC 2003. Standard Review Plan (NUREG–1620) for Staff Reviews of Reclamation Plans for Mill Tailings Sites Under Title II of The Uranium Mill Tailings Radiation Control Act", NUREG-1620, June 2003.

NRC 2008. DG-3024, "Standard Format and Content of License Applications for Conventional Uranium Mills," Draft Regulatory Guide DG-3024, May, 2008.

INTERROGATORY WHITEMESA RECPLAN REV. 5.0; R313-24-4; 10 CFR 40 APPENDIX A, CRITERION 4; INT 07/1: TECHNICAL ANALYSIS - SETTLEMENT AND POTENTIAL FOR COVER SLOPE REVERSAL AND/OR COVER LAYER CRACKING

REGULATORY BASIS

Refer to UAC R313-24-4 which invokes the following requirement from 10CFR40, Appendix A, Criterion 4: "The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade:

…(c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Executive Secretary will consider relaxing this requirement for extremely gentle slopes such as those which may exist on the top of the pile.

…Rock covering of slopes may be unnecessary where top covers are very thick (or less); bulk cover materials have inherently favorable erosion resistance characteristics; and, there is negligible drainage catchment area upstream of the pile and good wind protection as described in points (a) and (b) of this criterion.

Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient.

INTERROGATORY STATEMENT

Refer to Appendix D, Updated Tailings Cover Design Report of the Reclamation Plan, Rev. 5, and Drawings TRC-1 through TRC-8 in the Reclamation Plan, Rev. 5.0 :

1. *Please revise (i.e., steepen) the slopes of the top slope portions of the final cover system to provide an adequate factor of safety to ensure long-term stability of the covered embankment area considering:*

    a. *The potential for future slope reversal(s) and/or cracking to occur in the cover system due to long-term total and differential settlement or subsidence which could lead to conditions where ponding of precipitation could occur on the cover system in the future, after the end of the active institutional control period; and* *b. The significant disparity between the presently proposed topslope inclination ranges and published recommended ranges of slopes for final cover systems for uranium mill tailings repositories, surface impoundments, and landfills – namely ranging between 2% to 5% (e.g., see DOE 1989; EPA 1989; EPA 1991, and ITRC 2003 and EPA 2004).*

OR, alternatively, provide additional evaluations that clearly and unequivocally demonstrate (1) the ability to construct such gently sloped cover systems as proposed, designed, and specified and (2) the ability of the proposed embankment closure cover design to accommodate settlement-induced slope changes (including slope reversal) without increasing infiltration into the stabilized tailings impoundment.

2. *Provide technical justification for 1) quantitative acceptance criteria to be used as the basis for evaluating the potential for slope reversal within the cover system in terms of potential long-term total and differential settlement, 2) quantitative assessments of maximum tensile strain capacity and other engineering properties such as Atterberg limits of the materials to be used in design of the cover system, and 3) quantitative acceptance criteria, including maximum allowable linear and angular distortion values, including effects of bending within any select layer or layers of the cover, and (4) the minimum acceptable factor of safety for concluding that cover layer cracking will not occur.*

3. *Provide engineering analyses (including calculations and numerical modeling simulations as applicable) documenting the range of anticipated total and differential settlements within each of the containment cells. In doing so, use consolidation parameters obtained from site-specific testing of the tailings materials, reflecting both spatial and temporal variations in the tailings. Data from other sources may supplement (but not replace) site-specific test data in the analyses.*

4. *Demonstrate that tailings have been deposited in such a way that variations in tailings properties by location do not compromise the stability of the tailings as a foundation for cover system construction. Consider effects of sand-rich tailings zones lying adjacent to our near slime-rich tailings zones, due to deposition during slurry flow. Describe and account for effects of any different tailings placement methods (e.g., wet slurry vs. thickened slurry deposition) used throughout the mill's operating life. Identify and quantify the effects on stability of variations in such tailings physical characteristics as moisture content, consolidation coefficients, specific gravity, hydraulic conductivity (as listed in Appendix D Updated Tailings Cover Design Report, September 2011). Perform and provide results of numerical analyses using this information to project differential settlement across the tailings impoundments using software such as the Fast Lagrangian Analysis of Continuum (FLAC®) code (Itasca 2009) or other similar software, as appropriate. Alternatively, provide information to justify why such analyses are not warranted.*

5. *Include secondary settlement (i.e., creep) and any seismically induced settlement of the tailings in settlement analyses and consider their effects when assessing the anticipated performance of the cover system.*

6. *Demonstrate that the results of settlement analyses are consistent with results of drainage/dewatering analyses. Ensure that drainage/dewatering analyses reflect the tailings and drainage conditions (including slime drain system) existing in each cell.*

7. *Perform and report results of sensitivity and uncertainty analyses to demonstrate that the cover system will remain stable despite the effects of differential settlement. Report the time required to reach 90% consolidation.*

8. *As part of the analyses identified above, please also perform a seepage analyses to evaluate the shape of the phreatic surface within the tailings prism for each representative area within Cells 2 and/or 3, 4A, and 4B to be analyzed for consolidation timeframes and in differential settlement analyses. Ensure that effects of planned dewatering procedures and the dewatering system design configuration in each specific cell analyzed are reflected in seepage analyses.*

9. *Provide sensitivity analyses to assess the effect a of changes in tailings coefficients of consolidation parameters, void ratios, and tailings hydraulic conductivity values (note: it is acknowledged that values of all of these parameters are subject to uncertainty) on the amount of time required to reach approximately 90% consolidation of the tailings at each locations assessed within each cell and/or across individual tailings cells.*

10. *Using the information obtained from the analyses identified above, for each critical section defined, complete differential settlement analyses and compare the analyses results to the specified design criteria and evaluate the potential for slope reversal(s) to occur in the cover system over the tailings cells over the worst-case sections analyzed.*

11. *Provide information on the expected range of plasticity characteristics of the soil materials proposed for use for constructing the highly compacted upper portion of the radon attenuation and radon attenuation and grading layer of the proposed cover system, and specify design criteria (including maximum allowable values of both linear and angular distortion) to be used for evaluating the potential for cracking of this layer to occur as a result of any differential settlement that may occur.*

BASIS FOR INTERROGATORY

The proposed cover slope (minimum of 0.1% to a maximum of 1.0 %) is very flat and, based on the information provided, has to be considered to likely be problematic from the standpoint of potential long-term subsidence/differential settlement. 10CFR 40, Appendix A, Technical Criterion 4(c) specifies that embankment and cover slopes must be relatively flat after final stabilization to minimize erosion and provide conservative factors of safety assuring long-term stability (emphasis added). Technical guidance developed for and typically utilized by the U.S. Department of Energy on the UMTRA Project for design and construction of uranium mill *tailings repositories included typical repository topslope inclinations of 2 to 3 percent (U.S. DOE 1989, Section 3, Figure 3-3). Further, minimum technology guidance for final cover systems for surface impoundments recommended by the USEPA (EPA 1989; EPA 1991) consists of the following:*

> *"…a top layer…, the surface of which slopes uniformly at least 3 percent but not more than 5 percent, to facilitate runoff while minimizing erosion, …"*

Additionally, an EPA document published in 2004 (EPA) further discusses this guideline in the following context:

> *"…[In the Draft Technical Guidance for RCRA/CERCLA Final Covers, EPA states that] most landfill cover system top decks are designed to have a minimum inclination of 2% to 5%, after accounting for settlement, to promote runoff of surface water. …However, [EPA states that] in some cases involving the closure or remediation of existing landfills, waste piles, or source areas, flatter slopes may already exist and that the cost to increase the slope inclination by fill placement or waste excavation may be significant. In these cases, slightly flatter inclinations can be considered if the future settlement potential can be demonstrated to be small, if concerns about localized subsidence can be adequately addressed, and if monitoring and maintenance provisions exist to repair areas of grade reversal or subsidence…"*

The proposed cover topslope inclinations (minimum of 0.1%) are much flatter than the above recommended ranges. The cover design should include a topslope slope inclination that ensures that an adequate factor of safety is provided to maintain long-term stability of the completed embankment(s), considering the potential for future slope reversal(s) due to long-term differential settlement or subsidence, given a reasonable estimate of the range of different tailings characteristics and tailings consolidation conditions that may exist within the different tailings placement cells. The final topslope inclinations must ensure that the topslope portion of the embankment will maintain a positive slope across the entire embankment after settlement/subsidence, thus providing lateral runoff of precipitation without ponding throughout the performance period of the covered and closed embankment.

Drawings TRC-3 through TRC-8 of the Reclamation Plan Rev. 5.0 depict several areas where slopes are nearly flat and have low-lying areas already (e.g. over portions of Cell 2) where differential settlement, if it were to occur, could further aggravate these areas from the standpoint of further flattening or creating of larger areas of flat ground surface for future ponding of incident precipitation.

Available published information and/or testing should be used to estimate the maximum amount of strain/maximum distortion value that can be tolerated within the compacted layer over the design life of the embankment and not crack the radon barrier. Such a limit should be based on properties (e.g., range of plasticity indices) of the soils proposed for constructing the compacted portion of the radon barrier layer. Engineering analyses should be provided for various representative disposal configurations involving disposed tailings to demonstrate that predicted settlement/subsidence magnitudes and locations will not exceed specified acceptance criteria for strain or distortion value.

To quantify the amount of settlement in the tailings due to the placement of the interim and final soil covers, the Licensee has attempted to quantify the coefficients of consolidation (cv) and *compression indices (Cc) for the tailings based on back-analysis of existing settlement monitoring data from Cells 2 and 3. While this approach is a conceptually sound approach for obtaining site-specific parameters, successful implementation often proves to be problematic. For instance, high quality monitoring data is needed. Unfortunately, the monitoring data exhibits an appreciable amount of "noise" and numerous erratic shifts, making it uncertain as to which data points are the "real data" to which the modeled settlement response should be matched. This approach also typically requires that the initial portion of the load-settlement curve be well defined. Without this initial data, the total amount of settlement ultimately expected to occur can be difficult to accurately quantify, particularly if the rate of consolidation is rapid relative to the rate of loading (i.e., cover placement). Any settlement occurring during construction of the cover and before monitoring begins is lost, leading to questions as to how tightly the "bend" in the time rate of consolidation curve should be matched in the absence of a well-defined starting point for the settlement model. It should also be noted that assessing the goodness of the fit itself can also be problematic. For example, while the report states that the model values of Cc and cv were varied "until the observed settlement curve correlated well with the calculated settlement", it is the reviewer's opinion that the degree of correlation achieved was not always "well", particularly for the first and most meaningful part of the consolidation time history curve shown in Fig F-1, and for the entire plots shown for cells 2W1, 2W3, 3-1C, 3-1S. It may be simply fortuitous that the back-calculated values appear to be within the ranges suggested Keshian and Rager (cited by the Licensee), particularly recognizing that the ranges cover one or more orders of magnitude. It should also be noted that no assessment has been made as to whether or not the tailings' behavior in Cells 2 and 3 are applicable to the other cells.*

It is noted that the calculated/estimated amounts of settlement presented in the report appear to be based on assumed dry and saturated unit weights of 86.3 and 117.1 pcf, respectively. However, elsewhere in the report, (Section C.2.4 of sub-Appendix C in Appendix D), the tailings are described as having a dry unit weight of 74.3 pcf. Consistent characterization of the tailings throughout the report seems to be needed, or at least this variation should be accounted for when reporting values of settlement. It is also noted that all the back analyses involved the same initial void ratio for the tailings which is a very unlikely scenario given that the other consolidation parameters (which are not entirely independent of void ratio) were varied.

A key deficiency of the settlement assessment presented by the Licensee lies in the following conclusion: "Additional settlement due to the construction of the final cover is estimated to be on the order of 5 to 6 inches. The estimated amount of additional settlement is sufficiently low such that ponding is not expected with a cover slope of 0.5 percent." The calculated settlements are magnitudes of settlement without specified locations, whereas an assessment of ponding potential (i.e., localized grade reversal of the cover) requires that the spatial variation of settlement be known or calculated. The reported magnitudes of vertical settlement need to be translated into reliable estimates of differential settlement in order to properly assess the adequacy of the cover slope. In doing this, the Licensee should evaluate the various areas within individual tailings placement cells and/or or spanning more than one of the tailings Cells 2, 3, and 4A/B where tailings slurry deposition modes may vary, leading to different tailings conditions within and/or between cells (e.g., tailings areas comprised of sand/slime mixture located laterally adjacent to tailings areas containing mostly slimes, including, for example, areas near side slope portions of tailings placement cells where more sand-rich tailings may be *laterally juxtaposed against slime-rich tailings areas). The analysis should particularly account for varying thicknesses of compressible tailings along the side slopes of the cells as well as the potential for differences in stress conditions along such slopes. The locations and characteristics for the different tailings materials (such as moisture content, horizontal and vertical coefficients of consolidation, specific gravity, void ratios, unit weights, hydraulic conductivity, etc.) should be clearly shown for one or more analyzed critical cross-sections.*

While the above discussion focuses on the settlement of tailings, different conditions exist in Cell 1 adjacent to Cell 2 where mill debris and contaminated soils instead of tailings are to be placed and covered. Total and differential settlement based on the particular conditions of this cell together with their effects on both the liner and cover systems should be assessed.

To more reliably quantify total and differential settlements as well as settlement rates for the tailings impoundments, the Licensee should test tailings specimens to determine their consolidation properties. The number of specimens involved should be commensurate with anticipated variability of the tailings conditions in the containment cells. The Licensee should then consider performing coupled stress and seepage analyses of critical cross-section of Cells 2 and 3, and/or 4A/B. As a minimum, the settlement analyses should be compared with the drainage/seepage/dewatering analyses to demonstrate that they are consistent. It appears that such a check was not performed since the discussion of the results of the time-rate of consolidation/settlement does not make any reference to the dewatering analyses in sub-Appendix H, despite the fact that the back-calculated coefficients of consolidation of the former should be proportional to the hydraulic conductivity values of the latter (the coefficient of consolidation is a composite variable which includes hydraulic conductivity).

Unfortunately, the tailings dewatering analyses presented in sub-Appendix H do not adequately represent (i.e., account for) potential variations in the tailings properties, nor their potential distribution within the containment cells. In the models presented for Cells 2 and 3, isotropic conditions are assumed (which is very unlikely) and a single hydraulic conductivity value is assigned to all of the tailings (which might be acceptable if the effect/sensitivity of the parameter had been assessed parametrically – but it wasn't). The hydraulic conductivity value itself appears to be flawed, apparently being based on the geometric mean of four discrete hydraulic conductivity values taken from technical literature (representing four generic soil types ranging from medium sand to silty clayey) which span 5 orders of magnitude. It is inappropriate to use a type of average, single value to represent such a vast range of hydraulic conductivity. (Although there is seemingly contradictory information as to what was really used as the basis for the hydraulic conductivity in the analysis. On page J[sic]-4 of sub-Appendix H, the text states that hydraulic conductivity values are based on testing from the Canon City Mill tailings whereas attachment H-2 indicates that the hydraulic value is based on the aforementioned averaging of typical values. Clarification is needed). The tailings dewatering analyses should be revisited or at least clarified and better substantiated. To reliably quantify total and differential both drainage and settlement characteristics of the tailings, the Licensee should test actual tailings specimens from the site.

Drainage/seepage/dewatering analyses performed should reflect the tailings and drainage conditions (including drainage system) associated with each particular cell. One or more cross-sections may need to be considered. Due to uncertainty and/or inherent variability of the tailings materials, multiple analyses bracketing the ranges of anticipated engineering properties *should be performed. Contingencies for less-than-most-likely performance should be incorporated into the design of the cover system. Particular consideration should be given to variations in the magnitude of differential settlement as well as the time required to reach 90% consolidation. In light of the particularly large range in the coefficients of consolidation already presented by the Licensee, it can be misleading to cite or use "average" values when discussing or planning other activities (for example, see the monitoring section of the report (sub-Appendix I of Appendix D) which states, "a monitoring period of four years prior to final cover system construction is anticipated, based on the estimated time required to reach 90 percent consolidation." All references to settlement magnitude, rate, and duration should be provided as ranges.*

Given the erratic nature exhibited in the existing settlement monitoring data, it is recommended that the monitoring process be reviewed and revised to assure greater accuracy. As a minimum, the data should be reviewed as soon as it is gathered and its quality be checked by plotting it with previous data and making certain that the data makes sense (i.e., is consistent with expected trends; not showing significant amounts of upward displacement, for example). Questionable data should be confirmed or replaced with new measurements. Without such quality control measures, it may become difficult or impossible to demonstrate that 90% consolidation has been reached and that cover materials can be placed.

It is suggested that statements such as the following from page I-2 of sub-Appendix I of Appendix D: "typically less than 0.1 feet (30 mm) of cumulative settlement over a 12 month period is acceptable" be avoided because such statements might be mistakenly substituted for the real requirement of 90% consolidation.

The Licensee's assessment of settlement only addresses primary settlement and does not consider secondary settlement effects (i.e., creep) or seismically-induced settlement of the tailings. Secondary settlement and seismically induced settlement of the tailings (if any) and their subsequent effects on the cover system should be assessed. Assessment of settlement under seismic conditions is dependent upon the Licensee's seismic hazard analysis. Any revisions to the seismic hazard analysis may necessitate revisions to such an assessment.

NUREG-1620 (NRC 2003), Section 2.3.3, specifies that: "The analysis of tailings settlement will be acceptable if it meets the following criteria:

> *(1) Computation of immediate settlement follows the procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982). If a different procedure is used, the basis for the procedure is adequately explained. The procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982) for calculation of immediate settlement is adequate if applied incrementally to account for different stages of tailings emplacement. If this method is used, the reviewer should verify that the computation of incremental tailings loading and the width of the loaded area, as well as the determination of the undrained modulus and Poisson's ratio, have been computed and documented. Settlement of tailings arises from compression of soil layers within the disposal cell and in the underlying materials. Because compression of sands occurs rapidly, compression of sand layers in the disposal cell and foundations must be considered in the assessment of immediate settlement. However, the contribution of immediate settlement to consolidation settlement cannot be ignored. Clay layers and slime undergo instantaneous elastic compression controlled by their undrained*

stiffness as well as long-term inelastic compression controlled by the processes of consolidation and creep (NRC, 1983a).

(2) Each of the following is appropriately considered in calculating stress increments for assessment of consolidation settlement:

(a) Decrease in overburden pressure from excavation

(b) Increase in overburden pressure from tailings emplacement

(c) Excess pore-pressure generated within the disposal cell

(d) Changes in ground-water levels from dewatering of the tailings

(e) Any change in ground-water levels from the reclamation action

(3) Material properties and thicknesses of compressible soil layers used in stress change and volume change calculations for assessment of consolidation settlement are representative of in situ conditions at the site.

(4) Material properties and thicknesses of embankment zones used in stress change and volume change calculations are consistent with as-built conditions of the disposal cell.

(5) Values of pore pressure within and beneath the disposal cell used in settlement analyses are consistent with initial and post-construction hydrologic conditions at the site.

(6) Methods used for settlement analyses are appropriate for the disposal cell and soil conditions at the site. Contributions to settlement by drainage of mill tailings and by consolidation/compression of slimes and sands are considered. Both instantaneous and time-dependent components of total and differential settlements are appropriately considered in the analyses (NRC, 1983a,b,c). The procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982) for calculation of secondary compression is adequate.

(7) The disposal cell is divided into appropriate zones, depending on the field conditions, for assessment of differential settlement, and appropriate settlement magnitudes are calculated and assigned to each zone.

(8) Results of settlement analyses are properly documented and are related to assessment of overall behavior of the reclaimed pile.

(9) An adequate analysis of the potential for development of cracks in the radon/infiltration barrier as a result of differential settlements is provided (Lee and Shen, 1969).”

REFERENCES

DOE (U.S. Department of Energy). 1989. Technical Approach Document, Revision II. UMTRA-DOE/AL 050425.0002.

EPA (U.S. Environmental Protection Agency). 1989. Final Covers on Hazardous Waste Landfills and Surface Impoundments, Technical Guidance Document, EPA/530-SW-89-047, Office of Solid Waste and Emergency Response, Washington, D.C. URL: http://webcache.googleusercontent.com/search?q=cache:VEVCaJfyPDQJ:nepis.epa.gov/Exe/ZyPURL.cgi%3FDockey%3D100019HC.txt+site:epa.gov+EPA+Final+Covers+Guidance&cd=4&hl=en&ct=clnk&gl=us.

EPA 1991. Seminar Publication, Design and Construction of RCRA/CERCLA Final Covers. EPA/625/4-91/025.May 1991, 208 pp.

EPA 2004. (Draft) Technical Guidance for RCRA/CERCLA Final Covers. U.S EPA 540-R-04-007, OSWER 9283.1-26. April 2004, 421 pp. URL: nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10074PP.txt.

U.S. Nuclear Regulatory Commission 2003. "Standard Review Plan (NUREG–1620) for Staff Reviews of Reclamation Plans for Mill Tailings Sites Under Title II of The Uranium Mill Tailings Radiation Control Act", NUREG-1620, June, 2003.

INTERROGATORY WHITEMESA RECPLAN REV5.0 R313-24-4; 10CFR40 APPENDIX A CRITERION 4; INT 08/1: TECHNICAL ANALYSIS –EROSION STABILITY EVALUATION

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 4: "The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade:

… (c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Executive Secretary will consider relaxing this requirement for extremely gentle slopes such as those which may exist on the top of the pile.

The following factors must be considered in establishing the final rock cover design to avoid displacement of rock particles by human and animal traffic or by natural process, and to preclude undercutting and piping:

- *Shape, size, composition, and gradation of rock particles (excepting bedding material average particles size must be at least cobble size or greater);*
- *Rock cover thickness and zoning of particles by size; and*
- *Steepness of underlying slopes.*

Individual rock fragments must be dense, sound, and resistant to abrasion, and must be free from cracks, seams, and other defects that would tend to unduly increase their destruction by water and frost actions. Weak, friable, or laminated aggregate may not be used.

Rock covering of slopes may be unnecessary where top covers are very thick (or less); bulk cover materials have inherently favorable erosion resistance characteristics; and, there is negligible drainage catchment area upstream of the pile and good wind protection as described in points (a) and (b) of this criterion.

Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed must be well protected with substantial rock cover (rip rap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain must be evaluated to assure that there are not ongoing or potential processes, such as gully erosion, which would lead to impoundment instability.

INTERROGATORY STATEMENT:

Refer to Section 3.3.5 of the Reclamation Plan, Rev. 5.0 and Section 4.9 and Appendix G to Appendix D (Updated Tailings Cover Design Report), and Drawings TRC-1 through TRC-8 to the Reclamation Plan, Rev. 5.0: *Please provide the following:*

1. *To further confirm the appropriateness and currency of the calculated Probable Maximum Precipitation (PMP) value and as used, for example, in the ET cover design erosion protection rock rip rap sizing calculations, please provide a revised PMP calculation updating the PMP distribution that incorporates information from the following documents, in addition to HMR 49 (Hansen et al.1984):*
    - *"2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi". – March 2003 Jensen 2003); and*
    - *"Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah" – October 1995 (Jensen 1995)*

2. *Using the revised PMP information obtained from Item 1 above, provide revised calculations of required rock rip rap sizes for the cover sideslope areas using the updated method developed for round-shaped rip rap as described in Abt et al. 2008. Update and revise other erosion protection calculation presented in Appendix G, as required and appropriate, to reflect the revised PMP determination.*

3. *Please provide additional calculations to estimate the magnitude and location of a potential gully intrusion into each soil-covered portion of the proposed cover system (e.g., using the procedure described in Thornton and Abt 2008). Demonstrate that excluding rock (gravel) particles from the currently proposed flattest (0.1 % and 0.5%) top slope areas would adequately protect against sheet flow under potential precipitation conditions and would adequately control longer-term rill and/or gully initiation and development. Provide information on required "overdesign" of the cover thickness needed to accommodate maximum predicted gully depths and locations.*

4. *Provide additional detailed cross sections showing every interface that will occur between sidelope cover layers and topslope cover layers. Demonstrate that all applicable filter criteria will be met for each interface between each topslope cover layer component and the proposed granular filter layer on the sideslope, including standard filter gradation criteria as well as applicable permeability filter criteria (e.g., for filter layer underlying riprap on sideslope areas). Consider filter criteria for preventing migration of granular materials*

into an adjacent coarser grained granular layer (e.g., Nelson et al. 1986, Equation 4.35); for preventing piping of finer grained cohesionless soil particles into an adjacent coarser-grained material layer (e.g., Cedegren 1989, Equation 5.3); and for preventing erosion of a finer-grained material layer from occurring over the long term as a result of flows in an adjacent coarser (filter zone) layer (e.g., Nelson et al. 1986, Equation 4.36). Include consideration of different specific filter stability criteria (e.g., NRCS 1994, Tables 26-1 and 26-2) for determining the maximum allowable D15 of a granular filter layer material for preventing erosion of any adjacent layer (e.g., sacrificial soil layer) consisting of fine-grained/finer-grained particles, as a function of soil type. Address applicable filter permeability criteria for the filter layer in the sideslope cover system, including Table 26-3 of NRCS 1994.

5. *Provide revised cover system cross sections to include a thicker riprap layer on the cover sideslope areas (i.e., minimum thickness of 1.5 times the D_{50} of the rock rip size of 7.4 inches, or the D_{100} of the rock rip rap materials, whichever is greater) to bring the cover design into compliance with recommendations contained in Section 2.1.2 of NUREG-1623 (NRC 2002).*

6. *Provide revised construction drawings for the final cover that preclude the presence of low areas that have the potential for experiencing future concentrated flows (e.g., portion of cover overlying Cell 2 as depicted on Section B-3 on Drawing TRC-7) and that avoid areas having abrupt changes in slope gradient across the cells, (e.g., areas of cover having proposed 5h:1v slopes shown on Sections B-3 and C-3 on Drawings TRC-6 and TRC-7 and Detail 7/8 on Drawing TRC-8, etc..) to be consistent with UAC R313-24-4 10CFR40, Appendix A, Criterion 4.*

BASIS FOR INTERROGATORY:

When determining the PMP for facilities such as High Hazard and Moderate Hazard dams, the State of Utah currently requires the use of HMR 49, which DUSA has used in Attachment G to the Reclamation Plan 4.0 (Denison 2009) and referenced in Appendix D to the Reclamation Plan 5.0 (Denison 2011), but also in conjunction with the use of two other reports: (1) the "2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi. – March 2003" and (2) "Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah – October 1995." Although these two methods were developed (by the Utah Climate Center) for estimating PMF conditions for design of dams, these methods are considered to be more representative of actual meteorological conditions in Utah than those considered in HMR 49. The erosion protection calculations presented in Appendix G (Erosion Stability Evaluation) should to be revised as needed to reflect the revised PMP determination findings, as appropriate, to demonstrate that applicable erosion protection requirements will be met.

The Modified Universal Soil Loss Equation (MUSLE) was used (Appendix G to Appendix D to the Reclamation Plan) to evaluate erosion losses from the topslope areas of the cover due to sheet flow but does not consider the potential for gully development or intrusion due to the topographic features of the tailings area which are assumed to remain constant with time (Nelson 1986).

Although the Temple method (Appendix D) was appropriately used to evaluate the erosional stability of portions of the cover comprised of "topsoil and vegetation" and "topsoil mixed with gravel" –covered slopes, the method assumes only minor channeling, gullying, or rilling. Due to the relatively large and flat nature of the currently proposed topslope areas, these assumptions may or may not reflect actual conditions that are expected to occur. It is possible that less or more severe flow concentrations would occur and vegetation would or would not provide significant protection. Research has demonstrated that if localized erosion and gullying occurs, damage to unprotected soil covers may occur rapidly, probably in a time period shorter than 200 years (NUREG-1623 [NRC 2002]). It needs to be demonstrated that all slopes are designed to meet NUREG-1623 requirements, i.e., that "Soil slopes of a reclaimed tailings impoundment should be designed to be stable and thus inhibit the initiation, development, and growth of gullies." A procedure developed by Thornton and Abt (2008), which builds upon a preliminary procedure developed by Abt et al. 1997 (as discussed in Appendix B of NUREG-1623), provides a means of estimating the magnitude and location of a potential gully intrusion into the flat topslope areas of the cover.

Additional descriptive information and supporting calculations need to be provided to demonstrate that all applicable filter criteria are met for all topslope cover/ sideslope cover layer interfaces. Acceptable filter sizing criteria for preventing migration of the selected filter/bedding materials into the riprap and for minimizing or preventing erosion of the soil layer below the filter/bedding layer, and for meeting filter permeability criteria are described in NUREG/CR-4620 (Nelson et al. 1986), Cedegren 1989 and NCRS 1994.

In addition, currently, it is unclear from Drawings TRC-1 through TRC-8 of the Reclamation Plan Rev. 5.0 as to whether filter blankets or bedding layers are or are not included in some areas, for example, areas along toes of slopes, transition areas, diversion ditches and channels, stilling areas, and flow impact areas, which are typically areas described in NUREG-1623 as areas where filters are generally recommended. A demonstration of long-term layer stability is needed to justify the omission of a filter/bedding blanket in the final cover system and in any such areas.

Cross sections TRC-6 and TRC-7 provided in the Reclamation Plan Rev. 5.0 depict abrupt slope changes in the tailings cover when crossing Cell 2 to Cell 1 and Cell 2 to Cell 3. The cross sections should be revised to meet the above UAC R313-24-4, 10CFR40, Appendix A, Criterion 4 "….all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient."

NUREG-1623 (NRC 2002), Section 2.1.2 recommends that the minimum required thickness of a rock riprap layer be no less than 1.5 times the D_{50} of the rock riprap materials, or the D_{100} of the rock rip rap materials, whichever is greater.

REFERENCES:

Abt, S.R., Thornton, C.I., Batka, J.H., and Johnson, T.L. 1997. "Investigation of Gully Stabilization Methods with Launching Stone: Pilot Laboratory Tests" Prepared for the U.S. Nuclear Regulatory Commission, Washington, D.C. February 1997.

Abt, S.R., Thornton, C.I., Gallegos, H., and Ullmann, C. 2008. "Round-Shaped Riprap Stabilization in Overtopping Flow," Journal of Hydraulic Engineering, Vol. 134, No. 8, August 2008, pp. 1035–1041.

Bertram, G.E. 1940. An Experimental Investigation of Protective Filters. Graduate School of Engineering, Harvard University, Cambridge, Massachusetts. Soil Mechanics Series No. 7. pp. 1-21.

Cedegren.H.R. 1989. Seepage, Drainage, and Flow Nets. 3rd Edition. John Wiley $ & Sons, Inc., New York, NY.

Denison Mines (USA) Corporation. 2011. Reclamation Plan, Revision 5.0, White Mesa Mill, Blanding, Utah, September 2011.

Hansen, E., Schwarz, F., and Riedel, J. 1984. Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages. Hydrometeorological Report No. 49. U.S Department of Commerce, National Oceanic and Atmospheric Administration, Reprinted 1984.

Jensen, D. 1995. 2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi. - March 2003. Utah Climate Center.

Jensen, D. 2003. Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah - October 1995. Utah Climate Center.

Nelson, J.D., Abt, S.R., Volpe, R.L, van Zyl, D., Hinkle, N.E., and Staub, W.P. 1986. Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments. Prepared for Nuclear Regulatory Commission, Washington, DC. NUREG/CR-4620, ORNL/TM-10067. June 1986, 151 pp.

NRC 2002. U.S. Nuclear Regulatory Commission, "Design of Erosion Protection for Long-Term Stability", NUREG-1623, September 2002.

NRCS (Natural Resources Conservation Service) 1994. U.S. Department of Agriculture, Part 633, National Engineering Handbook, Chapter 26: Gradation Design of Sand and Gravel Filters. October 1994.

Thornton, C., and Abt, S. 2008. "Gully Intrusion into Reclaimed Slope: Long-Term Time-Average calculation Procedure", Journal of Energy Engineering, Vol. 134, No. 1, March 2008, pp. 15-23.

INTERROGATORY WHITEMESA RECPLAN REV. 5.0; R313-24-4; 10CFR40 APPENDIX A CRITERION 1; INT 09/1: LIQUEFACTION

REGULATORY BASIS

UAC R313-24-4 invokes the following requirement from 10CFR40 Appendix A, Criterion 1: The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific siting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6). The following site features which will contribute to such a goal or objective must be considered in selecting among alternative tailings disposal sites or judging the adequacy of existing tailings sites:

- *Remoteness from populated areas;*
- *Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources; and*
- *Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term.*

…While isolation of tailings will be a function of both site and engineering design, overriding consideration must be given to siting features given the long-term nature of the tailings hazards.

Tailings should be disposed of in a manner that no active maintenance is required to preserve conditions of the site.

INTERROGATORY STATEMENT:

Refer to Section 4.8 and Appendices C and F to the Appendix D, Updated Tailings Cover Design Report of the Reclamation Plan, Rev. 5:

1. *Provide revised liquefaction analyses that rely upon actual site-specific data for the tailings materials, rather than assumed parameters. In doing so, revise the Reclamation Plan to correctly and defensibly characterize tailings properties consistent with these revisions throughout the document.*
2. *Correct apparent errors and conduct revised analyses using parameter values that are based on site-specific data. Correct discrepancies between calculated results and summarized, reported results.*
3. *Demonstrate that conditions assumed for liquefaction analyses are consistent with or conservative compared to results of tailings dewatering analyses. If this is not true, revise liquefaction analyses to be consistent with or conservative compared to results of tailings dewatering analyses, report results, and demonstrate that impoundments will remain stable with regard to liquefaction.*

BASIS FOR INTERROGATORY

NUREG-1620 (NRC 2003), Section 2.2.3, specifies the following with respect to slope stability analyses and assessment of liquefaction potential: "…The analysis of slope stability will be acceptable if it meets the following criteria:

…(3) Appropriate analyses considering the effect of seismic ground motions on slope stability are presented.

…(j) Where there is potential for liquefaction, changes in pore pressure from cyclic loading are considered in the analysis to assess the effect of pore pressure increase on the stress-strain characteristics of the soil and the post-earthquake stability of the slopes. Liquefaction potential is reviewed using Section 2.4 of this review plan. Evaluations of dynamic properties and shear strengths for the tailings, underlying foundation material, radon barrier cover, and base liner system are based on representative materials properties obtained through appropriate field and laboratory tests (NRC 1978, 1979)….

NUREG-1620 (NRC 2003), Section 2.4.3, specifies that: "The analysis of the liquefaction potential will be acceptable if the following criteria are met:

(1) Applicable laboratory and/or field tests are properly conducted (NRC, 1978, 1979; U.S. Army Corps of Engineers, 1970, 1972).

(2) Data for all relevant parameters for assessing liquefaction potential are adequately collected and the variability has been quantified.

(3) Methods used for interpretation of test data and assessment of liquefaction potential are consistent with current practice in the geotechnical engineering profession (Seed and Idriss, 1971, 1982; National Center for Earthquake Engineering Research, 1997). An assessment of the potential adverse effects that complete or partial liquefaction could have on the stability of the embankment may be based on cyclic triaxial test data obtained from undisturbed soil samples taken from the critical zones in the site area (Seed and Harder, 1990; Shannon & Wilson, Inc. and Agbabian-Jacobsen Associates, 1972).

(4) If procedures based on laboratory tests combined with ground response analyses are used, laboratory test results are corrected to account for the difference between laboratory and field conditions (NRC, 1978; Naval Facility Engineering Command, 1983).

(5) The time history of earthquake ground motions used in the analysis is consistent with the design seismic event.

(6) If the potential for complete or partial liquefaction exists, the effects such liquefaction could have on the stability of slopes and settlement of tailings are adequately quantified.

(7) If a potential for global liquefaction is identified, mitigation measures consistent with current engineering practice or redesign of tailings ponds/embankments are proposed and the proposed measures provide reasonable assurance that the liquefaction potential has been eliminated or mitigated.

(8) If minor liquefaction potential is identified and is evaluated to have only a localized effect that may not directly alter the stability of embankments, the effect of liquefaction is adequately accounted for in analyses of both differential and total settlement and is shown not to compromise the intended performance of the radon barrier. Additionally, the disposal cell is shown to be capable of withstanding the liquefaction potential associated with the

> *expected maximum ground acceleration from earthquakes. The licensee may use post-earthquake stability methods (e.g., Ishihara and Yoshimine, 1990) based on residual strengths and deformation analysis to examine the effects of liquefaction potential. Furthermore, the effect of potential localized lateral displacement from liquefaction, if any, is adequately analyzed with respect to slope stability and disposal cell integrity.*

The liquefaction analysis presented by the Licensee is based on the procedures presented in Youd et al. (2001). While newer methods have been introduced and are being used, this method is still an acceptable, state-of-practice method provided that borderline finer-grained soils are appropriately assessed (see Boulanger and Idriss, 2006; Bray and Sancio, 2006; Boulanger and Idriss, 2011). Aside from the earthquake magnitude and ground acceleration, the most important parameter in the analysis is the in-situ penetration resistance parameter (which in this case is an SPT blowcount) which provides a measure of the soil's resistance to liquefaction. In the Licensee's analysis, this SPT blowcount has been assumed to be 4 without any substantial justification – the justification provided in the report is that the analyst considered the tailings to be "loose" and that such a term is often correlated with a blowcount in the range of 4 to 10. However, it seems that analyst could have alternatively assumed that the tailings were "very loose," leading to a blowcount in the range of 0 to 4, thus significantly affecting the outcome of the analysis. Also, elsewhere in the report (when approximating the shear strength of the drained tailings), the Licensee assumes that the tailings have a relative density of near zero, and a relative density of zero and a blow count of 4 are typically inconsistent.

A similar issue with consistency appears to exist in the characterization of the tailings' unit weight where dry and saturated unit weights of 86.3 and 117.1 pcf, respectively, are presented in Section F.2.2 of sub-Appendix F in Appendix D of the Reclamation Plan, Rev. 5.0, whereas a dry unit weight of 74.3 pcf is presented in Section C.2.4 of sub-Appendix C of Appendix D). Consistent characterization of the tailings throughout the report seems to be needed, and more importantly, with respect to liquefaction, a more substantiated blowcount describing the tailings is needed. If data doesn't exist, it must be collected, not manufactured.

It is noted that the results presented in Table F.5 'Summary of Liquefaction Results' do not agree with the calculated values shown in Attachment F.3. Further, it appears from the text that the Licensee intended to have the cover in place for the analysis (the Licensee should clearly explain the configuration of the impoundment and tailings reflected in the calculations); however, the weight of the cover seems to have been omitted from the calculated total and effective vertical stresses. Also, if the depth parameter "z" in the calculations is intended to reference from the top of the tailings as the datum, and given the stated "depth from top of tailings to water surface", it appears that effective stresses have been calculated incorrectly. Calculation of the overburden correction factor should also be checked.

Assessment of liquefaction is dependent upon the Licensee's seismic hazard analysis. Any revisions to the seismic hazard analysis may necessitate revisions to this assessment. Also, the applicability of the liquefaction hazard analysis is dependent upon the outcome of tailings dewatering analyses, and the Licensee should demonstrate that the results such analyses are appropriately interpreted (i.e., are at least consistent with, if not conservative) for the liquefaction hazard analysis.

REFERENCES

Boulanger, R.W. and Idriss, I.M. (2006). "Liquefaction susceptibility criteria for silts and clays." J. of Geotechnical and Geoenvironmental Eng., ASCE, Vol. 132, No. 11, pp. 1413-1426.

Bray, J.D. and Sancio, R.B. (2006). "Assessment of the liquefaction susceptibility of fine grained soils." J. of Geotechnical and Geoenvironmental Eng., ASCE, Vol. 132, No. 9, pp. 1165-1177.

Boulanger, R.W. and Idriss, I.M. (2011). "Cyclic failure and liquefaction: Current issues." Proc. Fifth International Conf. of Earthquake Geotechnical Eng., Santiago, Chile.

MWH Americas 2011. Appendix C - Radon Emanation Modeling, and Appendix F – Settlement and Liquefaction Analysis, contained in Appendix D, Updated Tailings Cover Design Report, White Mesa Mill, September 2011 to the Reclamation Plan, White Mesa Mill, Rev. 5.0, September 2011.

NRC 1982. U.S. Nuclear Regulatory Commission, "Regulatory Guide 3.8; Preparation of Environmental Reports for Uranium Mills", Washington DC, October 1982.

NRC 2001. U.S. Nuclear Regulatory Commission, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC, 2001.

NRC 2003. U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978." Washington DC, June 2003.

Youd, T. L., Idriss, I. M., Andrus, R. D., Arango, I., Castro, G., Christian, J. T., Dobry, R., Finn, W. D. L., Harder, L. F., Jr., Hynes, M. E., Ishihara, K., Koester, J. P., Liao, S. S. C., Marcuson, W. F., III, Martin, G. R., Mitchell, J. K., Moriwaki, Y., Power, M. S., Robertson, P. K., Seed, R. B., and Stokoe, K. H., II. (2001). "Liquefaction resistance of soils: summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils." J. of Geotechnical and Geoenvironmental Eng., ASCE, Vol. 127, No. 10, pp. 817-833.

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INTERROGATORY WHITEMESA RECPLAN 5.0 R313-24-4; 10CFR40 APPENDIX A, CRITERION 6; INT 10/1: TECHNICAL ANALYSES - FROST PENETRATION ANALYSIS

REGULATORY BASIS:

Refer to R313-25-8(4). Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, and surface drainage of the disposal site. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 6(1): "In disposing of waste byproduct material, licensees shall place an earthen cover (or approved alternative) over tailings or wastes at the end of milling operations and shall close the waste disposal area in accordance with a design which provides reasonable assurance of control of radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (ii) limit releases of radon-222 from uranium byproduct materials, and radon-220 from thorium byproduct materials, to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second (pCi/m^2s) to the extent practicable throughout the effective design life determined pursuant to (1)(i) of this criterion. In computing required tailings cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances may not be considered. Direct gamma exposure from the tailings or wastes should be reduced to background levels. The effects of any thin synthetic layer may not be taken into account in determining the calculated radon exhalation level. If non-soil materials are proposed as cover materials, it must be demonstrated that these materials will not crack or degrade by differential settlement, weathering, or other mechanism, over long-term intervals."

NUREG-1620 specifies that "Reasonable assurance [shall be] provided that the requirements of 10 CFR Part 40, Appendix A, Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, have been met."

INTERROGATORY STATEMENT:

Refer to Section 4.3 of Appendix D (Updated Tailings Cover Design Report) and Appendix B (Freeze/Thaw Modeling) to Appendix D to the Reclamation Plan Rev. 5.0:

1. *Please revise freeze/thaw analyses to incorporate the following:*

    a. *Extrapolation of frost depth to recurrence interval to a minimum period of up to 1,000 years, to the extent practicable, or, to not less than 200 years, using a Gumbel* *extreme statistics (probability functions) approach (e.g., Smith and Rager 2002; Smith 1999; Yevjevich 1982).*

b. *Additional justification for selection of an N -factor (surface temperature correction factor) of 0.6, instead of an N –factor of 0.7, based on published recommendations (e.g., DOE 1989).*

c. *Additional justification that using climate data for Grand Junction, Colorado in the Berggren Model Formula (BMF) is representative of site conditions at the White Mesa site Address the considerably lower elevation and average warmer temperatures of Grand Junction compared to the White Mesa site. Either (1) prepare and report results of the BMF calculations using a default location having an elevation and Design Freezing Index equal to or greater than those of the White Mesa site AND mean average temperatures equal to or less than those of the White Mesa site OR (2) justify that the Grand Junction data is applicable and representative as input to the BMF calculations for the White Mesa site.*

2. *Based on the results of the revised frost penetration analysis, justify revised soil parameter values for soils within the cover system above the projected frost penetration depth considering the effects of repeated freezing and thawing over the recurrence interval considered (referred to in Item 1.a above). Use these parameter values in performance assessment modeling, including infiltration modeling and radon attenuation modeling, consistent with recommendation provided in Sections 2.5 and 5.1 of NUREG-1620 (NRC 2003).*

3. *If applicable after addressing the instructions stated above, revise Appendix B to Appendix D of the Reclamation Plan to ensure that all intended text is present in the document.*

BASIS FOR INTERROGATORY:

The Division acknowledges that the Modified Berggren Formula has been used to estimate the depth of frost penetration at the site, relying upon input from a built-in long-term weather database. However, the input parameters do not account for extreme climate conditions. In addition, in Appendix B, it is noted that the mean annual temperature for Blanding given by Dames and Moore (1978) is 49.8 degrees F and the mean annual temperature for Grand Junction, CO, is 53.1 degrees F. The Grand Junction mean annual temperature used in the White Mesa calculations is higher, i.e, less conservative, than Blanding's mean temperature. Grand Junction's elevation is also considerably lower than that of either Blanding or the White Mesa site.

The use of a Gumbel extreme value statistics approach provides an accepted means for extrapolating a worst case value from a limited set of data. This technical approach has been successfully applied at other similar facilities (e.g., Monticello, Utah tailings repository cover – 200 year recurrence interval; Crescent Junction, Utah tailings repository cover- 1,000 year recurrence interval [e.g., see NRC 2008]). Extending the recurrence interval for the frost depth penetration analysis further informs predictions of potential future maximum frost penetration *depths and allows insights into the potential risk reduction afforded to performance assessment predictions made for evaluating the performance of the cover system over long term performance periods.*

U.S.D.O.E. (1989), based on recommendations by the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), and Smith (1999) recommend that an N-factor of 0.7 be used for landfill cover designs. Additional information should therefore be provided to support the selection and use of an N-factor value of 0.6, rather than 0.7, in the calculation, or alternatively, an N-factor value of 0.7 should be used in the calculation.

Section numbers in Appendix B of Appendix D of the Reclamation Plan suggest that sections are missing or that the section numbering is incorrect.

REFERENCES:

Denison Mines (USA) Corporation. 2011. Reclamation Plan, Revision 5.0, White Mesa Mill, Blanding, Utah, Appendix D: September 2011.

NRC 2003. NUREG-1620: Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978. Washington DC, June 2003.

NRC 2008. "Summary of Changes to Moab Disposal Cell Calculations". NRC ADAMS Website: Document Accession Number ML081700262.

Smith, G.M., and Rager, R.E. 2002. "Protective Layer Design in Landfill Covers Based on Frost Protection". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 128, No. 9, September 1, 2002, pp. 794-799.

Smith, G.M., 1999. Soil Insulation for Barrier Layer Protection in Landfill Covers, in Proceedings from the Solid Waste Association of North America's 4th Annual Landfill Symposium, Denver, Colorado, June 28-30, 1999.

U.S.D.O.E. 1989. Technical Approach Document, Rev. II, UMTRA-DOE/AL 050425.0002, Albuquerque, New Mexico.

Yevjevich, V. 1982. Probability and Statistics in Hydrology, 3rd Edition. Water Resources Publications, Littleton, Colorado.

INTERROGATORY WHITE MESA RECPLAN REV 5.0 R313-24-4; 10CFR40 APPENDIX A; INT 11/1: VEGETATION AND BIOINTRUSION EVUALATION AND REVEGETATION PLAN

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 1:-The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific siting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6). The following site features which will contribute to such a goal or objective must be considered in selecting among alternative tailings disposal sites or judging the adequacy of existing tailings sites:

- *Remoteness from populated areas;*
- *Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources; and*
- *Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term.*
- *The site selection process must be an optimization to the maximum extent reasonably achievable in terms of these features.*

In the selection of disposal sites, primary emphasis must be given to isolation of tailings or wastes, a matter having long-term impacts, as opposed to consideration only of short-term convenience or benefits, such as minimization of transportation or land acquisition costs. While isolation of tailings will be a function of both site and engineering design, overriding consideration must be given to siting features given the long-term nature of the tailings hazards.

Tailings should be disposed of in a manner that no active maintenance is required to preserve conditions of the site.

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 4: The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade:

(a) Upstream rainfall catchment areas must be minimized to decrease erosion potential and the size of the floods which could erode or wash out sections of the tailings disposal area.

(b) Topographic features should provide good wind protection.

(c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stabililty. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Executive Secretary will consider relaxing this requirement for extremely gentle slopes such as those which may exist on the top of the pile….

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 6(1): In disposing of waste byproduct material, licensees shall place an earthen cover (or approved alternative) over tailings or wastes at the end of milling operations and shall close the waste disposal area in accordance with a design which provides reasonable assurance of control of radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (ii) limit releases of radon-222 from uranium byproduct materials, and radon-220 from thorium byproduct materials, to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second (pCi/m^2s) to the extent practicable throughout the effective design life determined pursuant to (1)(i) of this Criterion. In computing required tailings cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances may not be considered. Direct gamma exposure from the tailings or wastes should be reduced to background levels. The effects of any thin synthetic layer may not be taken into account in determining the calculated radon exhalation level. If non-soil materials are proposed as cover materials, it must be demonstrated that these materials will not crack or degrade by differential settlement, weathering, or other mechanism, over long-term intervals.

INTERROGATORY STATEMENT:

Refer to Section 1.7.1, 3.3.1.0 and Appendices D and J of the Reclamation Plan Rev. 5.0: *Please provide the following:*

1. *Provide additional information (e.g., in the form of a survey and additional documentation of existing animal and vegetation species that exist at the White Mesa site and nearby surrounding region at this time to update the older information provided earlier.*
2. *Update the list of plant and animal species to include plant and animal species (e.g. burrowing animals) that could reasonably be expected to inhabit or colonize the White Mesa site within the required performance period of the embankment (1,000 years, and in no case less than 200 years). In revising these lists, account for the types of vegetation and soils present in the vicinity of the White Mesa site and proximity to the high quality northern pocket gopher and badger habitat indicated in Utah distribution maps (Utah Division of Wildlife Resources).*
3. *Please report the estimated range of burrowing depths and burrow densities for animal species found at the site and nearby surrounding region (once the updated study requested above is complete), and for burrowing species that may reasonably be expected to inhabit the site within the required performance period of the embankment (1,000 years, and in no case less than 200 years). Please comment on the root densities provided in Appendix D of the ICTM report. Indicate whether the*

correct root density units were used in Table D-3 and Figure D-1. Also verify that the correct values were used in the HYDRUS-2D infiltration model, since an erroneously high value of root density could overestimate plant transpiration and underestimate infiltration.

4. *Rectify the mischaracterization of two plant species as presented in the two referenced documents (Festuca ovina and common yarrow).*
5. *Provide additional documentation to support conclusions made regarding the ability of the proposed vegetation to establish at the cover percentages predicted. Also, provide additional discussion regarding the potential sustainability of the cover design and characteristics as proposed relative to changes that could occur due to the effects of natural succession and climate change during the performance period (1,000 years, and in no case less than 200 years).*
6. *Perform and report results of an additional infiltration sensitivity analysis to address the effects of deep-rooted plants projected by the updated analysis described above. In particular, account for any potentially deep-rooted species to assess the their effects of such deep-rooted species on the characteristics of soil layers in the embankment cover system. Please provide a forecasted percentage of potential species invasions in the ET cover system.*

BASIS FOR INTERROGATORY:

Burrowing animals have the potential to penetrate the cover system and disturb the waste tailings of a cell. The burrowing animal could disturb the cover system resulting in "channels for movement of water, vapors, roots, and other animals" EPA, Draft Technical Guidance for RCRA/CERCLA Final Covers, April 2004 [EPA 2004]). The extent of damage caused by animal burrowing depends on the animals burrowing depth ability. Mammals such as the badger and deer mouse have been reported at the site and/or nearby the site and can burrow to depths of 150–230 cm [4.9 to 7.5 ft] (Anderson and Johns 1977, Gano and States 1982, Cline, et al. 1982 and Lindzey 1976) and 50 cm [1.6 ft], respectively (Reynolds and Laundre 1988 and Reynolds and Wakkinen 1987, and Smith, et al. 1997). Moisture content and physical features of the soil can affect burrowing potential (Reichman and Smith 1990). Maximum burrowing depths for animals at or near the site should be identified and appropriate measures taken to protect the cover system, especially the radon barrier layer, from potential long-term damage/disruption by burrowing animals.

Although Dames and Moore (1978) did not report pocket gophers and reported badgers only had possibly a minor presence, the type of vegetation and soils present surrounding the facility is typical habitat and Utah distribution maps (Utah Division of Wildlife Resources) show that the facility is within or near the edge of high quality northern pocket gopher and badger habitat. Given the 34 years since the Dames and Moore study, these species could occur now and will likely occur at some point during the next 200 – 1000 years. Their potential presence needs to be acknowledged and considered in the design. Other burrowing species that are not addressed and should be assessed include coyote and red fox.

The prairie dog species that could occur in this area is Gunnison's prairie dog. The statement regarding maximum burrowing depths for Gunnison's prairie dog does not appear to represent *current data, for example Verdolin, Lewis, and Slobodchikoff (2008), which show studies with depths over one meter. The statement that prairie dogs are unlikely to colonize the tailing cells is generally true, but does not consider all potential events that could occur over an extended period of time, such as prolonged drought, fire, or natural succession, that could affect plant cover.*

The documents provide one reference (Waugh et al. 2008) for the ability to achieve 40% vegetation cover for a long-term average and 30% under drought conditions. More support is needed that this cover can be sustained long-term and under drought conditions. Regional data and/or data on the current plant cover of the grassland vegetation at the White Mesa Mill should be present to support these cover percentages. The ground cover measurements by Dames and Moore 1978 (provided on page 1-125 of Reclamation Plan) are substantially less than 40%, but were collected during a drought and were likely affected by past grazing.

The vegetation map and cover data presented in the Reclamation Plan Rev. 5.0 for the vegetation present at the facility are 35 years old and do not represent current conditions. In addition, some of the cells are identified as being partially reclaimed and no information is provided on reclamation methods or success that would support the claim of being able to achieve 40% average cover. Current data should be provided to support the estimates of potential cover expected to be achieved on the tailing cells. More detailed information should be provided on deep-rooted species that currently occur in the study area and that could become established on the tailing cells. There is little information provided on the composition of local plant communities.

The plan does not adequately address the potential for natural succession over the 200-1000 year time frame. The use of competitive grasses may exclude sagebrush for several decades, but may not work in perpetuity. Shrub succession in seeded grasslands is a common phenomenon, and appears to be occurring on portions of the seeded grasslands surrounding the White Mesa facility, based on current aerial photographs. There should be a discussion of natural successional processes that could occur. Big sagebrush is the regional climax dominant on deep soils such as the tailing cells will provide. The eventual occurrence of some amount of big sagebrush should be identified as a possibility and the analysis should include an evaluation of the compatibility of big sagebrush root systems with the cover design, including depth of the soil and compacted layers. The highly compacted zone is likely to exclude all or most roots, even for deep rooted species. References could be added to support this. There is a lower potential for establishment of piñon and juniper.

According to Dames and Moore (1978), Table 2.8-2, community types identified within the site boundary include Pinion-juniper Woodland, Big Sagebrush, and Controlled Big Sagebrush. Different published references indicate that Big Sagebrush in the western U.S. can exhibit deeper rooting depths (e.g., see Waugh, et al. 1994; Foxx, et al.1984; Klepper, et al. 1985, Reynolds 1990b). The statement in D.4.3 to Appendix D to Appendix D of the Reclamation Plan Rev. 5.0, that "… species like sagebrush, piñon pine, and Utah juniper have become dominant components of the regional flora primarily because of decades of overgrazing that has removed more palatable grasses and forbs and allowed less palatable woody species to establish and expand their range…" is an oversimplification and does not recognize that these species are the climax species over a large portion of the Intermountain area. While overgrazing has certainly *reduced the abundance of perennial grasses and has led to shrub/tree invasion in some areas, there is no evidence that these areas were primarily grassland prior to European settlement.*

Table D-3 lists root densities that were used in the infiltration modeling. The values range from zero to 6.2 grams per cubic centimeter. The same values are shown graphically in Figure D-1 and again in Appendix G, Figure G-1. It seems unreasonable to have such high root densities when the soil densities are no greater than about 2 grams per cubic centimeter. Clarify whether the units in Table D-3 (g cm-3) are correct. Alternative units might be milligrams (rather than grams) of roots per cubic centimeter or centimeters of root length per cubic centimeter of soil.

It appears that all of the conclusions in the analysis of the effects of climate change are based on one 23-year old study. Additional support is needed. In particular, the effects of extended droughts should be addressed in more detail.

The documents mischaracterize the native status of two species. Festuca ovina is considered to be introduced and not native throughout the entire lower 48 states (NRCS 2012). Common yarrow includes both introduced and native sub-species. The seed mix should specify the yarrow subspecies that is native to southern Utah. Several statements are made that the seed mix is comprised of natives, while it is actually a mix of native and introduced species.

In the Reclamation Plan Rev. 5.0, no information is provided for the Tamarisk-Salix community identified in Section 1.7.1. Based on current photography, they appear to be wetlands. It is unclear how they will be affected by reclamation activities.

REFERENCES:

Anderson, D. C., and Johns, D.W. 1977. "Predation by Badger on Yellow-Bellied Marmot in Colorado," Southwestern Naturalist, Vol. 22, pp. 283–284.

Cline, J.F.. 1979. Biobarriers Used in Shallow-Burial Ground Stabilization. Technical Report.. Pacific Northwest Laboratory PNL-2918. March 1, 1979.

Cline, J. F., K. A. Gano, and L. E. Rogers, 1980, "Loose Rock as Biobarriers in Shallow Land Burial," Health Physics, Vol. 39, pp. 494–504.

Cline, J. F., F.G. Burton, D. A. Cataldo, W. E. Skiens, and K. A. Gano. 1982. Long-Term Biobarriers to Plant and Animal Intrusion of Uranium Tailings, DOE/UMT-0209, Pacific Northwest Laboratory, Richland, Washington.

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, September 2011.

EPA (U.S. Environmental Protection Agency). 2004. (Draft) Technical Guidance for RCRA/CERCLA Final Covers. U.S EPA 540-R-04-007, OSWER 9283.1-26. April 2004, 421 pp. URL: nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10074PP.txt.

Foxx, T.S., G.D. Tierney, and J.M. Willimas, 1984. Rooting Depths of Plants Relative to Biological and Environmental Factors, Los Alamos Report LA-10254-MS, November 1984.

Gano, K. A. and J. B. States, 1982, Habitat Requirements and Burrowing Depths of Rodents in Relation to Shallow Waste Burial Sites, PNL-4140, Pacific Northwest Laboratory, Hanford, Washington.

Hakonson, T.E. 1986. Evaluation of Geologic Materials to Limit Biological Intrusion into Low-Level Radioactive Waste Disposal Sites. LA-10286-MS. Los Alamos National Laboratory, Los Alamos, New Mexico.

Lindzey, F. G. 1976. "Characteristics of the Natal Den of the Badger," Northwest Science, Vol. 50, No. 3, pp. 178–180.

Natural Resource Conservation Service (NRCS). 2012. Plants Database. http://plants.usda.gov/java/

Reichman, O.J., and Smith, S. C. 1990. "Burrows and Burrowing Behavior by Mammals," pp. 197-244 in H.H. Genoways, ed., Current Mammology. Plenum Press, New York and London. 1990.

Reynolds, T. D. and J. W. Laundre, 1988. "Vertical Distribution of Soil Removed by Four Species of Burrowing Rodents in Disturbed and Undisturbed Soils," Health Physics, Vol. 54, No. 4, pp. 445–450.

Reynolds, T. D. and W. L. Wakkinen, 1987. "Burrow Characteristics of Four Species of Rodents in Undisturbed Soils in Southeastern Idaho," American Midland Naturalist, Vol. 118, pp. 245–260.

Smith, E.D., Luxmoore, R.J., and Suter, G.W. 1997. "Natural Physical and Chemical Processes Compromise the Long-Term Performance of Compacted Soil Caps," in Barrier Technologies for Environmental Management – Summary of a Workshop. National Research Council, National Academy Press, Washington, DC., pp. D-61 to D-70.

Verdolin, Jennifer, Kara Lewis, and Constantine N. Slobodchikoff. 2008. Morphology of Burrow Systems: A Comparison of Gunnison's (Cynomy gunnisoni), White-tailed (C. leucurus), black-tailed (C. ludovicianus), and Utah (C. parvidens) Prairie Dogs. The Southwestern Naturalist 53(2): 201-207.

Waugh, W. J., M. K. Kastens, L. R. L. Sheader, C. H. Benson, W. H. Albright, and P. S. Mushovic. 2008. Monitoring the performance of an alternative landfill cover at the Monticello, Utah, Uranium Mill Tailings Disposal Site. Proceedings of the Waste Management 2008 Symposium. Phoenix, AZ.

INTERROGATORY WHITEMESA RECPLAN REV 5.0 R313-24-4; 10CFR40 APPENDIX A, CRITERION 6(4); INT 12/1: REPORT RADON BARRIER EFFECTIVENESS

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 6(4): Within ninety days of the completion of all testing and analysis relevant to the required verification in paragraphs (2) and (3) of 10CFR40, Appendix A, Criterion 6, the uranium mill licensee shall report to the Executive Secretary the results detailing the actions taken to verify that levels of release of radon-222 do not exceed 20 pCi/m^{2}s when averaged over the entire pile or impoundment. The licensee shall maintain records until termination of the license documenting the source of input parameters including the results of all measurements on which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. These records shall be kept in a form suitable for transfer to the custodial agency at the time of transfer of the site to DOE or a State for long-term care if requested.

INTERROGATORY STATEMENT:

Refer to Reclamation Plan Rev. 5.0, Section 3 (Tailings Reclamation Plan) and Appendix D (Updated Tailings Cover Design Report dated Sept 2011):

Please revise radon flux calculations using actual site-specific material properties data.

a. *Clearly demonstrate that values of material parameters:*

   1) *Are reasonably conservative*

   2) *Are based on site material samples, measured values, assumptions, or other origins*

   3) *Are based upon appropriate analytical methods and sufficient number of representative samples for cover soils and tailings*

   4) *Consider the variability and uncertainties in actual site-specific data.*

   5) *Are consistent with anticipated construction specifications*

   6) *Are based upon representative long-term site conditions.*

b. *Justify values of material parameters used in the radon flux calculations*

c. *Demonstrate that test methods and their precision, accuracy, and applicability are supported by suitable standards and procedures.*

d. *Justify that values chosen for radon emanation and diffusion coefficients are consistent with long-term moisture contents projected to exist within tailings and cover materials in the impoundments.*

e. *Demonstrate that the quality assurance program used in obtaining parameter data is adequate*

f. *Revise the design density and porosity values of cover soils to comply with the usual compaction of 95% of Standard Proctor (D 698). Alternatively, clearly justify the basis for the lower compactions utilized in the radon flux calculations and their expected long-term stability.*

g. *Please revise the tailings density, porosity, and moisture values to reflect expected long-term conditions in each of the disposal units. Alternatively, demonstrate the basis for the long-term stability of the values used in the radon flux calculations.*

h. *Please utilize one of the two accepted methods for long-term moisture estimates (D 2325 or Rawls correlation) with representative samples. Alternatively, justify the use of an acceptable alternative method.*

i. *Please resolve or justify the discrepancy between the 91.4 pcf "best correlation" between the Rawls and in-situ moisture data (Appendix D page C-4) and the density range of 94 to 111 pcf used in the radon flux calculations. Revise and report results of radon flux calculations, as necessary to reflect the resulting changes.*

j. *Please utilize a source term based on representative sampling and analysis of the sand, slime, and mixed tailings to 12-ft depths in sufficient and representative locations of each tailings area (e.g., Cells 2, 3, 4A, and 4B.). Alternatively, justify and use the average ore grade method identified in Reg Guide 3.64 for the radon flux calculations.*

k. *Please justify the assumed value of zero for Ra-226 concentrations in cover soils by sampling and measurement of background Ra-226 soil concentrations and comparison of their values with corresponding representative measurements in the proposed cover soils. Alternatively, use values of Ra-226 concentrations in radon flux calculations that are supported by cell-specific measurements.*

l. *Please utilize measured radon emanation coefficients that are representative of the sand, slime, and mixed tailings in the various tailings cell areas; emanation coefficients averaged over measurements for each tailings cell. Alternatively, use default values conservatively estimated from site-specific measurements.*

m. *Please utilize measured or calculated radon diffusion coefficients in radon flux calculations that represent the long-term properties of the tailings and cover soil materials.*

n. *Please provide written procedures for identifying and placing contaminated soils into the disposal cell(s) and substantiating characterization data and site history.*

o. *Provide a revised radon emanation model that incorporates lower values of initial bulk density for the erosion protection layer in the model. The bulk density value selected needs to fall within the range of bulk densities that is recommended (approximately 1.2 to 1.8 g/cm3, or about 75 to 112 pcf) in the section entitled "Soil Requirements for Sustainable Plant Growth" and listed in Table D-5 in Appendix D to the Reclamation Plan as the recommended range required for promoting sustainable plant growth.*

BASIS FOR INTERROGATORY:

a. *The material parameters used in the radon flux calculations are not shown to be reasonably conservative, and in some cases appear to be non-conservative. For example, the tailings density (1.19 g/cc) appears to correspond to only 71% of standard proctor (based on Appendix D Table 3.4-1). If tailings settle to a greater density upon cover placement, the required cover thickness is likely to increase.*

b. *The material parameters used in the radon flux calculations appear to ignore the variabilities and uncertainties in parameter values. For example, some random-fill moistures are estimated from 15-bar capillary suction values and others from the Rawls correlation, yet no account is given for their uncertainties, equivalence, or applicability in apparently combining them for the constant value of 7.8% moisture assumed for the range of cover layers (~78% to 92% of Proctor density based on Appendix D Table 3.4-1 values).*

c. *Supporting information was not found for the test methods, their precisions, accuracies, and applicability for the radon flux calculations.*

d. *Information was not found to identify the numerical origin of most parameter values used in the radon flux calculations, their basis in site samples, measurements, or assumptions.*

e. *Information was not found to link the radon emanation and diffusion coefficients used in the radon flux calculations to estimated long-term moisture contents at the site.*

f. *Information was not found to demonstrate that sufficient and representative samples were tested to adequately determine material property values. For example, the tailings radium and emanation values appear to be based on a single sample, whose identity, origin, or composition is not identified (sand, slime, mixture? [Attachment A.1.5]). Approximately half of all "random fill" to be used as cover soil appears to have never been sampled or characterized (Appendix D Table 2-1).*

g. *Information was not found about quality assurance applicable to the parameter data used in the radon flux calculations.*

h. *The consistency of material parameter values with anticipated construction specifications and representation of long-term site conditions is not demonstrated. For example, the material compactions of 71% for tailings, 82% for the first random fill layer, and 71% for the upper random fill layer may increase with time due to natural settlement under the cover weight and future land usage.*

i. *The target compaction values for two of the cover soil layers are less than the guideline compaction values.*

j. *The tailings density, porosity, and moisture value appear un-sustainable for long-term support of the overlying cover mass.*

k. *The deep in-situ moisture data referred to by NUREG-1620 Sec 5.1.3.1 (6) are intended for comparison with D 2325 or Rawls values, not for averaging with them. The intent is to assure that the measured D 2325 or Rawls values do not exceed the present field values. (i.e., the smaller of the 15-bar or in-situ moistures should be used).*

l. *The chosen long-term moisture values should have a clear and traceable origin in representative samples from the site.*

m. *The present Ra-226 concentration and radon emanation coefficient utilized for tailings in the radon flux calculations is not justified by sampling and analysis data from representative sands, slimes, and mixed tailings over the requisite depth interval and spatial distribution in the different tailings areas nor by the ore-grade method described in Regulatory guide 3.64.*

n. *The Reclamation Plan does not demonstrate that the proposed cover soil materials are not associated with ore formations or other radium-enriched materials or that their radioactivity is essentially the same as surrounding soils as demonstrated by an appropriate procedure. Procedures such as those in the MARSSIM manual are acceptable for this demonstration.*

o. *The single measured radon emanation coefficient of 0.19 lacks representation of sand, slime, mixed, and cell-specific materials, and in particular, any potentially different values derived from processing of alternate feed materials at the mill.*

p. *The radon diffusion coefficients used for tailings and cover soils in the radon flux calculations lack traceability to representative, valid estimates of long-term moisture contents, densities, and porosity values.*

q. *A written procedure was not found in the Reclamation Plan for identifying and placing in the disposal cell all contaminated soils on and adjacent to the processing site , substantiated by radiological characterization data and site history.*

r. *….In the referenced section of Appendix D to the Reclamation Plan, it is stated that bulk densities of emplaced cover materials will be specified in the cover design and will be controlled during cover construction to be within the sustainability range shown in Table*

D-5. The radon emanation modeling should therefore assume bulk density values for all cover layers that are representative of the range of recommended bulk densities.

NOTE: The same comments as above also apply to Appendix D (Vegetation Evaluation for the Evapotranspiration Cover) and Appendix H (Radon Emanation Modeling for the Evapotranspiration Cover) of the Infiltration and Contaminant Transport Modeling (ICTM) Report.

REFERENCES:

NRC 2000. NUREG-1575 Rev.1, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), August 2000.

NRC 2003. Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978. Washington DC, June 2003.

INTERROGATORY WHITEMESA RECPLAN REV 5.0 R313-24-4; 10CFR40, APPENDIX A, CRITERION 6(6); INT 13/1: CONCENTRATIONS OF RADIONUCLIDES OTHER THAN RADIUM IN SOIL

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 6(6): The design requirements in this criterion for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 square meters, which, as a result of byproduct material, does not exceed the background level by more than: (i) 5 picocuries per gram (pCi/g) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 centimeters (cm) below the surface, and (ii) 15 pCi/g of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm thick layers more than 15 cm below the surface.

Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more than one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed "1" (unity). A calculation of the potential peak annual TEDE within 1000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site must be submitted for approval. The use of decommissioning plans with benchmark doses which exceed 100 mrem/yr, before application of ALARA, requires the approval of the Executive Secretary after consideration of the recommendation of the staff of the Executive Secretary. This requirement for dose criteria does not apply to sites that have decommissioning plans for soil and structures approved before June 11, 1999.

Relevant NRC Guidance

Background Radiological Characteristics

> ***RG 3.8, Section 2.10****: Regional radiological data should be reported, including both natural background radiation levels and results of measurements of concentrations of radioactive materials occurring in important biota, in soil and rocks, in air, and in regional surface and local ground waters. These data, whether determined during the applicant's preoperational surveillance program or obtained from other sources, should be referenced.*

INTERROGATORY STATEMENT:

1. *Please propose appropriate soil background values (for different geological areas as needed) for Ra-226, U-nat, Th-230, and/or Th-232, as appropriate, with supporting data.*

2. *Please indicate whether elevated levels of uranium or thorium are expected to remain in the soil after the Ra-226 criteria have been met, and if so, describe your use of the*

radium benchmark dose approach (Appendix H of NUREG-1620) for developing decommissioning criteria for these radionuclides.

3. *Please provide a description of the instruments and procedures that will be used for soil background analyses, radium-gamma correlations, and verification data along with information about the sensitivity of the procedures.*

4. *Please provide final verification (status survey) procedures to demonstrate compliance with the soil and structure cleanup standards. The procedures should specify instruments, calibrations, and testing, and the verification soil sampling density should take into consideration detection limits of samples analyses, the extent of expected contamination, and limits to the gamma survey. The gamma guideline value should be appropriately chosen, and the verification soil radium-gamma correlation should be provided along with the number of verification grids that had additional removal because of excessive Ra-226 values. The plan should provide for adequate data collection beyond the excavation boundary. Surface activity measurements should demonstrate acceptable compliance with surface dose standards for any structures to remain onsite.*

BASIS FOR INTERROGATORY:

1. *Soil background values with supporting data were not found in the Reclamation Plan for Ra-226, U-nat, Th-230, and/or Th-232.*
2. *No assessment of potentially elevated levels of uranium or thorium was found in the Reclamation Plan for the post-Ra-226-reclamation site condition. This assessment should be included with the requisite benchmark dose approach if elevated uranium or thorium may remain.*
3. *The Reclamation Plan does not describe the instruments and procedures that will be used for soil background analyses, radium-gamma correlations, and verification data, nor information about the sensitivity of the procedures. Helpful information may be found in the MARSSIM Manual.*
4. *The requisite procedures were not found for final verification surveys of the site to demonstrate compliance with the soil and structure cleanup standards.*

REFERENCES:

NRC 1982. U.S. Nuclear Regulatory Commission, "Regulatory Guide 3.8; Preparation of Environmental Reports for Uranium Mills", Washington DC, October 1982.

NRC 2003. Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978. Washington DC, June 2003.

INTERROGATORY WHITE MESA RECPLAN REV 5.0 R313-24-4; 10CFR40 APPENDIX A; INT 14/1: COVER TEST SECTION AND TEST PAD MONITORING PROGRAMS

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 1:-The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific siting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6). The following site features which will contribute to such a goal or objective must be considered in selecting among alternative tailings disposal sites or judging the adequacy of existing tailings sites:

- *Remoteness from populated areas;*
- *Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources; and*
- *Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term.*
- *The site selection process must be an optimization to the maximum extent reasonably achievable in terms of these features.*

In the selection of disposal sites, primary emphasis must be given to isolation of tailings or wastes, a matter having long-term impacts, as opposed to consideration only of short-term convenience or benefits, such as minimization of transportation or land acquisition costs. While isolation of tailings will be a function of both site and engineering design, overriding consideration must be given to siting features given the long-term nature of the tailings hazards.

Tailings should be disposed of in a manner that no active maintenance is required to preserve conditions of the site.

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 6(1): In disposing of waste byproduct material, licensees shall place an earthen cover (or approved alternative) over tailings or wastes at the end of milling operations and shall close the waste disposal area in accordance with a design which provides reasonable assurance of control of radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (ii) limit releases of radon-222 from uranium byproduct materials, and radon-220 from thorium byproduct materials, to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second (pCi/m2s) to the extent practicable throughout the effective design life determined pursuant to (1)(i) of this Criterion. In computing required tailings cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances may not be considered. Direct gamma exposure from the tailings or wastes should be reduced to background levels. The effects of any thin synthetic layer may not be taken into account in determining the calculated radon exhalation level. If non-soil materials are proposed as cover materials, it must be demonstrated *that these materials will not crack or degrade by differential settlement, weathering, or other mechanism, over long-term intervals.*

INTERROGATORY STATEMENT:

***Refer to Section 8.0 of Attachment A (Technical Specifications and Attachment B (Construction Quality Assurance/Quality Control Plan) to the Reclamation Plan and Section 5.0 of Appendix D (Updated Tailings Cover Design Report) of the Reclamation Plan Rev. 5.0 (DUSA 2011a)**:*

1. *Please provide plans and specifications for constructing and performing monitoring and testing of a cover system section representative of the proposed ET cover system for verifying the hydraulic performance characteristics of the cover system. Demonstrate that the proposed test pad/plot will be sufficient in size to eliminate or minimize lateral boundary effects. Describe objectives and criteria for construction and testing of the test pad cover materials /layers. Include information in the CQAQC Plan regarding procedures for sampling and testing of the cover system section specifically pertinent to demonstrating the (short-term and long-term) performance of the ET cell cover design. Address, as part of the testing program, testing of parameters specifically recommended by Benson et al. 2011; Waugh et al. 2008; the National Research Council 2007; Albright et al. 2007; others) including, but not necessarily limited to:*

a. *Monitoring of in-situ soil water tension and volumetric water content as a function of time (e.g., using heat dissipation probes and TDR [time domain reflectometry]);*

b. *Monitoring of in-situ flux rates as a function of time (e.g., through use of one or more pan lysimeters as recommended by Benson et al. 2011 and Dwyer et al. 2007) on both north and south-facing slopes as required);*

c. *Physical sampling and laboratory testing for index properties, including Plasticity Index and saturated hydraulic conductivity, and other pertinent parameters including compaction properties, organic matter and CaCO3 content, and measurement of soil edaphic properties (properties that influence vegetation establishment and growth – e.g., see Waugh et al. 2008);*

d. *Other testing if needed for determining changes in water in storage and soil water characteristic curves (SWCCs, e.g., according to ASTM D6836 [ASTM 2008]) and monitoring for potential changes in SWCCs through time;*

e. *Conducting soil vegetation surveys (as recommended by Benson et al. 2011); and*

f. *Monitoring of relevant climatological parameters (precipitation and evaporation rates, temperature, barometric pressure, snow amounts, wind speed and wind direction, etc...), including continuous monitoring over several years necessary to understand how covers are influenced by fluctuations in climate and other environmental factors (Waugh et al. 2008) such as an extraordinarily wet year or consecutive wet years.*

2. *Provide additional information and plans and specifications for constructing and testing a cover system "test pad/test plot" prior to construction of the proposed ET cover system over the consolidated, dewatered tailings. Demonstrate that the proposed test pad/plot will be sufficient in size to eliminate or minimize lateral boundary effects. Describe objectives and criteria for construction and testing of the test pad cover materials /layers including but not limited to:*

a. *Acquisition of data of the types described in Item 1. above;*

b. *Determination of an acceptable zone (AZ) for soil textures in soils used for constructing the final cover system (e.g., Williams et al. 2010);*

c. *Determination of most effective means of "bonding" individual soil cover soil layers (e.g., Dwyer et al. 2007); and*

d. *Determination of appropriate lift thickness/placement and compaction equipment combinations (e.g., Dwyer et al. 2007).*

BASIS FOR INTERROGATORY:

The need for constructing and monitoring a cover test section representative of the proposed ET cover system, with supporting basis and rationale for building and monitoring such a test cover section, was previously addressed in a Round 1A Interrogatory submitted to DUSA on Revision 4.0 of the Reclamation Plan in October 2010. DUSA's response (DUSA 2011b) to that interrogatory indicated the following:

"Denison is not proposing a test pad for demonstrating short- and long-term performance of the alternative tailings cell cover system. Rather, Denison has completed extensive modeling of the cover system for demonstrating that the cover will perform effectively for a variety of climatic and vegetative scenarios. It may be possible to extend a portion of the cover system beyond the edge of the first tailings cell such that the hydraulic conditions within the cover system could be evaluated through time (in a test pad like setting) without causing deleterious effects to the cover above the tailings. This "test pad" would be further evaluated after approval of the cover design"; and

"Denison is proposing monitoring in situ performance of the alternative tailings cell cover system to include monitoring hydraulic conditions at nested intervals within the soil profile at three locations within the first tailings cell that is reclaimed. The depth intervals that are evaluated would depend on the final design specifications of the approved alternative cover system, but would likely represent data collected from three depths. The first depth interval would be located immediately below the soil-gravel admixture (0.6 feet), the second depth interval would be located near the midpoint of the maximum rooting depth (1.5 feet), and the third depth interval would be located at or slightly below the maximum rooting depth (3.8 feet) but above the proposed upper compacted layer;

"The pertinent hydraulic properties to be monitored would include soil water tension and volumetric water content. Soil water tension would be measured with a heat dissipation probe, while volumetric water content would be measured with a time domain reflectometry (TDR) probe. The use of these monitoring methods is consistent with what was used to monitor conditions as part of the Alternative Cover Assessment Program (ACAP). Changes in water

content through time can be used to assess changes in soil water storage through time. Measurements of volumetric water content and soil water tension can be related to the soil water retention and hydraulic conductivity curves to estimate a water flux rate and cover performance through time"…; and

"Climatological parameters are currently being measured at the site and include precipitation, wind speed, and wind direction. In addition, air temperature and barometric pressures are measured monthly for environmental air station calibrations. Based on this information in addition to supplemental climate data from the nearest weather station (Blanding, Utah station 420738), the daily amount of evapotranspiration can be computed."

Although the response provided by DUSA to the Round 1A Interrogatory includes a proposal to monitor the performance of the cover, additional details, including plans and construction specifications for constructing a representative cover section, and detailed sampling and testing procedures and associated quality assurance and quality control methods need to be provided that demonstrate that the test section and monitoring/testing program: (1) is consistent with applicable current published guidance for such programs: (2) is fully integrated with, and compatible with, the essential elements of the currently proposed ET Cover design; (2) that data acquired from the monitoring/testing program will allow the short-term and longer-term performance predictions made with regard to the proposed cover system to be validated.

Applicable recent published guidance documents include NUREG/CR-7028 (Benson et al. 2011), a peer-reviewed report published for the NRC in December 2011, which reports the findings from investigations of several earthen and soil/geosynthetic cover systems to assess changes in properties of cover materials in those cover systems 5 to 10 years following their construction. A key conclusion of the report is that findings from these investigations demonstrate that changes in the engineering properties of cover soils generally occur while in service (and that long-term engineering properties should be used as input to models employed for long-term performance assessments). The report indicates that changes in hydraulic properties occurred in all cover soils evaluated due to the formation of soil structure, regardless of climate, cover design, or service life. The report includes the following conclusions and recommendations:

- *Because cover systems change over time, they should be monitored to ensure that they are functioning as intended. Monitoring using pan lysimeters combined with secondary measurements collected for interpretive purposes (water content, temperature, vegetation surveys, etc.) is recommended; and*
- *At a minimum, at least one pan lysimeter having a minimum dimension of 10 m should be installed for performance monitoring. If only one lysimeter is installed, the location should be selected to represent the most unfavorable condition at the site.*

Additional relevant guidance documents include Waugh et al. 2008, Albright et al. 2007; Benson et al. 2007; and the National Research Council 2007, and Dwyer et al. 2007, which indicate that characteristics of the proposed alternative cover will inevitably change in the long term in response to climate, pedogenesis, and ecological succession.

Monitoring the proposed alternative cover system or monitoring of a test cover section simulating the cover system components and geometry) to assess the long-term performance of the alternative cover is needed to verify the characteristics and infiltration performance of the constructed cover system as well as to gain confidence in understanding long-term changes that may occur in the physical/hydraulic properties of the alternative cover system over time following its construction.

Additionally, a cover system test pad/test plot capable of assisting in confirming the performance of the proposed alternative cover system should be constructed and monitored. The proposed alternative cover design incorporates more loosely compacted soil layers. Dwyer et al. 2007, for example, describes results of recent research and field investigations of arid climate closure covers conducted by Los Alamos National Laboratory. As discussed in that report, lift thickness should be maximized for placement and compaction of a soil cover. During cover placement, it is crucial that each lift be bonded to the previous lift to cut down on the creation of interlift passageways (cracks) for the water to travel along as it passes from an overlying lift to a lower one. Test pads prior to cover material placement may prove beneficial in determining appropriate lift thickness/placement and compaction equipment combinations.

A full-scale cover system test pad/test plot can provide information that can lead to additional performance criteria for the cover design process. Quantification of soil properties, soil placement conditions and agronomic characteristics used in the test pad could, for example, help refine selection criteria for selection of onsite soils for use in final cover construction, including, further definition of soils that would result in a texture within a defined Acceptable Zone (AZ). The determination of the AZ for soil texture may be based on the field test pad demonstration, hydraulic property testing, and percolation modeling of the successful test plot soils.

REFERENCES:

Albright, W.H., Waugh, W.J., and Benson, C.H. 2007. "Alternative Covers: Enhanced Soil Water Storage and Evapotranspiration in the Source Zone." Enhancements to Natural Attenuation: Selected Case Studies, Early, T.O. (ed), pp 9-17. Prepared for U.S. Dept. of Energy by Washington Savannah River Company, WSRC-STI-2007-00250. URL: http://www.dri.edu/images/stories/research/programs/acap/acap-publications/10.pdf.

Benson, C.H., Sawangsuriya, A., Trzebiatowski, B., and Albright, W.H. 2007. "Postconstruction Changes in the Hydraulic Properties of Water Balance Cover Soils", Journal of Geotechnical and Geoenvironmental Engineering, 133:4, pp. 349-359.

Benson, C.H. W.H. Albright, W.H., Fratta, D.O.,Tinjum, J.M., Kucukkirca, E., Lee, S.H., J. Scalia, J., Schlicht, P.D., and Wang, X. 2011. Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment(in 4 volumes). NUREG/CR-7028, Prepared for the U.S. Nuclear Regulatory Commission, Washington, D.C., December 2011.

Denison Mines (USA) Corp. 2011a. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, September 2011.

Denison Mines (USA) Corp. 2011b. Responses to Supplemental Interrogatories – Round 1A for Reclamation Plan, Revision 4.0, November 2009. December 28, 2011.

Dwyer, S.F., Rager, R.E., and Hopkins, J. 2007. Cover System Design Guidance and Requirements Document. LA-UR-06-4715. EP2006-0667. Los Alamos National Laboratory. April 2007. URL: http://www.lanl.gov/environment/cleanup/req_docs.shtml

National Research Council 2007. Assessment of the Performance of Engineered Waste Containment Barriers. Board of Earth Sciences and Resources. The National Academies Press, Washington, D.C., 2007, 134 pp.

Waugh, W. J., M. K. Kastens, L. R. L. Sheader, C. H. Benson, W. H. Albright, and P. S. Mushovic. 2008. Monitoring the performance of an alternative landfill cover at the Monticello, Utah, Uranium Mill Tailings Disposal Site. Proceedings of the Waste Management 2008 Symposium. Phoenix, AZ.

Williams, L.O., Zornberg, J.G., Dwyer, S.F., Hoyt, D.L., and Hargreaves, G.A. 2010. "Design Rationale for Construction and Monitoring of Unsaturated Soil Covers at the Rocky Mountain Arsenal. 6th International Congress on Environmental Geotechnics, New Delhi, India. URL: http://www.ce.utexas.edu/prof/zornberg/pdfs/CP/Williams_Zornberg_Dwyer_Hoyt_Hargreaves_2010.pdf

INTERROGATORY WHITEMESA RECPLAN REV 5.0 R313-24-4; 10CFR40, APPENDIX A, CRITERION 9; INT 15/1: FINANCIAL SURETY ARRANGEMENTS

REGULATORY BASIS:

UAC R313-24-4 invokes the following requirement from 10CFR40, Appendix A, Criterion 9: Financial surety arrangements must be established by each mill operator prior to the commencement of operations to assure that sufficient funds will be available to carry out the decontamination and decommissioning of the mill and site and for the reclamation of any tailings or waste disposal areas. The amount of funds to be ensured by such surety arrangements must be based on Executive Secretary-approved cost estimates in a Executive Secretary-approved plan for (1) decontamination and decommissioning of mill buildings and the milling site to levels which allow unrestricted use of these areas upon decommissioning, and (2) the reclamation of tailings and/or waste areas in accordance with technical criteria delineated in Section I of this Appendix. The licensee shall submit this plan in conjunction with an environmental report that addresses the expected environmental impacts of the milling operation, decommissioning and tailings reclamation, and evaluates alternatives for mitigating these impacts. The surety must also cover the payment of the charge for long-term surveillance and control required by Criterion 10. In establishing specific surety arrangements, the licensee's cost estimates must take into account total costs that would be incurred if an independent contractor were hired to perform the decommissioning and reclamation work. In order to avoid unnecessary duplication and expense, the Executive Secretary may accept financial sureties that have been consolidated with financial or surety arrangements established to meet requirements of other Federal or state agencies and/or local governing bodies for such decommissioning, decontamination, reclamation, and long-term site surveillance and control, provided such arrangements are considered adequate to satisfy these requirements and that the portion of the surety which covers the decommissioning and reclamation of the mill, mill tailings site and associated areas, and the long-term funding charge is clearly identified and committed for use in accomplishing these activities. The licensee's surety mechanism will be reviewed annually by the Executive Secretary to assure, that sufficient funds would be available for completion of the Reclamation Plan if the work had to be performed by an independent contractor. The amount of surety liability should be adjusted to recognize any increases or decreases resulting from inflation, changes in engineering plans, activities performed, and any other conditions affecting costs. Regardless of whether reclamation is phased through the life of the operation or takes place at the end of operations, an appropriate portion of surety liability must be retained until final compliance with the Reclamation Plan is determined.

INTERROGATORY STATEMENT:

1. *Justify the decrease in costs estimated for mill decommissioning and reclamation of Cells 1, 2, and 3 from those estimated in the White Mesa Reclamation Plan, Rev. 4.0 dated November 2009. Explain why several estimated levels of effort (e.g., total effort for Mill Yard Decontamination, Ore Storage Pad Decontamination, Equipment Storage Area Cleanup and Cell 1 Construct Channel) are smaller in 2011 than those estimated in 2009. Explain and rectify apparent discrepancies between labor rates used in cost estimates and those presented in the exhibit in Attachment C titled "Labor Costs".*

2. *Identify analytes for which soil samples identified in the cost estimate for "Cleanup of Windblown Contamination" will be analyzed. Justify (or revise with justification) the assumed sample analysis cost of $50.*
3. *Revise and report estimated reclamation costs, incorporating responses to instructions listed above.*
4. *Estimate and report the costs for a third party to conduct decommissioning and impoundment reclamation in the coming year rather than at the end of planned life.*
5. *Please provide and justify estimates of costs associated with complying with the current Air Quality Approval Order (DAQE-AN1205005-06, issue date July 20, 2006) and License Condition 11.4 and 11.5 during final reclamation, as stated in Section 1.5 of Reclamation Plan 5.0, Attachment A, Technical Plans and Specifications.*
6. *Please state and justify the times projected to be necessary to dewater Cell 2 and Cell 3. Provide and justify estimates of all costs associated with the apparently lengthy dewatering time for Cell 2 and Cell 3.. Also see Interrogatory 7/01, item 8.*

BASIS FOR INTERROGATORY:

Comparing the cost estimate contained in Attachment C to Reclamation Plan Rev. 4.0 2009 with those contained in Attachment C to Reclamation Plan Rev. 5.0 2011 reveals differences that should be addressed. Contrary to expectations, the costs associated with mill decommissioning and reclamation of most of the cells and some durations and levels of effort are smaller in 2011 than they were in 2009. Some labor costs are not obviously supported by the data sources presented in the attachment.

Once Items 1 and 2 above have been addressed, the reclamation cost estimate should be revised and resubmitted.

Without justification for an assumption to the contrary, the Division interprets the cost estimate as applying to decommissioning and reclamation that occur at the projected end of facility life. If so, the Licensee should also estimate the cost to decommission the mill area and reclaim all ponds under conditions likely to exist within the next year. The financial assurance provided should ensure that funds sufficient to cover costs of decommissioning and reclaiming within the next year are available to the State.

Costs associated with complying with the current Air Quality Approval Order and License Condition 11.4 and 11.5 during final reclamation need to be included in the surety. Section 1.5 of Reclamation Plan 5.0, Attachment A, Technical Plans and Specifications, states that reclamation will comply with State of Utah Air Quality Approval Order (DAQE-AN1205005-06, issue date July 20, 2006).

The times required to dewater Cell 2 and 3 appear to will be lengthy, based on current dewatering rates. Costs associated with this lengthy dewatering time for Cell 2 and 3 need to be included in the surety.

REFERENCES:

Denison Mines (USA) Corp. 2009. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 4.0, November 2009.

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011.

INTERROGATORY WHITE MESA REC PLAN REV 5.0 R313-15-501; INT 16/1; RADIATION PROTECTION MANUAL

REGULATORY BASIS:

UAC R313-15-501; Surveys and Monitoring General invokes the following requirement from 10CFR40, Appendix A, Criterion 1: "(1) Each licensee or registrant shall make, or cause to be made, surveys that:(a) Are necessary for the licensee or registrant to comply with Rule R313-15; and(b) Are necessary under the circumstances to evaluate:(i) The magnitude and the extent of radiation levels; and(ii) Concentrations or quantities of radioactive material; and(iii) The potential radiological hazards.

INTERROGATORY STATEMENT:

Refer to Appendix D, Radiation Protection Manual for Reclamation: *Provide information on how these largely operational radiation protection practices will change to support the changed needs of decommissioning and reclamation. Describe how the Radiation Protection program will be evaluated and revised to address the range of activities required to support decommissioning and reclamation activities. The following are selected examples of topics (not exhaustive) that should be evaluated and possibly revised to support decommissioning and reclamation.*

- ***Section 1.3 Beta Gamma Surveys:*** *Conduct beta gamma frisk surveys where appropriate during decommissioning and reclamation.*
- ***Section 1.4 Urinalysis Surveys:*** *State the frequency of conducting urinalyses during decommissioning and reclamation.*
- ***Sections 2.1.2, 2.3.2, 2.4.2 Frequency/locations:*** *State how the frequency and locations for all monitoring methods will be modified to accommodate decommissioning and reclamation activities.*

BASIS FOR INTERROGATORY:

The Radiation Protection program provides information on regarding current operations but does not any information on how these practices will change to support reclamation. While reclamation will occur at a future date and the specific details may not be available at this time, it is important that the Radiation Protection Program identify the approach that will be taken to address these needs.

REFERENCES:

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011 :Attachment D Radiation Protection Manual for Reclamation September 2011

INTERROGATORY WHITE MESA REC PLAN REV 5.0 R313-15-1002; INT 17/1; RELEASE SURVEYS

REGULATORY BASIS:

UAC R313-15-1002; Method for Obtaining Approval of Proposed Disposal Procedures. A licensee or registrant or applicant for a license or registration may apply to the Executive Secretary for approval of proposed procedures, not otherwise authorized in these rules, to dispose of licensed or registered material generated in the licensee's or registrant's operations. Each application shall include:(1) A description of the waste containing licensed or registered material to be disposed of, including the physical and chemical properties that have an impact on risk evaluation, and the proposed manner and conditions of waste disposal; and(2) An analysis and evaluation of pertinent information on the nature of the environment; and(3) The nature and location of other potentially affected facilities; and(4) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in Rule R313-15.

INTERROGATORY STATEMENT:

Refer to Attachment D, Section 2.6, Release Surveys: *Revise to address the decontamination, release, and disposal of equipment and buildings necessary to support decommissioning and reclamation. Develop and present detailed release survey procedures and identify appropriate radiation survey equipment that will be used. Develop and present additional decontamination procedures during decommissioning and reclamation and include section on disposal of equipment that cannot be decontaminated.*

BASIS FOR INTERROGATORY:

The decommissioning plan indicates equipment and structural material may be removed, decontaminated and surveyed for unrestricted release. But the radiation protection plan does not include procedures, or identify instruments that would be used on conduct these release surveys. NUREG-1575 Supplement 1 "Multi-agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)" may be helpful in developing these procedures.

REFERENCES:

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011 :Attachment D Radiation Protection Manual for Reclamation September 2011

INTERROGATORY WHITE MESA REC PLAN REV 5.0 R313-12; INT 18/1: INSPECTION AND QUALITY ASSURANCE

REGULATORY BASIS:

UAC R313-12: an individual who has the knowledge and responsibility to apply appropriate radiation protection rules and has been assigned such responsibility by the licensee or registrant.

INTERROGATORY STATEMENT:

Refer to Attachment A, Plans and Technical Specifications, Section 1.6, Inspection and Quality Assurance: *Revise the provided the "Radiation Protection Manual for Reclamation" cited in this section, to define the responsibilities and duties of the Radiation Safety Officer.*

Refer to Attachment A, Plans and Technical Specifications, Section 1.8b, Inspection and Quality Assurance: *Revise the wording to indicate that the DRC* **must** *review and approve all design modifications to the Reclamation Plan.*

BASIS FOR INTERROGATORY:

Although Attachment A points to "Radiation Protection Manual for Reclamation" in identifying responsibilities and duties of the Radiation Safety Officer, the provided manual does not identify these responsibilities. The Radiation Safety Officers responsibilities during reclamation need to be identified, as they will be different than what is required during operations.

DRC must be designated to approve of any design modifications to the Reclamation Plan. Section 1.8b of Reclamation Plan 5.0, Attachment A, Technical Plans and Specifications, describes "Possible submittal to, and review by, DRC for approval" of design modifications. Attachment A needs to be revised to indicate that the DRC must review and approve all design modifications to the Reclamation Plan.

REFERENCES:

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011 :Attachment A, Plans and Technical Specifications

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011 :Attachment D, Radiation Protection Manual for Reclamation September 2011

INTERROGATORY WHITE MESA REC PLAN REV 5.0 R313-24; 10 CFR 40.42(J); INT 19/1: REGULATORY GUIDANCE

REGULATORY BASIS:

<u>UAC R313-24 incorporates 10 CFR 40.42(j) by reference:</u> As the final step in decommissioning, the licensee shall--(1) Certify the disposition of all licensed material, including accumulated wastes, by submitting a completed NRC Form 314 or equivalent information; and (2) Conduct a radiation survey of the premises where the licensed activities were carried out and submit a report of the results of this survey, unless the licensee demonstrates in some other manner that the premises are suitable for release in accordance with the criteria for decommissioning in 10 CFR part 20, subpart E or, for uranium milling (uranium and thorium recovery) facilities, Criterion 6(6) of Appendix A to this part.

INTERROGATORY STATEMENT:

Refer to Attachment A, Plans and Specifications, Sections 6.4 Guidance: *Please revise the decommissioning plan to reference and incorporate current guidance, namely NUREG-1757 "Consolidated Decommissioning Guidance"; NUREG-1575 "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)"; and NUREG-1575 Supplement 1 "Multi-agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)"*

BASIS FOR INTERROGATORY:

This document references the use of NUREG-5849: "Manual for Conducting Radiological Surveys in Support of License Termination" as the applicable guidance document. The current NRC guidance documents for decommissioning are NUREG-1757 "Consolidated Decommissioning Guidance"; NUREG-1575 "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)"; and NUREG-1575 Supplement 1 "Multi-agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)".

REFERENCES:

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011: Attachment A, Plans and Technical Specifications

INTERROGATORY WHITE MESA REC PLAN REV 5.0 R313-24,;10 CFR 40 APPENDIX A CRITERION 6(6); INT 20/1: SCOPING, CHARACTERIZATION, AND FINAL SURVEYS

REGULATORY BASIS:

UAC R313-24 incorporates by reference 10 CFR 40 Appendix A Criterion 6(6): The design requirements in this criterion for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 square meters, which, as a result of byproduct material, does not exceed the background level by more than: (i) 5 picocuries per gram (pCi/g) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 centimeters (cm) below the surface, and (ii) 15 pCi/g of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm thick layers more than 15 cm below the surface.

INTERROGATORY STATEMENT:

1. ***Refer to Attachment A, Plans and Specifications, Sections 6.6 Scoping Surveys & Figure A-1:*** *Provide a figure identifying the areas and survey grid sizes. Clarify how use of the large grids and the spacing shown in Figure A-1 will ensure compliance with the 100 square meter criteria. Explain how samples will be collected from these larger grids.*
2. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.6 Scoping Surveys:*** *Provide details (including information on instrument sensitivity) on the beta gamma radiation instruments that will be used for the scoping surveys. Indicate the frequency of calibration checks, daily operational checks, and other QA/QC requirements for the instruments. Also indicate whether these same instruments (used during facility operations) will be used for subsequent characterization, remediation, and final survey work.*
3. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.6 Scoping Surveys****: Explain how areas contaminated with radium, thorium, and uranium will be identified and surveyed to ensure they will not result in a dose that is greater than the radium standard alone.*
4. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.6 Scoping Surveys:*** *Identify what types of samples (e.g., grab or composite samples) will be collected to support developing the gamma correlation. Explain how locations for taking these samples will be selected. State how many correlations will be developed and how they will differ from each other.*
5. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.6 Scoping Surveys:*** *Identify the analytes including radioisotopes for which samples will be analyzed by chemical analysis and identify the preferred analytical method.*
6. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.6 Scoping Surveys:*** *Provide information on how other materials that may be left will be identified during scoping surveys. Identify additional survey procedures for alpha beta and gamma surface surveys as appropriate.*
7. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.7 Characterization and Remediation Control Surveys:*** *Explain how many and how samples will be collected to*

ensure the correlation developed for the scoping is consistent with the characterization and reclamation surveys. Explain how the correlation will be modified to address gamma variations that may arise during decommissioning and reclamation?

8. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.8 Final Survey, Figure A-2 and Attachment B Construction QA/QC Plan, Section 5.4.1:*** *Please clarify the terminology used in the two documents. Ensure that the activities described are consistent. Provide details on how the 10% of locations are selected for sampling. Demonstrate that collection of four samples as shown on Figure A-2 is sufficiently representative of the entire 100-square-meter area. Explain whether samples taken from the four sample locations identified in Figure A-2 will be analyzed separately or will be composited.*

9. ***Refer to Attachment A, Plans and Technical Specifications, Sections 6.8 Final Survey, Figure A-2:*** *Explain how the areas where final survey soil sample results exceed the criteria will be addressed. State the basis for determining whether additional removal will be required. A soil sample that exceeds the criteria may also indicate a problem with the gamma correlation. Since the majority of the area will be released based on the gamma correlation, explain how the gamma correlation will be reviewed to ensure the use of the correlation in place of sampling is still valid.*

BASIS FOR INTERROGATORY:

1. *The discussion in Section 6.6 does not clearly identify the survey grid sizes that will be used in the described areas. Figure A-1 describes a serpentine gamma survey path, but this also indicates that a total of 3 transects across the 30 meter grid will be made. With each transect representing only a 1-meter-square area, a significant majority of the grid is not surveyed, and compliance with the 100-square-meter standard cannot be documented. It is unclear how the 30m x 30m grid relates to the 50m x50m grid.*

2. *Without more detailed information on the instrument that will be used it is impossible to determine if the sensitivity is appropriate to verify compliance with the standard.*

3. *While the radium standard is appropriate for much of the site, as mentioned in the technical specifications there are areas that are contaminated with a combination of nuclides, how will these be identified, and what other survey procedures will be used to ensure the uranium and thorium are addressed.*

4. *The general criteria for identifying appropriate sample locations should be developed to ensure the resulting correlation is appropriate. Typically correlations are generated based on grab samples but the discussion does not detail how the samples will be collected. Also it appears that multiple correlations may be developed so proper communication regarding which correlation is appropriate for each area is necessary to ensure compliance with the soil standard.*

5. *Specifics on the analyses to be performed are necessary to evaluate the proposed correlations. The analytical methods need to be identified to ensure the appropriate analytical costs are included in the cast estimate.*

6. *Additional definition and description is required to provide assurance that all contaminants will be identified and properly processed during decommissioning and reclamation.*

7. *The gamma correlation that is developed for the scoping surveys may be valid, how will variations in gamma rates associated with excavation depth and differences in material at depth be addresses.*
8. *The radiological survey descriptions in the documents are not consistent. The characterization survey described in Attachment B is different than the characterization remediation survey described in Attachment A. Without consistent terminology and survey descriptions it is impossible to evaluate the survey descriptions. To ensure that collecting samples at only 10% of the remediated grids is sufficient, the criteria used as the basis for the 10% must be provided. Typically, composite soil samples for a 100 square meter area include between 5 and 11 aliquots to ensure the data is representative of the entire area.*
9. *The plan should contain a commitment to perform a radium-gamma correlation on the verification data, to track soil samples that fail the Ra-226 criteria, and to perform additional cleanup after a verification soil sample exceeds the Ra-226 standard. Just cleaning the failed grid is not adequate because the failed sample could indicate that the gamma value may not be conservative and that some of the unsampled grids may also fail to meet the standard. For example, the plan could indicate that neighboring grids would also be analyzed for Ra-226 or, if the number of failed grids is excessive, the gamma guideline would be adjusted downward and areas further remediated, as necessary.*

REFERENCES:

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011; Attachment A, Plans and Technical Specifications

Denison Mines (USA) Corp., 2011. Reclamation Plan, White Mesa Mill, Blanding, Utah, Radioactive Materials License No. UT1900479, Revision 5.0, Appendix E, September 2011: Attachment B, Construction Quality Assurance/Quality Control Plan