

**TAILING CELL CLOSURE DESIGN REPORT  
ENERGY FUELS RESOURCES  
CORPORATION  
PIÑON RIDGE PROJECT  
MONTROSE COUNTY, COLORADO  
KLEINFELDER PROJECT NO. 83088**

**September 17, 2010**

**DCN: 83088.5.U2-ALB08WP001  
Rev. 1**

**Prepared by:**



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September 17, 2010

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## 1.0 INTRODUCTION

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Energy Fuels Resources Corporation (EFRC) is planning to license, build and operate a conventional acid-leach uranium mill in the Paradox Valley of western Montrose County, Colorado. This facility, the Piñon Ridge Project, must satisfy the requirements for a Radioactive Source Material License in accordance with 6 CCR 1007-1, Part 18; Licensing Requirements for Uranium and Thorium Processing, of the Colorado Department of Public Health and Environment (CDPHE), enforced through its Radiation Management Unit. This report addresses the requirement to design and construct a cover over the mill tailings that will satisfy the criteria contained in Appendix A of 6 CCR 1007-1, Part 18.

### 1.1 Project Description

The proposed Piñon Ridge Project (Site) is located in Paradox Valley at 16910 Highway 90, approximately 14 miles west of Naturita, in Montrose County, Colorado. The Site's legal description is the Southwest  $\frac{1}{4}$  of the Southeast  $\frac{1}{4}$  of Section 5, all of Section 8, the North  $\frac{1}{4}$  of Section 17, and the Southeast  $\frac{1}{4}$  of the Northwest  $\frac{1}{4}$  of Section 17, Township 46 North, Range 17 West, of the New Mexico Principal Base and Meridian. The Site is located on both the Davis Mesa Quadrangle and Bull Canyon Quadrangle 1:24,000 United States Geological Survey (USGS) topographic/geologic maps. The Site location with respect to major geographic features is shown in Drawing C2-1.

The Piñon Ridge Project will process up to 500 tons of ore per day (TPD) but is designed to accommodate subsequent expanded production capacity of up to 1,000 TPD. The ore will be produced from mines within a reasonable truck-hauling distance. The facilities will include an administration building, a 17-acre mill, tailing cells totaling 90 acres, a series of connected evaporation ponds totaling 40 acres for initial production and expandable to 80 acres, a 5-acre ore storage pad, and an access road. The expected operating life of the mill, depending on future production rates, is 20 years (1,000 TPD) to 40 years (500 TPD).

The tailing cell system, designed by Golder Associates (Golder, 2008a), will consist of three cells (A, B, and C) constructed, operated, and covered successively through the life of the mill. The design substantively corresponds to the "prime option" of Criterion 3, Appendix A of 6 CCR 1007-1, Part 18, by configuring the tailings cells to be mostly below grade.

### 1.2 Purpose and Scope

This report is intended to document the regulatory basis, design objectives, and components of the mill tailing cover design. The tailing cell design, developed by Golder Associates as the basis for both construction and operation of the tailing

cells, is described in detail in the Tailing Cell Design Report (Golder, 2008a) and will not be addressed in this report.

The scope of this report includes a brief description of the regulatory criteria for tailing cover design, the design objectives derived from those criteria, and the design and construction of the cover components.

## 2.0 CLOSURE CRITERIA

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The tailing cover, in combination with the tailing cell (or impoundment) liners, will provide the system of barriers for the long-term containment of tailings according to the closure criteria in Appendix A of 6 CCR 1007-1, Part 18. This and other CDPHE regulations can be accessed via the internet at:

<http://www.cdphe.state.co.us/regulations/radiationcontrol/index.html>.

The relevant criteria are presented for the reader's convenience in Attachment A. These criteria address:

- Siting and design – Criteria 1, 4
- Groundwater protection – Criterion 5
- Tailing cover design – Criterion 6
- Leakage of hazardous constituents – Criterion 7

In the subsequent sections of this report, the relevant criteria will be referenced as appropriate as the basis for design of the tailing cover components or other design elements.

### 3.0 DESIGN OBJECTIVES

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The tailing cell closure design is based primarily on performance objectives. The primary objectives are:

- Provide containment of byproduct for 1,000 years (Criterion 6(1)(i))
- Limit Radon flux from the cover surface to  $<20 \text{ pCi/m}^2\text{s}$  (Criterion 6(1)(ii))
- Limit infiltration of moisture into, and release of contaminated liquid from, the tailings (Criteria 5B(1), 5E(3), 6(7), 7)

Secondary objectives include limiting the area of exposed tailings and facilitating progressive closure (Criterion 6A (1)).

## 4.0 TAILING CELL CLOSURE DESIGN

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### 4.1 Design Concept

The design concept for the Piñon Ridge Project tailings cover was developed around the foregoing closure criteria and design objectives. It also takes into account the results of recent research and field investigations of arid climate closure covers conducted by Los Alamos National Laboratory (Dwyer et al, 2007), Desert Research Institute (Albright et al, 2002; Bolen et al, 2001), and the Department Of Energy (Waugh, 2004; DOE, 2008). Those results, which include the assessments of performance of some of the UMTRA Title I tailing covers, indicate that the design concept used in the earlier generation of covers is not necessarily optimal.

The design typically applied to tailing covers for the earlier generation of mill sites (those remediated under the UMTRA Title I program) consisted of a rock cover or sacrificial soil cover over a compacted clay radon barrier. These covers were not intentionally revegetated but inevitably developed a volunteer population of grasses and shrubs. Some of these covers did not provide the barrier to infiltration, deep rooted vegetation or borrowing animals that was expected. In contrast, the research referenced above shows that a more effective design consists of a multi-layered cover that includes the radon barrier as before but also overlying layers with specific barrier functions limiting infiltration, biological intrusion, and erosion. This type of cover, called an evapo-transpiration (ET) cover or water balance cover, has been selected for the Piñon Ridge Project tailing closure. The ET cover has been designed to fit the tailing cell (impoundment) design with only minor changes to the top of the cell embankment to accommodate the cover at the time of closure. The ET cover design concept is consistent with a risk-informed, performance-based regulation per SECY-98-144 (NRC, 1998), which provides a licensee with the flexibility to propose methods other than those in the regulations as long as the applicant demonstrates how a proposed method will meet regulatory requirements.

### 4.2 Tailing Cell Design

The tailing cells have been designed (Golder 2008a) and will be constructed to satisfy the criteria in Appendix A of 6 CCR 1007-1, Part 18 for long-term containment of tailings and for monitoring of possible byproduct releases during operation. Specifically, the cell design accounts for:

- 1) Long-term stability and minimal potential for erosion of slopes (Criteria 4C, 5A(5)). The tailing cells are designed with slopes not steeper than 5h:1v, with final outslopes (slopes from the cell berms to the outer edge of the cells) at 10h:1v.
- 2) Prevention of downward migration of contaminants that could impact groundwater (Criteria 5A(1), 5A(2), 5E(1), 5E(3)). The tailing cells will

have double-geomembrane liners with an intermediate leak detection/collection system. The liner material is 60 mil HDPE and not susceptible to degradation in the presence of tailing solution. The liner will cover surfaces in contact with the tailings solutions and solids except for the interim cover. A dewatering (underdrain) system will remove drainable liquid from the tailings during mill operations and subsequently as needed, to remove the tailing liquid freed up both by natural gravity drainage of the tailings and by consolidation of tailings,

The components of the tailing cell impoundment structures, liner, and dewatering system have been designed to satisfy the long-term containment criteria. These components will not be removed or altered by the tailing cover design and construction. Some minor regrading of the crests of the tailing containment berms will be performed to merge the outslopes with the tailing cover; details of the regrading are discussed in Section 5.2.2.

### **4.3 Tailing Cover Design**

The tailing cover described in the following sections is based on both the tailing cell design, which can be considered relatively fixed at the time of license approval, and a number of variables that can be reasonably estimated now but will inevitably vary somewhat over the operating life of the mill. These variables are related to the ores processed through the mill, the mill operations as they affect tailing solids and solutions, tailing placement practices, dewatering, and weather. For example, actual ore radium contents will vary between the ores processed (affecting tailing source terms), and tailing placement practices will affect the distribution of slimes versus coarse fractions across each tailing cell. As data on these variables are accumulated during operations, refinements can be made in the tailing cover design, illustrated in Drawings C2-1 through C2-9, prior to cover construction.

#### **4.3.1 Cover Components**

The tailing cover has been designed to achieve the closure criteria in Section 2.0 and the design objectives described in Section 3.0. It will consist of multiple layers of natural earth materials, each layer designed for a particular function. The layers of the cover, from top to bottom, are illustrated on Figure 1 and Drawing C2-9, and the function of each is described below:

- Erosion barrier/ vegetative cover – provides protection against erosion and wind and water (runoff), limits infiltration to lower layers, and stores moisture to support vegetation
- Capillary break – provides the primary barrier to infiltration of water and a pathway to drain moisture laterally to the edges of the tailing cell

- Bio-intrusion barrier – provides a barrier against deep-rooted vegetation and burrowing animals as well as a pathway to drain moisture laterally to the edges of the tailing cell
- Radon barrier – provides the primary barrier to radon release from the tailing cell
- Geosynthetic Liner (composite geosynthetic) – positioned in the upper portion of the radon barrier, provides an additional barrier to moisture
- Interim cover – provides immediate protection against windborne release of tailings after cessation of cell operation and prior to placement of radon barrier, serves as a firm base for radon barrier construction

Each of these components, or layers, is described below, starting with the first layer to be constructed, the interim cover, and proceeding upward in the order of construction. The layers above the radon barrier will be sloped outward, toward the cell perimeter, at a grade of 0.02 or 2%.

Most of the cover layers will consist of native soil derived from excavations of the tailing cells (the portions of the cells below original natural grade). These soils have been extensively explored and characterized (Golder 2008a, 2008b, 2008e; Kleinfelder, 2008a). They consist primarily of shallow windblown (eolian) deposits of fine sand and silt classified in the Unified Soil Classification System as silt (ML), silty sand (SM), or well-graded sand (SW) underlain by reworked eolian and alluvial sand and silt. Some clays (CL) or clayey sands (SC) occur, as well. At the lower depths of some cell excavation, sedimentary bedrock including sandstone, claystone, mudstone, shale and gypsum or anhydrite may be encountered. Therefore, the term “native soil” as used in this report refers to any combination of the soils and sedimentary lithologies excavated from the tailing cells and stockpiled in the SW ¼ of Section 8, west of the mill location and outside of the mill license boundary. For the purposes of numerical analysis and design, the native soil is assumed to be a silty sand (SM) material; additional classification and compaction testing will be performed on the stockpiled soil prior to cover construction. This type of soil is non-plastic or has low plasticity and should not be sensitive to changes in moisture content below saturation; therefore, this soil should not be susceptible to swell or cracking with moisture content fluctuations.

### Interim cover

The interim cover will consist of not less than 2.0 ft of uncontaminated native soil placed in lifts over the regraded tailings surface (see Section 5.2.2) and compacted to not less than 85% maximum dry density per ASTM D-698 (Standard Proctor). This compaction requirement takes into account the expected condition of the underlying tailings; although dewatered of free-draining

moisture, the tailings are expected to retain substantial moisture content and remain uncompacted at the time of interim cover construction. These conditions are likely to make moisture-conditioning of the native soil impractical and to limit the size of equipment used for interim cover placement to small dozers with low ground pressure treads. Consequently, the lift thickness, estimated initially at 1.0 ft, will be determined in the field under initial placement conditions dictated by tailing density and retained moisture.

The interim cover will extend across the final tailing surface, terminating laterally against the geomembrane liner on the inside slope of the tailing cell impoundment berm (Figure 2).

### Radon barrier

The radon barrier will consist of 0.9 ft to 5.7 ft of compacted native soil, based on the results of numerical modeling using the RADON code, which is described in detail in Attachment B and discussed in Section 4.3.2. The radon barrier will extend across the interim cover and will terminate laterally against the inside slope of the tailing cell impoundment berm (Figure 2). The radon barrier thickness varies as a function of the thickness of underlying tailings. The radon barrier will be a minimum thickness of 0.9 ft at the perimeter of the tailings, where the tailings will be 1 ft or less, then thicken progressively to 5.7 ft over tailings that are 15 ft thick or more (5 ft of sand tailings over 10 or more feet of slime tailings). Due to the attenuation of radon in the upper 15 ft of tailings, no additional radon barrier is needed over tailings exceeding 15 ft of thickness. However, in order to establish the 0.02 grade needed in the overlying layers of the cover, the top surface of the radon barrier will be completed at a 0.02 grade towards the cell perimeter. As a result, the radon barrier may be more than 5.7 ft thick toward the center of the cells.

The bounding limits of radon barrier thicknesses were determined using the RADON code (the Visual Basic version of the RAECOM code) and the analytical procedures described in NRC Regulatory Guide 3.64, Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailing Covers (NRC, 1989). The RADON model, described under Section 4.3.2, included the tailings, interim cover, the geosynthetic liner, radon barrier, bio-intrusion layer, capillary break layer and erosion barrier/vegetative cover. The RADON model input and output values are listed in Table 1. For simulating the radon attenuation performance of the entire cover system, the geosynthetic liner was modeled in a position between the radon barrier and the interim cover; the actual location of the geosynthetic liner can vary between the top and the bottom of the radon barrier without significantly impacting radon flux into the overlying layers of the evapo-transpiration portion of the cover system.

The radon barrier cover soil will be placed in lifts of not more than 8 inches uncompacted thickness, moisture conditioned to within 2% of optimum moisture

content and compacted to not less than 95% maximum dry density per ASTM D-698 (Standard Proctor).

#### Geosynthetic liner (also called geomembrane-supported geosynthetic clay liner)

The geosynthetic liner layer consists of a thin geomembrane (LLDPE or HDPE plastic) laminated to a layer of sodium bentonite clay (geosynthetic clay liner or GCL) sandwiched between two geo-textiles that are needle-punched together. The geosynthetic liner is manufactured off-site and delivered in rolls. The geosynthetic liner is installed by rolling it out across the prepared surface on one of the lifts within the upper portion of the radon barrier.

The geosynthetic liner supplements the other cover layers, which would achieve the design objectives of radon attenuation and limiting of infiltration without the geosynthetic liner.

#### Bio-intrusion Barrier

The bio-intrusion layer will protect underlying layers of the tailing cell cover from burrowing animals and deep-rooted vegetation. It will consist of 0.5 ft of native soil matrix with nominal 3-inch rock (sound cobbles) and will be compacted to 85% Standard Proctor or approximately 100 pcf dry density. The cobbles will be placed so that they overlap within the soil matrix.

The cobble size was selected to be large enough to provide a barrier against burrowing by animals up to the size of prairie dogs. Minimum three-inch cobbles are too large for these animals to push aside or remove from the burrow. Larger predator animals such as coyotes and badgers are capable of moving 3-inch cobbles but would have no incentive to dig deeper than their prey could reside. Thus, if the 3-inch cobbles limit the burrowing depth of their prey, the predators will be similarly limited.

The bio-intrusion layer will extend laterally beyond the outside edge of the underlying radon barrier and terminate at the tailing cell berm (Figure 2).

#### Capillary Break

The capillary break layer will consist of 0.5 ft of granular soil (sand and gravel) satisfying a  $d_{15}/d_{85}$  particle size ratio with the overlying vegetative cover soil. This granular soil will be imported from an off-site source. The layer will have approximately 50% relative density, or about 111 pounds per cubic foot (pcf) dry unit weight, to make it essentially incompressible under design loads but preserving substantial effective (drainable) porosity.

Because of its low unsaturated hydraulic conductivity, the capillary break layer will have high air-entry pressures, causing moisture infiltrating downward from the cover surface to concentrate in the vegetative cover. In an unlikely case of

exceeding the ET cover storage capacity (e.g. for the cover soil moisture close to saturation after prolonged periods of high rainfall and infiltration), the capillary break will intercept most of the downward percolating moisture and drain it laterally along this layer to the top of the tailings cell embankment, where the moisture will discharge to the rock blanket covering the tailings cell outslope (Figure 2).

### Erosion Barrier/Vegetative Cover

The topmost element of the cover system is the erosion barrier/vegetative cover. As the name implies, this layer is designed to resist erosion by wind and runoff and to provide a growth medium for the vegetative cover. It will also be the primary barrier to infiltration of precipitation. The erosion barrier/vegetative cover has been designed according to guidelines suggested by the Nuclear Regulatory Commission in NUREG-1623, Design of Erosion Protection for Long-Term Stabilization, Appendix A for design of soil covers.

This cover will consist of 4.0 ft. of native soil compacted to 85 % Standard Proctor dry density with rock mulch (min.  $d_{50}$  = 0.5 inch durable rock) mixed with soil in the top 0.5 ft. In addition, the cover surface will be revegetated. The rock will meet the durability scoring criteria in Appendix D of NUREG-1623.

The native soil used in the erosion barrier/vegetative cover will have moderate susceptibility to frost action down to approximately 26 inches depth. However, precipitation during winter months will typically be low and moisture sufficient to saturate the soil will not normally be available. Consequently, freezing temperatures are not likely to disrupt the soil structure of the erosion barrier/vegetative cover.

The finished cover will be sloped at a grade of 0.02 away from the center of each cell toward the cell perimeter, as illustrated on Figure 2 and 3. The tailing cell erosion barrier/vegetative cover has been designed to withstand the Probable Maximum Flood (PMF) across this 0.02 slope resulting from the Probable Maximum Precipitation (PMP), addressing Criterion 6(1)(i) of Appendix A, 10 CFR 40, for containment for a 1,000 year period. The methods used for determining the PMF and the resulting peak velocities and shear stresses on the cover surface are described in Attachment C. The results of these analyses indicate that the maximum 1-hour rainfall depth for the 6-hour PMP Local Storm is 7.6 inches.

The erosional forces generated by runoff from storm events up to the PMP will be resisted initially by the rock mulch in the soil matrix, then by both the rock mulch and the vegetative cover. Vegetation will be established with a seed mix recommended by NRCS for the project area consisting of plants that are adaptive to the area's climatic conditions. The vegetation area cover is expected to vary from 35 to 70%, with 35% assumed for purposes of infiltration modeling.

The erosion barrier/vegetative cover will extend over the entire final area of the tailings terminating against, and transitioning into, the outslope rock blanket, as shown on Figure 2.

### Erosion Protection on Slopes

Erosion protection was developed based on modeling, described in Section 4.3.2 and Attachment C, of various cover and slope configurations to identify the combinations of slope gradients, slope lengths, and rock sizes that will provide protections against erosion during peak runoff from the Probable Maximum Precipitation (PMP) event. The erosion protection modeling is described in Section 4.3.2.

A rock blanket will be placed on the outslopes of each tailing cell from the toe of slope to the top of slope to provide protection against erosion of the underlying tailing cell dike and outer edge of tailing cell cover. The rock blanket will consist of 1.0 ft. of graded durable rock,  $d_{50} = 2.5$  inch, placed over 0.5 ft of sand/gravel bedding satisfying the  $d_{15}/d_{85}$  ratio with underlying native soil. The rock and underlying bedding material will satisfy the durability criteria in Appendix. D of NUREG 1623.

The outslope rock blanket and the underlying bedding layer will be placed over original (and existing) 10h:1v slopes. However, from the outside edge of the tailing cell berm to the outer edge of the tailing cover, the slope will be steepened slightly to 10h:1.2v to provide the space needed for the tailing cover to extend over the entire footprint of the underlying tailings. These features are illustrated in Figure 2.

The rock blanket protecting the 5h:1v slopes between cells A and B and between cell B and C will consist of the same rock and bedding layers as on the outslope, with the exception that the rock will be slightly larger with  $d_{50} = 3.5$  inch. Run-out rock aprons, consisting of the same rock material but with  $d_{50} = 8$  inches, will extend 15 ft beyond the toe of the outslope.

Rock in the rundown channels between tailing cells will be lined with this same rock but sized for  $d_{50} = 18$  inches (Drawings C2-6 and C2-7).

### **4.3.2 Modeling Results**

The design of the cover layers described in the previous section was an iterative process focused on optimizing the function of each layer and satisfying the design objectives of the cover system as a whole. The design was based in part on the properties of the available borrow soil (primarily the native soil) and on regulatory agency guidelines. Layer thicknesses were initially selected based on experience and engineering judgment, then evaluated and refined through numerical modeling of the cover performance against the three design objectives.

## RADON Modeling

The RADON computer code was used to predict radon flux at ground surface (top of tailing cover) and, in turn, to select the thicknesses of the radon barrier layer that, in combination with other layers in the cover, would limit radon flux to not more than 20 pCi/m<sup>2</sup>s averaged over the cover surface in accordance with Criterion 6(1)(ii) of Appendix A of 6 CCR 1007-1, Part 18.

The bounding limits of radon barrier thicknesses were determined using the RADON code (the Visual Basic version of the RAECOM code) and the analytical procedures described in NRC Regulatory Guide 3.64, Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailing Covers (NRC, 1989). The RADON model included the tailings, interim cover, the geosynthetic liner, radon barrier, bio-intrusion layer, the capillary break, and the vegetative cover.

Tailings material properties were obtained from Golder Associates, Inc. project design criteria (Golder, 2008a), and regional mine and mill data provided by Energy Fuels Resource Corporation. Tailings material properties were also obtained from the Department of Energy (2008) geotechnical investigation for the Moab Title I Uranium Mill tailings cell at the Crescent Junction, Utah disposal site. The material properties used in the modeling effort were estimated based on the aforementioned data, anticipated site conditions, construction practices and engineering judgment.

The RADON model input and output values are listed in Table 1. The RADON model calculations are documented in Kleinfelder document 83088.4.4-ALB10CA001 entitled "Radon Barrier Thickness Design" Rev. A (Attachment B).

**Table 1 RADON Model Input and Output**

**Input Parameters**

Scenario	Description	Number of Layers	Radon Flux Limit pCi /m <sup>2</sup> s	Optimized Layer	Radon Concentration Above Top Layer	Lower Boundary Radon Flux, pCi /m <sup>2</sup> s	Surface Flux Precision
1	5 feet Tailings (sands) with Source Term 302.5 pCi/g Over 10 feet Tailings (Slimes) with Source Term 1210 pCi/g	8	20	Radon Barrier	0	default	0.001
2	1 foot of Tailings (sands) with Source Term 302.5 pCi/g	7	20	Radon Barrier	0	default	0.001

Layer #	Material Type	Thickness, ft	Porosity	Dry Density, pcf	Radium Activity, R, pCi/ g	Specific Gravity	Volumetric Moisture Content
1	Tailings (slimes)	0.5 - 10	0.40	98.0	1210	2.69	20.4
2	Tailings (sands)	0.5 - 5	0.42	103.0	302.5	2.69	13.2
3	Interim Cover	2.0	0.39	100.3	0.98	2.65	10.2
4	Geosynthetic Liner	0.033	0.47 (clay)	90 (clay)	0.98	2.72	33.0
5	Radon Barrier	optimized	0.32	112.1	0.98	2.65	10.2
6	Bio-intrusion	0.5	0.39	100.3	0.98	2.65	10.2
7	Capillary Break	0.5	0.33	112.9	0.98	2.70	0
8	Vegetative Cover & Rock Mulch combined	4.0	0.39	100.3	0.98	2.65	10.2

Layer #	Gravimetric Moisture Content %	Total Density g/cc	Moisture Saturation Fraction	Radon Diffusion Coeff. cm/sec <sup>2</sup>	Emanation Coefficient (default)
1	13.0	1.77	0.49	0.013	0.35
2	8.0	1.78	0.33	0.023	0.35
3	6.3	1.71	0.26	0.029	0.35
4	23.0	1.77	0.70	0.004	0.35
5	5.7	1.90	0.32	0.022	0.35
6	6.3	1.71	0.26	0.028	0.35
7	0	1.81	0	0.070	0.35
8	6.3	1.71	0.26	0.029	0.35

### Output Values

Radon Barrier Thickness, min.	Radon Barrier Thickness, max.
27.4 cm, 0.9 ft	173.7 cm, 5.7 ft

### Infiltration Modeling

Numerical modeling of the entire cover system, from the cover surface to the interim cover/tailings interface, was conducted to address the requirement to limit infiltration of moisture into, and release of contaminated liquid from, the tailings (Criteria 5B(1), 5E(3), 6(7), and 7 of Appendix A of 6 CCR 1007-1, Part 18). After the radon barrier thickness was optimized for radon attenuation through the cover, infiltration through the cover was predicted using the UNSAT-H Version 3.01 computer model. This modeling was performed initially by HC Itasca Denver Inc. (HCID) under subcontract to Kleinfelder. Kleinfelder performed the updated UNSAT-H flow modeling and analysis to reflect the revised cover design. Attachment D presents a summary of the UNSAT-H flow modeling and analysis based upon the revised cover design.

The updated UNSAT-H flow modeling and analysis are documented in detail in Kleinfelder document 83088.4.4-ALB10CA003 entitled "Unsaturated Flow Modeling and Analysis" Rev. A, and in Kleinfelder document 83088.4.4-ALB10CA002 entitled "Piñon Ridge Closure Cover Geotechnical and Hydrologic Properties."

The input parametric values used for the UNSAT-H model include the soil properties developed through the Golder and Kleinfelder geotechnical investigations (Golder, 2008e), the design configurations and compaction requirements for each layer, the expected vegetation cover, and simulation of a bounding range of soil infiltration rates for a several year period.

The Uravan meteorological data, used by Golder (2008b) in designing the tailing cells, lack some parametric values needed for a detailed field water balance to estimate the surface infiltration rate for the tailing cover. Therefore, for the UNSAT-H calculation, well-known correlations between infiltration and rainfall (Stein, 2007) were used to estimate infiltration rates. The conservatively high range of surface infiltration selected for the modeling, from 8 mm to 20 mm/year over a several year period, exceeds the rates used for other sites at Monticello Utah, the Rocky Mountain Arsenal (RMA) Colorado, and at Ft. Carson, Colorado.

The results with this model show that the bio-intrusion/ capillary break zone performs as a capillary barrier under the estimated high infiltration rates assumed to persist over several years. The UNSAT-H model predicts that the moisture content of the vegetative cover will not reach saturation levels. The analysis also shows that the percolation rate below the geosynthetic liner into the interim cover is very low (i.e., 0.001mm/year).

Actual precipitation data for the Piñon Ridge site are being collected, but the period of record to date (started on 4/1/08) is too short to support infiltration modeling. Meteorological data will continue to be collected at the Piñon Ridge site through the mill construction and operating periods, and this record will be reviewed to determine if additional infiltration modeling is warranted prior to placement of the tailing cover on Cell A, the first cell to be covered. A minimum of 10 years of meteorological data should be available by the time Cell A is ready for closure and interim cover placement.

### Runoff and Erosion Modeling

To address the requirement to provide containment of byproduct for 1000 years (Appendix A, 6 CCR 1007-1, Part 18, Criterion 6(1)(i)), the cover must be able to resist erosion by the maximum runoff scenario applicable to the 1000-year design life. The existing time record of precipitation is not sufficient to support prediction of the 1000-year precipitation event, so the Probable Maximum Precipitation (PMP) event is used. The PMP is calculated using procedures outlined in Hydrometeorological Report No. 49 (HMR 49) (Hansen et al, 1977). The maximum runoff scenario for the PMP is the Probable Maximum Flood (PMF). The methods used for determining the PMF, and the resulting top and side slope cover design and tailing cell toe protection, follow guidelines suggested by the Nuclear Regulatory Commission in NUREG-1623, Design of Erosion Protection for Long-Term Stabilization (NRC, 2002). The PMP and PMF calculations are described in Attachment C.

The design precipitation event, the storm that results in the highest surface water runoff, is the 6-hour Local Storm PMP. The PMF runoff from the maximum one-hour intensity of this storm was modeled using the Rational Method. The Safety Factor Method was used to calculate the size of rock needed to provide protection of the top of the tailing cover, where the gradient will be relatively flat

at 0.02. The Stephenson Method was used for sizing of rock needed to resist erosion on steeper side slopes and out slopes. The results of these design calculations are listed in Table 2.

**Table 2 Tailing Cover Erosion Protection Components**

Erosion Protection Element	Material Size	Layer Thickness
Vegetated Soil Top Cover, 0.02 Slope	Minimum $d_{50}$ = 0.5 inches for rock-mulch size	Rock mulch in top 0.5 feet
10h:1v Rock Cover Outslopes	$d_{50}$ = 2.5 inches	12-inch minimum thickness Filter layer required
5h:1v Rock Cover Side Slope (1)	$d_{50}$ = 3.5 inches	12-inch minimum thickness Filter layer required
Riprap Rundown Channels	$d_{50}$ = 18 inches	36-inch minimum thickness Filter layer required
Cell Embankment Toe Protection	$d_{50}$ = 8.0 inches	24-inch minimum thickness Filter layer required

(1) Side slope between Cell A and B and between Cell B and C

Rock mulch (rock mixed into the top 0.5 ft of the erosion barrier/vegetative cover) will provide protection against erosion immediately upon construction. Subsequently, the rock mulch protection will be augmented by the vegetative cover. Vegetation seeding will occur as soon as construction of the rock mulch is complete, but the vegetative cover may take up to 15 years to become established. Once established, the vegetative cover will be sufficient in normal-precipitation years to provide the necessary erosion protection, but the Leaf Area Index (percent of ground covered) will vary with fluctuations in climatic factors and may not be sufficient during some years. Therefore, the rock mulch provides a more reliable barrier to erosion than vegetation alone.

## 5.0 CLOSURE CONSTRUCTION

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The tailing cell design (Golder 2008b) provides for a minimum of 3.0 feet of freeboard between the cell berm and the highest level of tailings on the inside slope of the cell. Following the hydraulic transport and discharge of tailings slurry into the tailing cells, the tailing solids will settle out of the slurry. Coarsest fractions will settle first, forming beaches close to the point of discharge, followed by successively finer fractions towards the center of the cell. This process will create a shallow bowl shape on the top of the settled tailing solids.

To make maximum use of the available space within each tailing cell, internal containment berms may be created by dozing coarse-fraction tailings from the tailing beaches toward the middle of the pond to build disposal cells internal to the primary cell berm. These internal berms will be constructed as each cell approaches its maximum capacity. Structural stability of the internal containment berms will be achieved by limiting the height and maintaining a broad crest and moderate slopes on each berm. However, should excursions of tailings from the internal containment cells happen, they will be fully contained within the permanent berms of the impoundment cell. Two sets of internal containment berms are illustrated on Figure 3. The actual number, locations and configurations of these internal containment cells will be determined by mill operations personnel based on capacity of the tailings to support earthwork activity and the weight of the relocated tailing sands.

When a tailing cell reaches its maximum capacity, closure construction will begin by reshaping the surface created by these internal containment cells. Tailing cell closure construction will be performed in conformance with the relevant requirements in the technical specifications for the Piñon Ridge Project (Golder, 2008c) as well as NUREG-1620 (NRC, 2003). Specific observation, measurements, and inspections to be performed during and after cover construction are described in subsequent sections of this report.

### 5.1 Phased Closure

The National Emission Standards for Hazardous Air Pollutants, 40 CFR 61, limits disposal in lined tailings cells to:

- (1) "Phased disposal in lined tailings impoundments that are no more than 40 acres in area and meet the requirements of 40 CFR 192.32(a) as determined by the Nuclear Regulatory Commission. The owner or operator shall have no more than two impoundments, including existing impoundments, in operation at any one time," or
- (2) "Continuous disposal of tailings such that tailings are dewatered and

immediately disposed with no more than 10 acres uncovered at any time and operated in accordance with §192.32(a) as determined by the Nuclear Regulatory Commission."

The tailing cell design (Golder 2008b) and the Facility Operating Plan (Exhibit B of the Environmental Report) describe how the first option will be utilized for the Piñon Ridge tailing disposal operations. No more than two tailing cells, each approximately 30 acres in size, will be in operation or otherwise uncovered at any time.

The tailings will be closed and covered in phases as well, in accordance with Criteria 6(3) and 6A(1) of Appendix A, 6 CCR 1007-1, Part 18. The cells will be covered in the same order as they were initially constructed – Cell A, then B, and finally C. Cell A will be closed prior to initiating operations in Cell C. Therefore, not more than two 30-acre cells will be in operation at any time

The cover will be constructed for each tailing cell within several years after cessation of that cell's operation. The time of cover construction after cessation of cell operation will depend on the rate of dewatering of each cell; the first step in cover construction will be preparation of the cell surface for placement of interim cover and will begin as soon as the tailing surface is dry and firm enough to support earthwork equipment.

## **5.2 Preparation of Tailings for Cell Closure**

### **5.2.1 Dewatering**

The tailing cell design (Golder 2008b) includes an underdrain system in each cell that will collect and remove drainable liquid from the tailings during and after operations. As the tailings are surcharged by loads imposed from successive cover layers, additional minor amounts of liquid will be released from the tailings as they consolidate. Liquid collected in the dewatering system will be returned to the mill circuit or discharged to the evaporation ponds.

The system will be monitored by water level measurements in the sump riser pipes until completion of tailing cover construction and for two consecutive quarters thereafter to confirm that no additional liquid is being collected in the sump. Once dewatering is complete in each cell, the dewatering system in that cell will be decommissioned. The sumps and risers will be backfilled with bentonite pellets and flooded with water to hydrate the bentonite and induce it to swell and seal the system. Risers will be cut off at least 3.0 ft below final cover surface.

### **5.2.2 Regrading**

The tailing surface will be regraded after dewatering and before placement of the interim cover. The final tailing surface remaining at the cessation of cell

operations will depend on the extent to which the internal containment cells are developed within each tailing cell. The amount of tailing excavation, shown on Figure 4 and Drawings C2-8 and C2-9, is based on the optimal position of the top surface of the radon barrier to be placed subsequently. The objective is to have the top of the radon barrier merge at a slope of 0.02 with the top of the tailing cell berm.

To accomplish this objective, tailings above the base level of excavation shown on Figure 4 will be relocated to create the space needed to place the interim cover and radon barrier. Hydraulic placement of tailings from the cell perimeter inward will cause the coarsest tailings, the sand fraction, to settle first, closest to the containment berms, and finer fractions (slimes) to settle toward the middle of the cell. At cell closure, sand tailings near the perimeter of each cell will be graded away from the inside slope of the tailing cell toward the cell interior. This regrading will create the vertical space, 7.7 ft, above the base level of tailing excavation for the 2.0 ft of interim cover and the 5.7 ft of cover needed at the center of the tailings, where the final tailing thickness will be greatest.

From a point approximately 65-70 feet inside of each tailing cell berm, the regraded tailing surface will ramp upward at a 0.02 slope to converge with the similar regraded surfaces from the other sides of the tailing cell, as illustrated on Figure 4 and Drawing C2-8 and C2-9. This surface will be parallel to, and 7.7 ft below, the top of the radon barrier providing the space for 2.0 ft of interim cover and 5.7 ft of radon barrier to be placed subsequently. Any internal containment berms within each cell will be incorporated into the regraded configuration of the cell.

### **5.2.3 Installation of Settlement Monitoring Points**

After regrading of the tailings and at the same time as the interim cover is placed, settlement points will be installed to provide the means for measuring the settlement of tailings during and after cover placement. The period of settlement monitoring is estimated to be 2-5 years, after which time the settlement points will be abandoned in place. The settlement monitoring program and abandonment measures are described below in Section 6.2.2.

Settlement monitoring points will be installed on a 200 ft north-to-south by 300 ft east-to-west pattern across each tailing cell, with the center of the pattern being the center point of the cell (Drawing C2-6). Each settlement monitoring point, illustrated on Figure 5 and Drawing C2-8, will consist of:

- A steel base plate placed on the top surface of the tailings
- A vertical steel riser pipe or rod, welded to the base plate, threaded at the top end

- A steel guard pipe, with a diameter at least 2 inches larger than the riser, set over the riser and resting on (but not connected to) the base plate and threaded at the top.
- A steel cap threaded to fit the top of the guard pipe.

Monitoring points will be extended upward when the various components of the final cover are added at a later time. If extended above the level of the geosynthetic liner, the liner penetration around the riser will be sealed in accordance with the liner manufacturer recommendations or, if necessary, the monitoring point will be reset above the liner and resurveyed. Additional lengths of both the riser and the guard pipe as well as external couplings for each will be used (as shown on Figure 5 and Drawing C5) to extend each settlement point so that the riser and guard pipe remain at least 2.0 ft above the surrounding cover surface.

### **5.3 Construction of Cover Layers**

After the tailing surface is reshaped as described above in Section 5.2.2, construction of the tailing cover will begin. The description and properties of each cover layer are described in Section 4.3.1. Except as noted in Section 5.3.2, cover construction will be performed in accordance with earthwork specifications in the project Technical Specifications (Golder, 2008c).

#### **5.3.1 Interim Cover Construction**

Construction of the interim cover will begin as soon as possible after regrading of the tailings (Section 5.2.2) has started. Interim cover will be placed progressively from the edges of each tailing cell toward the center, following tailing regrading as closely as tailing surface stability and safety considerations will allow.

To build out the interim cover from the tailing berm, native soil from stockpiles or other on-site sources will be dumped along the crest and inside slope of the tailing berm. From there, the soil will be moved by dozer and spread in lifts (estimated to be 1.0 ft thick on average) across the tailing surface. Compaction effort will be provided by multiple passes of the dozers. Moisture will be added only if needed for dust control; the underlying tailings are expected to have high moisture content at the time of interim cover placement. The minimum final thickness of the interim cover will be 2.0 ft, with actual thickness likely to be greater over the more compressible fine tailings in the center of the cell.

During interim cover placement, each settlement monitoring point will be installed as soon as workers can safely access the point location. Using hand tools, the interim cover will be removed to the top of tailings to create a space large enough for installation of the base plate/riser assembly. The tailing surface will be compacted and smoothed by hand tool to prepare a firm, uniform surface for the

base plate. After the base plate/riser assembly is in place, the guard pipe with cap will be placed over the rise and seated on the base plate. The interim cover will then be restored around the settlement monitoring point to complete the installation.

The interim cover will be in place to provide protection against windborne release of tailings until the radon barrier can be constructed. The latter event will occur only after tailing dewatering and the resulting settlement of tailings are essentially complete, as indicated by the asymptotic slope of the log time- settlement curve. The time required for this condition to develop cannot be predicted with certainty but is likely to be 1 to 3 years, based on experience with similar tailing cells.

### **5.3.2 Radon Barrier Construction**

Radon barrier construction in each cell will begin after the settlement monitoring data indicate that primary settlement (settlement resulting from consolidation of tailings due to dewatering) has reached approximately 90% of the asymptotic value on the log time-settlement curve. At the same time, any repairs needed in the interim cover will be performed and extensions will be added to the settlement monitoring point risers and guard pipes.

Native soil to be used in the radon barrier will be drawn from the soil stockpile, or from excavation of future tailing cells if these activities are occurring at the same time. Additional characterization and compaction testing will be performed on the soil selected for the radon barrier to ascertain that it either classifies within the parameters described in Section 4.3.1 or is different enough to require additional testing and numerical modeling using the RADON code. If the latter, then the soil in question will not be used until EFR submits the information necessary to demonstrate to CDPHE that the soil will perform satisfactorily in the radon barrier.

The radon barrier of each cell will be constructed in a continuous operation. Allowing for reasonable interruptions due to inclement weather, the radon barrier should be started and completed within one annual construction season. Radon barrier will not be placed when temperatures are likely to drop below freezing on a daily basis.

The geosynthetic liner will be installed within the upper portion (0.9 to 1.0 feet) of the radon barrier. Because installation procedures are specific to each manufacturer to preserve warranty protections, installation will be performed in accordance with the liner manufacturer's recommendations.

The top surface of the radon barrier will be completed at the elevations and grades required to achieve the final cover configuration, less the thickness of the ET cover. The top surface will slope at a uniform grade of 0.02 from the west-east centerline of the cell toward the tailing cell berms (Drawings C2-2 and C2-3).

### 5.3.3 Evapo-transpiration (ET) Cover Construction

The layers of the ET cover (bio-intrusion layer, capillary breaker, and erosion barrier/vegetative cover) will be constructed for each cell as soon as practicable after construction of the radon barrier. Each layer may be constructed across the entire cell before the next, or the layers may be constructed in stair-step order progressively across the cell.

It may not be feasible to construct both the radon barrier and the ET cover in the same construction season. If placement of the ET cover does not occur during that same year, the surface of the radon barrier will be scarified, moisture conditioned and recompacted prior to construction of the overlying ET cover.

Rock materials needed for the capillary break and top lift of the erosion barrier as well as the cobbles in the bio-intrusion layer will be imported from an off-site borrow source. At least one source of suitable, durable rock and crusher fines, the Cotter limestone quarry in La Sal, Utah has been identified. Closer sources in the San Miguel River valley are also expected to be available. Samples of rock material will be obtained for durability testing in accordance with NRC guidelines (NRC 1982, 2002, 2003) to demonstrate that the selected rock will meet NRC performance standards. The selected material will be produced off-site and transported by truck to the site for either temporary stockpiling or direct placement in the ET cover.

The rock mulch in the top lift of the erosion barrier/vegetative cover will be applied after the last lift of native soil is placed. Seeding of this finished surface will occur during the same year as ET construction and at the end of the season, before first snowfall. A specification for seeding has been developed based on NRCS recommended seed mixes and application methods.

### 5.4 Disposal of Mill Demolition Debris

A conceptual plan for mill decommissioning, decontamination and demolition is included in the Site Closure Plan. That plan recognizes that some mill components will be contaminated and must remain on site for disposal in tailing Cell C, the last one to be closed. The identification and quantification of mill material to be disposed on site is addressed in the Surety Proposal. At this point in the development of the Piñon Ridge project, the closure plan will provide a minimum of 100,000 cubic yards disposal capacity in a dedicated space (vault) within Tailing Cell C. The disposal vault will be a space approximately 900 feet long (west to east) by 300 feet wide by 10 feet deep although these dimensions may increase if additional space is needed (Drawing C2-3). The disposal vault will be underlain by not less than five feet of tailings or other soil-like material above the cell liner. These dimensions place the disposal vault in the upper level

of the center of the tailing cell, providing containment of the debris both laterally and vertically within the tailings.

The boundaries of the disposal vault will be formed by dozing sand tailings from the beach areas toward the center of the cell in the same manner as described in Section 5.0 for internal containment berms. In place of tailings, the disposal vault will receive debris from demolition of the mill and decommissioning of the evaporation ponds. These materials will be transported to the beach area of tailing cell C, then dumped directly from trucks or moved into the vault area by dozer. The debris will vary in composition, shape and size; therefore, debris will be selectively handled so that larger, less compressible debris is mixed with smaller, more pliant material to reduce residual voids in the deposited debris. Separate cells may be created, using berms made of sand tailings, to separate types of debris and to facilitate debris placement.

Debris will be stacked in lifts of nominal five-foot thickness, then flooded with soil/cement slurry designed to flow into and fill the residual voids in the debris lift before setting. The mix will include coarse tailings, Portland cement and water and will have low strength (less than 500 psi compressive strength) upon setting. This method of debris consolidation and stabilization was used successfully in the demolition and closure of the Homestake Mining Company uranium mills at its Grants, New Mexico operations.

#### **5.4.1 Mill Debris**

When the mill ceases operation and is decommissioned as described in the Site Closure Plan and Surety Proposal, some equipment and materials will be either free of contamination or can be cleaned sufficiently to allow release from the site for re-use elsewhere. Examples of materials that might be recycled include structural steel and siding, electrical controls, and fresh water pumps and tanks. Materials and equipment that have been in contact with uranium-bearing solids or solutions are not likely to be recyclable; these materials will be removed from the mill and deposited in the disposal vault in tailing Cell C. Examples of the contaminated material to be placed in the disposal vault will include:

- pipes
- leach tanks
- dryers
- SAG mill

In general, contaminated mill materials and equipment will be reduced in size to maintain the five-foot deposition lift limitation and to reduce volume before they are transported to tailing cell C and placed in the disposal vault.

#### **5.4.2 Evaporation Pond Residues and Liners**

During mill operations, raffinate from the mill and some of the liquid from the tailing cell dewatering systems will be sent to the evaporation ponds located

north of the tailing cells and within the license boundary. The ponds, designed by Golder (2008d), will cover up to 82.6 acres at maximum build-out and will include up to 20 individual ponds, each 4.13 acres. Ponds will be built and placed into operation as dictated by mill production levels and evaporation rates. As the liquid evaporates, the raffinate solution will become saturated with acid salts, which will precipitate and settle to the pond bottom. When each pond is removed from service, the residual liquid will be either evaporated or transferred to another pond. If a pond is decommissioned during the life of the mill, the residual solids will be removed and disposed of in the active tailing cell. When mill operations cease, residual liquids will be transferred to one or more ponds as needed to evaporate the remaining liquid, and the solids will be removed to the tailings. Liners will be cleaned to remove wind-transportable solids and left in place until the disposal vault is ready. At that time liners will be cut into pieces and placed into the disposal vault.

Eventually, only one pond will remain in operation to receive and evaporate the liquid collected in the tailing dewatering and leak collection systems. This last pond will remain in operation until drainage to the tailing Cell C dewatering system ceases. If necessary to expedite closure, native soil may be mixed into the residual liquid in the last pond to form a solid that can be excavated from the pond and placed in the disposal vault. The last pond liner can then be removed and placed in the disposal vault, as well.

## 6.0 PERFORMANCE ASSESSMENT

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A number of factors will contribute to the performance of the tailing cell covers, including cover material properties, meteorological parameters (precipitation, wind, temperature), and construction practices. The cover design has considered these factors but additional field testing and verification will be necessary to assure adequate long-term performance of the tailing cell covers. Pre-construction tests, post-construction inspections and long-term monitoring will be conducted as described below.

### 6.1 Pre-construction Testing

#### 6.1.1 Testing of Capillary Break/ Drainage Layer Candidate Materials

Several sources of borrow material may be considered for the clean granular soil to be used in the capillary break/ drainage layer and the overlying filter layer. EFR will conduct laboratory tests to quantify and compare the capillarity of the candidate materials and gradations of those materials for both layers. At least three candidate materials and gradations will be tested. The tests will be conducted in accordance with ASTM D425 - 88(2008), Standard Test Method for Centrifuge Moisture Equivalent of Soils, or the standard considered by ATSM to be best practice at the time of testing. Details of the test plan will be submitted to CDPHE prior to the testing, which will begin by the third year of mill operations.

#### 6.1.2 Field Test of Cover Design

Within three years after the mill begins operating, a field test of the ET cover will be conducted. The test will consist of constructing and monitoring the infiltration performance of the ET cover, especially the capillary break. The objective of the test is to determine the capillarity and other hydraulic properties of the capillary break under field conditions nearly identical to those expected in the tailing cell cover.

The mock cover will be constructed at a location outside of the license boundary, probably on the west side of the Site. The mock cover will be at least 100 ft by 100 ft in plan area, large enough to minimize lateral boundary effects. Layer thicknesses and slopes will be the same as in the cover design. The test cover will be seeded so that the effects of vegetation can be assessed within the time available for the field test.

To evaluate the contribution of the geosynthetic liner layer in the cover performance, one half of the test cover will include the geosynthetic liner within the radon barrier layer, and the other half will not. Lysimeters and moisture content measurements on samples of each layer will be used to compare the net infiltration to the radon barrier layer in each half of the test cover.

Alternative Cover Assessment Project (ACAP)-type pan lysimeters or approved equal will be installed in the capillary break near its lower boundary and near the top of the underlying mock radon barrier. The lysimeters will collect pore water resulting from percolation of infiltrating precipitation through the cover layers. Pore water volumes versus time will provide a means of evaluating the effectiveness of the cover in limiting the amount of water reaching the tailings (in the actual tailing cell cover) and will help to verify or calibrate the results of the UNSAT-H modeling (Section 4.3.2).

At least six months before EFR initiates closure of tailing Cell A, it will submit the results of these tests for CDPHE review and acceptance. Cover design changes may be made based on the test results.

## **6.2 Post-construction Monitoring**

Data collected during post-construction monitoring will be made available to CDPHE in GIS-compatible format. These data will be entered into the EFR site GIS system and will be available in real time to CDPHE.

### **6.2.1 Radon Canister Measurements**

Within one year after the construction (including seeding for vegetation) of the cover on each tailing cell, radon flux canisters will be placed on the cover surface. These canisters will be set at pre-determined locations in a grid pattern. Canisters will be collected on a scheduled basis and replaced with fresh canisters. Collected canisters will be tested by a qualified lab to quantify the amount of radon absorption over the collection period. The results of the radon canister measurements will provide verification, in accordance with EPA method 115 (40CFR 61 NESHAPS regulations), that the tailing cover is achieving the regulatory requirements to limit radon flux from the cover surface to not more than 20 pCi/m<sup>2</sup>s

### **6.2.2 Settlement Monitoring**

Settlement monitoring points, installed as described in Section 5.2.3, will be surveyed initially as soon as possible after they are installed to establish an initial or baseline set of coordinates for the top of each riser. The northing, easting, and elevation of the top of the riser will be surveyed to a precision of 0.05 ft and accuracy of 0.1 ft northing and easting and 0.05 ft of elevation. Survey control points will be established with the same precision and accuracy at tailing cell berm corners, providing line of sight to each monitoring points from at least two of these control points. The coordinates of the control points will be resurveyed at least annually until settlement monitoring ceases.

When extensions are added to each settlement monitoring riser and guard pipe, the top of the riser will be surveyed immediately before the extension is added, and the top of the extended riser will be surveyed immediately after the extension. Where extensions are made through the geosynthetic liner, the liner

will be sealed to the riser in accordance with the liner manufacturer's recommendations or the survey point will be reset on top of the liner and resurveyed.

Monitoring points will be surveyed not less than quarterly during the first two years after radon barrier construction and for at least two quarters after the ET cover is constructed. Survey frequency after that period of time will be sufficient to track the settlements until an asymptotic value is identifiable in the time-settlement record. Survey measurements will be recorded in a format that can be directly imported into the GIS database maintained by EFR and accessible to CDPHE. Each survey record will be signed and stamped by a Licensed Professional Engineer or Surveyor.

When CDPHE has concurred with EFR's findings that settlements are complete and monitoring can cease, the settlement monitoring points will be abandoned in place by backfilling the space below ground surface to within 0.5 ft of final cover surface with a slurry containing equal parts native soil and bentonite, then removing the remaining portions of riser and guard pipe so that the top 0.5 ft of cover can be manually finished to match the surrounding cover surface.

### **6.2.3 Dewatering Sump Monitoring**

The dewatering sump in each tailing cell will be monitored to measure the amount and rate of liquid released from the tailings in response to consolidation of the tailings during and after cover construction. The water levels in the sumps will be measured at least quarterly during and after cover construction until there is no additional collection of liquid in the sump for four consecutive quarters.

Liquid levels will be measured by either manually inserted gauges in the sump or permanently installed electrical water level gauges. Liquid will be pumped from the sump and discharged to the remaining evaporation pond(s) as necessary to maintain free flow of tailing liquid to the sump.

### **6.2.4 Visual Inspections**

In addition to the construction quality control practices applied to tailing cover construction and other related earthwork, performed in accordance with the project technical specifications (Golder, 2008c), EFR will conduct regular visual inspections of the cover after construction is complete. During the first two years after each cell cover is constructed, EFR site personnel will visually inspect and document:

- Structural condition of the cover; noting any cracks, depressions, or mounds
- Signs of erosion including rills, deflation (wind scour) basins, or downslope displacement of rock or soil
- Animal burrows, noting location, depth and apparent animal activity

- Condition of vegetation, especially percent of ground cover and height of vegetation

Personnel performing these inspections will record observations and data on a standard field inspection form (to be developed).

The frequency of visual inspections will vary according to weather, previous conditions of concern and the general condition of the cover. At a minimum, visual inspection of each cell cover will be conducted monthly during the first year after construction and quarterly thereafter. Additional inspections will be performed as soon as possible after major precipitation events that produce visible runoff in the diversions channels around the mill or at the surface water sampling stations.

## 7.0 LIMITATIONS

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Kleinfelder prepared this report in accordance with generally accepted standards of care in the project area at this time. This report may contain specifications, designs and drawings, (designs). Unless otherwise stated these designs are for conceptual planning and regulatory approval. They are not 100% design specifications and they shall not be used for final costing, design or construction. **This report may be used only by Energy Fuels Resources Corporation and only for the purposes stated.** All information gathered by Kleinfelder is considered confidential and will be released only upon written authorization by Energy Fuels Resources Corporation or as required by law. **Non-compliance with these requirements by Energy Fuels Resources Corporation or anyone else, unless specifically agreed to in advance by Kleinfelder in writing, will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party, and Energy Fuels Resources Corporation agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized use or non-compliance.**

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