TECHNICAL EVALUATION REPORT

ASSESSMENT OF THE DESIGN OF THE CRESCENT JUNCTION DISPOSAL CELL COVER

Prepared for:

S&K MOAB TAC TEAM

S&K AEROSPACE, INC.

GRAND JUNCTION, CO 81501

Prepared by:

MACTEC Development Corp., Inc.
751 Horizon Court, Suite 104
Grand Junction, Colorado 81506

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MACTEC

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MACTEC Development Corp., Inc.

751 Horizon Court, Suite 104

Grand Junction, Colorado 81506

Design Assessment Performed by:

MACTEC Electronic Signature

Joel Doebele
I am the author of this document
Project Health Physicist
2010.03.31 14:29:06 -06'00'

Joel D. Doebele

Assessment Reviewed by:

Jeffrey Lively
I have reviewed this document
Chief Scientist | Senior Principal Health Physicist
2010.03.31 15:50:17 -06'00'

Jeffrey W. Lively, CSP, RRPT

INTRODUCTION

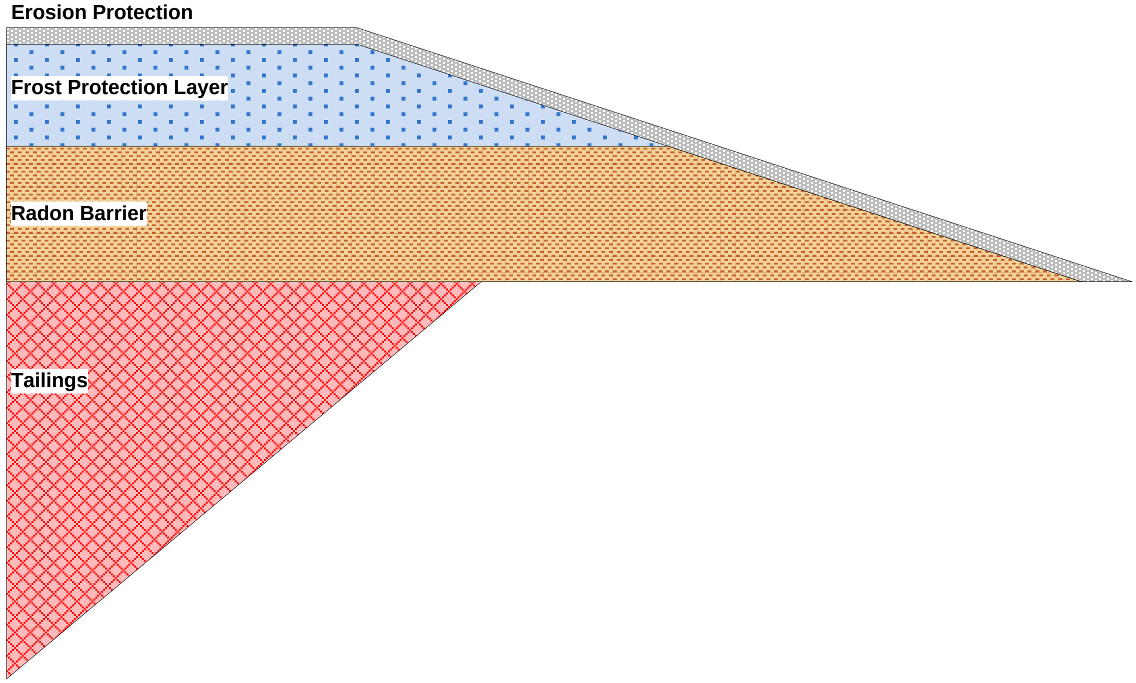
As part of the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project, the Department of Energy (DOE) is moving 16 million tons of uranium tailings from Moab, Utah. A dedicated disposal site is being constructed by the DOE in Crescent Junction, Utah to accept these tailings. The Crescent Junction disposal cell, located 30 miles north of Moab, has an area of about 200 acres. The Remedial Action Plan calls for the uranium mill tailings to be placed in the disposal cell in thin layers and compacted to a thickness of about 38 feet (DOE, 2008).

In order to conform with Environmental Protection Agency (EPA) standards set forth in 40 CFR 192, the disposal cell cover, by design, must be capable of liming the radon-222 atmospheric release rate from the disposal cell to 20 picocuries per square meter per second (pCi/m^2s) or less. The barrier must be designed to retain its effectiveness for 1000 years, as best as is reasonably achievable, and 200 years at a minimum (EPA, 2005). To meet the design requirements, the calculations performed in the *Remedial Action Plan Disposal Cell Design Specifications* (RAP) (DOE, 2008) address not only the thickness required to provide sufficient attenuation of the radon gas emanation, but also the cover design's resistance to erosion, freezing temperatures, earthquakes, and the settling of sediment.

DISPOSAL CELL EDGE DESIGN

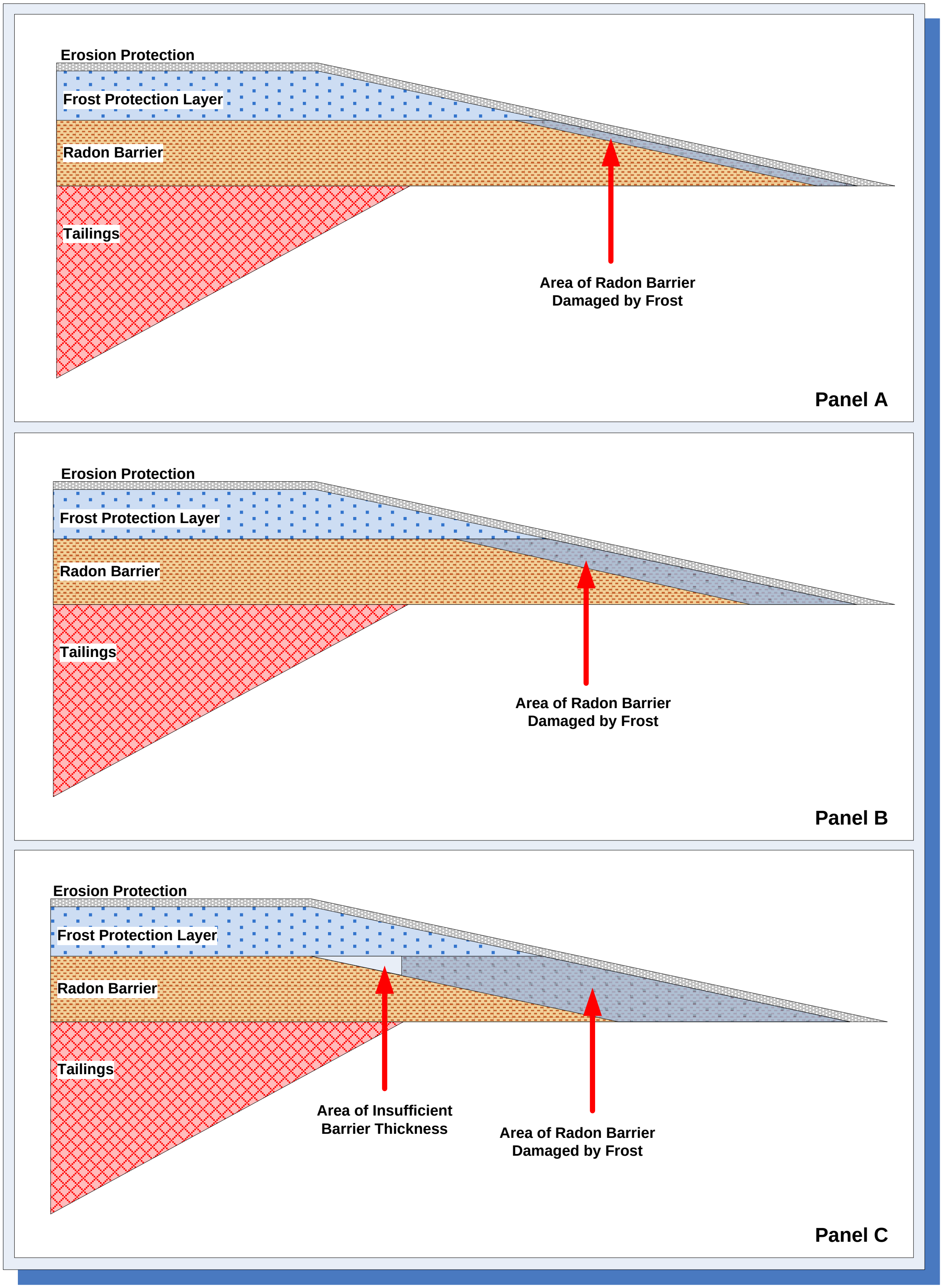
In order to provide correct water drainage and thus erosion protection, the edges of the disposal cell are sloped at a maximum steepness of 5:1 (horizontal: vertical). To meet this slope requirement, the disposal cell cover decreases in thickness near the edges (DOE, 2008). It is important to note that, as shown in Figure 1, the thickness of the interim barrier and the radon barrier remain uniform all the way to the edge of the disposal cell. The reduction in the overall cover thickness occurs in the frost protection layer, and not in the radon barrier as modeled (Jacobs Engineering, 2009). Since the required radon barrier thickness was determined without accounting for the radon attenuation provided by the frost protection layer, a decrease in its thickness would not initially change the ability of the cover design at the edge to meet the 20 pCi/m^2s limit (DOE, 2008).

Figure 1: Initial Disposal Cell Edge Cover Design (Jacobs Engineering, 2009)



This does not mean, however, that the thinner frost protection layer can be ignored. The frost protection layer over the disposal cell was set at 36 inches to provide protection to the radon barrier from seasonal freeze and thaw cycles. If the radon barrier is allowed to repeatedly freeze and thaw, its bulk density could be reduced and cracks and fissures could form (DOE, 2008). These changes could decrease the barrier's ability to limit the diffusion of radon gas. At the time of disposal, since no frost damage to the radon barrier has occurred, the thinner frost protection layer would not affect the ability of the radon barrier to meet the release limit. However, if the radon barrier at the edge did crack, fissure, or reduce in bulk density, the radon release rate at the edge could increase over time. The potential extent of frost damage to the radon barrier, and resulting region of insufficient barrier thickness, is illustrated in Figure 2.

Figure 2: Disposal Cell Edge Showing Potential Insufficient Radon Barrier Thickness



This decrease in frost protection thickness has raised concerns as to whether or not the edges of the disposal cell provide the required attenuation of radon gas. As a potential worst case scenario, Jacobs Engineering assumed that any portion of radon barrier material within 36 inches of the erosion protection layer would be lost due to frost damage. They then used the NRC's RADON program to calculate the radon flux at various locations along the edge of the disposal cell (Jacobs Engineering, 2009). The edge design considered by Jacobs Engineering, and a graph of the resulting calculations, are shown in Figure 3 and Figure 4.

Figure 3: Cover Design at Disposal Cell Edge (Jacobs Engineering, 2009)

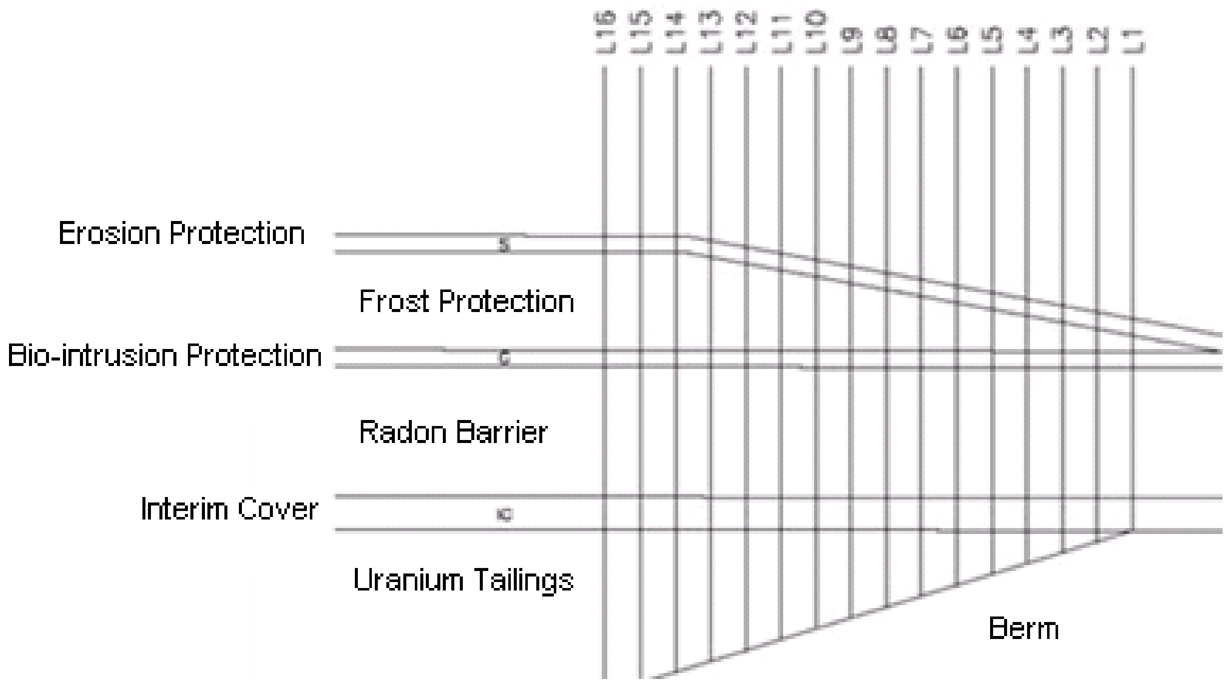
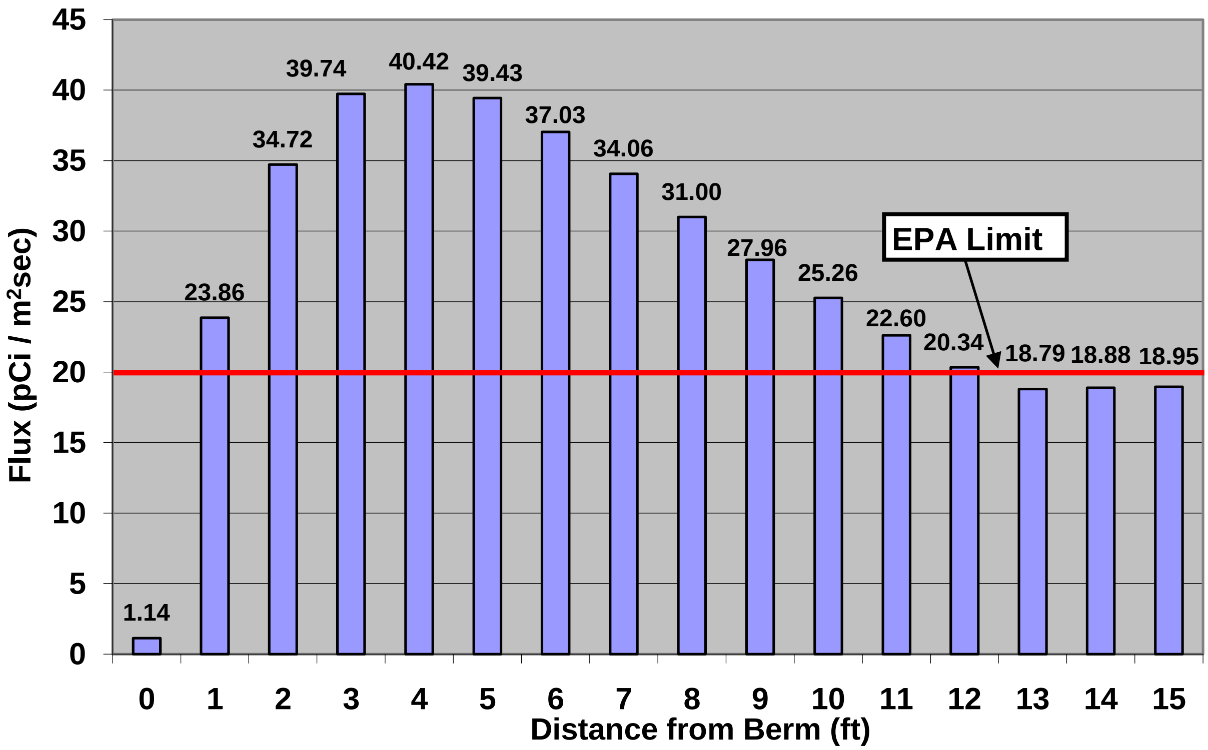


Figure 4: Radon Flux at Disposal Cell Edge (Jacobs Engineering, 2009)



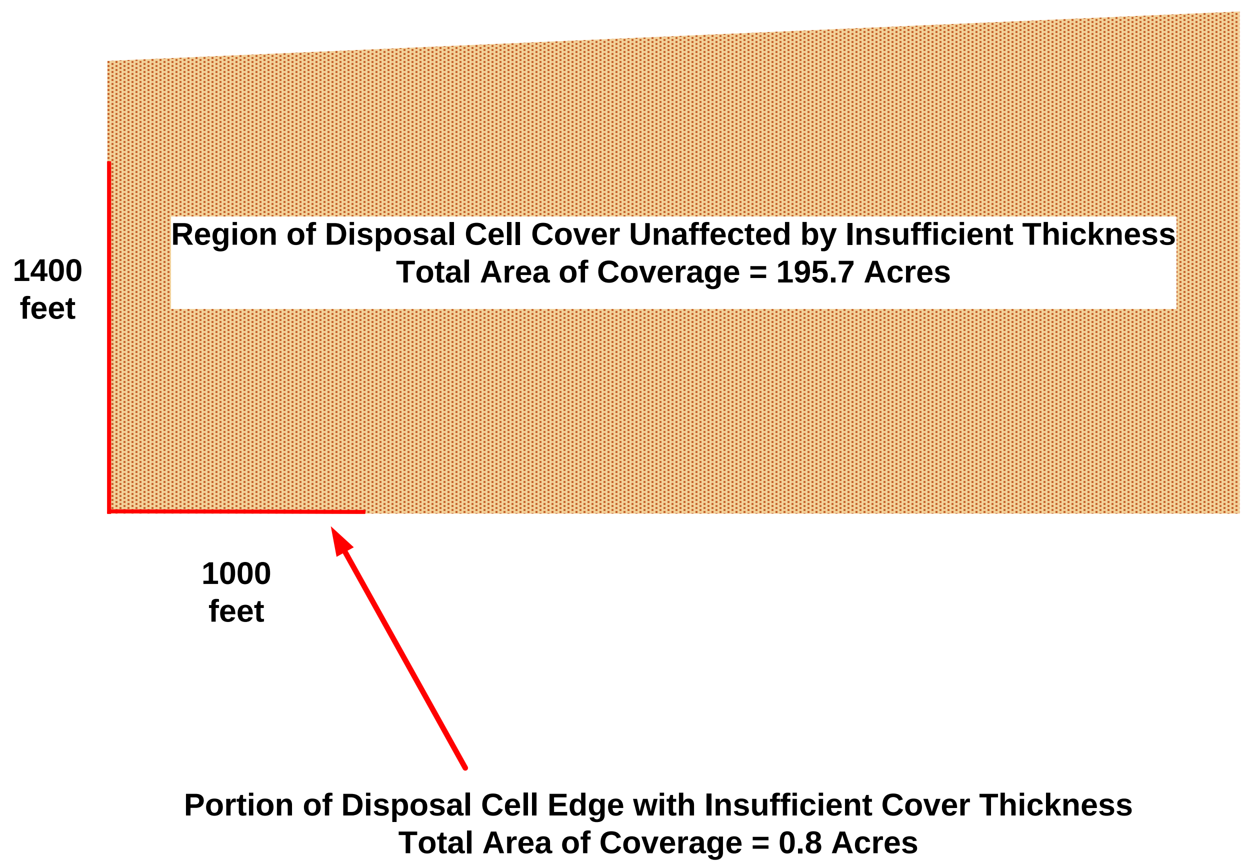
As Figure 4 shows, frost damage to the radon barrier material could result in local radon fluence from the cover near the disposal cell edge exceeding the 20 pCi/m^2s limit. Still, even if the cover does not provide the required amount of attenuation at the disposal cell edge, the ability of the site to conform to the required radon flux should not be affected.

As stipulated in the regulation at 40 CFR 192.02, the disposal site design is required to:

> (b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:
> (1) Exceed an average[2] release rate of 20 picocuries per square meter per second.
>
> [2] This average shall apply over the entire surface of the disposal site and over at least a one-year period. Radon will come from both residual radioactive materials and from materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

The regulation defines the disposal site to be the region inside the perimeter of residual radioactive material following the completion of control activities (EPA, 2005). By this regulatory requirement, if it can be shown that the cover design's *average* radon release rate over the entire disposal cell after completion does not exceed the limit, then higher localized release rates over the edges would be insignificant and permissible. The insufficient radon barrier thickness applies to a strip of the cover 14.3 feet wide and 2400 feet long over parts of the south and west edges of the disposal cell. As shown in Figure 5, the area of the disposal cell edge with insufficient thickness represents a minimal portion of the entire cover area, about 0.4%. Since the affected area is so small, the higher radon flux above the cover in this area should easily be compensated for by the lower radon flux over the remainder of the disposal cell. Thus, a calculation that accounts for the potential reduction in radon barrier effectiveness due to frost damage, but still shows overall disposal cell compliance with the EPA standard, would satisfy NRC requirements without design modifications or constructed revisions.

Figure 5: Disposal Cell Layout



CALCULATIONS

Figure 6 shows the top view (plan view) of the portion of the disposal cell edges along the west and south edges that are affected by the design flaw. For the purpose of performing calculations, the edges have been split up into one foot wide strips to match the work that Jacobs Engineering did, shown in Figure 3 and Figure 4. Since the flaw is known to affect the first 1400 feet of the west edge and the first 1000 feet of the south edge, the area of each L-shaped strip, shown in Figure 6, can be easily calculated. These areas can then be multiplied by the modeled radon fluxes (pCi/m^2s), shown in Figure 4, to find the total radon release rate over that portion of the cover in picocuries per second (pCi/s).

A similar calculation can be done with the remainder of the disposal cell's area and the applicable radon flux (pCi/m^2s). The modeled radon flux 15 feet from the edge of the berm is the same as the radon release rate over the remainder of the disposal cell cover (no input parameters to the RADON model change). The resulting radon release rates (pCi/s) from the bulk and edge portions of the disposal cell can be summed to find the total radon release rate over the entire disposal cell. This total release rate can then be divided by the total area of the disposal cell to give the average designed radon flux (pCi/m^2s) above the surface of the disposal cell. The total radon release rate over the entire disposal cell was found to be 15,098,143.43 pCi/s. Dividing this by the disposal cell's total area, 794,992.20 m^2, gives a designed average radon flux of 18.99 pCi/m^2s. A summary of the values used, as well as the resulting designed average radon flux, are shown in Table 1.

This calculation assumes that the future placement of tailings at the disposal cell edge is modified so that the design flaw in the frost protection layer is limited to the first 1400 feet of the west edge and 1000 feet of the south edge. Instead of following the initial design, the tailings should be placed in such a way that, even if frost damage to the radon barrier material occurs, the local radon flux at the disposal cell edge does not exceed the radon flux modeled over the bulk of the disposal cell (18.95 pCi/m^2s). If the tailings are placed in such a way that the local radon fluxes at the disposal cell edge are less than 18.95 pCi/m^2s, then this calculation would overestimate the designed average radon flux over the entire disposal cell.

Figure 6: Top View of Affected Portion of Disposal Cell Cover

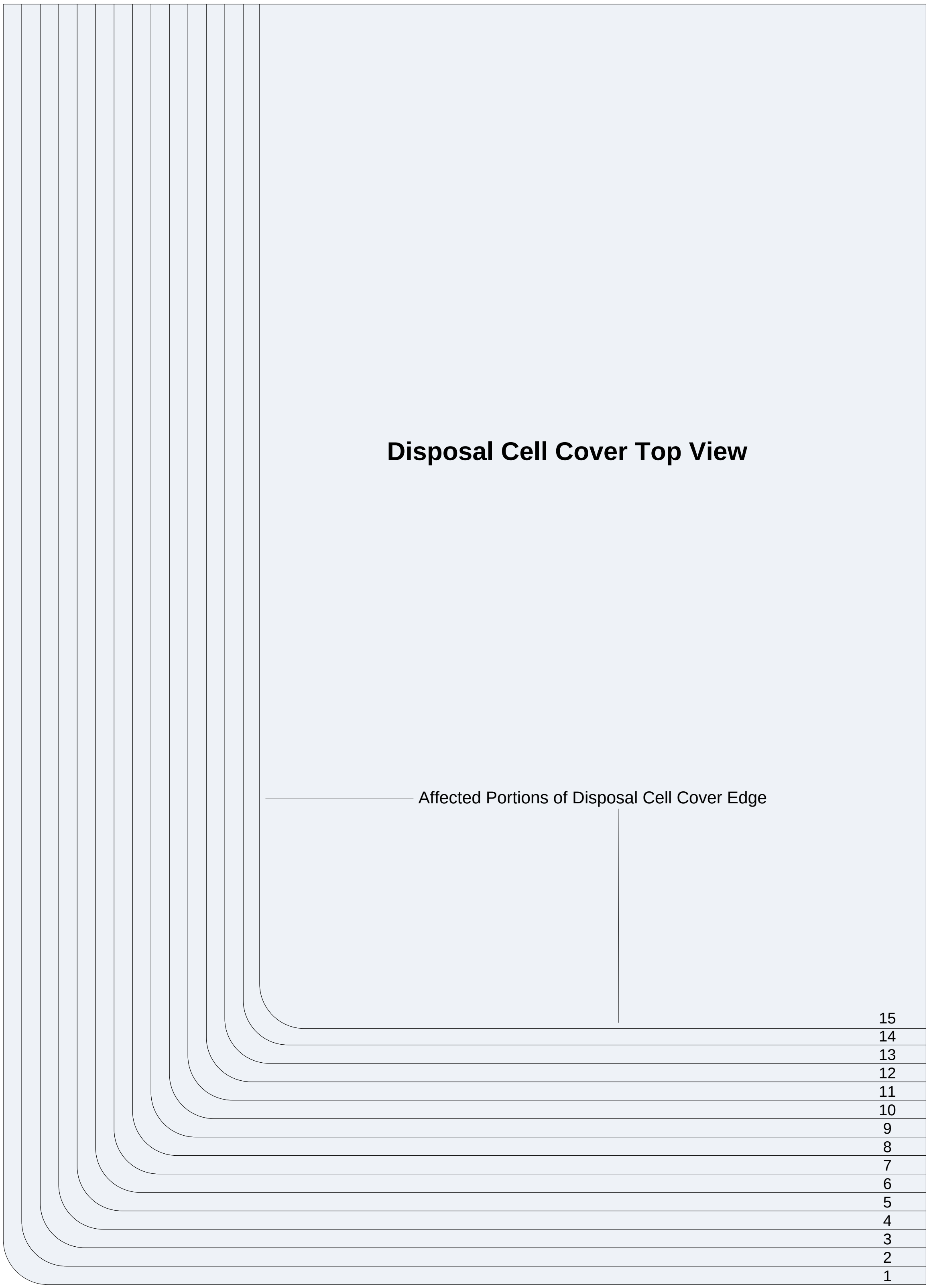


Table 1: Disposal Cell Areas and Radon Fluxes

Distance from Berm (feet) / Strip Label on Figure 6	Area (m^2)	Modeled Radon Flux from Figure 4 (pCi/m^2s)	Radon Release Rate (pCi/s)
1	222.87	23.86	5317.78
2	222.69	34.72	7731.75
3	222.50	39.74	8842.26
4	222.32	40.42	8986.05
5	222.13	39.43	8758.63
6	221.95	37.03	8218.64
7	221.76	34.06	7553.13
8	221.57	31.00	6868.79
9	221.39	27.96	6190.01
10	221.20	25.26	5587.57
11	221.02	22.60	4994.97
12	220.83	20.34	4491.69
13	220.64	18.79	4145.91
14	220.46	18.88	4162.26
15	791,888.86	18.95	15,006,293.99
Total Area (m^2):	794,992.20	Total Radon Release Rate (pCi/s):	15,098,143.43
Average Radon Flux (pCi/m^2s):	**18.99**		

As Table 1 shows, even though the local radon flux reaches over 40 pCi/m^2s over small portions of the disposal cell edge, the relatively small area affected by this higher flux is insignificant compared to the rest of the disposal cell. Even with the design flaw at the disposal cell edge, the designed average radon flux is still 18.99 pCi/m^2s. Thus, no changes to the disposal cell design are necessary to meet the EPA's regulatory requirement of 20 pCi/m^2s for the average radon flux over the entire surface of the disposal cell.

CONCLUSION

Based on the calculations presented above, there is no need to implement a new design for the south and west edges of the Crescent Junction uranium mill tailings disposal cell. There is also no need to remove and replace tailings that have already been placed in the disposal cell. While the ability of the radon barrier to provide radon attenuation as originally designed could be affected by the thinner frost protection layer at the edge, the local radon flux in the impacted area is unimportant to the regulatory requirement. To meet the design requirement set forth by the EPA, it need only be shown that, despite potential frost damage to the edge of the radon barrier, the designed average radon flux from the entire cover surface does not exceed 20 pCi/m^{2}s. The calculated design average of 18.99 pCi/m^{2}s, then, shows that the design of the Crescent Junction disposal cell is adequate to meet the EPA's regulatory requirement.

References

EPA, 2005. *Code of Federal Regulations Title 40: Protection of the Environment, Part 192: Health and Environmental Protection Standards for Uranium and Thorium Mill Tailing,* U.S. Environmental Protection Agency.

DOE, 2008. *Final Remedial Action Plan and Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah Disposal Site, Attachment 1: Draft RAP Disposal Cell Design Specifications,* U.S. Department of Energy, Office of Environmental Management.

Jacobs Engineering, 2009. *Evaluation of Insufficient Cover Thickness at Crescent Junction Disposal Cell Edge*, Jacobs Engineering, Oak Ridge, Tennessee.