ADDENDUM A

Final Remedial Action Plan
DOE-EM/GJ1547
March 2024

DOE Responses to NRC Comments

Number	Title	
April 2006	NRC Comments and DOE Responses, April 2006 Meeting	
June 2006	NRC Comments and DOE Responses, June 2006 Meeting	
February 2007	NRC Comments and DOE Responses, February 2007 Request for Additional Information	
September 2007	NRC Comments and DOE Responses, September 2007 Open Issues Meeting	
Final RAP 2008	NRC Comments and DOE Responses, Final RAP 2008	
December 2021	NRC Comments and DOE Responses, revised RAP 60% Design December 2021	
November 2022	NRC Comments and DOE Responses, revised RAP 90% Design November 2022	
August 2023	UNITED STATES NUCLEAR REGULATORY COMMISSION STAFF OPTIONS FOR MOVING FORWARD ON UNITED STATES DEPARTMENT OF ENERGY MOAB URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT ALTERNATIVE FINAL COVER SYSTEM 90 PERCENT DESIGN REPORT (DOCKET WM00110).	NRC Design Options
September 2023	DOE Moab UMTRA Responses to Nuclear Regulatory Commission (NRC) Staff Additional Comments on “Crescent Junction Disposal Site Alternative Final Cover System 90 Percent Design Report”	DOE agreement to NRC Design Options

ADDENDUM A – NRC COMMENTS AND DOE RESPONSES

April 2006 Meeting

Geology

1(a). "Linear feature - explain further why the stratigraphy of the Prairie Canyon Member defines the lineament..." It is asserted that the lineament is stratigraphically controlled, i.e., there is little direct technical support provided in the RAP that an informed reviewer could rely on to concur. The nature of the contact of the two members of Mancos Shale that are adjacent to or directly underlie the footprint take on importance for understanding present and future site conditions and the behavior of surface and ground water that flows across and through the contact zone. If the contact is stratigraphic, explain why is it not linear everywhere it is exposed. If the lineament cannot be explained definitively as stratigraphic, then it may be structural, such as a fault contact. Such a possibility would entail investigating whether or not it is a capable fault.

1(b). "...and that the linear feature is not offset by faults." The applicant's idea of explaining why the linear feature is not offset by faults (and the significance of such an observation) is potentially useful for showing structural integrity of the lineament only where it is exposed to scrutiny.

Response for 1(a) and 1(b):
The stratigraphic horizon referenced in this comment is represented by discontinuous concretionary masses of dolomitic siltstone that mark the top of the Prairie Canyon Member. These resistant concretionary masses are near the north edge of the disposal cell footprint in the south parts of Sections 22 and 23, as shown in the March 12, 2007, geologic map. Exposures of this stratigraphic horizon are not linear everywhere because the exposures are characteristically poor and the concretionary masses are discontinuous both along strike and along dip. Additionally, subtle spatial variations in strike and dip directions within the Mancos Shale, coupled with the topographic elevation of the individual exposures, cause the exposed masses to appear nonlinear in outcrop. Stratigraphic characteristics of the Prairie Canyon Member of the Mancos Shale at the Crescent Junction Site are similar to the descriptions provided in two important references (listed here).

Cole, R.D., R.G. Young, and G.C. Willis, 1997. *The Prairie Canyon Member, a New Unit of the Upper Cretaceous Mancos Shale, West-Central Colorado and East-Central Utah,* Utah Geological Survey Miscellaneous Publication 97-4.

Hampson, G.J., J.A. Howell, and S.S. Flint, 1999. "A Sedimentological and Sequence Stratigraphic Re-Interpretation of the Upper Cretaceous Prairie Canyon Member ("Mancos B") and Associated Strata, Book Cliffs Area, Utah, U.S.A.," *Journal of Sedimentary Research*, 69(2), pp. 414–433.

The revised calculation set for Surficial and Bedrock Geology of the Crescent Junction Disposal Site (Attachment 2, Appendix B) includes additional mapping results, stratigraphic descriptions, and literature citations that describe this important horizon in the Prairie Canyon Member.

2. "Provide photo(s) from the top of the Book Cliffs showing the lineament." [does not affect RAP]. This request was made to enable the NRC staff to inspect the lineament more clearly in a larger form than what is in the draft RAP.

Response:
Four photographs taken on July 19, 2005, from the top of the Book Cliffs just north of the site, showing the subject lineament, were sent to the NRC on May 3, 2006, for their inspection.

3. "Linear feature - evaluate any geophysical reflection data on fracture orientations in boreholes (005 and 023) and corehole (0201) north of the lineament." The objective of such investigations appears to be to obtain data on the characteristics of the contact zone and to seek evidence for the origin of the lineament. Such data may be potentially useful for assessing the geomechanical properties of the rocks, flow and transport properties and conceptual models of the rocks at and near the site.

Response:
Geophysical seismic surveys conducted at the site consisted of the refraction rather than the reflection method. The refraction survey was conducted to obtain shear wave velocities in the weathered Mancos Shale to determine its rippability characteristics. The refraction survey area was south of the lineament, and this survey method would not provide useful data for a lineament investigation.

4. "Low sun-angle photos - send a copy to NRC for inspection." [does not affect RAP]. The request was made because the photos were identified, but not provided in the draft RAP.

Response:
A set of low sun-angle photographs taken on July 27, 2005, was sent to the NRC on May 3, 2006, for their inspection.

5(a). "Document/evaluate rates of changes of surface geologic processes such as scarp retreat of the Book Cliffs…"

5(b). "…rock falls and roll distances (petroglyph dates),..." These geomorphic processes result in (i) erosion of the cliffs that dominate the site by gravity, running water and wind, (ii) the transport of rock particles of all sizes up to large boulders, and (iii) the deposition of the rock particles. The smaller particles, sizes up to small boulders, are shown on photos and reported to have been transported to (and impinge upon) the proposed footprint and beyond (lower elevations), largely by sheet wash. There is a need to quantify or otherwise bound the sediment loading of the surface drainage system for the next 200 to 1,000 years as input to the design of the impoundment to achieve the necessary performance.

Response for 5(a) and 5(b):

Northward scarp retreat of the Book Cliffs was estimated from average scarp retreat rates in the literature (listed here) for the Book Cliffs and for rock types in arid environments at 5 feet (ft) per thousand years.

Schumm, S.A., and R.J. Chorley, 1983. *Geomorphic Controls on the Management of Nuclear Waste*, prepared for the U.S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-3276.

Woodward-Clyde Consultants, 1983. *Overview of the Regional Geology of the Paradox Basin Study Region,* unpublished technical report ONWI-92, prepared for the Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio, March.

Rock art (petroglyphs) on several boulders at the base of the Book Cliffs is from the Fremont era of 200 BC to 1350 AD. This gives a minimum age of the rock falls as 650 years, but they could have fallen as long as 2,200 years or more ago. Calculation of the rock fall runout distance for rocks falling from the top of the Book Cliffs was made along two profiles, using an empirical angle that defines the limit of runout. Distances from the empirical rock-fall runout limits from the two profiles to the edge of the disposal cell footprint were 900 and 950 ft. This indicates the disposal cell and any access roads or infrastructure are far enough from the base of the Book Cliffs to not pose a hazard from rock falls.

The scarp retreat rate information was included in the revised calculation set for Site and Regional Geomorphology – Results of Literature Research (RAP Attachment 2, Appendix C). Information on rock-fall runout distances was included in the revised calculation set for Site and Regional Geomorphology   Results of Site Investigations (Attachment 2, Appendix D).

5(c). "...and rate of incision (headcutting) migration of West Kendall and Crescent Washes." In fact, the potential hazard to the proposed impoundment from any stream, wash or gully that may erode headward and intersect or otherwise affect the impoundment in the next 200 to 1,000 years needs to be fully investigated and evaluated as potential inputs to design for mitigation.

Response for 5(c):

Forecasts of headward erosion are in the revised calculation set for Photogeologic Interpretation and in the revised calculation set for Site and Regional Geomorphology Results of Site Investigations (RAP Attachment 2, Appendices G and D, respectively). The progress of headward incision of three tributaries of the West Branch of Kendall Wash was compared in the registered historical aerial photographs from 1944, 1974, and 2005. Results showed the progress of headcuts was approximately 1.3 to 2.3 ft per year over the 60-year period. At these rates, headward erosion would reach the site access road in about 250 years and just outside the southwest corner of the disposal cell in about another 250 years. Approximately 1,600 years of headcutting would be required to reach northwestward to Crescent Wash, where a capture of that drainage by the West Branch would be possible.

To protect the disposal cell from the headcutting, the outlet of the main diversion channel coming from the north side of the disposal cell has been extended away from the cell and with sufficient riprap at the outlet. In addition, a rock apron was also designed around the toe of the east, west, and south sides of the cell to protect against erosion and dissipate energy from cell runoff.

6(a). "Evaluate the effect (if any) of fractures on weathered Mancos Shale and on hydrology."

Because fractures exist at the site and beyond (from observations of pits, core and outcrops) in weathered (and unweathered) Mancos Shale, characteristics of fractures in both the Prairie Canyon and Blue Gate Members should be investigated only to the level of detail commensurate with their significance to design and to performance evaluations.

6(b). Suggest DOE prepare explicit characteristics of "weathered" and "unweathered" Members of the Mancos Shale, given that these are end members of a gradational series. The goal is to minimize ambiguous data from samples that are partially weathered or partially unweathered. Implicit in the description of the characteristics of the weathered Mancos Shale, such as fractures, is the need to describe the characteristics that distinguish the weathered Mancos Shale from the bedrock Mancos Shale (for both the Prairie Canyon and Blue Gate Members). DOE stated at the meeting that the weathered zone of the Mancos grades gradually into the unweathered (bedrock) Mancos, making it necessary to describe criteria to distinguish each type of shale.

Response for 6(a) and 6(b):
Characteristics of weathered and unweathered Mancos Shale bedrock for both the Prairie Canyon and Blue Gate Members were compiled from corehole lithologic logs and RQD data and are in Figure 8 in the revised calculation set for Surficial and Bedrock Geology of the Crescent Junction Disposal Site (RAP Attachment 2, Appendix B).

7. "Evaluate more fully the reason(s) for the abandonment of the course of the ancestral East Branch of Kendall Wash and assess if future drainage abandonments could occur and their effect on the site." The significance of a stream abandonment on a bajada or pediment for understanding future stability or predictability of drainage networks depends on the cause(s), rates of reestablishment of the drainage change, and future site conditions. The observation of large boulders in a wash in or near the abandoned system unusually far from the Book Cliffs suggests the possibility that a highly energetic, but localized, wash may occur again in a situation similar to that of the proposed footprint.

Response:
Additional characterization of the withdrawal area east of the proposed disposal cell footprint (including the East Branch) was conducted in October 2006. Several additional areas of large boulders were found associated with the East Branch and its ancestral drainages. These areas are at least 1 mile (mi) east of the disposal cell footprint and appear to be expressions of high-energy flows from the East Branch drainage system that heads in two canyons (known as Little Blaze Canyon and an unnamed canyon just to the west of it) that are reentrants into the Book Cliffs. Based on the difference in the depths of incision of the ancestral East Branch and the present East Branch at the point of capture, capture of the ancestral East Branch occurred approximately 6,000 to 9,000 years ago.

This additional information and the implications for the disposal cell area were included in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix

G).

8. "Erosion surfaces appear to be displaced from aerial photos - determine if they are displaced and their significance if they show Quaternary movement." Because displaced erosion surfaces may have been caused by neotectonic activity, they are potential clues to seismic sources. They may be also caused by a seismic structural deformation. Such potential surfaces were reported in RAP Attachment 2, Appendix G, Plate 1 and captions 'g' and 'h' for Low Sun Angle photograph.

Response:
Area "g" was investigated in May 2006 and determined not to be related to faulting. It had appeared from aerial photographs that Crescent Bench, a mantled pediment surface, was displaced down to the north. Upon inspection, the lower surface was not the same mantled surface as Crescent Bench; it was an unmantled surface on Mancos Shale, and the difference in height of the two surfaces could be explained simply by erosion rather than faulting.

Possible displacement of the Quaternary surface along a linear feature at area "h" was investigated in November 2006. No displacement was seen and the linear feature was determined to be an old dozer cut about 2 mi long made for a seismic survey line probably in the 1960s. Results from investigations of both areas "g" and "h" were included in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

9. "Expand the discussion on potential natural resources (oil/gas, salt/potash, uranium/vanadium, and gold) based on current economics." An update is prudent, given that gold is near its all-time high and oil is at its all-time high, for example.

Response:
Oil and gas are the geologic resources that have the highest potential for occurrence and development at the site area. The entire withdrawal area is currently leased for oil and gas, and several oil and gas test holes have been drilled recently just to the south and west of the withdrawal area. Exploration and production of oil and gas (if it occurs) is permitted in the withdrawal area and production could take place even under the 250-acre disposal cell by directional drilling.

The probability of occurrence of potash and other salt mineral resources is low in the site area because of post-depositional movement of the saline facies of the Paradox Formation toward the axis of the Salt Valley Anticline about 2 mi to the southwest of the site. As a result, these deposits at the site are thin to absent. Uranium and vanadium and copper and silver deposits are in the Morrison Formation in widely scattered locations more than 5 mi south of the site area; the low probability of the occurrence of these metals beneath the site and the greater than 3,000-foot depth of the Morrison Formation make their exploration and development economically unfeasible. Gold content is slightly higher in Mancos Shale in the site area than what normally occurs in shale; however, to warrant economic extraction, the gold content would have to be 10 to 100 times higher.

Additional information on these potential natural resources in the site area is in the revised calculation set for Site and Regional Geology Results of Literature Research (RAP Attachment 2, Appendix A). The discussion is based primarily on two BLM reports, which give the occurrence and development potential of these resources.

10. "If oil/gas resources are present below the site, and these were exploited, could subsidence (and how much?) occur?"

Response:
Possible oil and gas production from beneath the disposal site at depths of between 4,000 and 11,000 ft would not result in subsidence. Void (pore) space in the rock (typically a sandstone) that would contain the oil and/or gas typically amounts to as much as 20 to 25 percent of the rock volume. Recovery of the oil and/or gas (usually less than 50 percent of the resource) would therefore result in creating a void space consisting of only about 10% of the rock volume. Adequate grain support in the well-lithified sandstone of Paleozoic or Mesozoic age and the great depths of the possible production horizons would make surface subsidence highly improbable. No subsidence has been reported as a result of oil and gas production from numerous fields at similar depths in east-central Utah (personal communication in 2007 with David Tabet, Geologic Manager of Energy and Minerals Program for the Utah Geological Survey). This information was added to the Resource Development section in the revised calculation set for Site and Regional Geology Results of Literature Research (RAP Attachment 2, Appendix A).

11. "Further document the past occurrence of shallow gas in the Mancos Shale and its potential to occur at the site." Given that DOE reported evidence of natural gas in at least one of its boreholes on or near the site, that gas blowout preventers have been used by local drillers because of a known (little evidence presented) or presumed hazard, it is prudent to investigate the history, likelihood, expected magnitude of such a hazard at the site or at analogous sites in the area.

Response:
More details of the occurrence of gas in one borehole from the 1920s were added to the revised calculation set for Site and Regional Geology Results of Literature Research (RAP Attachment 2, Appendix A). No other shallow test wells from the area have reported gas, but the occurrence of gas in thick marine shale is not unusual.

12. From Disposal Cell Section: "The sheet flow process described in the geology section is expected to continue after cell construction and must be considered in the design." From a geological review perspective, the description of the sheet flow hazard (in the Geology Section) would need a technical basis to support an estimation of locations, rates and magnitudes of water and mass movements over the next 200 to 1,000 years.

Response:
Because the disposal cell is designed such that maximum flows coming down the main sheet wash path (in the east part of the cell) would be diverted westward and eastward around the perimeter of the disposal cell, sheet wash flow is not considered a hazard and determination of the rate of accumulation of sheet wash deposits is not necessary.

Seismology

13. "Indicate which faults are capable/not capable and basis for assumption." Identify the known and suspected faults in the area such that if any were of such size and distance from the site that, if seismogenic, would affect the site and need to be evaluated for its seismic loading potential.

Response:
Faults are identified as capable/not capable in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, Table 3). Known and suspected faults are identified and discussed in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, pages 5–12).

14. Provide rationale for using 6.2 for the floating earthquake when 5.9 is listed as the maximum earthquake on page 6.

Response:
Rationale to explain the difference between the estimation of the maximum predicted earthquake and the maximum historically recorded event is explained in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 5).

15. Indicate why some faults included in the calculations for the Cheney Site were not included for the Crescent Junction Site.

Response:
An explanation is given in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, page 11) that although the Cheney Site is used as a comparison for a site within the same tectonic province, the sites are not in the same location, so faults located closer to one site will have the potential of having larger impacts on the close site as compared to the farther site. Specific faults will be addressed on an individual basis that is relevant to both sites.

16. Provide velocity data from geophysics for the rippability study for the weathered and unweathered Mancos Shale below the site.

Response:
The geophysical investigation at the Crescent Junction Site was done specifically to access rippability of the Mancos Shale during construction of the disposal cell. As such, the investigation consisted of determining the seismic velocities of the weathered and unweathered shale deposits using compression wave data. Shear wave velocities and shear modulus are typically the parameters used to evaluate the stiffness of the foundational materials to evaluate if amplification of ground motions would be expected. However, on a qualitative basis, the seismic velocity data will be presented to support the claim that site amplifications will be negligible. Velocity data are provided in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 17).

17. Provide more justification to support the salt dissolution origin for the Thompson Anticline and Tenmile Graben structures.

Response:
A preliminary field investigation of several unnamed faults, associated with the Thompson Anticline (Willis 1986; Doelling 2001), showed no evidence of Quaternary movement (no Quaternary deposits were displaced by the faults). It was concluded that no recent movement has occurred along faults associated with the Thompson Anticline, and that they reflect slow, incipient subsidence related to dissolution of deep salt deposits along the northeast edge of the Paradox Basin.

The Tenmile Graben, which is approximately 35 km long, is a narrow zone of faulting displacing Cretaceous and Jurassic bedrock along Salt Wash southeast of the town of Green River. The graben is on the northwestern edge of an area typified by northwest-trending, elongated oval valleys that are collapsed or depressed anticlines. The graben is probably related to salt dissolution. The youngest rocks offset by this fault are the upper members of the Cretaceous Mancos Shale (Doelling 2001). No Tertiary rocks are preserved along the Tenmile Graben. Quaternary alluvium and eolian sediments do not appear offset by any of the faults (Doelling 2001). Because no evidence exists for Quaternary deformation of the Tenmile Graben, it is not considered a capable fault for seismic-hazard assessment purposes.

Further discussion is presented in RAP Attachment 2, Appendix E, pages 6–7 and 10–12.

18. Determine if Granite Creek and Ryan Creek Faults on the Uncompahgre Uplift are connected and what acceleration would result.

Response:
The possibility of Granite Creek and Ryan Creek Fault systems being connected was investigated. The two fault systems appear to be separate based on mapping both by Doelling (2001) and in a cross section by Ely et al. (1986). Because the Granite Creek and Ryan Creek Faults are roughly parallel and overlapping, the total fault trace would not increase if they were considered collectively. Several faults of similar strike parallel the Granite Creek Fault to the northeast. Both Granite Creek and Ryan Creek Faults may merge at depth with the major uplift-bounding (Uncompahgre) reverse fault. For purposes of the Moab Remedial Action Plan, the Granite Creek Fault zone is considered a capable fault.

Discussion on the connectivity of these faults is given in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E).

19. In Appendix B Table, change the Wells and Coppersmith rupture-length reference to Campbell.

Response:
The table in calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F), has been adjusted to make column headings more clear.

20. Provide latitude and longitude for fault systems in tables.

Response:

Latitudes and longitudes have been shown on all figures in the revised calculation sets for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E) and Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F).

21. Provide copy of Cheney RAP.

Response:
The Cheney RAP was sent to the NRC on May 3, 2006.

22. Provide justification for using 0.42 g for Cheney design while 0.21 g for Crescent Junction.

Response:
According to the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 18), the seismotectonic stability studies done for the Grand Junction mill tailings/Cheney Disposal Site identified a fault (Fault 8) with a length of 11.0 km at a distance of 9.0 km from the site. Although no evidence of Quaternary displacement was proven, it was considered to be capable on the basis of its apparent association with a possibly active regional structure, the Uncompahgre Uplift. This fault was adopted as the design fault for the Cheney Disposal Site, resulting in a recommended design acceleration of 0.42g. The capabilities of this fault and other faults related to the Uncompahgre Uplift have negligible impact on the Crescent Junction Site due to the distance of these faults to the Crescent Junction Site.

23. Address amplification when estimating the seismic design for the site.

Response:
The TAD (DOE 1989) states in Section 5.4.4 that for shallow soil sites with less than 30 ft of overburden above bedrock, the site surface acceleration is considered to be the same as the acceleration derived from the seismic study. In Campbell and Bozorgnia (2003) attenuation relations, the PHA equations account for local site conditions of the upper 30 meters of rock or soil. As defined in their paper, the site is categorized as a firm rock site, based on underlying geologic unit consisting of pre-Tertiary sedimentary rock (Late Cretaceous Mancos Shale). This category assignment is supported by the SPT data, which place the less-weathered Mancos Shale as a BC soil class as defined by the National Earthquake Hazard Reduction Program.

A discussion of amplification at the site is presented in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 17).

24. Provide any available reflection or geophysical data which may shed light on the stratigraphy and seismic velocity at the site.

Response:
Seismic velocity data from the rippability study summarized the three main geologic layers. The upper layer (alluvium and eolian deposits) ranged in depths from 4.5 to 18 ft, with seismic velocities ranging from approximately 1,160 to 1,330 feet per second (fps),

typical for unsaturated alluvial overburden soils. The base of the second layer (weathered Mancos Shale) was interpreted to vary between approximately 24 and 60 ft, with seismic velocities ranging from about 4,060 to 5,220 fps. Velocities for the unweathered Mancos Shale ranged from about 9,000 to 10,000 fps. These data are provided in the revised calculation set for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, page 17).

25. Make sure the earthquake distributions in Fig. 4 App. (E) are consistent with those in Fig. 1 App. (F).

Response:
Modifications were made for consistency in the revised calculation sets for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, Figure 4) and Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F, Figure 1).

26. Identify the different symbols in App. (E/B) and App. (F/A).

Response:
In RAP Attachment 2, the Appendixes have been modified in the revised calculation sets for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E) and Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F).

27. Address if liquefaction may occur at the site.

Response:
Tailings liquefaction is not likely because tailings would be placed in the cell at near-optimum moisture conditions (i.e., unsaturated), at compaction densities achieved with placement in lifts and rolling with construction equipment, and the fines content of the tailings. In the event that zones of tailings do become saturated, the calculated stress ratio required to cause liquefaction of the tailings is higher than the seismic stress ratio for all of the cases considered, indicating that liquefaction would not occur. Liquefaction is discussed in the revised calculation set for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D).

June 2006 Meeting

Ground Water Hydrology

1. What is the deepest weathered Mancos Shale encountered at other sites? Is it similar to the approximately 20-foot (ft) thickness found at the Crescent Junction Site?

Response:
The weathered zone in the Mancos Shale at the Shiprock, New Mexico, Legacy Management Site is approximately the same thickness as the weathered Mancos Shale at the Crescent Junction Disposal Site. Packer tests conducted at the Shiprock Site suggest that the weathered zone (the zone with relatively higher permeabilities) extends to a depth of approximately 35 ft. Below that depth, the permeabilities are approximately 3 to 4 orders of magnitude lower than in the upper weathered zone.

2. What is the basis for concluding that water encountered in the 300-ft-deep characterization holes is connate?

Response:
The ground water in the Mancos Shale is suspected to be connate based on several factors, including its salinity, variable ground water levels, and isolation from sources of recharge. In August 2006, the ground water was sampled in wells 0203 and 0208 and analyzed for radiocarbon (^{14}C). Results of the analyses show that the age of the ground water exceeds 40,000 years, which is the approximate detection limit for radiocarbon age dating. A calculation set describing the results of ^{14}C dating of ground water from two wells (0203 and 0208) at the disposal site is included in a new calculation set for Radiocarbon Age Determinations for Ground Water Samples Obtained From Wells 0203 and 0208 (RAP Attachment 3, Appendix F).

Water Resources Protection Strategy

3. Provide geochemistry data on water from the 300-foot-deep holes.

Response:
A hard copy of the requested data was provided to NRC at the meeting. A summary of geochemistry data for the Crescent Junction Site is included in RAP Attachment 5, Appendix H, Background Ground Water Quality.

Disposal Cell Design and Engineering Specifications

4. Recommendation was made on rock size and filter requirements that only the Abt-Johnson method and not the Stephenson method be used with the objective of reducing filter layer thicknesses and rock thickness and size on the side slopes. Ted Johnson indicated that perhaps only the south side slope and the drainage channel(s) may require a filter layer (east, west, and north side slopes may not require a filter layer), but a thinner filter layer could be used. Also, the thickness of the rock does not have to be twice the D_{50}, and that 1.5 times the D_{50} would suffice.

Response:
The calculation set for Erosional Protection of Disposal Cell Cover (RAP Attachment 1, Appendix H) was revised using the Abt-Johnson method, which reduces the size of the rock on the side slopes. The filter layer will be eliminated on the east, west, and north side slopes, but is necessary on the south side slope to accommodate runoff from the surface of the disposal cell. A filter layer will also be used under the riprap along the toe of the north side slope. The rock layer thickness will be kept at twice the D50 or near the D100 size requirements.

5. The proposed toe protection on the south side slope for a scour depth of 1 foot is too low, as cited in Figure 4 in the calculation set for Erosion Protection of Disposal Cell Cover. The total thickness of the rock was acceptable, but the thickness of rock for protection of the south slope apron should be re-evaluated according to NUREG-1623, page D-19.

Response:
The apron protection on the south slope was recalculated to be 2.5 ft deep, and this was incorporated in the calculation set for Erosional Protection of Disposal Cell Cover (RAP Attachment 1, Appendix H).

6. The issue was discussed on how to handle sedimentation in the north drainage channel from small precipitation events while maintaining a full channel to accommodate the Probable Maximum Precipitation. Suggestion was made that DOE consider eliminating the north drainage channel and just use toe protection buried below grade as is proposed for the south side slope.

Response:
Diversion of upland runoff around the north side of the disposal cell involves conveying runoff to the west of the cell without eroding materials at the toe of the north slope of the cell. Diversion also involves accommodation of sediment from upland runoff that may settle out due to the decrease in gradient from 2 percent (in upland areas) to 0.5 percent (along the toe of the north slope). These factors are included in the current design along the north slope of the disposal cell. Erosion protection along the north slope of the disposal cell will consist of (1) a rock mulch on the slope above the anticipated level of flow along the toe of slope, (2) riprap on the slope within the anticipated level of flow along the toe of slope, (3) riprap on an apron extending from the toe of slope and (4) buried riprap in a trench beneath the apron, extending below the estimated depth of scour. A channel will be constructed along the toe of the north slope to facilitate placement of erosion protection materials; the channel will drain to the west-southwest at a 0.5 percent slope, and it is anticipated that it will fill with sediment from upland runoff. The above design changes were incorporated in the revised calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

7. The NRC agrees with construction of a cut-off wall at the end of the north drainage channel. Instead of using a gabion basket for this wall, use of a rock-filled trench is proposed. This is because the basket wire will deteriorate during the 1,000 year life of the cell.

Response:
A rock-filled trench will be used without the gabion baskets. This design change was incorporated in the revised calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

8. The proposed radon barrier is highly conservative and DOE can re-evaluate in the interest of reducing layer thicknesses. Major factors influencing radon barrier thickness are the Ra-226 concentration of tailings and, to a lesser degree, the moisture content of the barrier.

Response:
The Ra-226 values have been revised in the calculation set for Average Radium-226 Concentration for the Moab Tailings Pile (RAP Attachment 1, Appendix K) to reflect the average of known concentrations. Previous Ra-226 values (one standard deviation above the mean) were 868 to 954 pCi/g. The updated mean Ra-226 value for the Moab pile is 707 pCi/g.

9. NRC contends that placement of contaminated railroad ties in the disposal cell will not pose a problem because they are creosote treated and will be exposed to very little moisture over the long term.

Response:
None required.

Vicinity Properties

10. DOE will continue to do gamma screening surveys on the 1971 EPA list as time/budget allows. If vicinity property remediation is done where contamination was left in place above 40 CFR 192 standards (Supplemental Standards), NRC will review/approve the completion report and application for Supplemental Standards. If no Supplemental Standards are applied, NRC will not review/approve the completion report.

Response:
None required.

General

11. NRC believes that later in the UMTRA Project, draft and final RAPs were merged into one document. NRC explained that ultimately the RAP needs to contain construction specifications and drawings (e.g., the documents that would be bid upon for the remediation work). DOE explained that because of contractual matters regarding conceptual versus final design, there will likely be a distinction in the draft versus final (degree of completeness).

Response:

The draft RAP will not contain detailed plans or specifications. The draft RAP does include an outline of technical specifications for construction and reclamation of the disposal cell to provide input on how the disposal cell will be constructed and how construction quality assurance testing will be conducted. DOE's current contractor does not have the contractual scope to complete these documents. To facilitate review and approval of the final RAP, DOE is still seeking NRC's review of the draft to ensure that the Crescent Junction Site and proposed design features meet applicable NRC guidance and the standards set forth in title 40 of the *Code of Federal Regulations* (40 CFR 192. U.S. Environmental Protection Agency (EPA), "Promulgated Standards for Remedial Actions at Inactive Uranium Processing Sites"). Based on the draft RAP and NRC comments, DOE's new contractor in 2007 can complete the detailed plans and specifications and submit a final RAP.

2007 Request for Additional Information

Geology and Seismology

G1. Geomorphology: Provide additional evidence that the discontinuous east-striking line of low, north-dipping, cuesta-like mounds just north of the disposal cell footprint near the top of the Prairie Canyon Member of the Mancos Shale are formed by resistant dolomitic siltstone concretions.

RASR, page 2-7, section 2.3.3. The text indicates "geomorphic features include...... (4) a discontinuous east-striking line of low, north-dipping, cuesta-like mounds formed by resistant dolomitic siltstone concretions near the top of the Prairie Canyon Member of the Mancos Shale just north of the disposal cell footprint." This linear feature also shows up on most aerial photographs of the site and was visited during the site visit in December 2006. These cuesta-like mounds may have been formed by resistant dolomitic siltstone concretions, but additional evidence should be provided that this is the case and is not a structurally-controlled feature, possibly a fault. Are there analogous mounds in other locations away from the site where the top of the Prairie Canyon Member of the Mancos Shale outcrops producing similar cuesta-like features or is there other evidence to support the mounds have been formed due to resistant dolomitic siltstone concretions?

Response:
See response for 1(a) and 1(b) in the NRC Comments and DOE Responses for the April 2006 Meeting.

G2. Geomorphology: Evaluate headcutting rates for West Branch Kendall Wash and evaluate the possibility of stream capture of Crescent Wash by West Branch Kendall Wash.

RASR, page 2-7, section 2.3.3. The text indicates "geomorphic features include...... (6) incised channels of the West and East Branches of Kendall Wash and the slow northward advance of headward incision of the West Branch of Kendall Wash." West Branch Kendall Wash is experiencing headcutting. This head cutting is progressing toward Crescent Wash. Text in section 2.4.1 indicates this headward advance will have to be monitored. Additionally, in the RASR Appendix A, DOE has committed to obtaining aerial photographs from 1944 to try to determine headcutting rates. Stream capture was verified on the abandoned wash shown as number 5 on the high-altitude vertical photographs, and this possibility should be explored for West Branch Kendall Wash.

Response:
See response for 5(c) in the NRC Comments and DOE Responses for the April 2006 Meeting.

G3. Geomorphology: Determine why constant roadway maintenance is required for Route 70 in the vicinity of the site and determine if similar problems could occur with the disposal cell.

RASR, page 2-7, section 2.3.4. The text describes "constant roadway maintenance required for Interstate Highway 70, which traverses Mancos Shale just south of the site." The text indicates that "analyses of the Mancos Shale and Mancos Shale-derived soils did not show the presence of swelling clay or highly plastic materials at the Crescent Junction Disposal

Site." It appears DOE has assumed that road failures are due to montmorillonite clays and since montmorillonite clays are not present at the cell site the hazard does not exist. Has DOE considered that road failure is due to something other than montmorillonite swelling clay that may also be present at the Crescent Junction cell site? lnterstate 70 and the cell will be located on the same geologic material and the maintenance problems encountered on 1-70 should be investigated fully to determine if they could occur on or within the cell.

Response:
Expanded discussion of the well-known problem of swelling clay because of the presence of montmorillonite in Mancos Shale is included in the revised calculation set for Site and Regional Geology – Results of Literature Research (RAP Attachment 2, Appendix A). Rigid concrete pavement and concrete slab structures pose a problem if built on swelling Mancos Shale. If no such structures are constructed at the disposal cell, then the swelling clay should not pose a hazard. The text of the RAS Report was changed to restate the results of analyses of Mancos Shale and Mancos Shale-derived soils.

G4. Geomorphology: Clarify the depth of the disposal cell and on what material the cell will be constructed.

RASR, page 4-3, section 4.1.2. Text in this section indicates "the disposal cell excavation is anticipated to be into the Quaternary materials, as well as into upper portions of the weathered and fractured Mancos Shale." On page 7-1, section 7.0, the text indicates the anticipated depth of excavation is 15 to 20 feet (ft). Figure 7-2 shows the excavation limits as approximately 10 ft below bedrock. Figure 7-3 shows the cell directly on the weathered Mancos Shale contact. It is unclear how far the cell will be placed into the Quaternary alluvial material and/or the weathered and fractured shale. Will the top several feet of weathered shale be removed or will the cell be placed directly on the first contact of the weathered Mancos Shale? The depth of the cell and what material the cell will be placed on should be clearly stated and consistent throughout the Report.

Response:
The base of the disposal cell will grade to the south at approximately a 2 percent slope, roughly following existing grades. Typical sections that cut north-south and east-west through the disposal cell, as well as the section locations, are shown on the revised figures in Section 7 of the RAS. The depth of excavation across the site varies in limited areas from as shallow as approximately 12 ft to as deep as approximately 21 ft. On an average basis, the depth of excavation is approximately 16 ft.

Also shown on the figures is the approximate contact between the Quaternary alluvial soils and weathered Mancos Shale, as estimated from borehole and corehole data. On average, the excavation will be approximately 11 ft in Quaternary alluvial soils, and approximately 5 ft in weathered Mancos Shale. There is a small area in which the Mancos Shale is estimated to be slightly below the excavation depth. In this area, a small remnant of the Quaternary alluvial soils will be left in place. This area is internal to the disposal cell.

Therefore, the remnant of alluvial soils will not act as a pathway for seepage migration out of the disposal cell. In the area of the dikes, a minimum of 5 ft of excavation into the weathered Mancos Shale will be required in order to prevent a lateral pathway for flow out of the disposal cell.

A revised Figure 7–2, a new Figure 7–3, and a revised Figure 7–4 have been inserted into Section 7.0 of the RAS.

G5. Geomorphology: Discuss slump features identified near the site. Indicate why slumping will or will not have an impact on the site during the compliance period.

Attachment 2, Appendix G, High-Altitude Vertical Photographs (6), page 3. There is mention of a slump block or mass-wasting feature on the north side on the Book Cliffs in Horse Haven and at several other locations. The text indicates the slides were likely initiated in wetter times during the Pleistocene. What is the basis for this conclusion that the slides likely occurred in wetter times during the Pleistocene? Wetter Pleistocene could have been the condition at the site only about 12,000 years ago and may be relevant to the next 1,000 years projection. Are there analogous site(s) along Book Cliffs that have known high or higher (and/or low or lower) rates of slumping hazards similar to those at Crescent Junction?

Response:
In most of arid to semi-arid Utah, it has been recognized that most landslides are presently inactive, or they become active only during periods of extremely high amounts of precipitation. Times of glaciation during the Pleistocene were during a climate of much lower temperatures and much larger amounts of precipitation than at present and were favorable for the formation of landslides (Shroder 1971). The landslides north of the site in the Book Cliffs were likely active during the most recent glacial episode in the late Pleistocene, and they may have formed then or during earlier glacial episodes in the Pleistocene. This reference on landslides in Utah by Shroder (1971) and additional discussion are included in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

G6. Geomorphology: Explain the origin and age of the pediment-mantling deposits and surfaces located near the site.

Attachment 2, Appendix B, page 7, Section 2.5, discusses the "pediment-mantling deposits" reported by the applicant. Has DOE considered that these deposits might be indicative of former, uplifted pediments? If they are tectonic- geomorphic features, what clues do they provide to rates of erosion, episodes of differential uplift, possibly faulting? If the surfaces are tectonic-geomorphic in nature, is the age of the surfaces known, or is it possible to determine the approximate age, and if tectonic activity produced the surfaces, is this significant to the design of the disposal cell?

Response:
The origin of the pediment-mantling deposits is discussed in the revised calculation set for Site and Regional Geomorphology – Results of Literature Research (RAP Attachment 2, Appendix C). Intact pediments mantled by alluvial material are west of the withdrawal area

and represent alluvial deposits from the ancestral Crescent Wash. No evidence for fault displacement has been seen around the pediments to indicate they have been uplifted. The location and characteristics of the mantled pediment surfaces are consistent with their origin as alluvial deposits from ancestral drainages from the Book Cliffs that were preserved as pediment mantles after stream capture by drainages in Mancos Shale. It is possible that a new mantled pediment surface could start to form after an estimated 1,600 years after capture of Crescent Wash by incisional headcutting of the West Branch of Kendall Wash, as described in the revised calculation set for Site and Regional Geomorphology – Results of Site Investigations (RAP Attachment 2, Appendix D). This erosional process, if it occurred, is far enough away to the west to not affect the disposal cell.

G7. Mining, Oil & Gas: Discuss current or past mining, mineral, and oil and gas claims for the site or within a radius near the site that have similar geologic characteristics.

RASR, page 3-4, section 3.4. The statement is made that "Pockets of natural gas were encountered during the drilling conducted as part of this project. Commercial exploration for oil and gas has been, and continues to be, common in the Crescent Flat area." Also, many boreholes are noted on the USGS quadrangle as well as mining pits. Is there a possibility that this site could cause a conflict with future mining claims?

Response:
An expanded discussion of oil and gas resources and exploration in the site area is in the revised calculation set for Site and Regional Geology – Results of Literature Research (RAP Attachment 2, Appendix A). In that calculation set, it is stated that the withdrawal area is leased for oil and gas, and that surface exploration would not be prohibited from the area, except for the disposal cell (approximately 250 acres). Directional drilling would allow the area under the disposal cell to be explored. No active mining claims are in the withdrawal area, and the establishment of the withdrawal area precluded new mining claim locations. After the disposal cell is constructed, most of the withdrawal area will be released, and mining claim locations will be allowed. As noted in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G), the pits southeast of the withdrawal area along old U.S. Highway 50, initially thought to have been made for gold exploration, were actually made for exploration for road metal for highway construction.

G8. Mining, Oil & Gas: Discuss past mining, mineral, and oil and gas activities that may have occurred at the site.

Attachment 2, Appendix A, Resource Development, page. 5, para 1. This section refers to a petroleum accumulation 3 mi SSW, without extrapolating the potential significance. However, there is an oil accumulation about 3 mi WNW of the site that is not mentioned. It is not known if this play is in the Mancos or deeper (reference is a booklet on Grand County geology by Utah Geol Survey dated 1987). The statement is made, "Data concerning the targeted gas horizons and the actual results of this exploration are not currently available. When will additional data be obtained on oil and gas targets in the site vicinity and on pressurized gas pockets? This may bear on potential future disruptive activities that may be safety related.

Has DOE checked for past drilling activities at the proposed site? Old drill sites and improperly abandoned drill-holes may provide a pathway for water and transient drainage from the cell to impact groundwater. Geophysical survey logs, borehole logs, geological descriptions and cross sections may be available for the site area. Also, driller's reports of subsurface conditions such as groundwater, brines, pressurized gas, deformable holes and other information may be available.

Response:
Discussion of oil and gas resources for the withdrawal area and nearby surrounding area was expanded in the revised calculation set for Site and Regional Geology – Results of Literature Research (RAP Attachment 2, Appendix A). Included in the revision is information on oil and gas wells and fields from the Oil and Gas Fields Map of Utah (Chidsey et al. 2004), the Utah Division of Oil, Gas and Mining oil and gas information website, the Mineral Potential Report for the BLM Moab Planning Area (Tabet 2005), and the Mineral Report by the BLM on the DOE Proposed Disposal Site (Bain 2005).

G9. Seismology: Describe the association of the earthquakes that are located close to the Little Grand Fault No. 9 and the proposed site. Examine the possibility that the two earthquakes in the vicinity of the Little Grand Fault may have resulted from movement on this fault.

Attachment 2, Appendix F, Figure 7, page 13. There are earthquakes located very close to Fault No. 9. Does Fault No. 9 have a bearing as to the design earthquake for the site? Earthquake locations are not known accurately due to lack of instrumentations in the vicinity of the site. Provide good evidence that the Little Grand Fault is not capable.

Response:
The two events in question are a July 30, 1953, event with an estimated intensity of 5, and a March 31, 1954, event with an estimated intensity of 4. Both events are cataloged as non-instrumental events in the Catalog of Earthquakes Occurring in the Eastern, Central, and Mountain States of the United States, 1534-1986 [SRA (Stover, C.W., G. Reagor, and S.T. Algermissen, 1984, United States earthquake data file: U.S. Geological Survey Open-File Report 84-225.)].

Epicenter accuracy for both events is estimated to be within 0.5 to 1 degree, or approximately 30 to 60 mi (SRA). The source for the catalog comes from the University of Utah Seismograph Station (Arabasz et. al, 1979). In this earthquake listing, non-instrumental epicenters are assigned coordinates corresponding to the location of the town or city where the felt effects were strongest. In this case, the coordinates were assigned to the location of the town of Green River. Therefore, the earthquake location is fairly uncertain, and in actuality could have occurred at any location within 30 to 60 mi of Green River. Due to the low magnitude of the events (estimated by converting intensity to Richter magnitude) of 4.3 and 3.7, respectively, it is unlikely that either of these events would result in a surface rupture. Therefore, it is unlikely that the true location of these events could be better estimated by field evidence.

The capability of the Little Grand Fault (earlier referred to as the Little Grand Wash Fault) was evaluated during the seismotectonic study performed for the Green River Site, as discussed in the calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, page 14). Based on the lack of offset in the alluvial, colluvial, and talus materials overlying the fault, it was concluded during that study that the fault is not capable. Later mapping of the fault (Chitwood, J.P., 1994.

Provisional Geologic Map of the Hatch Mesa Quadrangle, Grand County, Utah, Utah Geological Survey, Map 152, scale 1:24,000), (Doelling, H.H., 2001. *Geologic Map of the Moab and Eastern Part of the San Rafael Desert 30’ × 60’ Quadrangles, Grand and Emery Counties, Utah, and Mesa County, Colorado,* Utah Geological Survey Map 180, scale 1:100,000) also did not observe any offset of Quaternary deposits.

Further capability of the Little Grand Fault was also evaluated in April 2007 to specifically examine the eastern portion of this fault that is closest to the site. South of the Green River, Utah, Site, displacement on the Little Grand Fault is more than 500 ft. Displacement on this easterly-striking normal fault (down to the south) decreases eastward. The fault was checked for evidence of Quaternary movement for approximately 6.5 miles along its eastern part (using mapping mainly by Doelling [2001] and Chitwood [1994]), starting where the fault passes under old U.S. Highway 50 in the SE¼ Section 27, T.21S., R.17E. The fault becomes less distinct eastward through Green River Gap (where displacement is only a few tens of feet) and to the easternmost place where it is recognized by Chitwood (1994) along the left fork (or west branch) of Floy Wash in the SE¼ Section 22, T.21S., R.18E. In places along the fault where it is overlain by Quaternary pediment-mantling material or terrace gravels, no displacement of these units was seen. Based on this traverse of the eastern part of the Little Grand Fault, it is concluded from the lack of Quaternary displacement that the fault is not capable.

The information above has been included in revised calculation sets for Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration (RAP Attachment 2, Appendix F) and for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E).

G10. Seismology: Explain why some faults that show no evidence of Quaternary faulting are considered capable while others are not.

Attachment 2, Appendix F, Table 3, page 16. Table 3 indicates that Fault No. 7 shows no evidence of Quaternary faulting, but it is considered as a potential design fault. Meanwhile, Faults 4, 5, and 6 also do not show Quaternary faulting but they are not potential design faults. Please provide appropriate rationale to explain this discrepancy.

Response:
Discussion as to the capability of these faults based on literature review is discussed in the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E, p.14). In this discussion, it is explained that unnamed faults 1, 2, and 3 are all of similar strike and appear to be features related to salt subsidence related to the Thompson Anticline. Faults 1 and 2 were investigated in 2005 and showed no sign of Quaternary movement. By association, fault 3 is assumed to also be related to subsidence of the Thompson Anticline. It was concluded that there is sufficient evidence to suggest faults 1, 2, and 3 are not active, and therefore not potential design faults. Unnamed faults 4, 5, and 6 appear to be splays of the Salt Valley Anticline. As discussed on page 9 of the calculation set, there is sufficient evidence to suggest these faults are related to dissolution and collapse of the Salt Valley Anticline, are not active, and therefore are not potential design faults.

Fault 7 is unique from the other unnamed faults in that it does not appear to be related to salt subsidence. The likely age of disturbance is between Late Cretaceous and early Eocene and there is no known Quaternary displacement on this fault. However, the age of faulting has not been substantially documented in literature, nor has it been field verified.

Therefore, it has been conservatively assumed that this fault, due to lack of thorough investigation, will be considered a potential design fault. This consideration has negligible impact on the seismotectonic characterization of the site, as the peak horizontal acceleration (PHA) estimated for fault 7 of 0.13g is below the recommended design PHA of 0.22g.

G11. Geology: Discuss additional field work that has taken place to confirm or deny the existence of faults.

Attachment 2, Appendix A, Structural Setting, page 5, para. 2. The statement is made, "Surface field work and an additional search for well data in the area will be undertaken to confirm or deny the existence of the fault." Clearly indicate what additional field work has taken place and document the findings.

Response:
No surface evidence of a northeast-striking fault was found in the southwest corner of the withdrawal area during field work in April 2006. The existence of a fault in that area had been inferred from differences in depths to the base of the Mancos Shale found in two nearby oil test wells drilled in the 1920s. The surface location of only one of the old test wells has been found. Results of the search for this fault and any other faults in the withdrawal area are in the revised calculation set for Surficial and Bedrock Geology of the Crescent Junction Disposal Site (RAP Attachment 2, Appendix B).

G12. Geology: Explain the origin of the fault associated with the axis of the Thompson

Anticline and why this fault shows up to 90 ft of displacement in some locations but no apparent displacement of the Mancos.

Attachment 2, Appendix G, low sun-angle photographs (e.), page 4. Potential fault. The graben strikes N20W and is located 2 miles from withdrawal area, at Thompson Anticline. One fault shows displacement of up to 90 ft. No displacement of these faults is discerned at contact with Mancos. There is no additional evidence to support that no displacement has occurred at the contact with the Mancos. Clearly identify this fault on the seismic map and explain why there is no apparent displacement in underlying Mancos. How small a displacement could have been detected given the methods used?

Response:
The origin of the faults along the axis of the Thompson Anticline is discussed in the revised calculation set for Site and Regional Geology – Results of Literature Research

(RAP Attachment 2, Appendix A) and the revised calculation set for Site and Regional Seismicity – Results of Literature Research (RAP Attachment 2, Appendix E). An investigation of faults in the area was conducted in November 2005. Displacement of the resistant sandstone beds of the Blackhawk Formation and Castlegate Sandstone that cap the Book Cliffs is well exposed along the faults, but displacement (even though it apparently occurs) in the underlying soft and mostly talus-covered Mancos Shale is not exposed. This observation is in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G).

G13. Geology: Discuss the two pediment remnants near the site identified by DOE that are vertically offset.

Attachment 2, Appendix G, Low sun-angle photographs (g), page 5. A potential fault has been identified by DOE. Two pediment remnants are vertically offset about 45 ± 5 ft, center of Sec 33. It is uncertain whether the surfaces are two different pediment surfaces or is the same surface that is faulted. If it's a fault, it appears to be young and is close to the site and could be a capable fault. This potential fault warrants further assessment.

Response:
See Response for 8, in relation to area "g", in the NRC Comments and DOE Responses for the April 2006 Meeting.

G14. Geology: Investigate the linear feature striking N 70 E that appears on the Plate 1 aerial photograph extending from Horse Heaven to the northeast and through Crescent Wash to the southwest.

This linear feature is not noted by DOE in the RASR. However, it was noted and discussed by NRC staff during the site visit in December 2006. Additional field investigation should be considered to determine if there is any evidence that this feature is a fault, and if so, if it is capable.

Response:
Characteristics of the N70E-trending linear feature were investigated in March 2007 and are discussed in the revised calculation set for Photogeologic Interpretation (RAP Attachment 2, Appendix G). No evidence for faulting was seen along the length of the feature from Crescent Wash to the south part of Horse Heaven. A prominent joint system in the Blackhawk Formation strikes approximately the same direction as the trend of the linear feature, and several parallel rotational slump blocks in the south part of Horse Heaven trend in a similar direction. It was concluded that the linear feature is an expression of the prominent joint system, which is important for landslide erosion on the north side of the Book Cliffs, but will not affect the disposal site area.

G15. Seismology: Provide the basis for choosing the parameter values, in Attachment 1,

Appendix D, Liquefaction Analysis, for water content, type of sand (clean/silty), and relative density, and provide their uncertainties. Provide the necessary justification for using Fig. 11.8 mentioned in the calculations, although the design earthquake for the site is less than that mentioned in the figure.

Justification for the parameter values was not provided. Changes in these parameters may change the condition of the layer from being non-liquefiable to being liquefiable.

Response:
The calculation for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D) has been updated to reflect tailings test results. The key tailings parameters used in the liquefaction analyses were compacted unit weight and fines percentage (derived from the tailings testing). The unit weight representing compaction to 90 percent of Standard Proctor density (50 percent relative density) was used, and fines percentages representing the minimum and mean measured values were used.

The calculation set for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D) was revised, and changes were made to text in RAS Section 4.2.2.

Geotechnical Stability

GT1. Characterization of Site Stratigraphy and Tailings: DOE and Golder Associates have indicated several data quality issues with test data from the laboratory used for geotechnical testing. As examples, there are questions on permeability test inconsistencies (Attachment 5, Appendix K), and there are several open comments on data quality from a Golder letter dated March 23, 2006 (Attachment 5, Appendix J). Provide a list of all unresolved issues with the test data quality and discuss the status of resolution of each of the issues.

Response:
All issues pertaining to test data quality have been resolved in revised calculation sets that were completed for the draft final RAP.

With regard to the calculation set for Supplemental Geotechnical Properties of Native Materials (RAP Attachment 5, Appendix K): Data quality checks of the original laboratory data revealed that retests would be needed for the triaxial compressive strength and hydraulic conductivity analyses of sample number 154 at 20 ft. Laboratory results of this retest are presented in Appendix C of this revised calculation.

In addition, data quality checks also indicated that retests of hydraulic conductivity would be required for sample numbers 152 at 23 ft, 154 at 12 ft, and 156 at 12 ft. Laboratory results of these retests are contained in Appendix D of this revised calculation. With the completion of the triaxial and hydraulic conductivity retests, which are documented in Appendixes C and D of this revised calculation, all data quality deficiencies associated with the original calculation were resolved.

With regard to the calculation set for Geotechnical Laboratory Testing Results for the Moab Processing Site (RAP Attachment 5, Appendix J): On August 16, 2006, the laboratory responded to the comments in Golder Associates' March 23, 2006, letter. In conjunction with their response, the laboratory issued page changes to the May 3, 2006, *Certificate of Analysis*. These page changes were inserted into both the electronic version of the May 3, 2006, data set and the paper copies of that data set.

During QA verification of the final data set, S.M. Stoller discovered one remaining error in the May 3, 2006, *Certificate of Analysis*. In a letter dated February 21, 2007, the laboratory responded and sent one additional page change to the May 3, 2006, data set. With the inserted page changes, the data contained in the May 3, 2006, *Certificate of Analysis* is now deemed to be complete and validated. No additional action is required. Appendix C contains, in chronologic order, each of the letters that were generated during the data review process. Page changes issued by the laboratory are included in the May 3, 2006, *Certificate of Analysis*, which is contained in Appendix B of this calculation.

GT2. Characterization of Site Stratigraphy and Tailings: In Section 4.1.2 of the Remedial Action Selection Report, DOE indicates that all of the materials that will be used in construction of the disposal cell cover will be obtained from the cell excavation. Based on the boreholes and test pits conducted at the disposal site, provide representative cross sections of the Quaternary materials and weathered Mancos Shale. Using these cross sections, provide estimates of the volumes of materials available from the excavation and a demonstration that the volumes will be adequate to construct both Alternative covers being considered without the need for additional borrow areas.

Response:
Section locations and cross sections are provided in Section 7 of the RAS as part of the response to Comment G4. The disposal cell layout has been based on a capacity for 12 million cubic yards (yd^3) of residual radioactive material (RRM). The objective of the excavation and cell construction was to achieve a balanced cut-and-fill, subject to the constraint that the height of the tailings above adjacent ground would be minimized while the base of the disposal cell would be cited beneath the top of the weathered Mancos Shale. All of the excavated material is intended to be used for cell-construction. Excess excavated material (if produced) will be placed on the top of the disposal cell as additional cover material or on the side slopes as additional embankment material.

The cell will be excavated into weathered Mancos Shale, with an anticipated average depth of excavation of 16 ft. This excavation will provide approximately 3.4 million yd^3 of Quaternary alluvial and colluvial soils and approximately 1.7 million yd^3 of weathered Mancos Shale. This excavated material will be used to construct the perimeter embankment and cover for the disposal cell. For this cell layout, the required embankment volume is approximately 1.2 million yd^3. The required volume for the UMTRA Project cover is approximately 2.9 million yd^3, and the required volume for the Alternative cover is approximately 3.6 million yd^3. Assuming an average of 13 to 15 percent shrinkage for the two cover systems, the excavation produces approximately the quantity required for cover and dike construction.

The following three tables summarize the estimated amounts of material to be excavated within the footprint of the disposal cell, along with approximate material requirements for the two proposed cover alternatives.

Table 1. Materials Excavated from Within Disposal Cell Footprint

Material	Volume (million yd^3)

Quaternary alluvium	3.42
Weathered Mancos Shale	1.69
Total cut material	5.11

Table 2. Materials Required for Disposal Cell Construction (UMTRA Project Cover)

Material	Volume (million yd^3)
Berm (Quaternary alluvium and weathered Mancos Shale)	1.24
3.9 ft of Radon Barrier (weathered Mancos Shale)	1.29
3.0 ft of Frost Protection (Quaternary alluvium and weathered Mancos Shale)	0.99
1.0 ft of Interim Cover (Quaternary alluvium and weathered Mancos Shale)	0.33
Net Excess cut (Quaternary alluvium and weathered Mancos Shale)	1.26
Net Excess cut (Quaternary alluvium and weathered Mancos Shale) accounting for 15 percent shrinkage with compaction	0.49

Note: Rock-Mulch Barrier and Infiltration and Barrier account for 0.17 million yd^3 each and are derived from off-site borrow sources.

Table 3. Materials Required for Disposal Cell Construction (Alternative Cover)

Material	Volume (million yd^3)
Berm (Quaternary alluvium and weathered Mancos Shale)	1.24
8.8 ft of Monolithic Cover (Quaternary alluvium and weathered Mancos Shale)	2.91
1.0 ft of Interim Cover (Quaternary alluvium and weathered Mancos Shale)	0.33
Net Excess cut (Quaternary alluvium and weathered Mancos Shale)	0.61
Net Excess cut (Quaternary alluvium and weathered Mancos Shale) accounting for 8 percent shrinkage with compaction	0.25

Note: Rock-Mulch Barrier and Infiltration and Barrier account for 0.17 million yd3 each and are derived from off-site borrow sources.

GT3. Characterization of Site Stratigraphy and Tailings: In Section 2.5 of the Remedial Action Selection Report, DOE indicates that the presence of swelling clays in the Mancos Shale is a potential geologic hazard. Provide discussion of the samples tested and the corresponding test results that demonstrate that swelling clays will not be a problem at the Crescent Junction Disposal Cell.

Response:

Swelling clays are a component of the Mancos Shale in the western U.S., and are a geologic hazard in terms of volume change from variations in water content. This is not a factor at the base of the disposal cell (where variations in water content are not expected). In the disposal cell cover, variations in water content should be accommodated within the frost-protection zone of the cover.

In general, a plasticity index greater than 15 can be an indication of highly swelling clays (International Building Code, 2003. Section 1802.3.2, International Code Council, Country Club Hills, Illinois). The average plasticity index of the weathered Mancos Shale is 11 (Geotechnical Properties of Native Materials, RAP Attachment 5, Appendix E). Therefore, the weathered Mancos Shale is likely to be slightly to moderately expansive in the area of the disposal cell, which can be accommodated in the design of disposal cell.

GT4. Slope Stability: In general, the various analyses make it unclear what exactly the cover and clean-fill dike are composed of. The slope stability analyses were performed using only the Alternative Cover. In the Remedial Action Selection Report (Figure 5.1), DOE indicates that the cover is composed of a mixture of "slopewash, eolian soils, and weathered Mancos Shale." The slope stability analysis considers the cover (radon barrier) to be composed of only "sheet wash and eolian soils" (Attachment 1, Appendix C, Table 1). There is a similar discrepancy for the clean-fill dike. Table 1 of the slope stability analysis shows the clean-fill dike material to be recompacted "weathered Mancos Shale," while Attachment 1, Appendix C, page 7, describes the clean-fill dike as "recompacted weathered Mancos Shale, alluvial, and eolian soils." Provide clarification of these discrepancies and discussion of any resulting impact on the slope stability analyses.

Response:
The perimeter embankment (clean-fill dike) and cover will be constructed from the material excavated from within the footprint of the disposal cell, consisting of Quaternary alluvial, colluvial, and eolian soils and weathered Mancos Shale. The only segregation of these materials will be for construction of the radon barrier, where weathered Mancos Shale will be used. The rest of the structures will be constructed with a mixture of these excavated materials. This composition of materials is represented in the revised calculation for Slope Stability of Crescent Junction Disposal Cell (RAP Attachment 1, Appendix C).

GT5. Settlement: Include additional information as part of the settlement analysis presented in Attachment 1, Appendix D. Provide a tabulation of the material layers considered in the analysis, references to the tests performed (or other basis) to determine each layer's settlement analysis parameters, and the resulting engineering parameters. Also provide a description or figure indicating the locations chosen for settlement analysis to demonstrate that the worst, average, and best settlement conditions have been selected and the largest differential settlement conditions have been analyzed.

Response:
The calculation set for Settlement, Cracking, and Liquefaction Analysis (RAP Attachment 1, Appendix D) has been updated to incorporate tailings-consolidation test results. Settlement analysis calculations were conducted for the largest anticipated tailings thickness (38 ft) and the largest anticipated thickness of cover and interim cover (13 ft). Settlement was analyzed at approximately the 1/3 and 2/3 depths within the tailings profile, and added to provide estimated total settlement of 1 ft or less (for primary settlement).

For differential settlement, the location within the disposal cell anticipated to have the highest potential for differential settlement is along the perimeter of the inside of the disposal cell, where the tailings thickness varies from 38 ft to zero over a distance of 76 ft. Other areas of tailings within the disposal cell would not the have the tailings thickness variation as along the cell perimeter, and would be spread in lifts and compacted.

GT6. Settlement: In Section 4.2.2 of the Remedial Action Selection Report, DOE indicates that settlement will be low due to the methods of mixing, placement, and compaction of the tailings in relocating the contaminated material to the Crescent Junction Disposal Cell. Provide additional description of the procedures for bringing the excavated wet tailings to optimum moisture at placement and compaction.

Response:
Initially upon excavation from the Moab tailings pile, the moisture content of the slime tailings is likely to exceed optimum conditions for compaction. Excavated slime tailings will therefore be mixed at the Moab site with the drier sand tailings. Mechanical mixing will yield an average water content that is appropriate for the transportation technique selected by the remedial action contractor. The transported tailings will be placed in the disposal cell and processed by the following procedure: (1) dumping from trucks along a working face or specific area, (2) spreading in lifts with a dozer, and (3) compacting the spread lift of tailings with a compactor. Water will be added as necessary (by spraying) for dust suppression. From this process, the tailings should be near optimum water-content conditions during compaction in the cell.

GT7. Settlement: Provide a discussion of whether or not there are plans for monitoring settlement during and following construction of the disposal cell. If there are plans, provide details of the monitoring plan; if there are no plans, provide the basis for not monitoring.

Response:
Because the tailings will be placed, spread, and compacted in the disposal cell in lifts, with significant time between tailings placement and cover construction, significant tailings settlement is not anticipated. Monitoring of settlement of the cover surface is planned for confirmation of cell performance, by monitoring of settlement plates or survey monuments.

GT8. Cover Design: In Section 5.0 and Figure 5-1, DOE discusses and portrays two different cover alternatives, but does not indicate which is planned or preferred. Provide a discussion on the factors that will determine which of the two covers will be used.

Response:
Both cover alternatives will meet the appropriate performance standards in 10CFR192 and NRC guidance. Selection of the cover alternative will be based on permitting and construction costs.

GT9. Cover Design: In its settlement analysis (Attachment 1, Appendix D), DOE analyzes settlement and cracking for only the UMTRCA cover. In its slope stability analysis (Attachment 1, Appendix C), DOE only analyzes the stability with the Alternative cover. Provide a discussion of why different covers are used from analysis to analysis and how the analyses presented conservatively band both covers being considered.

Response:
The UMTRCA cover was analyzed for settlement and cracking because of the compacted clay radon barrier in the cover system. Settlement and cracking of the Alternative cover is not as critical for cover system performance due to the increased thickness of the total cover and the lower level of compaction effort during construction. The Alternative cover was used in the slope stability analysis because it represents the thickest cover configuration and, therefore, the highest slope heights. However, the UMTRCA cover has been conservatively analyzed by changing the properties of the cover to represent the compacted clay properties of the weathered Mancos Shale. The actual UMTRCA cover consists of several layers, but the compacted clay represents the weakest of those layers.

The calculation set for Slope Stability of the Crescent Junction Disposal Cell (RAP Attachment 1, Appendix C) has been updated to include these analyses. The computed factors of safety are similar to the Alternative cover analysis. Critical failure surfaces pass predominately through the perimeter embankment. Therefore, the stability of the disposal cell is relatively insensitive to cover-material thickness, and to the shear strength of the cover material and compacted tailings.

GT10. Cover Design: In Section 4.1.2 of the Remedial Action Selection Report, regarding the potential for "bathtubbing", DOE indicates that the excavation will be into the weathered Mancos Shale, which has hydraulic conductivities of from 10^{-4} to 10^{-3} cm/sec. Elsewhere, DOE estimates the hydraulic conductivity of the cover to be 7×10^{-5} cm/sec. Discuss the basis for concluding that both of the covers being considered have conductivities as low as $7 \text{x} 10^{-5}$ cm/sec. In addition, discuss the potential for the cell excavation to extend to a depth that removes most of the weathered Mancos Shale, and thus result in a base conductivity much less than the assumed 10^{-4} cm/sec.

Response:

Excavation for the disposal cell is anticipated to average approximately 16 ft, which results in the removal of alluvial/colluvial materials and notching the base of the disposal cell below the surface of the weathered Mancos Shale. The weathered Mancos Shale transitions into unweathered Mancos Shale, with minimal fracturing, at depths of 60 to 80 ft below the original ground surface. Because the base of the disposal cell will be in the uppermost weathered Mancos Shale, the thickness of the weathered Mancos Shale beneath the disposal cell will be approximately 40 to 60 ft.

The key parameter for the evaluation of bathtubbing is not the hydraulic conductivity of the cover, but the net rate of infiltration through the cover. The net infiltration is dictated by the hydraulic conductivity of the cover materials as well as the thickness and water-holding capacity of cover materials to retain moisture for evapotranspiration. After the onset of steady-state drainage conditions, the net infiltration rate for both Alternative and UMTRA covers is conservatively estimated to be on the order of 1×10^{-7} cm/sec (or 0.1 ft/year).

The potential for bathtubbing as well as the potential for tailings leachate to migrate laterally and enter nearby gullies and washes is evaluated below. The key stratigraphic zones are summarized in the following table.

Zone	Approximate Thickness (ft)	Hydraulic Conductivity or Flux Rate	
		(cm/sec)	(ft/yr)
Cover	9-11	$1.0 \text{x} 10^{-7}$	0.1
RRM	35-45	$3.0 \text{x} 10^{-5}$	30
Weathered Mancos Shale	40-60	$2.1 \text{x} 10^{-3}$	2100
Unweathered Mancos Shale	2,400	$3.6 \text{x} 10^{-8}$	0.036

Because the influx of meteoric water is controlled by the design flux through the cover, meteoric water could migrate downward at an average rate of 0.1 ft/year (RAP Attachment 3, Appendix G). Steady-state infiltration through the cover would occur as unsaturated flow and gradually penetrate down to the top of the unweathered Mancos Shale. Inasmuch as the hydraulic conductivities of the RRM and the unweathered Mancos Shale are larger than the design flux through the cover, conservative assumptions indicate that the resulting downward flow could pass through the entire stratigraphic sequence and build up a zone of saturation at the top of the unweathered Mancos Shale, where the flux (at a unit gradient) would be a factor of 2.8 smaller than 0.1 ft/year.

The downward movement of meteoric water through this stratigraphic column is explained in terms of a simple water balance. For a flux of 0.1 ft/yr, the flow through the 250-acre disposal cell is approximately 1.09 million ft^3/yr [15.5 gallons per minute (gpm)]. The downward flux (at a unit gradient) into the unweathered Mancos Shale is conservatively 0.036 ft/yr or approximately 0.39 million ft^3/yr (5.6 gpm) over the area of the disposal cell. Therefore, approximately 0.70 million ft^3/yr (9.9 gpm) could migrate laterally away from the perimeter of the disposal cell footprint.

The leachate would eventually be consumed by slow vertical leakage into the unweathered Mancos Shale (RAP Attachment 3, Appendix G). If more realistic assumptions are considered, there is no potential for mounding or lateral spreading to occur in the weathered bedrock. Regardless of the assumptions that are considered, there is very little risk of potential discharge of leachate into surface drainages.

Surface Water Hydrology and Erosion Protection

SW1. Design of Erosion Protection for North Diversion Channel: The RAP indicates that riprap will be provided for the north slope of the disposal cell and the left side of the diversion channel and that the rock will be designed to protect against velocities produced by the PMF in the channel. However, it appears that the design of the riprap may also need to be based on velocities and shear stresses that will occur in gullies that discharge into the diversion channel. It appears that a significant number of gullies have formed and will discharge into the diversion channel in an unpredictable manner. The staff concludes that these gullies are likely to produce the design condition for the rock in the channel.

Staff review of the RAP indicates that DOE computed the scour depth, using assumptions associated with flows occurring perpendicular to the diversion channel, and the staff concludes that DOE'S assumptions related to gully size and discharge are appropriately conservative. However, the size of the riprap should also be based on similar assumptions. It is likely that the flow velocities occurring in these gullies will exceed the velocities in the diversion channel, thus requiring larger riprap sizes. In addition, the proposed rock cutoff wall and/or rock toes should be designed for the gully velocities, and the size and volume of rock should be adjusted accordingly.

DOE should either revise the design to account for velocities in the gullies, or provide additional justification for the current design.

Response:
The riprap along the base of the channel will have a median rock size of 20 inches to resist flow velocities from gullies discharging into the diversion channel. The riprap will be placed in adequate volume to act as self-launching riprap that will fill in scour holes to the maximum predicted scour depth. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix

G).

SW2. Design of Riprap for the Diversion Channel Outlet: Staff review of the design of the riprap for the diversion channel outlet indicates that the rock size and volume may not be adequate to prevent head-cutting and gully intrusion into the channel. The assumptions related to flow distribution across the outlet structure do not appear to account for localized flow concentrations. Further, the volume of the rock provided does not appear to be adequate to fill in scoured areas during the occurrence of major floods.

During the December site visit, the staff observed significant gullies downstream of the site, relatively close to the southwest corner of the proposed cell. Because the drainage area to this area will be increased by diverting flows in the diversion channel, there is a significant potential for large gullies to form and migrate upstream toward the disposal cell.

The design condition for computing the rock size and volume should be based on assumed areas of flow concentrations occurring downstream of the outlet structure. The velocities in these areas of flow concentration should then be used to compute the scour depth, rock size, and rock volume, based on collapse of the rock structure on a slope of about 1V on 2H. It is relatively obvious that flows occurring on the steep 1V on 2H collapsed slope will likely result in very large rock sizes. Alternately, DOE could provide a design where the downstream slope of the structure is constructed on a pre-formed specific slope, such as 1V on I0H, thus reducing the rock size requirements.

DOE should revise the design or provide additional justification that the design is adequate to prevent head-cutting into the diversion channel. If DOE chooses to make revisions, the design of the outlet for this diversion channel could be similar to other Title I designs that have been previously approved. Guidance may also be found in NUREG-1623.

Response:
The outlet structure has been modified to include a pre-formed, 1V:10H, buried rock structure excavated to the maximum predicted scour depth. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW3. Design of West Slope and Toe of Disposal Cell: Based on observations of on-site gullies during the site visit, the staff considers that flows discharging from the currently-proposed location of the diversion channel outlet could potentially erode the west side slope and/or toe of the disposal cell. Based on the size, depth, and relative closeness of the existing gullies immediately downstream of the southwest corner of the proposed cell, it appears that gullies of similar size and depth could form immediately adjacent to the toe and could erode to a depth that could undercut the rock toe.

DOE should revise the design of the west slope and toe of the disposal cell by: (1) increasing the rock size and volume of the toe; (2) extending the outlet of the diversion to the west so that the west side slope of the cell is not affected; or (3) changing the footprint and alignment of the west side of the cell.

Response:
The outlet of the diversion channel has been extended westward to minimize impacts on the west side slope of the cell. This modification has been made to the calculation set for

Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW4. Delineation of Competent Mancos Shale: On page 5 of Appendix G, DOE indicates that riprap will extend to the computed scour depth or to where competent Mancos Shale is encountered. In general, the staff considers that many Mancos Shale formations may not be extremely hard or durable if exposed to weathering. If riprap is keyed into such formations, erosion and loss of rock volume could occur. Further, during the site visit where the test pit was observed, the staff did not observe any competent shale layers that would provide suitable protection if exposed by erosion.

DOE should provide a clear description and definition of what will be done to determine the competency of Mancos Shale in those areas where riprap will be extended below grade or where erosion is expected to occur. Alternately, DOE could provide rock of sufficient volume to extend to the expected depth of scour.

Response:
DOE has selected the alternate approach; riprap volumes have been increased such that the rock will extend to the expected depth of scour. The riprap will not be keyed into the Mancos Shale. This modification has been made to the calculation set for Diversion Channel Design, North Side Disposal Cell (RAP Attachment 1, Appendix G).

SW5. QA/QC Procedures for Rock Production: Based on observations made during the December site visit, it appears that the rock in either of the proposed quarries is somewhat variable, depending on the location where rock will be produced within the quarry. DOE should provide additional information to document the quality assurance and quality control (QA/QC) procedures that will be implemented during rock production at the quarries to address this variability and to assure that rock of acceptable quality will consistently be produced. DOE should discuss how acceptable rock will be identified and unacceptable rock avoided as part of the QA/QC procedures for rock production.

DOE should describe the lithologic variability of the rock sources and identify features adverse to rock durability and resistance to weathering. Variability is also the basis for selecting representative samples for durability tests and petrographic analysis. Discuss how representative samples were obtained. Potential features could include mudstone/clay interbeds, conglomerate/calcrete beds, bedding planes, or fractures that could be vulnerabilities to freeze thaw and reduction in rock size. Explain how the mudstones and limestones above and below the sandstone will be able to be avoided in producing the sandstone.

Petrographic analysis, together with published literature, should be used to identify the minerals and percentages. Petrographic analysis should clearly identify the rock source of the sample. Mineralogy of the sandstone cement should be identified and the type of clays, if present.

In addressing the above items, consider the sedimentologic, stratagraphic, and petrologic analysis given in Currie, Brian S. "Upper Jurassic-Lower Cretaceous Morrison, and Cedar Mountain Formations, NE Utah-NW Colorado: Relationships between Nonmarine Deposition and Early Cordilleran Foreland-Basin Development", Journal of Sedimentary Research, Vol. 68, No. 4, July 1998.

Response:
The selected rock for use as erosion-protection material will be assessed in two phases. The first phase will be evaluation of the potential rock quarries from testing of representative rock samples from each quarry for durability. Rock quality designation values will be calculated using the test methods for rock type outlined in NUREG-1623. Testing will include petrographic analyses, with specific emphasis on bedding planes and fracturing, as well as the presence of clay minerals or soluble minerals. The results of the first phase will be determination of rock quarries that can produce acceptable rock for erosion protection.

The actual rock quarry to be used will be selected from the quarries that can produce acceptable erosion-protection material based on production and transportation cost, production schedule, material variability, and other factors. The second phase of evaluation will be confirmation that rock from the selected quarry will meet required durability requirements and particle-size distribution specifications. This evaluation will consist of testing of rock samples produced from the selected quarry either at the quarry or as delivered to the disposal cell site. The frequency of testing is usually based on a test per ton or cubic yard of rock, and is structured to represent rock production from startup to completion of operations. Rock not meeting the durability or particle-size requirements during this second phase of evaluation will be rejected.

Water Resources Protection

GW1. Discuss how tailings drainage will be confined to the weathered and unweathered Mancos Shale and be precluded from seeping along the contact between the weathered Mancos Shale and the overlying unconsolidated Alluvial/colluvial material and possibly migrating offsite.

RASR (Remedial Action Selection Report), page 2-7, section 2.3.2. There is NRC interest in the contact between the weathered Mancos and the overlying alluvial sediments to determine if this contact could provide a pathway for tailings drainage, especially where paleochannels exist and cut into the Mancos Shale bedrock as noted in this section. Up to 25 ft of weathered alluvial material mantles Mancos Shale at the site. Horizontal hydraulic conductivity and vertical hydraulic conductivity have been determined for the weathered Mancos Shale, but hydraulic conductivity has not been determined for the alluvial material overlying the weathered Mancos. If hydraulic conductivity is greater within the unconsolidated overlying material, which is likely the case, this may allow for preferred pathway or a "path of least resistance" for tailings drainage to seep from the tailing pile along this contact and migrate downgradient and offsite.

Response:
Excavation for construction of the disposal cell will be through Quaternary alluvial/colluvial soils and into the weathered Mancos Shale. In addition, the inside slope of the disposal cell excavation will be tied into the compacted perimeter embankment. Where buried swales exist that are deeper than the average depth of excavation, the unconsolidated materials will be excavated from the buried swales. Therefore, potential pathways for lateral tailings drainage migration will be cut off by the inside slope of the disposal cell excavation and the compacted perimeter embankment. Tailings drainage will thus progress vertically downward into the weathered Mancos Shale. The DOE response to

comment GT10 describes what happens to the tailings drainage after it enters the weathered Mancos Shale.

GW2. Calculate the approximate volume of leachate that may drain from the tailings and the volume of water that is expected to seep through the cover. Estimate the distance and depth this volume of leachate may seep from the tailings impoundment.

RASR, page 4-8, section 4.3.4. The statement is made that "the average moisture content of the tailings will probably be biased on the wet side of optimum, leaving enough residual moisture to drain from the tailings under the influence of gravity." The cover will have a lower hydraulic conductivity than the underlying Mancos Shale to prevent "bathtubbing." Has DOE attempted to calculate the approximate amount of leachate that may drain from the volume of tails expected based on an approximation of "the wet side of optimum?" If so, has the volume of Water calculated been modeled to determine its approximate flow path and distance from the site? There is a concern that leachate may not penetrate the weathered Mancos Shale and prefer to migrate along the weathered Mancos Shale and Quaternary alluvial material contact. If this were to occur, would this result in offsite drainage or the possible development of seeps in either Crescent or Kendall Washes, especially if leachate were to migrate along the paleochannel(s) cited in the text?

The text in this section also notes that DOE will monitor the accumulation of transient drainage with a standpipe tapping a sump at the downgradient toe of the disposal cell. How far into the weathered Mancos Shale is the sump to be constructed or will it only be in the alluvial material? Is only one sump anticipated, or will a series of sumps be considered at the downgradient toe of the cell? Please clarify or develop a plan and basis for location of the sumps. Clarify the "action level" and the plan for pumping and disposal of water from the sump(s).

Response:
The water content of the Moab tailings as excavated and hauled to the Crescent Junction Disposal Cell is likely to be near optimum to above optimum relative to the required compaction effort (at Standard Proctor density). The tailings are anticipated to lose moisture, becoming nearly optimum in water content because of evaporation that is anticipated to occur during mixing, dumping and spreading of the tailings prior to compaction.

The excavated Moab tailings will be placed in the disposal cell and processed by the following procedure: (1) dumping from trucks along a working face or specific area, (2) spreading in lifts with a dozer, and (3) compacting each lift of tailings with a compactor. This tailings-handling process, when performed in an arid climate such as that at the Crescent Junction Site, should dehydrate the tailings to nearly optimum water content during compaction in the cell. Evaporation from the compacted tailings surface should continue to dry the tailings further until the subsequent lift of tailings is placed. Water will be added as necessary (by spraying) for dust suppression.

Based on experience at other DOE Title I sites where uranium mill tailings have been relocated, some drainage of tailings porewater has been observed. Sumps will be constructed in weathered Mancos Shale, along the downslope (south) side of the cell, as a best management practice to collect potential drainage from the tailings. The volume of leachate that might drain from the tailings can be estimated from the difference between the water content of the tailings at optimum water content and at residual water content (drained conditions). This estimate is inherently biased to the high side because evaporation of porewater from the surface of the tailings is expected during dumping, spreading, and compaction, and during the intervening time between placement of successive lifts of tailings.

The average water content (by dry weight) of the transitional tailings at optimum conditions for compaction is approximately 18 percent, and the residual water content averages approximately 15 percent. For 12 million yd^3 of compacted RRM (primarily tailings), this water content difference is equivalent to approximately 5 percent of the total RRM volume, or 600,000 yd^3 (121 million gallons) of leachate. This volume draining over the anticipated period of RRM placement (approximately 20 years) results in an average drainage rate of 12 gpm.

Leachate from the disposal cell would migrate downward as unsaturated flow through the weathered Mancos Shale until it reaches the unweathered Mancos Shale, approximately 60 to 80 ft beneath the original ground surface. Because the conservatively estimated seepage flux (approximately 0.15 ft/year averaged over the footprint of the disposal cell) is higher than the hydraulic conductivity of the unweathered Mancos Shale (approximately 0.036 ft/year as the geometric mean from packer testing), the leachate could perch at the top of the unweathered Mancos Shale and would be expected to migrate laterally along the top of the unweathered Mancos Shale. During the performance life of the disposal cell, conservatively estimated accumulation of leachate and its lateral migration would occur entirely within the weathered Mancos Shale. If more reasonable assumptions are considered, there would be no accumulation or lateral spreading of leachate below the disposal cell (RAP Attachment 3, Appendix G).

GW3. Provide additional data, evidence, or research to support the claim that water in the Mancos Shale beneath the cell location is connate water.

Attachment 3, Appendix D, page 4. The statement is made that "Coreholes 0201, 0203, 0204, and 0208 have continued to yield water at relatively constant rates, signifying that the connate water intercepted by these coreholes is stored in larger compartments, which will require more pumping to deplete. The continued pumping from these larger compartments is deemed unnecessary because the concept that the connate water is trapped in porous zones with limited volume was already demonstrated at corehole 0202."Provide a basis that water in four coreholes is stored in larger compartments. Has DOE considered that fractures may have provided a connection for groundwater flow, thus indicating that behavior of water in the four coreholes is more indicative of groundwater flow than that of corehole 0202?

Response:
The ground water in the Mancos Shale is suspected to be connate based on several factors, including its salinity, variable ground water levels, and isolation from sources of recharge. In August 2006, the ground water was sampled in wells 0203 and 0208 and analyzed for radiocarbon (^{14}C). Results of the analyses show that the age of the ground water exceeds 40,000 years, which is the approximate detection limit for radiocarbon age dating; this would make the ground water at least late Pleistocene in age. A complete summary of the sampling and analysis of the ground water is presented in a new calculation set for

Radiocarbon Age Determinations for Ground Water Samples Obtained from Wells 0203 and 0208 (RAP Attachment 3, Appendix F).

GW4. Attachment 4, Appendix B, page 35, section 8.7.2. Discuss proposed modifications to the model based on the likelihood that much of the groundwater transport through the Mancos Shale is through fractures or other large-scale features.

On the very last line of section 8.7.2, the comment is made that, "Thus, if ground water moves dominantly by fracture flow, some modifications will likely be required." In section 8.8, paragraph two, the statement is made, "Because of the low-bulk hydraulic conductivity, much of the ground water transport through the Mancos Shale is likely to be through fractures or other large-scale features. Based on the two statements, modifications of the model may be required." Discuss what modifications have been made to the model to resolve this discrepancy.

Response:
The following text section from Section 8.8 of the calculation describes how the model would be adapted to fracture flow:

> "Adaptation of the model to fracture flow would be accomplished by decreasing the concentrations of sites and minerals (normalizing to a liter of ground water)."

However, no modifications to the model are deemed necessary because the Mancos Shale is preeminently a confining unit that contains isolated pockets of connate, briny ground water, which exists in fractures and apertures and is essentially immobile. The Mancos Shale provides effective hydrogeologic isolation to the Crescent Junction Disposal Site. If through-flow were to exist, it would be under the conditions of very long travel times, as indicated by the ^{14}C age date, exceeding 40,000 BP, which was obtained for the uppermost ground water.

GW5. Attachment 4, Appendix B, page 35, section 9.0, paragraph 2. Discuss what hydrologic investigations are to be used to yield more useful units of travel time and distance for the model, or alternatively, provide a sensitivity analysis to assess the impact of chemical attenuation at the site.

One of the conclusions of Appendix B is that project personnel will need to couple the results from the model with the results from hydrologic investigations to yield more useful units of travel time and distance. Furthermore, in lieu of further investigations, a sensitivity analysis is proposed to assess the impact of chemical attenuation at the site. Provide the additional analysis as based on the conclusion in this Appendix.

Response:
The hydrologic investigations required for improving the travel time and distance estimates were conducted as part of the Hydrologic Characterization. The data interpretation presented in the calculation set for Vertical Travel Time to Uppermost (Dakota) Aquifer (RAP Attachment 3, Appendix E) develops the travel time and distance topics requested in this comment. The resulting travel time ranges from 4,860 to 48,600 years based on effective porosities of 0.05 and 0.005, respectively. These porosities are a factor of 50 and 5, respectively, lower than the porosity of 0.25 that was used in the geochemical calculation. If a porosity of 0.25 is used in the calculation, the resulting travel time to the

uppermost (Dakota) aquifer becomes 243,000 years.

Radon Attenuation and Site Cleanup

R1. Please provide more detail on the process for inclusion or exclusion of identified vicinity properties.

Response:
DOE has committed to perform gamma surveys on all of the properties on the EPA list. The surveys will also include soil samples from the areas of highest gamma readings to demonstrate compliance with Radium-226 soil standard. From these measurements an inclusion/exclusion report will be prepared, documenting whether a property exceeds the EPA standards (an inclusion) or does not exceed, resulting in an exclusion.

DOE will follow the enclosed flowchart in making the inclusion/exclusion decision. The flowchart was revised to reflect NRC comments. Instead of relying on visual evidence to confirm the presence of tailings, DOE will rely on visual evidence to confirm that a point source is caused by uranium ore, fossil wood, or fossil dinosaur bones. Point sources usually stand out as gamma anomalies with readings from 100 to 1,000 microroentgens per hour.

Consequently, vicinity properties will be excluded if gamma and soils samples do not exceed EPA standards or if the only elevated readings are point sources caused by uranium ore, fossil wood, or fossil dinosaur bones. An included property will undergo further assessment on both the exterior and interior of the structure to ensure all deposits exceeding EPA standards are identified and remediated.

R2. Please provide more detail on which areas will require supplemental standards and the justification for use of supplemental standards on these areas.

Response:
DOE is currently considering the use of supplemental standards on several areas on the millsite, Policaro vicinity property, and BLM properties surrounding the millsite. Examples of where DOE does not plan to remediate include: contamination under the highway asphalt; contamination around high-pressure natural gas lines and buried electric and fiber optic lines; and contamination on steep slopes where access is not feasible and cleanup would cause excessive environmental damage.

DOE understands that additional information is required to substantiate the application. Depending on which provision of 40 CFR 192.22 is cited, the following minimum information is provided:

Proposed use and justification of applying supplemental standards.

Engineering alternatives studied, including costs to implement.

Radiological levels.

Health risks of leaving RRM behind.

Potential for tailings movement or disturbance.

Property owners' notification and input.

DOE has a lot of experience in applying supplemental standards for similar scenarios at other UMTRA sites and can share examples if NRC desires.

Interior Inclusion/Exclusion Survey

Indoors

Does gamma radiation (exposure rate readings) in any $9.3\ m^2$ area average

20 µR/hr above background and are elevated readings due to residual radioactive materials (RRM)

Yes

Include

Yes

Complete Radiological Assessment

No

Does gamma radiation in any

$9.3\ m^2$ area average

30% above

Background

Yes

Evidence of RRM present from exterior survey

Yes

Take Baseline RDC Measurement

Working Level (WL)

0.02

Yes

Include

No

No

No

Exclude

Exclude

Exterior Inclusion/Exclusion Survey

History

Conduct Interview with the homeowner(s), check EPA gamma survey database and any other additional information pertinent to the property prior to the inclusion/ exclusion survey (knowledge of tailings hauled to property)

Outdoors

Perform exterior gamma survey

Does gamma radiation in any 100m^2 area average 30% above background

No

Collect one background soil sample in the area of highest gamma exposure rates

Soil sample less than 5 pCi/g

Yes

No

Yes

Does strong (visual) evidence suggest that uranium ore or naturally occurring radioactive materials (NORM) (petrified wood, dinosaur bone, etc.) is causing elevated readings

No

Collect and analyze soil samples using either the OCS or HPGe counting systems to determine radium (Ra-226) and/ or uranium concentrations as required

Do Ra-226 concentrations in any 100m2 area average 5 pCi/g for surface or 15 pCi/g for any subsurface 15 cm (6-inch) layer above background

No

Yes

Are the elevated gamma readings and radium concentrations due to the presence of residual radioactive materials (RRM) (optional isotopic analyses)

No

Yes

Yes/Can't tell if RRM related

Recommendation Include Property

DOE Concurrence

Finish Radiological Assessment of entire property

Perform Interior Gamma Survey

September 2007 Open Issues Meeting

Further response for February 2007 GT (Geotechnical) Issues

1. **GT 2 -** As part of its volume balance analysis, DOE indicates that a 13 to 15 percent shrinkage factor should be applied from excavated material to compacted material. DOE uses the 15 percent shrinkage factor for the UMTRA cover option, but only assumes an 8 percent shrinkage for the Alternative cover. DOE needs to explain the basis for using an 8 percent shrinkage factor for the Alternative cover, or otherwise describe the source of material to make up the shortage if the 15% shrinkage factor also applies to the Alternative cover.

   Response
   The final design uses the UMTRA cover option. The alternative cover has been dropped.

2. **GT 3 –** In response to the previous request for additional information on swelling clays, DOE has indicated that "the weathered Mancos Shale is likely to be slightly to moderately expansive in the area of the disposal cell, which can be accommodated in the design of the disposal cell." In the final RAP, DOE needs to include information on how it has factored or plans to factor the Mancos Shale expansive characteristics into the cell design.

   Response
   The Mancos Shale formation can exhibit characteristics of moderate swelling, due to the possible presence within the shale of expansive clays and thin gypsum lenses, which expand when hydrated. Though possible, expansion of the shale is not considered to be problematic for the following reasons:

   a) The shale formation has extremely low hydraulic conductivity, and though the top surface of the shale will be wetted during the time when tailings are being placed and later as excess capillary water migrates to and along the cell floor the water will not migrate very far into the shale formation. The thickness of the shale being wetted is not likely more than 1 to 2 feet and the volume of expansive clay or gypsum in that thin layer of shale cannot expand enough to be of consequence. For example, if two feet of shale is hydrated, and 25% of the two feet thickness is expansive material, and the expansive material expands 50% (typical for some types of gypsum) the total expansion would be 3 inches.

   b) Minor expansion, if it occurs, will take place when the Mancos shale is initially wetted. At that point, the cell is being excavated and the first layers of tailings are being placed. There will not be anything in place at that point that could be damaged by minor soil movement. Damage from soil expansion and contraction tends to occur when a sensitive structure such as a building or highway undergoes differential movement. The disposal cell is not a sensitive structure, especially in the early stages of cell excavation and tailings placement.

c) Expansion and/or contraction of expansive soils takes place when significant changes in moisture content occur. When moisture content is relatively constant, expansion and/or contraction does not occur. A relatively thin layer of Mancos shale may expand when initially hydrated, but once several feet of tailings have been placed over the shale, the moisture content at the cell floor should remain relatively constant. Whether the cell eventually dries out or has some residual moisture at the cell floor long-term, it should not be subject to moisture fluctuations that would result in significant cycles of expansion and contraction.

Geotechnical Stability

3. At this time, DOE has indicated that construction details will be provided with the final RAP. This will include the proposed sequence of construction and the detailed construction specifications, including contaminated material and cover layer placement procedures, Therefore, until this information is submitted and reviewed, the approval of construction details and specifications remains an open issue.

Response
In the final RAP, Section 7.2 contains the Construction Details and Addendum B contains the Final Design Specifications.

4. DOE will implement an inspection and testing program to ensure quality control of the construction of the various components of the cell. This program will be described in the Remedial Action Inspection Plan to be submitted with the Final RAP. Therefore, until this information is submitted and reviewed, the approval of the testing and inspection details of the quality control program remains an open issue.

Response
Addendum E contains the Remedial Action Inspection Plan (RAIP) for NRC's review.

5. The factor-of-safety from the DOE slope stability analysis of the long-term pseudo-static condition is just equal to the required minimum value of 1.0 DOE should provide a discussion of these results in terms of the conservative factors in the seismic input assumptions and the analysis as a whole as justification for the factor of safety not exceeding the minimum allowed.

Response
New Slope Stability calculations were performed with computer program, SLIDE, V 5.0 by Rocscience. The SLIDE program analyzes the slope with multiple methods to determine factor of safety, including Bishop Simplified, Janbu Simplified, Janbu Corrected, Spencer, Morgenstern-Price, and Corps of Engineers Methods. Bishop and Janbu methods employ limit equilibrium analysis method, Spencer and Morgenstern-Price methods use both force equilibrium and moment equilibrium to determine safety factors. In this analysis, Spencer results yielded the lowest factor of safety.

The analysis was performed for the End of Construction (short-term) and Long-term cases. Stability of the disposal cell perimeter embankment and cover system was also assessed for the design seismic event for both the short term and long term cases. Seismic conditions were analyzed using guidance provided in the Technical Approach Document (TAD) 1989. The TAD requires the use of pseudo-static approach where Peak Horizontal Acceleration (PHA) value of 0.22 g (previously determined) is taken as half of PHA or 0.11 g for End of Construction case, and 2/3rd of PHA or 0.15 for Long-term case.

The analysis results, summarized in the following table, indicate that the Safety Factor of the critical slope exceeds the Safety Factor required by the TAD for all of the cases. The stability results indicate that the proposed disposal cell site, perimeter embankments, and cover system will be stable when constructed of on site materials and with the planned embankment geometry.

Summary of Slope Stability Analysis

Loading Condition	Calculated Factor of Safety	Factor of Safety Required by TAD
End-of-construction:		
Static	2.15	1.3
Pseudostatic (k_h = 0.11g)	1.31	1.0
Long-term:		
Static	2.78	1.5
Pseudostatic (k_h = 0.15g)	1.51	1.0

K_h = pseudostatic coefficient

6. Both cover options include a 6-inch "infiltration and biontrusion" layer. DOE should provide a detailed description of the function and composition of this layer, and how the composition will serve to meet the functional requirements.

Response

The infiltration and Biointrusion layer has 3 primary functions: It provides positive drainage of any surface water that seeps through the upper layers of the cover and transmits the infiltration to the side slopes of the cover, it provides a barrier against burrowing animals, and it provides a break in the soil regime to discourage root growth into the radon barrier.

The infiltration and biointrusion layer is overlain by a 3-ft layer of soil and a final surfacing of 0.5 ft rock armoring. All three layers act together to resist intrusion into the cell, limit infiltration into the RRM and provide frost protection for the underlying radon barrier.

A description of these cover layers has been included in Section 7.1 of the RAS.

7. In its alternate monolithic cover design, DOE merely indicates a thick mixture of alluvial, Aeolian, and Mancos shale materials. Unless this cover option is eliminated in the final design, DOE should provide a discussion of how it would be constructed to provide a cover of less than or equal to 10-7 cm/sec infiltration rate.

Response

The alternative cover option has been eliminated.

Surface Water Hydrology and Erosion Protection

8. Design of Riprap for the Diversion Channel Outlet: Staff review of the design of the riprap for the diversion channel outlet indicates that the rock size and volume may not be adequate to prevent headcutting and gully intrusion into the channel. Based on observations during site visits in the area, it appears that existing gullies along the west and southwest sides of the disposal cell are deeper than the proposed scour depth of 5 feet. The staff has observed several gullies that are significantly deeper than 5 feet, and the increased drainage area from the north diversion channel may result in gullies that will be similar in depth.

Although the scour model used may be acceptable, the assumptions related to flow distribution across the outlet structure do not appear to adequately account for localized flow concentrations.

The design condition for computing the scour depth, rock size, and volume should be based on assumed areas of very large flow concentrations occurring downstream of the outlet structure. The current assumption of a flow concentration of 3 is probably not adequate. In addition, DOE should carefully analyze the gullies that currently exist and determine an appropriate scour depth for the design of the diversion channel outlet, based on potential headcutting of existing gullies. This information was originally requested in geomorphic comments that were submitted earlier (Comment 3c from 04/06 meeting).

Response
The revised cell design has replaced the north diversion channel with a wedge of compacted surplus material from the excavation. Flow from the north will be diverted around the disposal cell to the east and west. An analysis of sediment transport potential and sediment supply to the area immediately north of the wedge indicates that the wedge will not erode but rather trap sediment from the north and increase in volume over time. After the flow turns southerly at the ends of the wedge it will erode channels that will carry the flow to the east and west branches of Kendall Wash after bypassing the disposal cell. Although the natural ground slope will not direct the flow toward the disposal cell, large diversion berms are to be constructed to ensure that the flow will bypass the cell.

9. Selection of Rock Source: The staff notes that DOE has considered several rock sources, but has not selected any specific source. The staff also recognizes that DOE does not plan to produce and place rocks until several years in the future. However, the staff considers it important for DOE to preliminarily select a specific source and use data from that source to develop a complete design and construction package. Even though DOE has committed to using design criteria such as NUREG-1623 and other NRC suggested guidance, this should be done in the interest of resolving as many issues as possible, prior to construction.

It is important to note that the sizing and the design of the erosion protection is dependent on the specific gravity of the rock, the angularity of the rock, and the quality of the rock placement. For example, the specific gravity is currently assumed to be 2.65, but this may be optimistic for a sandstone source. The rock is also assumed to be angular, but if rounded boulders are used, the rock size may need to be increased by as much as 40 percent.

The staff considers that DOE should develop a preliminary design that is based on the use of a specific rock source. DOE should then provide data from this source regarding rock durability tests, rock production procedures (at the proposed quarry), rock placement procedures, and other QA/QC information.

Response
A source for the riprap will be selected and included as a part of the final RAP along with rock durability tests, rock production (at the proposed quarry), and rock placement.

The Aggregate and Riprap specification contains the following quality requirements:

NRC TABLE OF SCORING CRITERIA FOR ROCK QUALITY

Laboratory Test	**Weighing Factor**			**Score**										
	Limestone	**Sandstone**	**Igneous**	10	9	8	7	6	5	4	3	2	1	0
Specific Gravity	12	6	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	2.25
Absorption, %	13	5	2	0.10	0.30	0.50	0.67	0.83	1.0	1.5	2.0	2.5	3.0	3.5
Sodium Sulfate, %	4	3	11	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
LA Abrasion, % (100 revolutions)	1	8	1	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
Schmitt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	0

Notes:

1. Scores were derived from Tables 6.2, 6.5, and 6.7 of NUREG/CR-2642, *Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review, 1982.*
2. Weighing Factors are derived from Table 7 of "Petrographic Investigations of Rock Durability and Comparisons of Various Test Procedures," by G.W. Dupuy, *Engineering Geology*, July 1965. Weighing factors are based on inverse of ranking of test methods for each rock type. Other tests may be used; weighing factors for these tests may be derived using Table 7, by counting upward from the bottom of the table.
3. Test methods should be standardized, if a standard test is available and should be those used in NUREG/CR2642, so that proper correlations can be made.

ACCEPTABLE ROCK SCORES

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the pile, the rock must score at least 50% or the rock is rejected. If the rock scores between 50% and 80% the rock may be used, but a larger D_{50} must be provided (oversizing). If the rock score is 80% or greater, no oversizing is required.
- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65% or the rock is rejected. If the rock scores between 65% and 80%, the rock may be used, but must be oversized. If the rock score is 80% or greater, no oversizing is required.

ROCK OVERSIZING

Oversize rock as follows;

- Subtract the rock score from 80% to determine the amount of oversizing required. For example, a rock with a rating of 70% will require oversizing of 10 percent (80% - 70% = 10%).
- The D_{50} of the stone shall be increased by the oversizing percent. For example, a stone with a 10% oversizing factor and a D_{50} of 12 inches will increase to a D_{50} of 13.2 inches.
- The final thickness of any layer of oversized stone shall increase proportionately to the increased D_{50} rock size. For example, a layer thickness equals twice the D_{50}, such as when the plans call for 24 inches of stone with a D_{50} of 12 inches, if the stone D_{50} increases to 13.2, the thickness of the layer of stone with a D_{50} of 13.2 should be increased to 26.4 inches.

Water resources Protection

10. Points of Compliance: No points of compliance have been established and I don't believe they need to be for chemical concentrations, however, I believe DOE needs to better explain how they will demonstrate cell performance and monitoring for performance. DOE has modeled the expected lateral spreading of contaminants in the weathered Mancos Shale and estimated a 10 year ring, 200 year ring, and 1000 year ring. I would think that if contamination is expected to spread to the 10 year ring, why not monitor for cell performance? If no contamination or fluids occurs at year 10, cell is performing better than anticipated. If it occurs before, DOE should have a plan to install wells at further out to monitor for performance. No chemically, only the presence or absence of cell fluid is needed to monitor performance because the geochemical nature of the Mancos (saline and briny) and its been written off as a source of water. AI also believe that DOE should be specific as to how many standpipes are going to be installed to monitor cell performance, at the edge of the cell. In RAP, Attachment 3, Appendix G, page 12, last bullet, states, "Up to three piezometers (standpipes) are recommended to monitor the accumulation of leachate within the footprint of the disposal cell, during the transient drainage period, to verify that bathtubbing dissipates as steady-state conditions are achieved. In addition, the piezometer may be used to monitor subsurface hydrologic condition after steady-state drainage is achieved." However, the RAP, page 4-7 states, "DOE will monitor the accumulation of transient drainage with a standpipe tapping a sump at the down gradient toe of the disposal cell…." And on top of page 9-2, "A temporary standpipe to monitor transient drainage is discussed in Section 4.0 of this document." I take this statement to mean DOE has discarded the recommendation made in the RAP, Attachment 3, Appendix G, page 12.

Basically, I have two concerns.

1. DOE should monitor the toe of the cell for leachate and cell performance to make sure they do not have fluids migrating at the unweathered Mancos Shale - Alluvial material interface. I think one locations is not enough for a cell of this size and is contrary to eh recommendation in the RAP. These multiple locations should be defined.
2. The overall performance of the cell and the disposal strategy of allowing the cell to leak over time needs to be confirmed. DOE has determined that all the fluids will be contained within a defined perimeter around the cell and within the weathered

Mancos Shale. They should be required to monitor for this performance for the presence/absence of cell fluids.

Response
The disposal cell has been designed with four locations for standpipes to monitor the presence/absence of cell fluids. The 4 standpipes are along the down gradient interior boundary of the cell (Addendum C Final Design Drawings) The details of the standpipe are shown on drawing E-02-C-104 in that Addendum. If any water accumulates in the standpipe following closure of the cell it can be removed and stored in a cell water retention pond.

During construction of the cell, the slope of the bottom will promote drainage to a temporary sump in the dirty construction area. This water will either evaporate or will be pumped and used as dust control on contaminated areas within the cell. As the construction continues, the amount of water accumulation at the fresh face of construction can be monitored along with any water in the already installed standpipes. This would also provide information for documentation and for future planning.

A decision on future action to monitor water outside the cell would be developed under an observational approach. If there were indications that a larger volume of water than anticipated was accumulating within the cell, there would be studies/modeling performed to ascertain what or if there was an impact and if further action was warranted.

Radon Attenuation and Site Clean Up

11. Editorial: 9.1.3 DOE states that for Th-230 a supplemental standard under criterion "f" will be imposed. 192.21 f refers to the restoration of groundwater. Did they mean "h"?

Response
The correction will be included.

12. Analytical: 9.1.3 DOE stated they will use statistical correlations for radium in lieu of soil sampling. They also state that thorium may be an issue on site. If an area contains RRM other than Ra-226 wouldn't that cause correlations to be severely inaccurate?

Response
The correlation is based on gamma or exposure rate readings detected in the field. If an area contains RRM other than Ra-226, such as Th-230, it would not affect the radium in soil versus gamma correlation due to the fact that Th-230 does not contribute significant amounts of gamma radiation. For the areas identified on the site that may contain RRM other than Ra-226, the soil sampling frequency will be increased in order to adequately demonstrate that the appropriate soil clean-up standards have been met.

NRC Comments to Final RAP (2008)

NRC Comment	Comment	DOE Response
(1) D. Gillen	Will DOE perform cell cover settlement monitoring post closure If so, add language reflecting DOE's commitment.	Cell cover monitoring language added to RAS Section 4.6 and RAIP Section 6.11. Draft Language provided to D. Gillen 3/13/08
(2) D. Gillen 3/21/08	RAIP – Pg. 7 of 25 – 2nd bold heading "In-Place Density Testing of Waste Cell Spoil Material Embankment" - this Section doesn't belong here.	Section will be removed.
(3) D. Gillen 3/21/08	RAS Pg. 7-1, last paragraph – Sum of quantity of individual cell components do not equal total quantity indicated.	Error in quantity of wedge quantity. Clarifying language provided 5/8/08.
(4) D. Gillen 3/20/08	Cover thickness inconsistencies in RAS and Calculations C-10 and C-11. (8',9',10')	The correct final cover thickness is 9'. The RAS text will be corrected to reflect this. Revised calculations provided to NRC 5/8/08.
(5) D. Gillen 3/20/08	Cover cracking typo, RAS, pg.4-9, allowable strain given as .065 and .056 in same paragraph.	.065 is correct value. RAS text will be revised.
(6) T. Johnson / M. Fliegel	Rock quality results in Section 6.6 – The overall score for the tan, friable SS appears to be too high based on the individual scores	Rock lab made error in overall score of tan, friable SS
(7) M. Fliegel / T. Johnson / R. Johnson conf. call 4/17/08	Discuss concerns regarding Silliman rock – test crush Silliman rock to see if poor quality rock breaks up, perform petrographic analysis on Silliman rock types, perform analog study	DOE is no longer proposing Silliman rock as a source. For RAP approval, DOE will propose Fremont Jct. as sole source. Revised Section 6.6 will be submitted to NRC ASAP.

Comments from 5/19/08 meeting at NRC offices		
RAS Document		
(8) D. Gillen	Table 4-1, pg 4-4 – check CJ dike fill moisture content of 17.4%	Table 4-1 dike fill moisture content revised to 11.7% - sent to NRC 6/24/08
(9) D.Gillen	Section 4.24, pg. 4-9, .065 & .056 % both used as maximum strain, Also correct delta / l information in the text per Calc C-15.	Revised text provided to NRC 6/24/08
(10) D.Gillen	Section 5.2.1, pg.. 5-3 explain how 12% long term moisture for radon barrier was determined.	Response provide to NRC 6/24/08
(11) D.Gillen	Section 7.0 – add description of purpose for each cover layer component	Text provided to NRC 6/24/08
(12) D.Gillen	9/07 Open Issues Meeting – Comment response No. 6 calls for a 4' frost protection layer while design has 3'.	Revised Response Text Provided to NRC 6/24/08
RAIP		
(13) D. Gillen	Globally in document – replace tailings with RRM	Tailings replaced with RRM throughout – Revised RAIP sent to NRC 6/24/08
(14) D. Gillen	Pgs 7 & 8, incorrect indenting	Corrected – revised RAIP to NRC 6/24/08
(15) D. Gillen	Section 6.3.5 – Remove 'In-Place Density Testing" from heading	Corrected
(15) D. Gillen	Section 6.4.3 – Make clear testing requirements when CAES not used	Corrected
(16) D. Gillen	Cover drawing pg. 15 – remove "Random Fill" from drawing	"Random Fill" replaced with proper material description
(17) D. Gillen	Section 6.7.1, 2^{nd} paragraph, remove "Table 2"	Completed
(18) D Gillen	Section 6.8.1 remove "Erosion and Rip-Rap Type A & B"	Completed

Specifications		
(19) D Gillen	Earthwork – 1.2.6 – Need definition of Select Granular Material	Spec Revised – Revised Specs sent to NRC 6/24/08
(20) D Gillen	Earthwork – 3.11.1 correct typo –"brake" should be "break"	Corrected
(21) D Gillen	Earthwork – 3.11 – Need subsections for embankment, wedge etc.	Spec Revised
(22) D Gillen	Earthwork – 3.14 – Need range for moisture control spec	Spec Revised – within 3 % of optimum for RRM, Radon Barrier, within 5% of optimum for embankments, wedge
(23) D Gillen	RRM Placement – Make requirements consistent with RAIP, add moisture range	Specs, RAIP consistent – moisture % for RRM placement within 3% of optimum
(24) D Gillen	Final CAP Layers, Section 2.2 – make reference to Aggregate spec for gradation requirements for cover rock	Reference added
(25) D Gillen	Final Cap Layers – Section 3.2.5 – need compaction procedure reference i.e., per ASTM ….	Reference Added
(26) D Gillen	Final CAP Layers, Section 3.2.1 – 200 sieve is only testing requirement – need to add others	DOE would like to discuss with NRC
(27) D Gillen	Aggregate & Rip-Rap – Section 1.4.2.2 do we need liquid limit and plastic limit testing?	Liquid Limit and Plastic Limit requirements eliminated
Calculations		
(28) D Gillen	Calculation C-15, pg.6 – is there an error in delta / length calc?	Calc Revised – Provided to NRC 6/24/08
Health Physics		
(29) T Youngblood	Written comment provided – Section 9.1.3 page 9-2 – does DOE have technical basis document for use of GPS / Gamma Scan ?	Basis Documents for use of Gamma Scan provided to NRC 5/28/08
Conf Call 6/23/08		
Health Physics		
(30) T Youngblood	Section 9.1.3, Pg 9-3, mention in text that Supp Stds requires NRC approval	Language added to Section 9.1.3
(31) T Youngblood	Section 9.1.3, Pg 9-3, use language in VP Completion Reports to address Th 232 remediation standards.	

Groundwater		
(32) R Linton	Comment from Draft RAP not addressed, Attachment 3, Appendix E, pg.7 – Uses both 6.7E-8 cm/s and 4.5E-8 cm/s, which one is correct?	The 6.7E-8 cm/s value is correct. The calculation set has been revised to reflect the correct value.
(33) R Linton	Comment from Draft RAP not addressed, Attachment 4, Appendix B, Section 9 Conclusions – states that geochemical results should be coupled with the field testing (i.e., hydraulic parameters) to yield more useful assessment of chemical attenuation at the Crescent Jct Site. Does DOE plan to do this?	Section 3.4 was clarified to indicate that the results of the geochemical attenuation modeling was coupled with the hydraulic parameters obtained by the field testing to yield a more useful assessment of the chemical attenuation at the Crescent Jct. Site.
(34) R Linton	Calculations in the RAP estimate a lateral travel distance in the weathered Mancos from transient drainage of tailings fluids. DOE should consider monitoring the weathered Mancos for cell leakage outside of the cell foot print.	RAS Section 7.2.4, Transient Drainage, has been modified to state that 4 existing wells, one on each side of the repository will be recompleted as weathered Mancos Shale monitoring locations.
Moab Mtng 6/26/08		
(35) T Johnson	Erosion of ends of energy dissipaters feeding sed ponds – the ends of the dissipaters will head cut – need to address this issue.	Design has been modified to incorporate a buried 10:1 slope at the end of the dissipaters with approximately 10” rock
(36) T Johnson	CJ cell N diversion ditch – If unlined ditch at the toe of the wedge fills with sed, will the rock lined cell channel handle the flow from the wedge and also the cell cover? Confirm calculation.	Calculation C-04, Area between Cell and Wedge has been revised and Drawings E-02-C-500 and E-02-C-501 have also been revised. A more detailed response is provided in Attachment 1 to this Table.
(37) T Johnson	Drawings need to provide more detail on wedge - cell tie-in. Reference drawings E-02-C-501, E-02-C-502.	Additional provided on Drawings E-02-C-501, E-02-C-502

(38) T Johnson	Rock Gradations – In some cases the D50 rock specified is too small. For example the south top slope rock requires a D50 of 1.8". The calculations state that the D50 should be 1.8 inches. However, the specifications state that a D50 of 1.5 – 2.0 inches is required, possibly resulting in undersized rock.	A revised rock gradation spec was approved by T. Johnson via conference call on 6/30/08. Revised specs will be incorporated. The RAIP has been revised to include verification that fines are dispersed evenly throughout the rock during placement.
(39) T Johnson	Rip Rap Placement – RAIP document should include manual testing of the rock thickness against the CAES data to ensure specified thickness is being obtained.	RAIP has been revised to add requirement for manual rock testing check every 10,000 cubic yards of rock placed.
(40) R Johnson	Suggested conducting durability testing of the other than grey basalt rock present at the Fremont Junction quarry.	Samples were collected on 6/26/08 and durability testing is currently being conducted. Test results will be provided to NRC when they are available.
(41) R Johnson	RAS Section 6.6.3.3, page 5, 3rd paragraph, 2nd sentence – specify a depth range instead of several "several feet"	Text was revised to indicate 3 ft.
(42) R Johnson	RAS Section 6.6.3.3, page 6, 2nd paragraph, 3rd sentence – delete this sentence – not substantiated by rock testing.	Confirmed with R. Johnson on 7/9/08 that sentence is ok to leave as is.
(43) R Johnson	RAS Tables Section 6-15 and 6-16, page 9 –check the sample description for Samples 2B and 5B "Weathered Basalt" vs "Basalt cobble"	The description of the degree of weathering from the petrographic analysis was included where available. This information is not available for samples TP-3A and TP-3B.
(44) R Johnson	RAS Section 6.7.2 – 2nd paragraph, 2nd to last sentence – Rock which "passes"…should be "retained".	This sentence was clarified.
(45) R Johnson	Section 6.6. Discuss discrepancies between 1988 and 2007/2008 field observations.	Sections 6.6.1, 6.6.2, and 6.6.3 were clarified to explain the discrepancies.

(46) R Johnson	6.6.3.3. Explain how natural analogs are being used.	This section was clarified to explain that natural analogs provide insight for long-term performance of engineered covers.
(47) R. Johnson	Reference Section: Would like copy of Smith et al. 1997.	A copy of this report was forwarded to R. Johnson.
(48) R. Johnson	6.6.4.1. Expand this section to include x-ray diffraction results.	This section was expanded to include results from the 1988 x-ray diffraction analysis.
(49) R. Johnson	Section 6.7. Change title to "Rock Selection During Production"	The title was changed as requested.
(50) R. Johnson	Section 6.7.2. Clarify size of material removed by crushing.	Section 6.7.2, 3rd paragraph, 1st sentence states that the crushing will "provide appropriate sizes to meet the gradations specified in Addendum B (see Table 3)". This paragraph was clarified to state that sizes smaller and larger than specified in Addendum B will not be retained.
(51) R. Johnson	Section 6.7.3. Discuss potential heterogeneities field personnel needs to look for.	This section was expanded as requested.
(52) R. Johnson	Section 6.7.4. 2nd paragraph. Clarify that removed rock is crushed away.	This sentence was clarified as requested.
(53) R. Johnson	Include that durability testing will be conducted every 10,000 yards even though it is specified in the RAIP.	Section 6.7.2 was expanded to indicate testing will be conducted every 10,000 yards.
(54) R. Johnson	State NRC has approved the Fremont Junction rock source for the Green River cell.	This is stated in Section 6.6., 3rd paragraph, 2nd sentence.
Call w Dan Gillen 6/30/08		
(55) D Gillen	RAIP – Section 6.7.1, pg 17 of 27 – Reference to ASTM 1140 should be revised to ASTM 422 as in the specs	Corrected
(56) D Gillen	RAIP – Section 6.7.4 – Inspection and Testing, pg. 18 of 27, 1st	Language added

	paragraph – add moisture content of (3% of optimum)	
(57) D Gillen	RAIP – Section, 6.8.2, last paragraph, add a bullet that addresses manually checking the thickness of the rock placed to ensure	Bullet added to manually check rock thickness every 10,000 cubic yards of rock placed.
(58) D Gillen	RAIP – Section 6.9.4, pg 22 of 27, 1st paragraph, add moisture content requirements (5% of optimum)	Language added
(59) D Gillen	RAS – new Section 7.0 – description of Radon Barrier purpose – add that radon barrier also limits infiltration (not just contains radon).	Language Added
(60) D Gillen	RAS – Section 7.0 – The heading for “Erosion Control” is mislabeled as “Frost Protection”	Corrected
(61) D Gillen	RAS Section 5.2.1 – comment to revised Section – See Comment Response No. 10 need to expand 1st paragraph – where does “typical” moisture content from tailings come from? Do we have data?	Typical tailings moisture content explanation provided in text and in Attachment 2 to this Table.

60% Design Submittal for ET Cover – NRC COMMENTS AND DOE RESPONSES

December 2021

DOE Moab UMTRA Responses to Nuclear Regulatory Commission (NRC) Staff Comments on "Crescent Junction Disposal Site Alternative Final Cover System 60 Percent Design Report"

By letter dated August 30, 2021, the U.S. Department of Energy, Office of Environmental Management (DOE-EM) and Moab Uranium Mill Tailings Remedial Action Project submitted for the U.S. Nuclear Regulatory Commission (NRC) staff's review and comment, a report titled, "Crescent Junction Disposal Site Alternative Final Cover System 60 Percent Design Report," (Design Report) (NRC Agencywide Documents Access and Management System Accession Number ML21243A286). Consistent with the approach used in the review of the 2008 Remedial Action Plan (RAP) (ADAMS Accession Number ML080920459), the NRC staff's review process was informed by the "Final Standard Review Plan (FSRP) for Uranium Mill Tailings Radiation Control Act Title I Mill Tailings Remedial Action Plans" (ADAMS Accession Number ML110190562) and more recent applicable technical guidance in 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," Revision 1 (ADAMS Accession Number ML032250190).

In its comments below, the NRC staff uses the terms "existing cover" and "proposed cover." The term "existing cover" refers to the rock cover approved in 2008 (and shown in Figure 1 of the Design Report). The term "proposed cover" refers to the evapotranspirative (ET) cover profiles shown in Figure 5 of the Design Report.

General Comment

In the Design Report, the DOE identified two potential cover profiles for Crescent Junction. One, or both, profiles will be installed on the top slopes (i.e., the north facing 2% slope and the south facing 2.5% slope) and DOE stated it will make this decision later in the design process. The Design Report does not discuss alterations to the cover system on the 5H:1V side slopes. Therefore, for the purposes of its comments provided below, the NRC staff assumes that the existing design will be maintained for those slopes. It appears that the proposed design alters the rock sizing at the toe of the slopes. The NRC staff has comments about this approach in the Section on surface water hydrology and erosion protection.

A: The current intent is not to change any slopes. However, the project is evaluating rock size and rock layer thickness of the rip rap deployed on the side slopes and drainage trenches to determine whether it is practical to redeploy any overly conservative rock size or layer thickness. All minimum NUREG requirements will be satisfied.

Comments Related to Geotechnical Stability

1. In Section 6 and Appendix B of the Design Report, DOE discusses unsaturated modeling of the proposed cover. The Design Report describes the input parameters

used in UNSAT-H and provides a summary of the output. The NRC staff appreciates the extent of the modeling that has been done to support the 60% design and understands the approach taken to design the proposed cover. ET covers rely on storage of water within the cover and removal of the water by evaporation and transpiration to limit percolation through the bottom of the cover. Conventional covers rely on a low permeability layer to limit percolation through the bottom of the cover. Because of these fundamentally different processes for management of water, the NRC staff offers the following comments for DOE's consideration.

a. As currently presented, the UNSAT-H model is challenging for the NRC staff to verify. DOE could consider either providing input files, output files, or some type of combination to facilitate the NRC staff's future review.

   A: A table identifying all input and output parameters will be included in the design report. Also, the input files and output files will be included as an appendix or submitted as a separate set of files.

b. The UNSAT-H model considers multiple scenarios in an attempt to account for different vegetation and climate conditions that could exist over the 1,000-year performance period. To provide confirmation that the cover will function as intended, DOE should consider monitoring sensitive and important design parameters before and after turnover of the site to DOE-Legacy Management (DOE-LM). It may be possible to perform monitoring in the standpipes along the southern edge of the disposal cell. Alternatively, remote sensing technologies could be used to infer water storage in the ET cover system.

   A: Agree. The standpipes will be left in place to allow for monitoring of any potential saturated conditions. Additionally, discussions with DOE LM will include adding remote sensing technologies that they feel are useful for long term monitoring.

c. The UNSAT-H analysis is based heavily on the moisture retention properties of the cover soils as well as the properties of the vegetation. The UNSAT-H modeling shows that the ET cover appears be effective at limiting percolation through the cover system. It is unclear to the NRC staff how the information in the design calculations relates to the technical specifications. One example is with the soil used in the surface admixture. The design is based on the van Genuchten properties, but the technical specifications only limit the maximum particle size and state that the soil should be a uniform, fine-grained, dry material free of roots, debris, organic, or frozen material. The NRC staff recognizes that the technical specifications have not been as refined as the design and that the relationship between the design calculations and technical specifications may become more apparent at the 90% design.

   A: The 90% design submittal will link the soils used in the performance modeling with the specifications.

2. The Design Report presents an updated settlement analysis in Section 7, with detailed calculations included in Appendix D. The calculation methodology in Appendix D appears reasonable. However, it is not clear if the settlement calculation is based just on the settlement of the residual radioactive material (RRM) under its own self weight, or if the influence of the cover system is accounted for in the calculation. The settlement

calculation is based on a peak elevation of 5,000 ft, but engineering drawing E-02-C-301 shows that peak elevation of the RRM being at 5,000 ft and the top of the final cover system being above that.

A: The calculations are based on the specific surcharge loads of the RRM and ET Cover. The explanation of this will be expanded in the 90% submittal. The drawings were very crude for the 60% submittal as the design methodology was the emphasis of effort to inform NRC of the design methodology specifics. The drawings will be clarified and expanded in the 90% submittal.

3. DOE-LM and NRC have observed (and are dealing with) settlement challenges at several Title I and Title II disposal cells, especially those with relatively long and shallow top slopes. These challenges have become more of an issue since the NRC's concurrence on the 2008 RAP. The settlement analysis approach used in Appendix D is reasonable but may not completely consider variability in the material properties that could become apparent over longer distances. The NRC staff recognizes that DOE-EM has significantly more control over the mixing of RRM in Moab and placement of RRM at Crescent Junction when compared to past practices at other Uranium Mill Tailings Radiation Control Act Title I and Title II sites. This aspect of operations at Crescent Junction may be sufficient to minimize the potential for differential settlement at the site. The NRC staff is not asking for a new or additional analysis at this time; this comment is intended to highlight the need to remain focused on proper mixing and placement of the RRM. It may also be useful to discuss long-term settlement challenges with DOE-LM staff.

   A: Agree. This issue will be discussed with DOE LM.

4. Section 9 of the Design Report addresses the potential for liquefaction in the disposal cell at Crescent Junction; the liquefaction analysis from the 2008 RAP was included in Appendix J. In reviewing the 2008 analysis, the NRC staff recognizes that DOE considered a scenario in which the RRM become saturated and determined that liquefaction is not a concern. The proposed change to the cover system does not alterthe placement methods for the RRM. Additionally, the ET cover is anticipated to improve the hydraulic performance of the cover system. If both of these statements remain true, the 2008 liquefaction analysis does not necessarily need to be updated.

   A: The assumption at this time is that both of those statements are true and the 90% design submittal will demonstrate that.

5. Section 10 of the Design Report addresses slope stability. The Design Report states that the slope geometry and materials are those described in the 2008 RAP and that the existing slope stability analysis will not be changed or amended. The slope stability analysis in the 2008 RAP is included as Appendix I to the Design Report. The NRC staff recognizes that the while the cross section of the final cover system will change, the slope length and angle will remain the same. As long as DOE can demonstrate that the existing slope stability analysis is representative of the critical cross section with the revised cover system, it does not necessarily need to be updated. However, if the design of the ET cover is modified in a manner that is not consistent with the 2008 analysis (i.e., thicker, heavier soils are used, or the cover system on the 5H:1V side slopes is modified), the slope stability analysis should be updated.

A: Agree.

Comments Related to Surface Water Hydrology and Erosion Protection

1. The NRC staff reviewed the erosion calculations in Section 3 and Appendix F of the Design Report. The NRC staff is familiar with the methodology used to design the surface admixture. However, the NRC staff is not able to verify the calculations presented in Appendix F. To facilitate the NRC staff's review, it would be helpful to include a sample calculation with parameter values, not just formulas, in the 90% design. Alternatively, Tables F-4, F-5, F-6, and F-7 could be modified to include the calculated value for each formula used in Appendix F. Either method would improve transparency in the calculations and allow the NRC staff to verify that the appropriate parameters were used and check that correct unit conversions were made. Specific examples where the NRC staff was not able to verify the calculations are identified below.

   A: The spreadsheet that was utilized to compute the output values will be provided for your review

   a. Using equations F-2 and F-3, the NRC staff was able to confirm the calculations in Table F-2. However, when using equations F-2 and F-3 to confirm the calculations in Table F-3, the NRC staff arrived at different values for the time of concentration. It is not clear to the NRC staff whether a different methodology was used to calculate the time of concentration for the north slope.

      A: Table F-3 incorrectly had values from time of concentration calculation based on DOE guidance summarized in Table F-9. Values in table F-3 were corrected with the time of concentration utilizing the Kerplich equation.

   b. For Equation F-6, the unit weight of the soil is not stated. Also, shear stress is typically reported in pounds per square foot (psf), instead of pounds per cubic foot (pcf).

      A: Value added -- specific weight of soil is 2.76 g/cm3 = 172.2 pcf. PCF changed to psf for shear stress.

   c. In Equation F-8, the value of P_c is not stated. It is not clear how the calculated value of Y_s in Equation F-8 factors into the design.

      A: Pc is the percentage of gravel. In this case 33% by volume was used. The depth of the rock/soil admixture layer is the total of Ys + Ya.

2. The Design Report does not discuss the potential for the presence of dispersive soils within the cover at Crescent Junction. Dispersive soils can be more susceptible to erosion. The presence of dispersive soils in covers can result in removal of soil from the cover and lead to the formation of erosion rills or voids. Therefore, the presence of dispersive soils represents a long-term maintenance concern for DOE-LM. It is not clear if the dispersion characteristics for soils at Crescent Junction have been evaluated. A joint discussion between DOE-EM, DOE-LM, and NRC may be helpful in addressing this issue.

   A: Soil samples from cover soil borrow material have been submitted for testing of soil dispersion. The testing methodology will include a pinhole test (ASTM D4747) and a crumb test (ASTM D6572) for each submitted sample. The NRC staff reviewed the drainage rock calculations in Appendix C of the Design Report. As presented in the Design Report, the NRC staff understands that the rock cover on the 20% (5H:1V) side slope is not being altered, but DOE plans to modify therock contained in the drainage trenches at the base of the side slopes. Please confirmthat DOE intends to resize the rock for the trenches at the base of the side slopes.

A: The project is evaluating the rock requirements for erosion control including the rock on the 5:1 slopes. There are no plans to change the slope, but we are evaluating whether the rock deployed is overly conservative and if there may be a potential to repurpose some of that rock. All NUREG minimum requirements will be met.

3. Similar to comment 1 in this Section, the NRC staff is familiar with the calculations and methodology to size rock for side slopes and perimeter trenches. Please clarify the following with respect to these calculations:

    a. Is Equation C-1 or C-2, (or both) used to size rock in this calculation? Note that Equation 1 points to Table 8 for results, but there is no table in this package that pertains to rock size.

       A: Equation C-1 is used for side slopes while equation C-2 is used for the bottom of the slopes below the side slopes. Reference to table 8 was deleted. Correct reference is "Table C-1 provides a summary of the computed results for the side slopes. Table C-2 provides a summary of the computed results for the bottom of each respective drainage channel."

    b. If Equation C-2 is used, please identify the value used for the flow concentration factor, C_f.

       A: See reply above. The Cf used is 3 as recommended in Abt et al 1991. Verbiage in Appendix C changed to reflect this value.

    c. It is not clear what length is used to convert from the peak flow Q (in cubic feet per second, cfs) to the unit flow of q (cfs/ft).

       A: The length is included as a column in each table. The length is divided by 43,200 per DOE 1989.

Comments Related to Radon Attenuation

1. The NRC staff evaluated the alternative cover design described in Chapter 5, "Radon Attenuation," and Appendix H, "Radon Flux Calculations." The alternative cover would modify the existing design from a 4-foot thick radon barrier covered by 4 feet of rock armoring, frost protection, and biointrusion layers to a 3-foot thick radon barrier covered by 2 feet of gravel/soil admixture and alluvium. Given the reduced margin in the alternative cover design, the NRC staff used the procedures in NUREG/CR-3533, "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design," to determine the sensitivity of the design to changes in long-term soil moisture content, a critical parameter in determining radon diffusion coefficients and cover effectiveness. The value of long-term soil moisture content assumed in the DOE's calculation is 12 dry weight

percent (dry wt. %). The NRC's confirmatory analysis indicated that the cover performance would not be acceptable if the long-term moisture content of the radon barrier (shale soil layer) was 11 dry wt. % or lower, which may indicate relatively little margin in the selection of this parameter value. Furthermore, the *in situ* moisture content of weathered Mancos Shale is 7 dry wt %, over 5 dry wt % lower than the value assumed in the DOE's analysis, which may raise a question of whether the DOE's value is representative of long-term conditions at the site. For these reasons, the NRC staff suggests that the DOE provide additional justification for the assumed long-term moisture content of the shale radon barrier.

In Section 6.2.3, "Conclusions," of its 2008 Technical Evaluation Report on the 2008 RAP (ADAMS Accession Number ML082060216), the NRC staff stated, "NRC noted that DOE [sic] choice of mean long-term moisture content of the radon barrier is based on calculated and measured 15-bar moisture content rather than the *in situ* moisture content of the Mancos Shale. NRC ran the RADON computer code using an additional value for mean long-term moisture content of five percent and the radon barrier thickness was sufficient to meet the Environmental Protection Agency radon flux standard." This statement explains that in 2008, the NRC staff evaluated whether a value for long-term moisture content of 12 dry wt. % measured in the laboratory was sufficiently conservative by evaluating the design using a lower value of 5 dry wt. %, and determined that the design would meet the EPA's radon flux standard using either a value of 5 dry wt. % or 12 dry wt. %. As explained above, a value of 5 dry wt. % in the alternative cover design, which would be representative of *in situ* moisture content of the Mancos Shale, would not meet the EPA's radon flux standard.

In Appendix H, "Radon Flux Calculations," Section H.1.1.5, "Moisture Content," the DOE should provide additional justification for the 12% mean laboratory measured value (i.e., using method ASTM D3152) of the long-term moisture fraction of remolded Mancos Shale. The mean long-term gravimetric moisture content in 16 *in situ* samples of weathered Mancos Shale was 7% (2008 Final Remedial Action Plan [FRAP]), Addendum D, Calculation C-5, Table B-2, Radon Barrier Design). As noted in FSRP, Section 5.3.1.1, "Evaluation of Parameters," estimated values of the long-term moisture content will be compared to present *in situ* values to assure that the long-term value does not exceed the present field value derived from samples taken at a depth of 120 to 500 cm (but not close to water table).

A: Agree. Long term moisture content of soils will be further evaluated in the 90% design submittal.

2. In Appendix H, "Radon Flux Calculations," Section H.1.1, "Input Data for Radon Flux Modeling," if a portion of the modeled cover could be affected by freeze-thaw events, that portion should be represented in the model with lower density and corresponding higher porosity values than the unaffected portion (see Criterion 5.1.3.1(5) of NUREG-1620). In the 2008 FRAP, the freeze-thaw depth was estimated to be 43 inches, with a recurrence interval of 200 years, and the thickness of the rock armoring, frost protection, and biointrusion layers of four feet was deemed sufficient to ensure the freeze/thaw cycle would not affect the radon barrier. However, the surface admixture thickness above the radon barrier in the alternative cover design is less than or equal to 24 inches.

   A: The intent of the density values for the cover soil is to place them at about 90% of the standard proctor that approximates each respective soil in situ density. In other words, the planned density should be the long-term density given all expected climatic and pedogenic process. It is anticipated that the saturated hydraulic conductivity may increase with time in the upper portion of the cover profile and this has been taken into consideration in the unsaturated modeling of the profiles.

3. Section 5.1.1, “Cover Thickness and Layer Data,” states, “Two different surface admixture thicknesses (18 inch and 24 inch) were computed dependent on the slope lengths (Figure 5).” Consider adding a figure similar to FRAP Figure 7-8, “Transition of Disposal Cell Top Cover to Side Slopes,” to show the final alternative cover profile where the top cover transitions to the side slopes.

   A: A final decision has not been made on the cover profile - whether multiple profiles or a single profile will be used. Given that we will consider adding the suggested figure to the report in the 90% submittal.

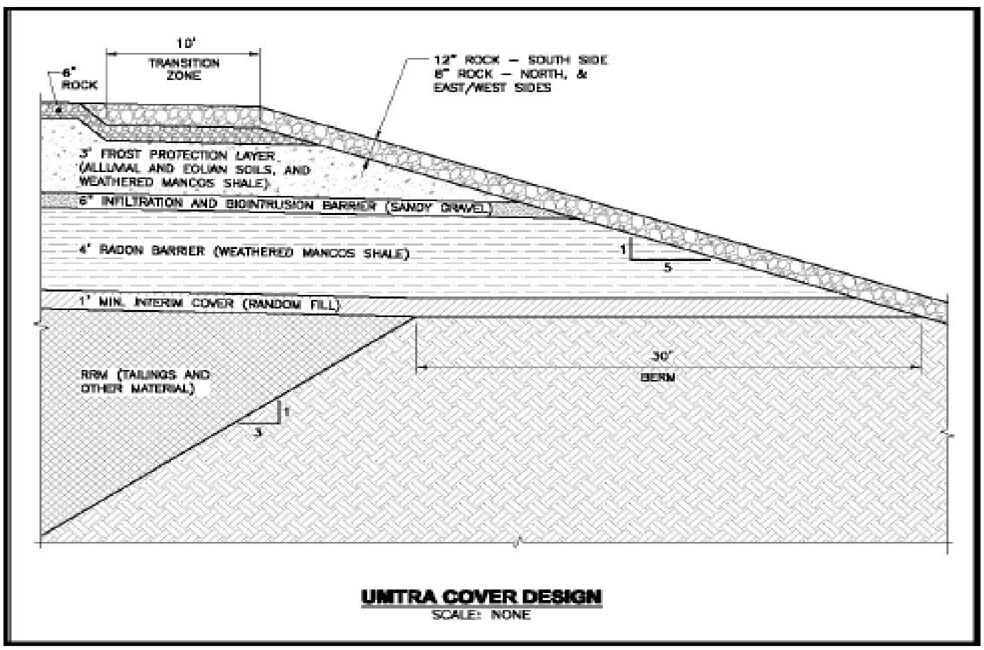

Figure 7-8. Transition of Disposal Cell Top Cover to Side Slopes

Technical Specifications

No additional comments beyond what was mentioned in comment 1c above.

Post Construction Monitoring Plan

In addition to the comment on post construction monitoring mentioned in Geotechnical Stability comment 1b above; the NRC staff offers the following comments on the post construction monitoring plan.

1. In Appendix F, it is recognized that some winnowing or movement of fines in the ET cover may occur. Therefore, it may be helpful to identify a threshold limit for when maintenance or repair is needed. This would allow DOE to focus on the overall performance of the cover.

A: Agreed. Will include in 90% submittal

Will DOE-LM have a role in post construction monitoring prior to turn over of the site for long-term care and maintenance?

A: The timing and mechanism for transfer of the Crescent Junction site from DOE-EM to DOE-LM is not known at this time; however, discussions between organizations and stakeholders regarding post construction and long-term monitoring are on-going.

2. How will the post construction monitoring plan be incorporated into the long-term surveillance plan? Will all items from post construction monitoring be performed in the long-term, or will the observed performance and experience developed during post construction monitoring inform what activities are included in the long-term surveillance plan?

   A: The timing and mechanism for transfer of the Crescent Junction site from DOE-EM to DOE-LM is not known at this time; however, discussions between organizations and stakeholders regarding post construction and long-term monitoring are on-going.

National Environmental Policy Act

1. While not necessary at this stage of the review process, the NRC staff is interested in understanding how DOE plans to comply with the National Environmental Policy Act (NEPA) for this action. Are the activities proposed in the Design Report within the scope of what was considered in the 2008 Environmental Impact Statement (EIS)? Or does DOE plan to supplement the EIS to address the changes to the design? The NRC staff was a cooperating agency on the 2008 EIS, so understanding DOE's plan will inform the NRC staff's NEPA related activities going forward.

   A: Moab UMTRA staff are actively engaged with DOE subject matter experts to determine the most appropriate path forward for NEPA. Moab UMTRA will coordinate all future plans and schedule with NRC.

Administrative Items

1. In Table 7, "Profile 1: Radon Flux," there appears to be a typographical error in the value provided for the radon diffusion coefficient for the top layer (admixture) of cover. The value should be 820.7E-09, and not 872.0E-09.

A: The listed value is the correct value --- 872.0E-9. Refer to output table below. The difference between 8.20.7E-09 and 872.0E-09 is believed to be the approximation of input parameters.

Layer	Thickness	Ra-226	Emanat	Porosity	Moisture	Diff Coeff
No.	[m]	[pCi/g]	Fract		[dry wt_%]	[m2/s]
1	2.866	1349	.35	0.44	15	1.121E-6
2	2.134	707	.35	0.44	15	1.121E-6
3	0.305	1.9	.35	0.38	9	1.620E-6

4	0.914	2.3	.35	0.33	12	414.8E-9
5	0.152	1.9	.35	0.38	9	1.620E-6
6	0.457	1.27	.35	0.25	6	872.0E-9

2. In Section H.1.1.5, “Moisture Content,” there is no discussion of the assumed moisture contentfor the interim cover material.

A: Discussion of this soil shall be added to the 90% submittal.

3. General Comment Added by DOE:

As part of future closure, the project will evaluate disposal of used construction equipment in the disposal cell. The equipment will be separated from RRM material. Clean soil will be placed between the end of the RRM and the placement of equipment which will be buried in clean fill soil. The ET Cover will extend over the buried equipment. The concept will be included in the 90% design submittal.

90% Design Submittal for ET Cover – NRC COMMENTS AND DOE RESPONSES

November 2022

DOE Moab UMTRA Responses to Nuclear Regulatory Commission (NRC) Staff Comments on "Crescent Junction Disposal Site Alternative Final Cover System 90 Percent Design Report"

By letter dated April 6, 2022, the U.S. Department of Energy, Office of Environmental Management (DOE-EM) and Moab Uranium Mill Tailings Remedial Action Project submitted for the U.S. Nuclear Regulatory Commission (NRC) staff's review and comment, a report titled, "Crescent Junction Disposal Site Evapotranspiration Cover System 90 Percent Design Report," (Design Report) (NRC Agencywide Documents Access and Management System Accession No. ML22096A243). Consistent with the approach used in the review of the 2008 Remedial Action Plan (RAP) (ML080920459), the NRC staff's review process was informed by the "Final Standard Review Plan for Uranium Mill Tailings Radiation Control Act Title I Mill Tailings Remedial Action Plans" (ML110190562), and more recent applicable technical guidance in NUREG-1620, Revision 1, "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."

On November 2, 2021, the NRC staff provided feedback on DOE-EM's 60 percent design for the Crescent Junction cover system (ML21298A067). Staff reviewed the 90 percent design to understand how the design has changed in response to our comments. Staff's comments from the 60 percent design have not been repeated below, unless the comment pertains to an issue that remains relevant.

In its comments below, the NRC staff uses the terms "existing cover" and "proposed cover." The term "existing cover" refers to the rock cover approved in 2008 (and shown in Figure 1 of the Design Report). The term "proposed cover" refers to the evapotranspiration (ET) cover profile shown in Figure 5 of the Design Report. From top to bottom, the proposed cover consists of a 2-foot-thick gravel/soil admixture, a 4-foot-thick shale layer (which serves as the radon barrier), and a 1-foot-thick interim cover layer on top of the residual radioactive material (RRM). Additionally, the staff understands that that DOE is not changing the angle of the side slope of the disposal cell, but is considering re-evaluating the minimum rock diameter and thickness to provide erosional stability. Staff appreciates that DOE is narrowing its design approach. The NRC staff continues to develop a better understanding of ET cover system design and performance. Our comments on the 90 percent design may focus on slightly different areas, as staff continues to gain knowledge and experience with ET covers.

Comments Related to Geotechnical Stability

NRC Comment 1:

1. In Section 6 and Appendix B of the Design Report, DOE discusses unsaturated modeling of the proposed cover. The Design Report describes the input parameters

used in UNSAT-H and provides a summary of the output. The NRC staff appreciates the extent of the modeling that has been done to support the 60 percent design and understands the approach taken to design the proposed cover. ET covers rely on storage of water within the cover and removal of the water by evaporation and transpiration to limit percolation through the bottom of the cover. Conventional covers rely on a low permeability layer to limit percolation through the bottom of the cover. Because of these fundamentally different processes for management of water, the NRC staff offers the following comments for DOE's consideration.

a. The design of the cover system is based heavily on the moisture retention properties of the cover soils as well as the properties of the vegetation. The NRC staff's comments on the 60 percent design provided feedback on the relationship between the design calculations and the Technical Specifications. In addition to the particle size requirements that were in the 60 percent design, staff recognizes that DOE has modified the Technical Specifications to include agronomic testing to determine if organic material or other soil additives are needed to support vegetation. This change is helpful. It may be worth further discussion to better aid the NRC staff's understanding of the relationship between the design and the Technical Specifications.

DOE Reply 1:

The cover soil intended for the upper portion of the cover (generally top foot) will be tested for agronomic properties. The reason for this is to determine whether soil amendments may be required to better establish native vegetation. The addition of any amendments will be done during seeding operations. Any amendments should have no significant impact on the cover soil's hydraulic properties. Thus, agronomic testing and potential subsequent soil amendment on cover soil will have no impact on the cover sensitivity simulations.

Modeling showed that the PODR is reached at a depth significantly less than the cover depth and thus water balance is not the critical factor to determine the cover depth. The point of diminishing returns (PODR) is generally the depth of cover whereby an additional inch of soil depth no longer reduces percolation - in all of these cases, it was the depth that produced an annual zero flux rate. The Design Report, Appendix B included multiple sensitivity analyses that included varied soil input parameters. The cover soil borrow material comes from on-site excavations. There are generally two soil textures - overburden or alluvium and the underlying Mancos shale. Multiple samples of each soil texture were measured. These unsaturated hydraulic property values were each modeled separately to determine the set of values that would require the thickest cover to produce the PODR. The intent of the sensitivity analyses were to make sure that the cover profile proposed effectively minimizes flux due to meteoric water but also to qualify all of the on-site cover soil borrow sources. Values from the literature for similar soil textures, as well as. values produced from similar soil textures on the Grand Junction project were included in the sensitivity analysis to determine the worst case set of hydraulic priorities (values that required the deepest PODR). The worst-case alluvium properties and the worst-case Mancos shale properties were then combined in a second set of sensitivity analyses in a cover profile as proposed. The worst-case vegetation properties were also evaluated.

The combined worst case input parameters (soil and vegetation) are included in the

Profile 2 graph that shows the PODR for the beyond worst-case scenario whereby the wettest year on record while forcing 100% infiltration of all precipitation was applied in consecutive years. The output from these sensitivity analyses showed little sensitivity to the soil input parameters. The worst-case soil texture with the worst-case vegetation parameters subjected to the beyond worst-case climate scenario resulted in a PODR of 140 cm. That is, zero flux is produced with a cover depth of 140 cm (PODR was 89cm to 140 cm depending on the soil textures utilized as input -- refer to the Design Report, Appendix B, Table B-10). Additional sensitivity analyses performed utilizing Grand Junction soil properties suggested in a previous review resulted in a worst case PODR of only 109cm (PODR was 83cm to 109cm). Our cover depth is 213 cm. Consequently, water balance is not driving the depth of cover and further altering soil texture or vegetation properties will have no impact on the cover design. Keep in mind that if one simply compares the proposed cover design results to the existing UMTRA cover profile - the proposed ET Cover reduces recharge to zero while the existing UMTRA cover profile allows recharge at close to the precipitation rate at the site.

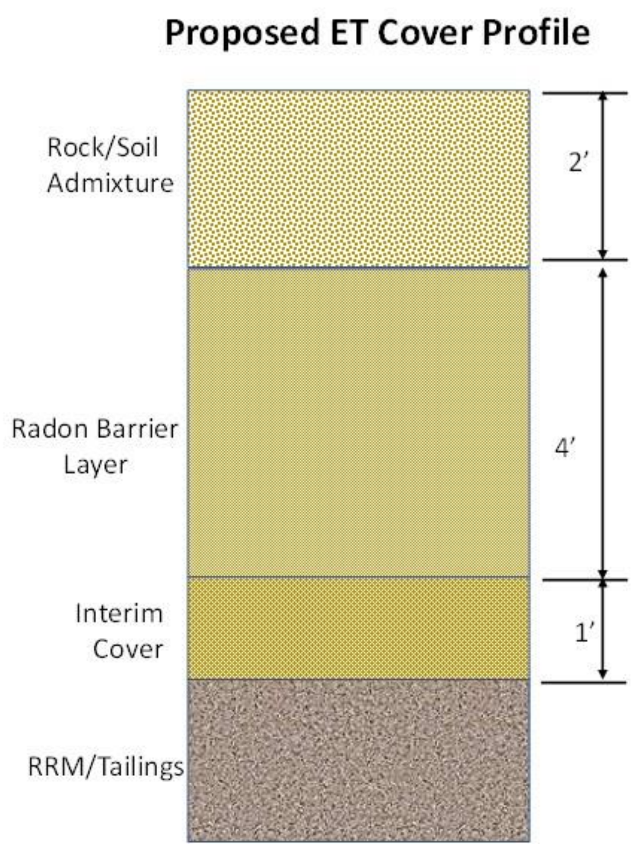

Figure 1. Proposed ET Cover with 2ft Surface Admixture Layer

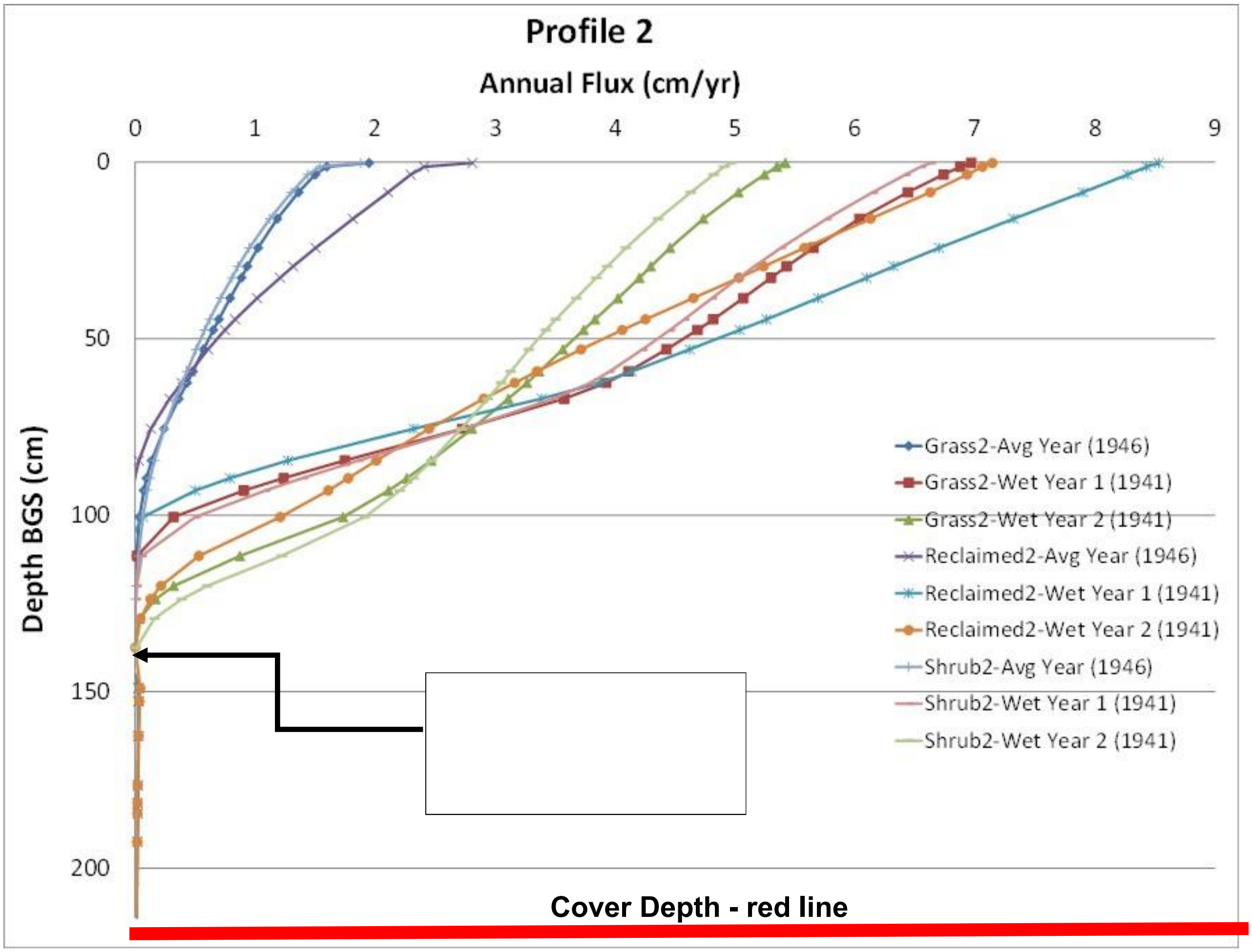

Figure 2. PODR Results for Profile shown in Figure 1

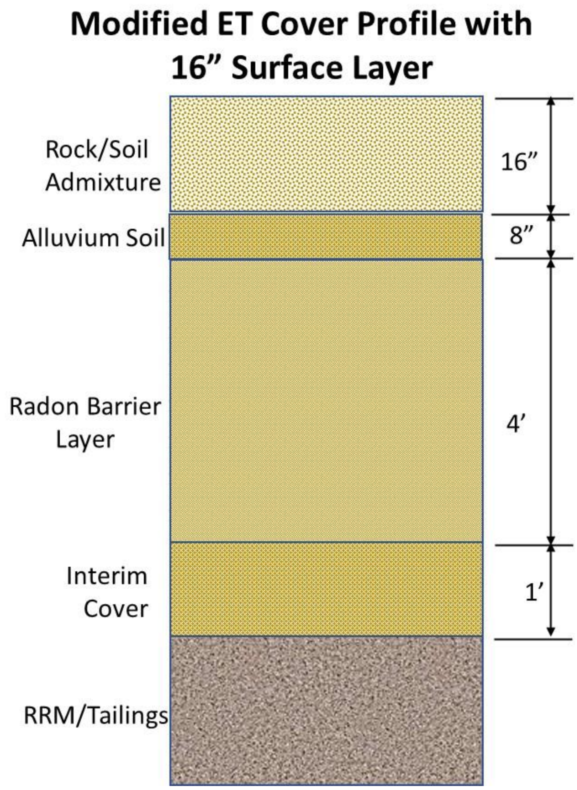

Figure 3. Profile with Thinner 16" Surface Admixture Layer

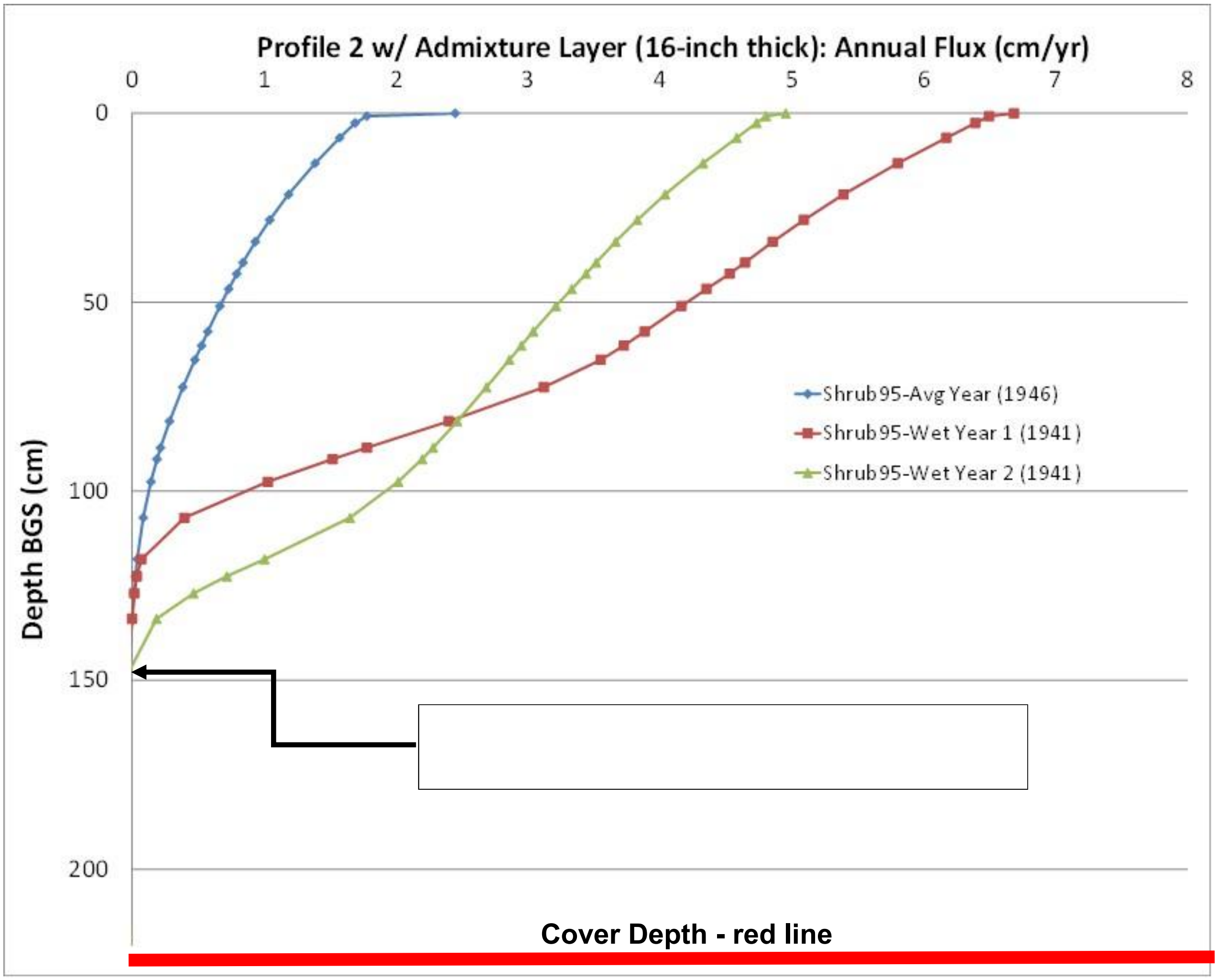

Figure 4. PODR with Results from Simulations Using Profile show in Figure 3

NRC Comment 2:

2. As mentioned in the NRC staff's comments on the 60 percent design, settlement challenges have become apparent at several Title I and Title II disposal cells. This is potentially an issue at sites with relatively long and shallow top slopes. The settlement analysis approach used in Appendix D is reasonable as it considers the mixing of RRM that occurs prior to placement in the disposal cell. However, as currently presented, the settlement analysis is based on the conditions at one location. As a result, the analysis does not consider variability in the material properties that could become apparent over longer distances. The NRC staff recognizes that DOE-EM has significantly more control over the mixing of RRM and placement of RRM when compared to past practices at other Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I and Title II sites. This ability to mix materials may minimize variations in material properties and a corresponding decrease in the potential for differential settlement. The NRC staff is not asking for a new or additional analysis at this time, but it may be worth identifying a tolerable amount of differential settlement so that resources are appropriately focused for DOE-Office of Legacy Management (DOE-LM) during long-term surveillance.

DOE Reply 2:

The settlement analysis evaluated the worst-case condition - shallowest tailings compared to deepest tailings to ensure that ponding is not possible. This means the full slope length of the cover was evaluated. The conservative consolidation results estimate a potential slope change of 0.1% compared to the design slope of 2% to 2.5% - thus there is no possibility of producing ponding on the cover due to differential settlement. Settlement issues at other DOE sites was discussed with DOE LM. DOE LM informed us settlement issues at other UMTRA sites generally resulted from slimes and saturated conditions as well as equipment disposal within slime tailings. At Crescent Junction, all RRM is placed in a controlled manner. The RRM is mixed and dried in Moab and then transported and placed within the Crescent Junction disposal cell based on approved procedures included in the Remedial Action Plan. There are no saturated conditions and thus no primary consolidation in a saturated soil that is traditionally the larger portion of total consolidation. The calculations conservatively assumed that there would be primary consolidation. Second, all RRM are placed at similar densities and moisture contents with a controlled compaction specification that requires the soil be placed at 90% of the maximum dry density per ASTM D698. Third, there are no untreated slimes placed in the disposal cell. Furthermore, we have proposed that large equipment that pose a differential settlement threat be buried adjacent to the RRM to further ensure there is no unexpected differential settlement in the RRM area of the disposal cell.

NRC Comment 3:

3. Section 10 of the Design Report addresses slope stability. The current design has the same slope and material properties as what was evaluated in the 2008 RAP and accepted by the NRC staff. There is no expectation for an updated slope stability analysis at this time. This comment is included as a reminder or placeholder in the event that a change is made to the design that is different from what was considered in 2008 (i.e., thicker, heavier soils are used, or the cover system on the 5H:1V side slopes is modified), the slope stability analysis should be updated.

DOE Reply 3:

Slopes will not change; thus, slope stability analyses will not be updated. The outer slope lengths will actually decrease some due to the thinner cover (7 ft thick instead of the UMTRA profile of 9ft) thus slightly improving slope stability factors of safety.

Comments Related to Surface Water Hydrology and Erosion Protection

NRC Comment 1:

1. The NRC staff reviewed the erosion calculations in Section 3 and Appendix F of the Design Report and appreciates the explanations and modifications that DOE has provided in the 90 percent design. The NRC staff is familiar with the methodology used to design the surface admixture. However, the NRC staff remains concerned about the erosion control aspects of the cover at Crescent Junction, particularly given the relatively thin amount of soil on top of the radon barrier. The staff understands that the design calls for a gravel/soil admixture at a 30 percent rock to 70 percent soil uniformly

mixed through the 24-inch depth. The gravel/soil admixture will overlie the 48-inch-thick shale layer that will serve as the radon barrier. Staff remains concerned in the ability of the gravel/soil admixture to resist erosion without forming gullies or erosion rills. The design calls for the rock component of the admixture to have a D50 of 2.3-inches. Staff has not been able to identify an overall gradation of the gravel/soil matrix; the Design Report and Technical Specifications do not clearly articulate what the final grain size distribution will be for this component of the cover system. Further input on this topic is available in the comments related to soil properties below. Without understanding the final grain size distribution of this layer, staff is concerned that it may be susceptible to erosion and the formation of gullies. This may represent a long-term maintenance issue for DOE-LM. Although not explicitly stated in the guidance document, NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization," was developed around the concept of rock-to-rock contact. With a gravel/soil matrix consisting of 30 percent gravel, the rock-to-rock contact will not be as prevalent as was envisioned in NUREG-1623. As a result, the design may be more susceptible to erosion. Guidance from the U.S. Army Corps of Engineers (USACE) in Engineering Manual 1110-2-1601, Hydraulic Design of Flood Control Channels (USACE, 1994) suggests that well graded riprap be used and identifies target values for the D85 to D15 ratio. Options to consider with the design to make it more resistant to erosion include: increasing the rock size in the gravel/soil matrix; concentrating the gravel in the upper portion of the admixture and filling in the voids with smaller diameter particles (similar to what was done at the Monticello, UT site); or utilizing a shallower slope on the top deck of the disposal cell. Staff recognizes the need to consider erosion resistance, the ability to support vegetation, and the ability to limit percolation can be counter to each other. Further discussion may be warranted to arrive at a design that satisfies each of those goals.

DOE Reply 1:

Albright et al 2010, Dwyer et al 2007 (reference provided), and EPA -909-R-11-007 (reference provided) state that rock/soil surface admixtures mitigate soil loss due to erosion and prevent rill and/or gully formation. Abt et al 1988 (NUREG/CR-4651) states that results of rock mixed with soil are more stable than riprap only. Personal communication with Ted Johnson during early work on the design of the closure for the Northeast Church Rock UMTRA site -- Ted and I discussed the rock/soil admixture design summarized in Dwyer et al 2007 with his concurrence. He suggested using the NUREG1623 "Design of Erosion Protection for Long-Term Stabilization" as a means to satisfy NRC requirements prior to formal acceptance of the rock/soil admixture design by NRC staff. If finer portions of the soil are removed by erosive forces, the larger particles (rock) remain behind and form an "armored" surface, sometimes referred to as a "desert pavement."

This surface is much more stable and resistant to surface erosion due to both surface water runoff and wind erosion. The NRC staff states the soil layer is relatively thin – it is 2-ft thick (16-inch thick was also analyzed with a higher rock to soil ratio). The NRC states that the grain size distribution is not clearly articulated – it consists of alluvium soil mixed with rock at 30% by volume. Grain size distribution of installed cap rock is submitted with these comments (Cap Rock file name) and the alluvium soil properties are contained in DBSA soil testing report submitted as well as in the FRAP, Attachment 5 found at: https://www.energy.gov/em/moab/crescent-junction-disposal-site. Would like to discuss with NRC what expectations are for this request? The NRC suggests: Options to consider with the design to make it more resistant to erosion include: increasing the rock size in the gravel/soil matrix; concentrating the gravel in the upper portion of the admixture and filling in the voids with smaller diameter particles (similar to what was done at the Monticello, UT site); or utilizing a shallower slope on the top deck of the disposal cell. Reply: The rock soil admixture is designed to prevent rill/gully formation. The rock was sized to prevent movement due to erosive forces from the probable maximum precipitation event (PMP). Any erosion of fine-grained soil will leave rock in place that will eventually be rock to rock if enough soil erodes. The rock size is conservatively the largest rock based on the entire disposal cell footprint and combination of Dwyer admixture calculations and NUREG 1623 Long-Term Stability of Rocky Soil Cover. For example, the upper part of the slope length only requires rock with 1/3-inch diameter. Refer to provided tables for calculated rock sizes required as a function of slope length - a D50 of 2.3-inch is currently recommended for the entire disposal cell cover (Tables 1 and 2). The only portion of the disposal cell cover that actually requires the larger rock is the base of slope along the south slope. The entire remainder of the cover requires a much smaller rock size. Thus, including larger rock is very conservative. The consideration to place a greater ratio of rock near the surface would be dictated by the site conditions. That is, if precipitation or wind events allowed for some erosion of the finer grain soil, the rock portion would not be dislodged and thus would become naturally more of the ratio near the surface. Finally, the soil to be mixed with the rock is soil excavated from the site and is currently the overburden or alluvium above the Mancos shale layer. This soil is less fine than the Mancos shale soil and is basically what you see at the site on the surface currently. There are not significant rill/gully formation at the site on similar grades while this soil is best to maintain a natural blend of native vegetation.

Table 1. Rock Size – South Slope

Slope Length (ft)	Rock Size D_c (in.)	use Rock Size D_c (in.)
1,300	2.3	2.3
1,200	2.2	2.3
1,100	2.1	2.3
1,000	2.0	2.3
900	1.8	2.3
800	1.7	2.3
700	1.5	2.3
600	1.4	2.3
525	1.2	2.3
500	1.2	2.3
400	1.0	2.3
350	0.9	2.3
300	0.8	2.3
200	0.6	2.3
100	0.3	2.3

Table 2. Rock Size - North Slope

Slope Length (ft)	Rock Size D_c (in.)	use Rock Size D_c (in.)
548	1.0	2.3
500	0.9	2.3
400	0.8	2.3
300	0.7	2.3
200	0.5	2.3
100	0.3	2.3

Based on the NRC comment, an alternative thinner (16") surface admixture was analyzed having 8" thick layer of rock mixed with an 8" thick layer of soil:

Evaluation of the surface rock/soil admixture was evaluated based on this comment to increase the ratio of rock to soil to 50% each by volume. That is, an 8-inch layer of rock (D50 2.3") would be evenly mixed with an 8-inch layer of alluvium cover soil to produce a 16-inch-thick surface rock/soil admixture layer. This revised layer satisfies the erosion performance objectives. It was also modeled altering the upper 2-ft to include the thinner surface rock admixture with the altered hydraulic properties based on the increased rock content overlying a thin alluvium soil layer that then sites on the 4-ft radon barrier. Graphical summary of this modeling simulation is shown above - right of comment #1 for your information -- no significant change to water balance results. The modeled cover is still 7-ft thick. The PODR is a little deeper in the profile but still produces a net zero flux within the cover profile. Furthermore, the altered profile was modeled without vegetation and the PODR is satisfied within the cover profile. Graphical summary of these modeling results is shown below the ET Cover Vegetation Comment #2 reply summarizing results without vegetation, below. Thus, the water balance performance objectives are also satisfied with the thinner admixture layer with a higher rock content.

Abt and Johnson (1991) recommends a minimum rock layer thickness be 2 times the D50. The riprap design for the side slopes utilized this while the prior analysis of the surface rock and drainage trenches with slopes less than 10% a thickness of 3 times D50 was used. In the case of the surface rock/soil admixture; an armorment thickness of rock is actually greater than 3 times the D50. The D50 is 2.3-inches while the depth of rock is 8-inches resulting in an armorment thickness ratio of 3.5. Details of the modeling results from the profile with the thinner surface admixture layer will be made available upon request.

NRC Comment 2:

2. As discussed in our comments on the 60 percent Design Report, the potential for the presence of dispersive soils within the cover at Crescent Junction is not addressed in the submittal. The presence of dispersive soils may make it more challenging to meet the longevity requirements in Title 40 of the Code of Federal Regulations Part 192, “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings,” and also represents a long-term maintenance concern for DOE-LM. This is an issue that needs to be resolved for the NRC to be able to concur on the revision to the design. A joint discussion between DOE-EM, DOE-LM, and NRC may be helpful in addressing this issue.

DOE Reply 2:

Testing was completed on dispersive soil. This was submitted to the NRC. There were two sets of tests completed on soil samples taken from within the existing disposal cell cover and borrow sources. First a series of tests featuring the crumb test (ASTM D6572) were performed. This is a relatively simple test and perhaps the most applicable for our site. It is most applicable because it simulates the change from unsaturated to saturated conditions that would be of concern given erosion due to precipitation on the surface of the cover. All crumb tests showed the soil was Grade 1 - nondispersive. Second a series of pinhole tests were performed (ASTM D4747). These are less applicable to cover surface erosion because they attempt to simulate the potential for piping that could happen in an earthen dam. These tests produced results of nondispersive soil from grade 1 to grade 3. Test results included in this submittal

NRC Comment 3:

3. The NRC staff reviewed the drainage rock calculations in Appendix C of the Design Report. As presented in the 90 Percent Design Report, the NRC staff understands that the rock cover on the 20 percent (5H:1V) side slope is not being altered, but DOE plans to modify the rock contained in the drainage trenches at the base of the side slopes. Additionally, the NRC staff understands that DOE intends to resize the rock for the trenches at the base of the side slopes. The narrative discussion in Section 4 of the Design Report only discusses modifying the rock around the perimeter of the final cover system. If the intent is to modify the rock diameter on the side slope, please clearly communicate that intent in the next iteration of the design.

DOE Reply 3:

Verbiage will be clarified to state that rock size along slopes of the disposal cell shall be modified. The size and depth of rock at the base of slopes will not change. The side slope angles will not change. The following table (Table 3) are provided to show the proposed rock size/depth changes on the disposal cell side slopes.

Table 3. Proposed Rock Size Changes

	Revised values		Original Values	
	D50	RipRap thickness	D50	RipRap thickness
North Slope	3.0	6.0	4.0	8.0
South Slope	3.0	6.0	6.0	12.0
West Slope	2.0	4.0	4.0	8.0
East Slope	2.0	4.0	4.0	8.0

Comments Related to Radon Attenuation

NRC Comment:

The NRC staff has reviewed the radon attenuation aspects of the ET cover design, but has not updated its confirmatory analysis for radon attenuation at this time. Staff plans to update those calculations at the next iteration of the design. Staff will consider the long-term moisture content of the radon barrier as well as freeze-thaw impacts to the radon barrier at that time.

DOE Reply:

The design report included a sensitivity analysis of the long-term moisture content based on the borrow soil investigation performed on the site and previously accepted by the NRC. This sensitivity analyses was performed in response to a request made by the NRC in the 60% design review. The design analyses also included a sensitivity of changes due to freeze/thaw conditions. The analyses confirmed that a 4-ft thick clay radon barrier is required in the cover profile. The 60% design included a radon barrier that was only 3ft thick. This 4ft thick radon barrier included in this proposed ET Cover matches the thickness of the radon barrier in the approved UMTRA cover profile. The placement conditions (moisture and density) match that from the 4ft radon barrier in the UMTRA cover profile that had NRC approval.

Comments Related to Biointrusion

NRC Comment 1:

1. Discuss the potential for biointrusion at the site by documenting the types of burrowing animals or insects that have been observed in the site vicinity or could potentially inhabit the site in the future. For instance, a burrowing example (assumed to be at the site), is shown on page 6 of Attachment 2 of the Post Construction Monitoring Plan report. This discussion should include information on deepest depths and volumes of burrows they might be expected to excavate, and maximum rock sizes that have been shown to deter such burrowing by these animals at other sites (if available). The impact of deep-rooted plants (i.e., invasive species or proposed ET cover species) over the service life of the cover should also be considered in this discussion; as shown in Table 1, several of the plant species proposed for the ET cover have maximum rooting depths that could damage the radon barrier and potentially exceed the depth to the tailings, which are located at a depth of ~7-feet.

Table 1. Proposed Seed Mix (from Section 2.01, Bullet E of the Technical Specifications) and Potential Maximum Rooting Depths.

Common Name	Maximum Rooting Depth
Tall Wheatgrass	2.46 ft (Nie et al., 2008) 4.33 ft (Nie et al., 2008)
Basin Wildrye	>6.56 ft (Reynolds and Fraley, 1989)
Russian Wildrye	6-8 ft (nrcs.usda.gov) 8-10 ft (fs.fed.gov) 4.26 ft (Table 5.4 of Hauser, 2009)
Alkaligrass	0.997 – 1.93 ft (mean rooting depth, umces.edu)
Inland Saltgrass	9.02 ft (Young, 2015)
Alkali Sacaton	1.33 ft (minimum, usda.gov)
Galleta Grass	0.98 ft (Peace et al., 2004)
Four-wing saltbush	39.37 ft (Stromberg, 2013) 6.66 ft (Lee and Laurenroth) 1.97 ft (Wallace et al., 1980) 12.86 ft (average; Foxx et al., 1985)

DOE Reply 1:

To NRC staff – none of the pictures in the post-construction monitoring plan are from the Crescent Junction site. They are from other sites in other parts of the country. They were included as examples only. With regard to documenting the biointrusion at the site, we don't understand the need for this. We have improved the conditions against biointrusion compared to the previous design. There was no design criterion for biointrusion in the original design. The rock in the biointrusion layer of the UMTRA cover profile is D50 2-inch diameter and 6-inches thick. The rock in the ET Cover surface admixture layer is D50 2.3-inch diameter (15% larger) and volume is 33% greater (thickness of 8-inches compared to 6-inches). Thus, the ability of the proposed cover design is better able to resist burrowing than the currently approved UMTRA cover profile. Additionally, part of the biointrusion design is not to prevent burrowing but to discourage it. At similar sites where the rock/soil admixture has been installed; burrowing takes placed around the cover but limited on it because the burrowing is much easier in adjacent areas without the rock in the soil compared to the cover that has the rock in it. A Biological Assessment was conducted for both Moab and CJ as part of the EIS; however, it is an assessment of threatened and endangered species only. There is no available assessment of other mammals, including burrowing mammals. Therefore, we have only observational evidence which indicates that badgers and prairie dogs are in the area of the Crescent Junction Cell. Badgers are found in the vicinity of prairie dog colonies because that is their primary food source. We have not observed prairie dogs on the top of the cell or the top of the adjacent wedge. For discussion on vegetation, refer to the reply to comment below.

NRC Comment 2:

2. Based on the information regarding the potential for biointrusion at the site, as requested above, justify the removal of the biointrusion rock layer at a depth of 3.5-foot as shown in Figure 1 of Section 1, "Existing Final Cover System." Furthermore, discuss the protective measures (e.g., rock material, adequate soil thickness) that will be incorporated in the cover design to minimize cover degradation from the anticipated burrowing and root penetration. Section 11, "Biointrusion," states that the "rock/soil admixture layer of 2.3-inch-diameter D50 rock, which composes 30 percent of the volume of this surface layer, will discourage burrowing of small mammals." However, Albright et al., 2010, referencing Cline et al., 1981, note that prairie dogs and ground squirrels have burrowed more than 200 millimeters into crushed rock layers with a D50 of 60 millimeters or less. They further note that "larger rock would be needed to stop larger animals such as prairie dogs and badgers."

DOE Reply 2:

The Final Remediation Action Plan states that the biointrusion layer was included to (a) provide positive drainage of any seepage at this depth; (b) provide a capillary barrier to reduce infiltration; (c) prevent burrowing animals; and (d) discourage root intrusion. Each of these objectives are discussed below:

a. An intent of the cover is to prevent percolation into the underlying waste and thus remain as dry as possible and definitely in an unsaturated state. Consequently, if saturated seepage occurs, the performance objective has not been satisfied. Therefore, the inclusion of this biointrusion layer to laterally route saturated flow to the perimeter of the cover makes no sense and should never occur.
b. The rock layer was installed with no filter medium above or below it. Thus, the fine-grained soils above the rock layer are free to migrate into the voids in the rock layer. By filling these voids, the effectiveness of a capillary barrier is reduced or even eliminated. Furthermore, the surface rock armor allows 100% of precipitation to infiltrate into the frost protection soils until the storage capacity of that soil is exceeded and moisture will continue downward into the biointrusion layer whether

a capillary barrier exists or not. This moisture will then continue down through this rock layer into the underlying radon barrier soil and eventually the waste. This is confirmed via current monitoring practice at the site with the vertical stand pipe placed where saturated conditions deep in the cover have been identified. This is created by the layering that encourages infiltration and prevents water removal via ET. Consequently, the current cover design is flawed and requires correction which the proposed ET Cover does.

c. There are no specific biointrusion design criteria cited for the disposal cell. The type of burrowing animal the layer is to prevent from burrowing through it was not cited. There were no design calculations associated with the biointrusion layer. It appears that the biointrusion layer may have been included because it was part of a typical prescriptive cover profile for UMTRA sites rather than a specific need.
d. As previously stated, the biointrusion rock layer has no filter layer above it and thus the fine-grained upper soil is free to move into the pore spaces of the rock layer. Thus, the layer is not likely to prevent root intrusion from passing through it. Furthermore, the existence of this layer creates a capillary barrier with the underlying finer-grained radon barrier. Because the surface layer is allowing 100% infiltration of precipitation, this moisture is migrating down into underlying layers. This moisture has likely passed through the capillary barrier formed by the biointrusion layer over the radon barrier. The moisture cannot move back up as the profile dries due to the reverse effect of the capillary barrier. Thus, the moisture content in the radon barrier is increasing with time. This increased moisture content will attract deep rooted vegetation intrusion when vegetation is established on the cover. The rock armor may have wind-blown sediment deposited in it over time and allow for the establishment of some vegetation. The vegetation will likely be deep, woody rooted plants.
e. Albright et al (2010) states that the inclusion of a compacted clay layer such as the radon barrier is an effective biointrusion layer.
f. (The surface rock armor layer and the biointrusion layer are repetitive. That is, they are both 6-inches deep composed of the same size rock. The proposed surface admixture layer that includes 8-inch-thick layer of rock (D50 2.3") mixed into the surface cover soil has 15% larger rock and 33% more rock volume than the 6-inch rock layer. Furthermore, Abt et al 1988 (NUREG/CR-4651) stated that results of rock mixed with soil are more stable than riprap only.

NRC Comment 3:

3. Discuss the impact of a potentially degraded cover (i.e., resulting from biointrusion) on the performance of the cover including the including the impacts on the radon flux calculations provided in Section 5. “Radon Attenuation.” In addition to unearthing buried waste, burrowing animals and invertebrates can alter physical and hydraulic soil properties that influence erosion and the soil water balance of covers (Albright et al., 2010). Williams et al., (2022) observed that radon fluxes were higher in regions where woody vegetation or aggressive insects had established on select UMTRCA covers. They attributed these higher fluxes to soil structure induced by root activity and insect burrowing in the radon barrier, as well as higher radon diffusion coefficients associated with lower water saturation in areas influenced by root water update.

DOE Reply 3:

The radon barrier layer was adjusted to be a 4-ft thick layer identical to that approved in the original UMTRA cover profile for the site compared to the 3-ft thick radon barrier proposed in the 60% design. Thus, the revised cover profile contains a 4-ft thick radon barrier composed of compacted Mancos shale soil. Albright et al., 2010 states that a rock/soil surface admixture will mitigate erosion. We believe the proposed surface rock/soil admixture provides a better biointrusion layer that the 6-inch layer of rock previously proposed. Refer to reply to comments 7, 8, and 9. We believe that the proposed ET Cover will better encourage shallow, thin-rooted vegetation such as native grasses than the approved UMTRA cover profile. Because of the layering of the UMTRA cover profile, we believe that the UMTRA cover profile will attract more deep, woody-rooted vegetation than an ET Cover. I served as a technical reviewer for the NUREG/CR-7288 "Evaluation of In-Service Radon Barriers over Uranium Mill Tailings Disposal Facilities – Vol. 1 and 2." This document evaluated potential changes in installed radon barriers. Part of my conclusion was that the changes you discuss resulted in hydraulic property changes that were taken into account in the water balance modeling and less so in changes that affect radon flux. The study showed that although there might be isolated change that affect performance - the overall performance of the radon barriers remains effective with no overall degradation taking into account the full area of the disposal cells cover systems.

Comments Related to ET Cover Vegetation

NRC Comment 1:

1. Discuss the ecological basis (e.g., a reference or analog site) for the proposed ET cover seed mix that is shown in the table in Part 2, Section 2.01, Bullet E, of the Technical Specification Report. One of main objectives of cover revegetation is to create a soil environment that is similar to nearby undisturbed areas (i.e., reference areas or analog sites) and establish plant communities that are well adapted to that environment (Albright et al., 2010). The reference area or analog site can also be used to assess the revegetation success of the ET cover. As such, this discussion should include detailed information regarding the native vegetation and soils in nearby undisturbed areas.

DOE Reply 1:

The seed mix was provided by a vegetation expert upon review of native vegetation in the area. We have requested assistance from DOE LM on a preferred seed mix, but unfortunately have not received a reply to our request. Vegetation was shown to be relatively insensitive to the water balance results. Vegetation is not considered in the calculations associated with design of the rock/soil admixture. Thus, there is no critical success criteria for the establishment of vegetation. However, the rock/soil surface admixture has successfully encouraged a healthy native stand of native vegetation - comparisons have shown the admixture produces a better stand of vegetation than undisturbed analog sites in the vicinity of the cover systems. Also refer to reply to *ET Cover Vegetation NRC Comment #2* below.

NRC Comment 2:

2. Provide the following information related to the establishment of cover vegetation:

a. The revegetation success criteria as well as the ecological basis for the selection of the revegetation criteria.
b. The time frames for the revegetation target values.
c. Details regarding how the proposed revegetation success criteria will compare to the reference area of analog site.

DOE Reply 2:

Vegetation is not critical to the design of the cover for erosion nor water balance. Thus, no success criteria have been established. Refer to the graph showing that the annual flux rate estimated for the ET Cover profile without any vegetation is zero (Figure 5). Also refer to the comparison of the PET (demand for water) for the site compared to the precipitation (supply of water) whereby the demand for water is about 6 times greater than the actual supply of water (Figure 6). Thus, a well-designed ET Cover without ponding should produce no percolation with or without vegetation. A graph summarizing modeling results for the modified cover profile with a thinner (16inch) surface admixture is also showed here for information - results show that the PODR is also satisfied within the cover profile depth (Figure 7).

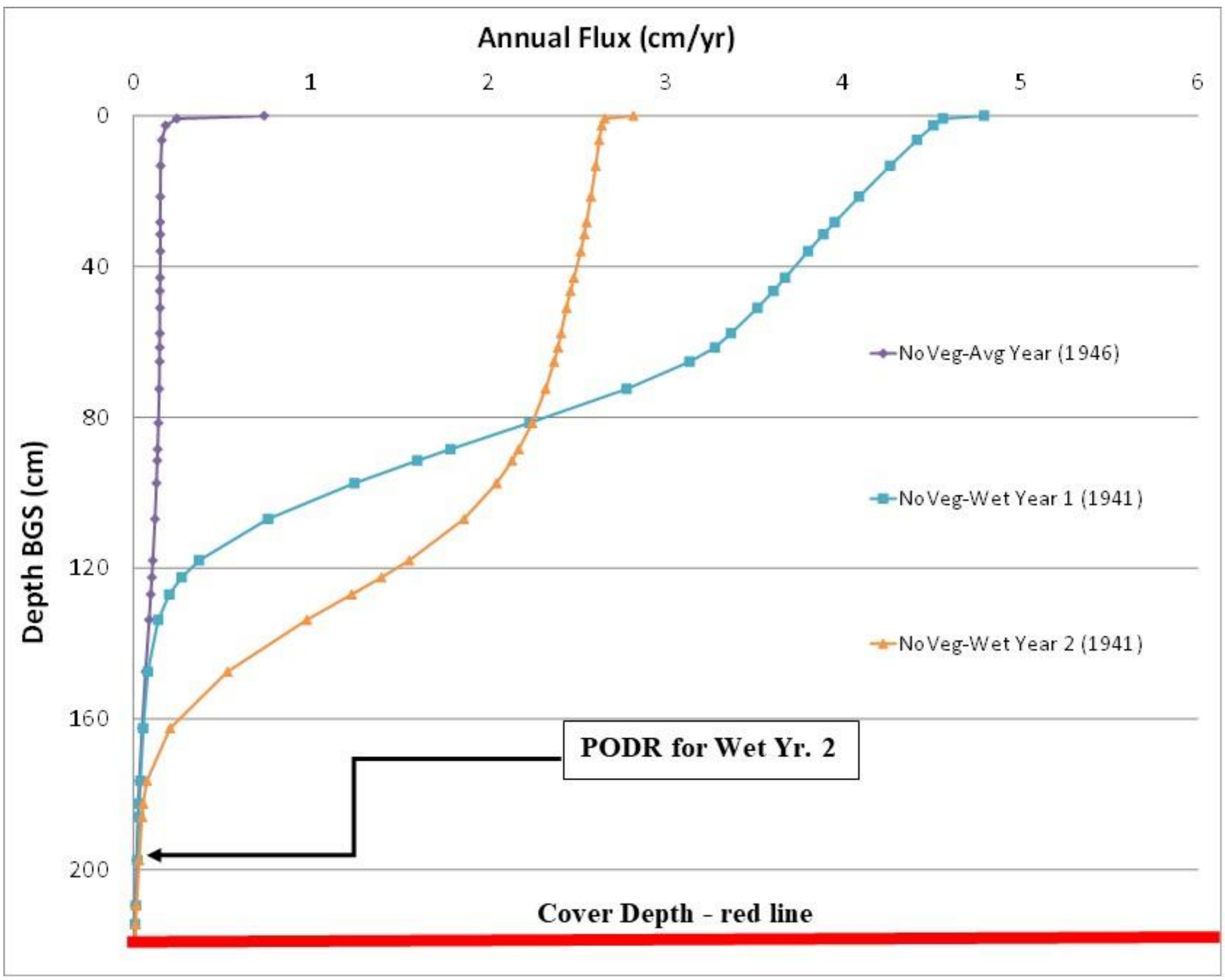

Figure 5. PODR for Profile with 2ft Thick Surface Admixture Layer

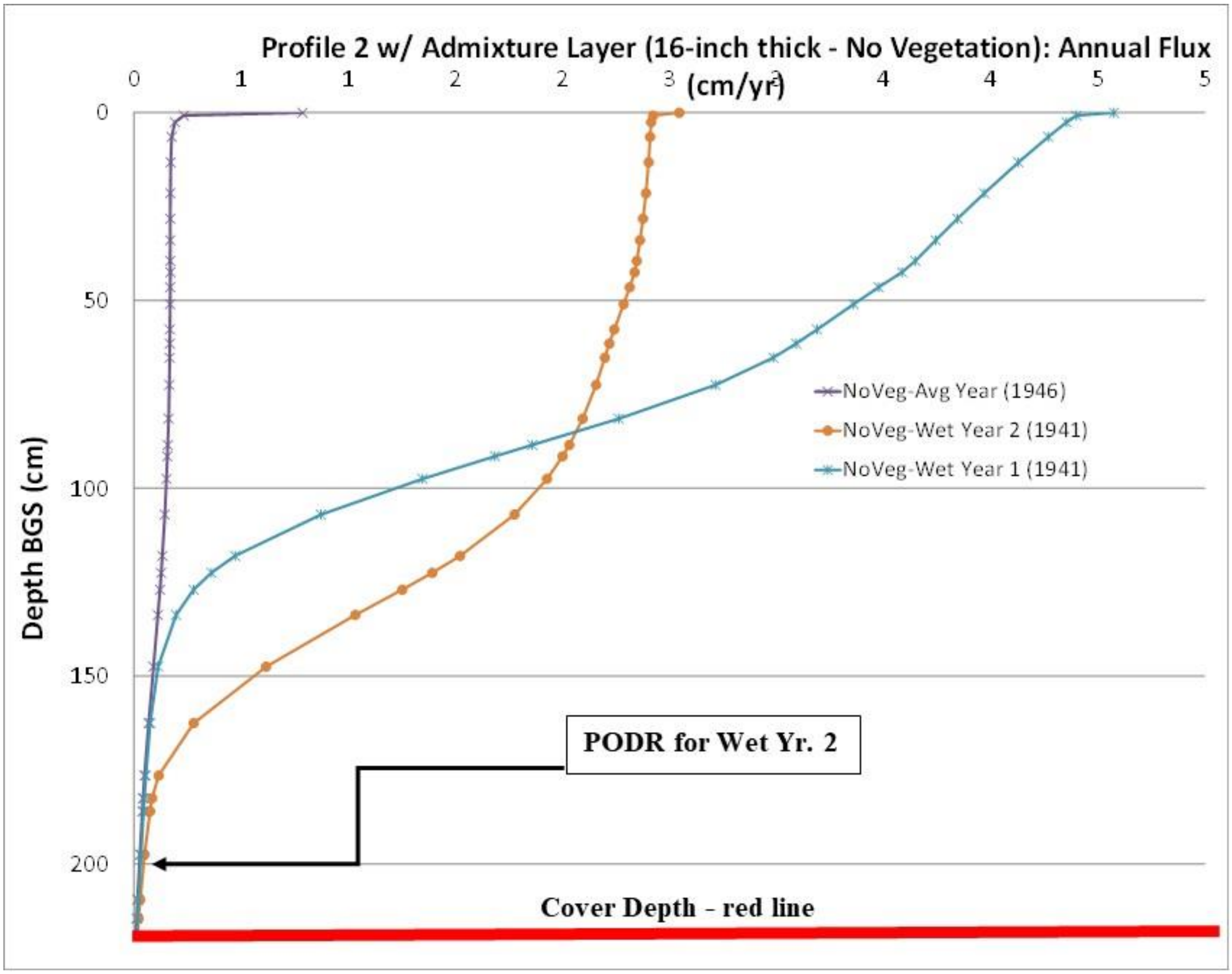

Figure 6. PODR for Profile with 16” Thick Surface Admixture Layer

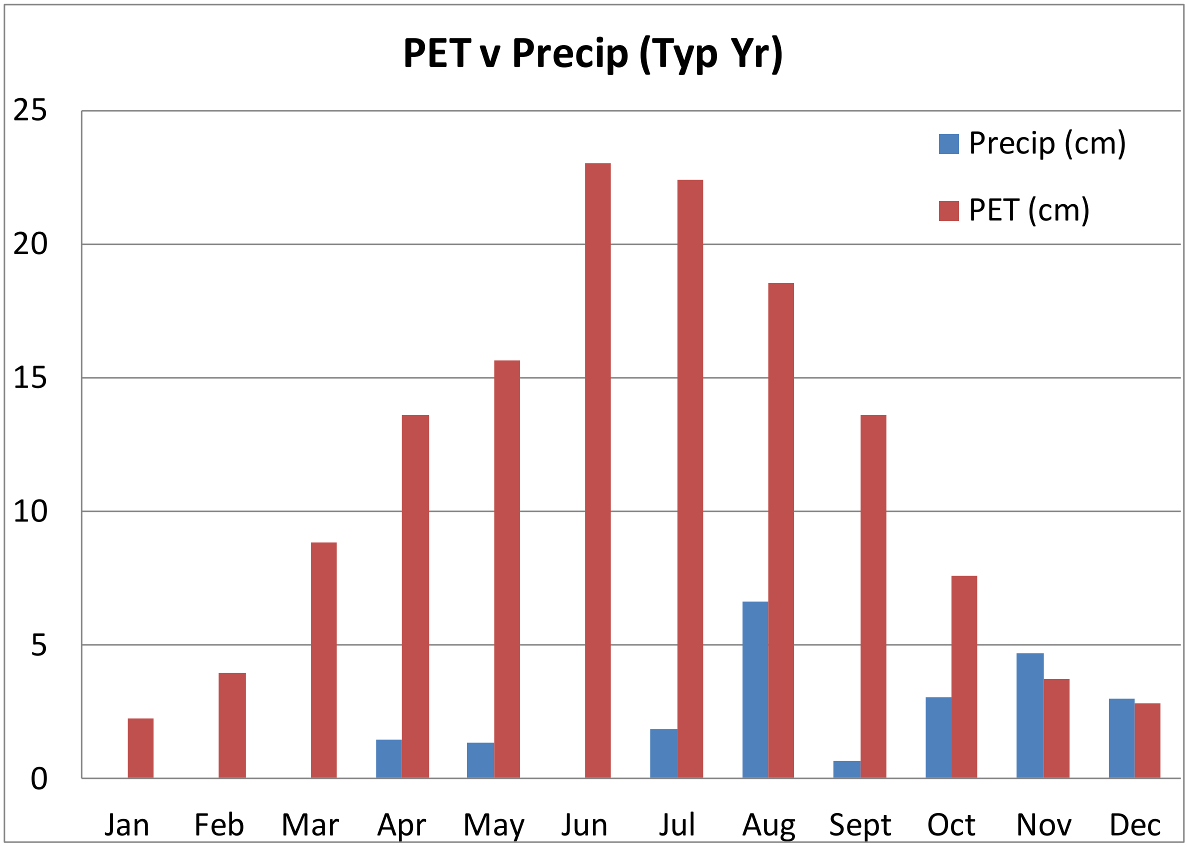

Figure 7. Climate Demand for Water (PET) v. Climate Supply of Water (Precipitation)

Comments Related to Soil Properties

NRC Comment 1:

1. Section 6, "Unsaturated Modeling of Cover System," and Section B.1.2, "UNSAT-H Input Parameters," state that the "input parameters utilized in the computer simulations for the ET cover were developed based on values reported in the Final Remedial Action Plan (FRAP), (DOE, 2008), various literature cited, laboratory analyses (Development Bank of Southern Africa ((DBSA), 2020), and experience." This report should be provided to support the NRC's review of the proposed ET cover soil properties (i.e., DBSA, 2020, Laboratory Report for Dwyer Engineering LLC, Project: Crescent Junction, performed by Daniel B Stephens & Assoc, September 9, 2020).

DOE Reply 1:

Report provided as part of this submittal (DBSA 9/9/20).

NRC Comment 2:

2. Section B.1.7, "Soil Properties," states that because varied soil properties were reported in the FRAP (2008), the computer simulations attempted to bound the reported soils. This report is referred in several places in Appendix B. For example, Table B-3, "Soil Samples Hydraulic Properties," refers to the FRAP, Attachment 5, Volume 1, Appendix K, Table 1). According to the FRAP, Volumes I and II of the Field

and Laboratory Results are provided in Attachment 5 of the Draft RAP and were not submitted with the FRAP. This information should be provided for NRC to review in the context of the proposed ET cover.

DOE Reply 2:

The FRAP Attachment 5 PDF files are too large to email, but are available at the following online site: https://www.energy.gov/em/moab/crescent-junction-disposal-site

NRC Comment 3:

3. Table B-3, “Soil Samples Hydraulic Properties” refers to alluvium and shales samples from the DOE report “Cover Performance Enhancement Tests at the Grand Junction, Colorado Disposal site: Construction Documentation Material Testing, and Instrument Calibration,” report number LMS/GRJ/SO7112 dated February 2013. Since the hydraulic properties of these samples were used in the water balance modeling sensitivity analyses, this report should be provided for NRC staff to review.

DOE Reply 3:

Report provided -- "Cover Performance Enhancement Tests at the Grand Junction, Colorado, Disposal Site: Construction Documentation, Material Testing, and Instrument Calibration February 2013" in PDF format (LMS/GRJ/S07112).

NRC Comment 4:

4. As stated in the Section B.1.7, “Soil Properties,” the computer simulations attempted to bound the reported soils due to their variability. Section 2.4 of the Technical Specifications states that: “cover soil to be used with this surface admixture layer shall be tested prior to placement for agronomic properties to determine whether nutrient and/or organic material amendment is required and to what extent.” However, the target soil properties, the appropriate ranges, and the specific borrow source(s) for the ET cover soils should be clearly defined (i.e., in Section 6 and/or Appendix B as well as in the Technical Specifications). Sufficient volumes of available material should also be identified. The specified target properties should include the following: soil pH; organic content, CaCO3 content; nitrogen, potassium, and phosphorous content; electrical conductivity; salt content; cation exchange capacity; clay content (and type); soil texture (U.S. Department of Agriculture (USDA)); particle size distributions and limits; porosity; Atterberg limits; bulk density; moisture content. A reference or analog site1 may be used to help determine the target bulk densities and any necessary soil amendments for the borrow source (Waugh et al., 1994).

DOE Reply 4:

The soil properties required as input parameters for the design of the ET Cover profile specifically for the water balance modeling, erosion, and radon attenuation were provided in the applicable sections. The area the disposal cell is being constructed serves as the borrow source for the cover soils. There is more than enough available cover soil reinforced by the fact that some of the excavated soil utilized in the diversion wedge located just north of the disposal cell has more soil piled on it than originally planned due to the excess cut excavations. Agronomic properties of the soil to be used in the cover's surface rock/soil admixture layer are planned to be tested by the contractor for applicable agronomic properties to best determine what amendments the soil will require (if any) to maximize vegetation establishment.

NRC Comment 5:

5. Justify the selection of an alluvial soil with 30 percent rock and a D50 of 2.3-inches for the entire layer thickness of the water storage layer, rather than just the upper portion (i.e., as a gravel mulch layer). Typically, loamy soils are recommended for ET covers and soils containing gravel and rock (i.e., particles larger than 2 mm) may be unsuitable for use in ET cover soil as they can reduce the water holding capacity and dilute the nutrient-supplying capacity of the soil (Hauser, 2009). ET cover guidance developed by the State of Colorado (Colorado Department of Public Health and Environment (CDPHE), 2013) recommends that the soil used for the cover contain less than or equal to 15 percent gravel (i.e., greater than 2 mm, retained on the No. 10 sieve) in addition to limiting the maximum particle size to less than 2-inches in the longest dimension. One of main objectives of cover revegetation is to create a soil environment that is similar to nearby undisturbed areas (reference areas or analog sites) and establish plant communities that are well adapted to that environment (Albright et al., 2010). As such, an appropriate reference area or analog site can also be used to assess the suitability of the proposed ET cover soils.

DOE Reply 5:

The soil comes from on-site excavations. The cover soils are loam soils: generally classified as silt loam, sandy loam, or silty clay loam. The cover design was based on the measured values of these local soils. The provided design analyses demonstrated that the local soils meet the applicable criteria. The CDPHE guidance document recommends an ET Cover profile 2.5ft thick for the region adjacent to the Crescent Junction site. The Crescent Junction proposed ET cover is almost 3 times that thick. Without exception, every deployment of a cover system utilizing the rock/soil admixture surface layer has produced a better stand of native vegetation than undisturbed areas in the vicinity or its natural analog counterpart. Albright et al., 2010 states that a surface rock/soil admixture is effective at reducing erosion.

NRC Comment 6:

6. Provide the basis for the porosity values in listed in Table 4, "Radon Flux Calculations Summary," in Section 5, "Radon Attenuation," and discuss these values with respect to the saturated water contents provided in Table B-3. In Table 4, the porosity of the top layer (Admixture) is 0.27, while the porosity of Mancos Shale soil layer is 0.31. In Table B-3, "Soil Samples Hydraulic Properties," the saturated water contents listed for the top layer and radon barrier are higher than the porosities shown in Table 4. For example, the saturated water contents of the existing radon barrier samples 5 and 6 are 0.4171 and 0.4203, respectively, while the reported values for shale from TP154 and the Grand Junction site are 0.4803 and 0.38, respectively. The saturated water content of alluvium samples range from 0.3584 to 0.42. The saturated water content should not be larger than the porosity since water can only fill the pore space. Furthermore, discuss how using higher porosity values would impact the calculated exit radon fluxes that are provided in Table 4.

DOE Reply 6:

The radon barrier layer is the same thickness as that of the previously approved cover profile. The potential change in properties in the upper portion due to freeze/thaw conditions was included in the design calculations and shown to be adequate to meet the applicable regulation and performance criterion. The soil properties used were from the previously approved borrow source investigation.

NRC Comment 7:

7. Section 3.07 (C) of the Technical Specifications states that, for the surface admixture cover soil, the compacted soil density is to be 90 percent of the maximum dry density as determined by American Society for Testing and Materials (ASTM) D698 and that the tolerance for this placement density is plus or minus 5 pcf. However, CDPHE (2013) notes that "for most soil textures, the growth-limiting bulk density is in the range of about 83 to 88 percent of the maximum standard Proctor density (ASTM, D698)." Justification for specifying a compacted soil density at the upper end of the recommended range should be provided. Details regarding the placement specifications of this layer to prevent over-compaction should also be provided. For instance, CDPHE, 2013 and Interstate Technology Regulatory Council, 2003 recommend placing cover soil in relatively thick lifts (i.e., 18-inches to 2-foot) to control compaction along with the use of low-ground-pressure equipment during soil placement.

DOE Reply 7:

The surface admixture layer will have a demonstration plot to determine lift thickness and placement techniques. Placement of surface admixtures at a relative density of 90% of MDD has been shown to be successful at similar projects in similar climates. The 90% of MDD is within the recommended cover soil density range for an ET Cover per the CDPHE (2013). The growth-limiting bulk densities are from USDA publications and are directed toward agriculture crops, not native species intended for deployment on cover systems such as grasses. Furthermore, the natural or in situ bulk density of soils tends to be about 90% of the MDD (ASTM D698). Thus, this is a natural density for the establishment of the intended vegetation on the cover surface.

Comments Related to Water Balance Modeling

NRC Comment 1:

1. Provide a detailed discussion of the performance objectives of the ET cover. This discussion should specify the ET cover design percolation rate (i.e., percolation from the base of the cover), the basis for the selection of this rate, and how the ET cover will be monitored in the short-term to ensure that it performs as designed. The NRC staff recognizes Crescent Junction is a relatively dry site, but understanding the design percolation rate may help inform any monitoring needs.

DOE Reply 1:

Refer to reply to *NRC Comment on Geotechnical Stability #1* and *NRC Comment on ET Cover Vegetation #2.*

NRC Comment 2:

2. Section B.1.7, "Soil Properties," notes that the computer simulations attempted to bound the reported soils and used "worst-case" soils. What are the implications of these "worst-case" soils on the vegetation success and how vegetation is modeled in

the computer simulations? In other words, can credit be taken for the selected vegetation-related parameters as described in Sections B.1.5, “Vegetation Data” and B.1.6, “Soil Properties Related to Vegetation.”

DOE Reply 2:

Refer to reply to *NRC Comment on Geotechnical Stability #1* and *NRC Comment on ET Cover Vegetation #2.*

NRC Comment 3:

3. Section B.1.5, “Vegetation Data,” states that measured vegetation parameters are not available for the Crescent Junction sites and that vegetation parameters utilized in the simulations are based on those obtained from the Northeast Church Rock, NM site (Cedar Creek, 2014). Although corrections are applied to account for the observed reduced vegetation surface coverage, justification for the reliance on the Northeast Church Rock site for vegetation parameters (including vegetation succession) should be provided since the Crescent Junction site is approximately 300 miles to the northwest of the Northeast Church Rock site. Supporting information should include a detailed comparison of the soils and native vegetation between the Church Rock Mill site and the Crescent Junction site. However, given that the distance between these two sites is substantial, vegetation parameters should ideally be obtained from a reference site that is similar to the Crescent Junction site and borrow source areas (or a similar nearby undisturbed area).

DOE Reply 3:

Refer to reply to *NRC Comment on Geotechnical Stability #1* and *NRC Comment on ET Cover Vegetation #2.*

NRC Comment 4:

4. The potential impacts of climate change on the ET cover vegetation should be considered. For example, potential drought conditions on the performance of the ET cover, associated with a significant amount of vegetation dieback, and followed by extreme precipitation events.

DOE Reply 4:

Climate change. The worst-case scenario for water balance modeling producing the deepest PODR is produced by wet conditions. It was demonstrated that "beyond worst case" conditions will not produce percolation given the proposed ET Cover profile. It was demonstrated that change in vegetation did not have a significant impact on the results. If the climate gets hotter and drier, the water balance is not an issue; and the erosion deterrence included in the design will work to mitigate soil loss.

NRC Comment 5:

5. Is the monthly distribution of precipitation, shown in Figure B-2 and Figure B-3 based on data?

DOE Reply 5:

Figure B-2 is based on actual data from Thompson Springs, Utah (1946) – it states this in the figure caption.

National Environmental Policy Act

NRC Comment 1:

1. Staff appreciates understanding DOE-EM's approach to the National Environmental Policy Act (NEPA) with this revision to the RAP for Moab as it will inform the NRC's approach going forward. Staff has not made any decisions on how it plans to comply with NEPA for this action at this time.

DOE Reply 1:

DOE proposes using the DOE Categorical Exclusion List to satisfy NEPA requirements for the redesigned cell cover. The Cat Ex numbers are B6.1 (e) and B6.1 (h).

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 29, 2023

Matthew Udovitsch
Acting Federal Cleanup Director
Moab Uranium Mill Tailings Remedial Action Project
U.S. Department of Energy
200 Grand Avenue, Suite 500
Grand Junction, CO 81501

SUBJECT: UNITED STATES NUCLEAR REGULATORY COMMISSION STAFF OPTIONS FOR MOVING FORWARD ON UNITED STATES DEPARTMENT OF ENERGY MOAB URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT ALTERNATIVE FINAL COVER SYSTEM 90 PERCENT DESIGN REPORT (DOCKET WM00110).

Dear Mr. Udovitsch:

In October 2022, the U.S. Nuclear Regulatory Commission (NRC) staff provided feedback on the U.S. Department of Energy, Office of Environmental Management (DOE-EM) 90 percent design for an evapotranspiration (ET) cover system at the Crescent Junction facility. The submittal is available in the NRC's Agencywide Documents Access and Management System (ADAMS) accession number ML22262A067. The NRC staff understands the DOE-EM is pursuing these changes to the cover system to minimize the amount of infiltration through the cover system and to reduce construction costs related to the amount of imported rock in the cover system. In December 2022, DOE-EM provided responses to the NRC staff's comments (ML22336A207).

The NRC has reviewed DOE-EM's December 2022 submittal and appreciates DOE-EM's consideration of our comments. After reviewing DOE-EM's responses, the NRC staff remains concerned about the ability of the proposed design to meet the regulatory requirements in 40 CFR Part 192. Specifically, the NRC staff remains concerned about the following aspects of the design.

- The ability of the ET cover to resist erosion in the long-term. The regulations in 40 CFR 192.02(a) require the control of residual radioactive materials be effective for up to one thousand years, to the extent reasonably achievable, and in any case for at least 200 years. Additionally, 40 CFR 192.02(d) requires that the site is stabilized in a manner that minimizes the need for future maintenance. Based on the NRC staff's review, the proposed rock-soil admixture is susceptible to gully formation. Formation of gullies on the cover system may require future maintenance. NRC guidance in NUREG-1623 Design of Erosion Protection for Long-Term Stabilization was based on use angular rock with rock-to-rock contact. The NRC discussed in that document that a riprap layer with the rock voids filled with soil provides similar stability characteristics. However, the DOE's proposed rock-soil admixture results in rock to soil contact, which has not been similarly evaluated for stability. The flume studies that form the basis for the design approaches in NUREG-1623 were based on angular rock, which can have different friction characteristics than rounded rock that has typically been used for erosion resistance. The combination of reducing the amount of rock-to-rock contact and the use of rounded rock results in an approach that is outside of the considerations used in the development of NUREG-1623.

- The ability of the cover system to protect the radon barrier. The regulations in 40 CFR Part 192.02(b)(1) require that releases of radon be limited to 20 pCi/m^2s. As currently proposed, the decrease in thickness of the cover system above the radon barrier increases the potential degradation of the radon barrier due to frost, root penetration, and desiccation. A portion of the radon barrier will be located above the frost penetration depth, resulting in the potential for cracking or damage to that layer. Additionally, the shallower depth of the radon barrier increases the potential for root penetration into the radon barrier. This could result in a drying effect within the radon barrier as well as create fast pathways once the roots decay, both of which could result in an increase in radon flux. Finally, the shallow depth of the radon barrier, especially in an arid climate, increases the risk of desiccation cracking. These degradation mechanisms can create cracking and fast pathways, as well as decrease the moisture content of the radon barrier. The NRC staff observes that the radon flux calculations are particularly sensitive to the moisture content of the radon barrier. Considered together, these aspects of the cover system make it challenging for the NRC staff to reach a reasonable assurance finding related to meeting the radon flux criteria.

For these reasons, the NRC staff is highly unlikely to be able to accept the proposed changes to the remedial action plan in its current form. The NRC staff recognizes DOE-EM's interest in ET covers and offers the following suggestions or approaches to DOE-EM. One of, or a combination of these suggestions, could be incorporated into the design to facilitate NRC acceptance. Note that the NRC staff's suggestions are based on the hydrogeology, site layout, and waste characteristics at the Crescent Junction disposal cell. At Crescent Junction, the disposal cell is underlain by a thick clay layer and there are no nearby groundwater users (ML082060216). The Mancos shale was estimated by DOE to be approximately 2,400 feet thick beneath the site. Localized pockets of water do occur within the Mancos shale however they are not potable due to very high concentrations of total dissolved solids ranging from 23,000 mg/L to 42,000 mg/L. Additionally, the NRC staff observes that the residual radioactive material (RRM) excavated at Moab is dried and mixed before it is placed at Crescent Junction. DOE-EM has developed rigorous specifications for placement of RRM. The drying, mixing, and placement specifications results in a more homogeneous material. As a result, there is less potential for differential settlement of the cover system than is typically encountered at mill tailings sites. These site features mean the potential for erosion of the cover system and the release of radon are the more risk significant performance factors at Crescent Junction.

With these site-specific features in mind, the staff offers eight suggestions for DOE-EM's consideration. The first five suggestions are focused on changes to the design to facilitate NRC acceptance. The last three suggestions can be viewed as potential changes to reduce construction costs. The remaining suggestions are focused on the radon barrier.

Suggestion 1 – Increase quantity of rock within the ET cover

DOE-EM could consider increasing the ratio of rock to soil in the admixture from a 30:70 mix by volume to a 50:50 mix (evenly split by volume), or even 70:30 mix (with rock being the predominant feature by volume). If DOE-EM follows the rocky soil slope approach outlined in NUREG-1623, the calculation should be based on the grain size analysis of the rock and soil when they are combined. Note that under this approach, minor channeling, rilling, or gully formation may occur.

Suggestion 2 – Concentrate the rock within the ET cover closer to the surface

As currently designed, rock will be present throughout the 24-inch depth of the admixture. DOE-EM could consider a design change to concentrate more of the rock within the upper 6 to 12 inches of the admixture. The remaining thickness of the cover above the radon barrier could remain as soil.

Note that while suggestions 1 and 2 are offered independently, they may be particularly effective if they are combined as they would provide more rock-to-rock contact at and near the surface of the cover system.

Suggestion 3 – Flatten the slope of the ET cover

If DOE-EM continues to follow the rocky soil slope approach to verify erosion resistance, maintaining the proposed 30:70 rock to soil ratio in the admixture, but decreasing the slope angle may result in an acceptable design. Similar to suggestion 1, if the rocky soil slope approach is used, it should be based on the grain size analysis of the rock and soil when they are combined.

As discussed above, the potential for differential settlement at Crescent Junction is minimized through mixing and placement of RRM. Given the lower potential for differential settlement, the slope of the ET cover would not necessarily need to be as steep as is currently proposed in the design. This type of change may prompt a re-evaluation of the rock size on the cover system side slopes. The NRC staff recognizes that a flatter slope may result in more infiltration through the cover system, which may not be acceptable at other sites with more groundwater resources.

DOE may also consider field and/or laboratory studies, as well as analog sites, evaluating the erosion resistance of rock-soil admixtures that were not within the envelope of materials considered within NUREG-1623.

Suggestion 4 – Increase thickness of cover

The NRC staff's 2008 technical evaluation of the remedial action plan for the site, considered a frost penetration depth of 45 inches (ML082060216). Keeping the radon barrier below the frost penetration depth is one way to provide adequate protection against freeze/thaw effects within the radon barrier. DOE-EM could consider increasing the overall thickness of the cover above the radon barrier. Note that the increase in thickness does not necessarily need to be the rock-soil admixture. The extra thickness can result from adding soil between the top of the radon barrier and the bottom of the admixture layer. Increasing the thickness of the cover system above the radon barrier would provide additional soil water storage capacity and rooting media for vegetation.

Suggestion 5 – Reliance on some form of maintenance

The requirements in 40 CFR Part 192.02(d) states that 'each site on which disposal occurs shall be designed and stabilized in a manner that minimizes the need for future maintenance.' DOE-EM could propose relying on a limited form of maintenance to maintain the function of the cover system. An example would be repairing gullies once they reach a certain depth.

Suggestion 6 – Using biointrusion layer to prevent deep gully formation

The currently approved design calls for inclusion of a 6-inch thick rock layer buried 4-ft below the final surface to serve as a biointrusion layer. DOE-EM's proposed 90 percent design does not include a biointrusion layer. If the biointrusion layer is included in the design moving forward, DOE-EM could evaluate the ability of the buried rock layer to stop or cut off gully formation using the methodology in NUREG-1623, Appendix D, Section 3.2.2. The NRC staff recognizes the drainage area estimation used in DOE-EM's 90 percent design is based on conservative assumptions and is therefore acceptable. Calculations related to flow velocities and shear stresses within the gully should be based on peak velocities. If it can be demonstrated that a buried rock layer can cut off gully formation, any cover material present above the buried rock layer could be viewed as sacrificial and not risk significant. This approach could allow for much smaller rock sizing, or potentially the elimination of rock in the upper portions of the cover. Note that this approach may result in the presence of deep gullies on the cover system. While the gullies could be visually alarming, they would be an expected performance feature under this approach.

Suggestion 7 – Alter design approach

Alternatively, DOE-EM could alter the design approach and follow the methodology for an unprotected soil slope in Section 2.2.1 and Section 2.4.1 of NUREG-1623. In following this approach, DOE-EM may be able to reduce the amount and size of rock present in the ET cover. Given the long slope lengths at Crescent Junction, the NRC staff recognizes that this approach may result in a nearly flat slope. As mentioned in suggestion 3, this approach could warrant a re-evaluation of the rock size on the cover system side slopes.

Suggestion 8 – Varying admixture design based on slope length

As currently designed, the admixture assumes one rock size over its entire slope length. The calculations are based on the longest slope length of approximately 1300 ft. The NRC staff recognizes this approach is conservative, especially in areas of the cover with shorter slope lengths. DOE-EM could consider re-evaluating the admixture design for the north facing slope of the ET cover, which has a maximum slope length of approximately 566 ft. Alternatively, DOE-EM could consider re-evaluating the admixture design for a set distance on the upper portion of any slope. For example, the admixture on the upper 200 ft of slope length could be re-evaluated and the admixture on the lower portion of the slope could remain as proposed in the 90 percent design.

The NRC staff is available to clarify its comments, if necessary. While these suggestions are largely focused on addressing erosion resistance of the ET cover, any changes DOE-EM pursues should consider and balance the overall performance objectives of the site. The NRC staff looks forward to working with DOE on this revision to the remedial action plan for the Moab project.

A copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records System component of the NRC's ADAMS. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions regarding this letter, please contact me at (301) 415-0724, or by e-mail at douglas.mandeville@nrc.gov.

Sincerely,

Signed by Mandeville, Douglas
on 08/29/23

Douglas Mandeville, Sr. Project Manager
Uranium Recovery and Materials Decommissioning Branch
Division of Decommissioning, Uranium Recovery,
and Waste Projects
Office of Nuclear Material Safety
and Safeguards

Docket No.: WM00110

cc: C. Pulskamp (DOE) Moab Mill
ListServ

LETTER TO M.UDOVITSCH, DOE-EM, USNRC STAFF OPTIONS FOR MOVING FORWARD COMMENTS ON USDOE MOAB URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT ALTERNATIVE FINAL COVER SYSTEM 90 PERCENT DESIGN REPORT DATE August 29, 2023

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DOE Moab UMTRA Responses to Nuclear Regulatory Commission (NRC) Staff Additional Comments on "Crescent Junction Disposal Site Alternative Final Cover System 90 Percent Design Report"

By letter dated August 29, 2023, the U.S. Department of Energy, Office of Environmental Management (DOE-EM) and Moab Uranium Mill Tailings Remedial Action Project submitted for the U.S. Nuclear Regulatory Commission (NRC) staff's review and comment, a report titled, "UNITED STATES NUCLEAR REGULATORY COMMISSION STAFF OPTIONS FOR MOVING FORWARD ON UNITED STATES DEPARTMENT OF ENERGY MOAB URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT ALTERNATIVE FINAL COVER SYSTEM 90 PERCENT DESIGN REPORT (DOCKET WM00110)."

DOE acknowledges NRCs concerns about the ability of the cover system to resist long-term erosion and protect the radon barrier. The NRC staff has stated the 90% design submitted for revision of the cover system is highly unlikely to be accepted in its current form. However, incorporating one of, or a combination of the NRC submitted suggestions, into the design will facilitate NRC acceptance. The NRC offered eight suggestions for DOE-EM's consideration to allow for acceptance of the revised cover system. The following NRC suggestions are listed with each corresponding DOE response.

NRC Suggestion 1: Increase quantity of rock within the ET cover.

DOE-EM could consider increasing the ratio of rock to soil in the admixture from a 30:70 mix by volume to a 50:50 mix (evenly split by volume), or even 70:30 mix (with rock being the predominant feature by volume). If DOE-EM follows the rocky soil slope approach outlined in NUREG-1623, the calculation should be based on the grain size analysis of the rock and soil when they are combined. Note that under this approach, minor channeling, rilling, or gully formation may occur.

DOE Reply 1:

DOE accepts this suggestion. DOE plans to increase the rock to soil ratio to 60% rock to 40% soil by volume. The admixture depth is proposed to be 10-inches. More specifically, rock having a D50 of 2-inches shall be mixed with excavated alluvium soil to produce the surface layer of the proposed cover system. The D50 rock will allow for the existing surface rock layer and biointrusion rock layer to be repurposed and utilized in this proposed cover surface admixture layer. This mixture is based on preliminary calculations performed that adhere to both NUREG1623 [the resultant D75 value utilized in the Horton (1945) equation described in NUREG 1623, Section 2.1.1 is derived from the mixture of the D50 rock mixed with the alluvium soil at a volumetric ratio of 60:40]. This surface layer also adheres to the surface admixture design described in Dwyer et al (2007).

The following figure is a summary of the proposed cover profile revised per the NRC suggestions. **Note: the revised cover profile shown is a draft subject to final design analyses.**

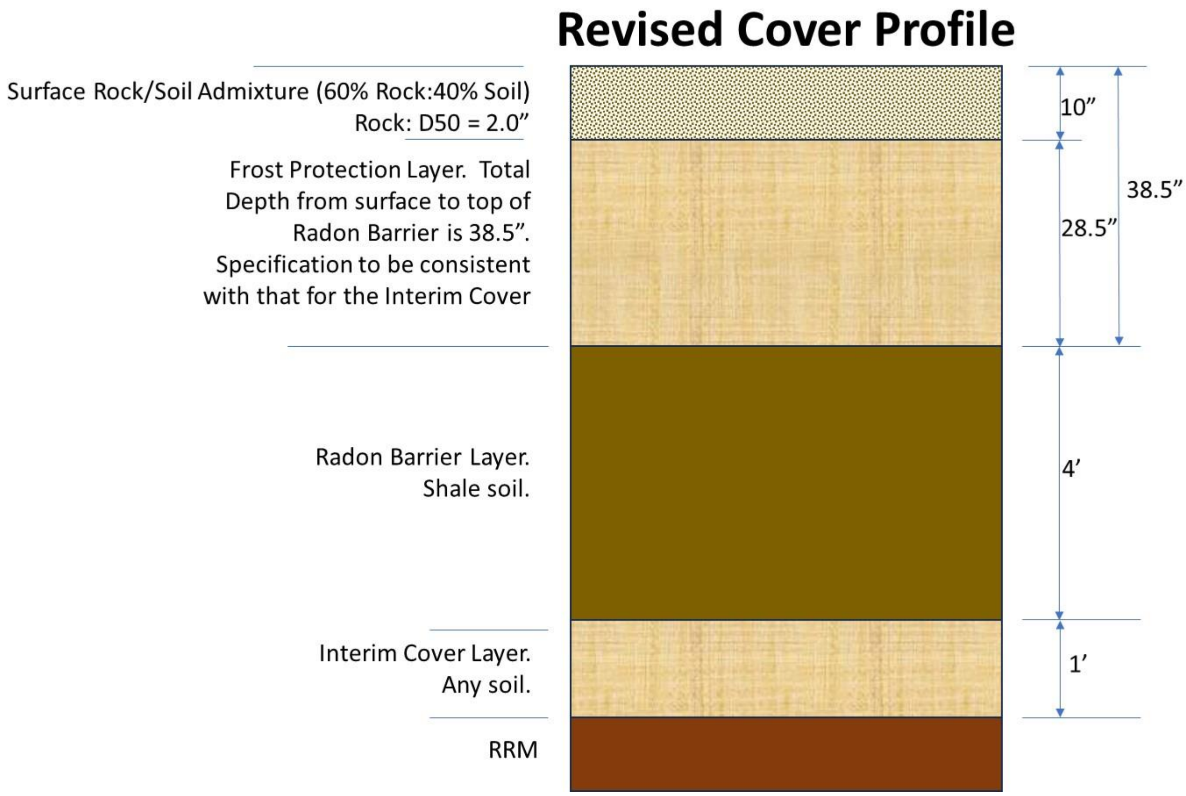

Figure 1. Proposed Cover Profile subject to Final Design Analyses

NRC Suggestion 2: – Concentrate the rock within the ET cover closer to the surface.

As currently designed, rock will be present throughout the 24-inch depth of the admixture. DOE-EM could consider a design change to concentrate more of the rock within the upper 6 to 12 inches of the admixture. The remaining thickness of the cover above the radon barrier could remain as soil.

Note that while suggestions 1 and 2 are offered independently, they may be particularly effective if they are combined as they would provide more rock-to-rock contact at and near the surface of the cover system.

DOE Reply 2:

DOE accepts this suggestion. DOE plans to mix the rock into the surface layer whereby all of the mixed rock is within the upper 10-inches of the cover profile.

NRC Suggestion 3: – Flatten the slope of the ET cover

If DOE-EM continues to follow the rocky soil slope approach to verify erosion resistance, maintaining the proposed 30:70 rock to soil ratio in the admixture, but decreasing the slope angle may result in an acceptable design. Similar to suggestion 1, if the rocky soil slope approach is used, it should be based on the grain size analysis of the rock and soil when they are combined.

As discussed above, the potential for differential settlement at Crescent Junction is minimized through mixing and placement of RRM. Given the lower potential for differential settlement, the slope of the ET cover would not necessarily need to be as steep as is currently proposed in the design. This type of change may prompt a re-evaluation of the rock size on the cover system side slopes. The NRC staff recognizes that a flatter slope may result in more infiltration through the cover system, which may not be acceptable at other sites with more groundwater resources.

DOE may also consider field and/or laboratory studies, as well as analog sites, evaluating the erosion resistance of rock-soil admixtures that were not within the envelope of materials considered within NUREG-1623.

DOE Reply 3:

DOE evaluated this suggestion and found that it is not practical to flatten the slope of the impoundment cover surface for a couple of reasons. The natural slope where the impoundment is under construction is 2%. The impoundment is about one-third built with the RRM, interim cover, and radon barrier placed to date. The side slopes have been constructed with rip rap size based on the designed slope and slope lengths for the current configuration. To flatten the slope would require significant rework on previously placed material. It may be feasible to increase the height of the southern side slope, but that would require larger rip rap than has currently been purchased and placed to date. Because of these complications, DOE has decided to maintain the existing slope and slope lengths of the final cover surface.

NRC Suggestion 4: – Increase thickness of cover

The NRC staff's 2008 technical evaluation of the remedial action plan for the site, considered a frost penetration depth of 45 inches (ML082060216). Keeping the radon barrier below the frost penetration depth is one way to provide adequate protection against freeze/thaw effects within the radon barrier. DOE-EM could consider increasing the overall thickness of the cover above the radon barrier. Note that the increase in thickness does not necessarily need to be the rock soil admixture. The extra thickness can result from adding soil between the top of the radon barrier and the bottom of the admixture layer. Increasing the thickness of the cover system above the radon barrier would provide additional soil water storage capacity and rooting media for vegetation.

DOE Reply 4:

DOE accepts this suggestion. DOE acknowledges NRCs concern about freeze/thaw effects on radon barrier. The FRAP (2008) analyses states that 38.5" of soil cover is adequate for a vegetated cover. DOE therefore proposes to increase the cover thickness to allow for 38.5" of cover above radon barrier. The following conclusions and recommendations are taken from the NRC approved FRAP (2008):

> ***Conclusions and Recommendations:***
>
> *Based on results of the freeze/thaw analysis, a maximum frost penetration of 41.5 inches (1.05 m) should be assumed for design of the Moab uranium tailings cover at the Crescent Junction Disposal Site, using a rock cover, and 38.5 inches (0.98 m) if a vegetated cover is used.*

The design depth of frost protections depends on the type of cover chosen in the final design.

NRC Suggestion 5: – Reliance on some form of maintenance.

The requirements in 40 CFR Part 192.02(d) states that 'each site on which disposal occurs shall be designed and stabilized in a manner that minimizes the need for future maintenance.' DOE-EM could propose relying on a limited form of maintenance to maintain the function of the cover system. An example would be repairing gullies once they reach a certain depth.

DOE Reply 5:

DOE accepts this suggestion. DOE-EM plans on providing monitoring and maintenance of the site after construction is complete until the DOE has confidence the site is stable and performing as designed. DOE has submitted and will modify to include the cover redesign the Remedial Action Inspection Plan. This report describes planned monitoring activities for the site intended to identify and remedy any potential problems that may develop including those associated with erosion should any develop.

NRC Suggestion 6: – Using biointrusion layer to prevent deep gully formation.

The currently approved design calls for inclusion of a 6-inch-thick rock layer buried 4-ft below the final surface to serve as a biointrusion layer. DOE-EM's proposed 90 percent design does not include a biointrusion layer. If the biointrusion layer is included in the design moving forward, DOE-EM could evaluate the ability of the buried rock layer to stop or cut off gully formation using the methodology in NUREG-1623, Appendix D, Section 3.2.2. The NRC staff recognizes the drainage area estimation used in DOE-EM's 90 percent design is based on conservative assumptions and is therefore acceptable. Calculations related to flow velocities and shear stresses within the gully should be based on peak velocities. If it can be demonstrated that a buried rock layer can cut off gully formation, any cover material present above the buried rock layer could be viewed as sacrificial and not risk significant. This approach could allow for much smaller rock sizing, or potentially the elimination of rock in the upper portions of the cover. Note that this approach may result in the presence of deep gullies on the cover system. While the gullies could be visually alarming, they would be an expected performance feature under this approach.

DOE Reply 6:

DOE-EM does not plan to include the rock layer at depth. DOE has determined that the layer is not technically justified.

NRC Suggestion 7: – Alter design approach.

Alternatively, DOE-EM could alter the design approach and follow the methodology for an unprotected soil slope in Section 2.2.1 and Section 2.4.1 of NUREG-1623. In following this approach, DOE-EM may be able to reduce the amount and size of rock present in the ET cover. Given the long slope lengths at Crescent Junction, the NRC staff recognizes that this approach may result in a nearly flat slope. As mentioned in suggestion 3, this approach could warrant a reevaluation of the rock size on the cover system side slopes.

DOE Reply 7:

DOE-EM has altered the design approach to adhere to achieving a stable slope as described in NUREG 1623, Appendix A. The results of the preliminary analyses have resulted in an altered cover profile to address erosion issues as described in Replies 1 and 2 above.

NRC Suggestion 8: – Varying admixture design based on slope length

As currently designed, the admixture assumes one rock size over its entire slope length. The calculations are based on the longest slope length of approximately 1300 ft. The NRC staff recognizes this approach is conservative, especially in areas of the cover with shorter slope lengths. DOE-EM could consider re-evaluating the admixture design for the north facing slope of the ET cover, which has a maximum slope length of approximately 566 ft. Alternatively, DOE-EM could consider re-evaluating the admixture design for a set distance on the upper portion of any slope. For example, the admixture on the upper 200 ft of slope length could be re-evaluated and the admixture on the lower portion of the slope could remain as proposed in the 90 percent design.

DOE Reply 8:

DOE-EM currently proposes to keep the profile consistent for the entire cover, but reserves the right to vary the admixture design based on slope and slope length as the design is finalized.