5.0 RADIATION PROTECTION

This chapter of the standard review plan establishes the guidelines for NRC staff to perform and document its review of the proposed radiation protection design for disposal cell covers, for the cleanup of soil and structures contaminated with byproduct material (soil removal, building demolition and disposal or decontamination), and for the proposed radiation safety controls and monitoring during reclamation and decommissioning activities. The radiation standards to be addressed in the evaluation of the reclamation plan include 10 CFR Part 40, Appendix A, Criterion 6(1), which establishes a long-term radon flux limit and direct gamma exposure (background) level for the tailings disposal cell cover, and Criterion 6(5), which requires that the radioactivity of near-surface cover materials be essentially the same as surrounding surface soils. Also, the decommissioning plan, whether submitted as part of the reclamation plan or provided in detail as a separate document, should comply with 10 CFR 40.42(g)(4) and (5,) which requires a description or procedures indicating how the licensee will demonstrate that the residual radioactivity levels in land and on structure surfaces meet Appendix A, Criterion 6(6) (see Appendix H guidance in this standard review plan on the radium benchmark dose approach for cleanup of residual radionuclides other than radium). In the review, the staff should consider any licensee-proposed alternatives to Appendix A criteria as described in the Introduction of Appendix A to 10 CFR Part 40.

5.1 Disposal Cell Cover Radon and Gamma Attenuation and Radioactivity Content

5.1.1 Areas of Review

The areas of review for radon attenuation (radon barrier design) are the radiological and physical properties of the contaminated and cover materials and the application of the computer code or other methods used for calculating the estimated long-term radon flux from the completed disposal cell. The areas of review for the control of gamma radiation from the disposed waste and for the radioactivity content of the cover are the proposed methods to demonstrate compliance with the regulations. This area would also include consideration of disposal of wastes from processing alternate feed materials and non-11e.(2) byproduct material in uranium mill tailings impoundments, if such action is proposed.

The radon barrier portion of the disposal cell cover is the layer or layers designed to reduce radon flux from the cell. Other cover layers contribute to radon attenuation and may be considered in the flux calculation.

For the radon barrier design, the staff should review (1) the bases, assumptions, and procedures for determining the input parameter values of the tailings and other wastes and radon barrier materials (such as the sampling and testing programs); (2) procedures for materials placement in the disposal cell, as presented in the reclamation plan construction specifications; (3) the description of the model (numerical or analytical) used to approximate the average long-term radon flux at the cover surface; and (4) if the standard computer codes for estimating radon flux (RADON, RAECOM) are not used, references for the methodology used to calculate the long-term radon flux from the cover.

For cover gamma attenuation, the staff reviews the proposed procedure to calculate or measure the gamma level (exposure rate or count rate) on the cover. For the radioactivity content, the staff should review the proposal for measurements in the upper 61 cm [2 ft] of cover. Alternatively, the staff should review proposed control measures on the cover material before placement to demonstrate that the average radioactivity content of this layer is not distinguishable from local surface soil and to demonstrate that it does not include waste or rock containing elevated levels of radium.

5.1.2 Review Procedures

5.1.2.1 Radon Attenuation

The radon barrier design, as presented in the reclamation plan, should be reviewed along with the data supporting the design. Chapter 2.0 of this standard review plan presents review areas, procedures, and acceptance criteria for geotechnical information related to material properties and cell stability. The staff members assigned the health physics and geotechnical reviews should coordinate the review of the radon attenuation design and analysis. The geotechnical properties of the cover layers will be considered in the context of their influence on the cover integrity by considering long-term moisture content of the radon barrier. Materials underlying the radon barrier are evaluated for stability so that the cover will not experience cracking from settlement or subsidence, as discussed in Chapter 2.0.

In addition, the health physics reviewer should:

(1) Evaluate the basis for selection of parameter values for tailings and cover material properties to determine if the values are based on appropriate measurements or estimates and will lead to a reasonably conservative estimate of the radon flux. The scope and techniques used for site investigations should be examined to ensure that the field investigation (boring, sampling, and surveying) and testing programs will produce representative data needed to support the conclusions of the analyses.

(2) Assess whether parameter values are consistent with anticipated construction specifications and reflect expected long-term conditions at the site. The radon flux estimate must represent the average flux, for periods of more than 1 year but less than 100 years, and consider that the cell design life is 1,000 years.

(3) Determine whether the parameter values reflect the meteorological and hydrological conditions at the disposal site, bulk density, type of material, and the influence of overlying material layers. The cover material moisture content must be determined by accurately measured values or reasonably conservative estimates. Preferably more than one method is utilized, as there are limitations to each method and the long-term moisture content of the radon barrier is one of the most important parameters in the flux model.

(4) Determine that the radium (Ra-226) activity concentration in picocuries per gram (pCi/g) within the tailings cell has been, or will be, measured directly from representative tailings

samples, and other large-volume sources of contaminated material, utilizing an acceptable method. If the tailings were placed so that specific areas in the pile contain higher Ra-226 content (e.g., slime tailings), then Ra-226 values and the modeling should represent the layering or localization of the significantly elevated Ra-226 levels in the upper 3.6 m [12 ft], as deeper material generally has little effect on the radon flux. This approach is necessary because modeling higher concentrations of Ra-226 in the upper few feet of the pile would result in a higher radon flux estimate than using an average Ra-226 value for the entire upper 3.6 m [12 ft]. Also, if large quantities of material containing thorium-230 (Th-230) levels significantly higher than the Ra-226 levels are placed in the upper portion of the pile, the 1,000-year Ra-226 concentration (Ra-226 remaining from the residual Ra-226 and from the decay of Th-230) should be considered for that layer of material in the modeling.

In accordance with Footnote 2 of Criterion 6(1), the radon emissions from covering materials should be estimated as part of developing a closure (reclamation and decommissioning) plan. If any layer of the cover will contain material with above-background levels of Ra-226 or Th-230, the licensee should model that layer with a conservatively high estimated Ra-226 level, or should commit to measure the cover radionuclide level(s) during or after placement to confirm the adequacy of the radon attenuation design. A commitment from the licensee to confirm the cover Ra-226 content in the reclamation completion report should be present if the borrow site measurements are limited and the possible cover Ra-226 level could prevent the radon flux from being in compliance.

(5) Evaluate each code input parameter value, keeping in mind that the code default parameter values are not always conservative, and then consider the set of parameter values as a whole (balance of conservatism and uncertainty). It is the total flux model that will be approved, not individual parameter values. Consider that the void ratio, the density, porosity, and moisture saturation values should be typical of the soil type in each layer of the cell. The radon flux model should result in a representative and a reasonably conservative (given the uncertainty in some values) long-term radon flux estimate.

(6) A measured, not a calculated, disposal cell average radon flux is required by Appendix A, Criterion 6(2), as soon as practical after placement of the radon barrier, and Criterion 6(3) stipulates that radon-222 release rates must be verified for each portion of the pile or impoundment as the final radon barrier for that portion is placed, when phased emplacement of the final radon barrier is included in the applicable reclamation plan required by 10 CFR Part 40, Appendix A, Criterion 6A(1). Therefore, the reviewer should document in the technical evaluation report whether the reclamation plan stipulates if the radon barrier is to be placed in phases or as a fairly continuous operation. In either case, the final radon barrier must be placed as expeditiously as practicable. However, some tailings cells have evaporation ponds on top that can't be covered until the ground-water correct action is complete. A commitment to measure and document the radon flux on the final radon barrier, as required by Criterion 6(2) and (4), should be in the reclamation plan. Before the measurements are performed, a map of the disposal cell indicating the measurement locations and outline of tailings and

cover extent should be reviewed by the NRC staff before the measurements are performed.

(7) Guidance on the disposal of wastes from processing alternate feed materials and non-11e.(2) byproduct materials in uranium mill tailings impoundments is presented in Appendix I to this standard review plan. The staff should use this guidance when evaluating requests to dispose of such materials and consider their impact on the radon attenuation design.

5.1.2.2 Gamma Attenuation

Most radon barriers should be thick enough to reduce the gamma level of the disposal cell to background. To demonstrate compliance with this aspect of Criterion 6(1), the cover gamma attenuation can be calculated based on the shielding value of the cover soil. Alternatively, the licensee commits to (1) measure the gamma level at 1 meter above the completed cover (or radon barrier) with at least one measurement per acre and (2) demonstrate that the average gamma level for the cell is comparable to the local background value.

5.1.2.3 Cover Radioactivity Content

At some mill facilities, uranium deposits, open pit uranium mines, overburden piles (soil moved from the pit area), and/or reclaimed mining areas are on or near the site. All of these areas would contain elevated levels of uranium, radium, and the other radionuclides in the uranium decay chain. In determining what surrounding soil values may be compared to the radionuclide content of the disposal cell cover, the mining areas reclaimed/restored under state regulations may be included. Also, consideration of the low health risk of human exposure to the cell cover and the perpetual custody of the cell by the government may be part of the risk-informed approach. If the average radioactivity (mainly radium level) for the cover material exceeds the average value for surrounding soil, the reclamation plan should contain a statistical analysis of the distributions of surrounding soil (not necessarily undisturbed background) and cover radioactivity to demonstrate that they are not significantly different.

5.1.3 Acceptance Criteria

5.1.3.1 Radon Attenuation

The radon attenuation design will be acceptable if it meets the following criteria:

(1) The one-dimensional, steady-state gas diffusion theory for calculating radon flux and/or minimum cover thickness is used. An acceptable analytical method for determining the necessary cover thickness to reduce radon flux to acceptable limits or to determine the long-term radon flux from the proposed cover is the computer code RAECOM (NRC, 1984) and the comparable RADON code (NRC, 1989). The main difference between the two codes is that RADON does not have the optimization for cost benefit calculations. The staff will use the RADON code to verify the analysis. Other methods that estimate the average surface radon release from the covered tailings may be

acceptable, if it can be shown that these methods produce reliable estimates of radon flux.

(2) With the RAECOM and RADON computer codes, the radon concentration above the top layer is either set to a conservative value of zero or a measured background value is used. The precision number (the level of computational error that is acceptable) is set at 0.001.

(3) The estimates of the material parameters used in the radon flux calculations are reasonably conservative, considering the uncertainty of the values. For all site-specific parameters, supporting information describing the test method and its precision, accuracy, and applicability is provided. The basis for the parameter values and the methods in which the values are used in the analyses are adequately presented. Moisture-dependent parameter values (e.g., radon emanation coefficient and diffusion coefficient) are based on the estimated long-term moisture content of the materials at the disposal site.

The materials testing programs employ appropriate analytical methods and sufficient and representative samples were tested to adequately determine material property values for both cover soils and contaminated materials. In the absence of sufficient test data, conservative estimates are chosen and justified. The quality assurance program for parameter data is adequate and the data are available for inspection. All parameter values are consistent with anticipated construction specifications and represent expected long-term conditions at the site.

(4) The contaminated material thickness is determined from estimates of total tailings production or waste placement and the areal extent, from boring logs, or changes in elevation from pre- to post-operation. Either the estimated thickness of a tailings source is used, or alternatively, the RADON code default value of 500 cm [16.4 ft] is used (NRC, 1989).

(5) Dry bulk densities of the cover soils and tailings material are determined from Standard Proctor Test data (American Society for Testing and Materials D 698) or Modified Proctor Test data (American Society for Testing and Materials D 1557). Radon barrier materials are usually compacted to a minimum of 95 percent of the maximum dry density as determined by American Society for Testing and Materials D 698 or to a minimum of 90 percent of the maximum dry density as determined by American Society for Testing and Materials D 1557. Field or placement densities to be achieved based on the construction specifications are used in the calculations. If the pile is stabilized in place, the *in situ* bulk density for the tailings is used in the analysis.

Porosities are measured by mercury porosimetry or another reliable method, or the method for estimating the porosity of cover soils and tailings materials using the bulk density and specific gravity given in Regulatory Guide 3.64 (NRC, 1989) is used.

If a portion of the modeled cover (radon attenuation layers) could be affected by freeze-thaw events, that portion is represented in the model with lower density and

corresponding higher porosity values than the unaffected portion. The U.S. Army Corps of Engineers (1988) and the DOE (1988) have demonstrated that freeze-thaw cycles can increase the permeability of compacted clay by 40 to 300 times the original value. For fine-grained soils with some sand (50-percent fines), the DOE conservatively estimated that freeze-thaw cycles could lower the density by 14 percent (DOE, 1992). Also see the discussion in Section 2.5.3 of this standard review plan.

(6) The long-term moisture content that approximates the lower moisture retention capacities of the materials or another justified value is used. Estimated values for the long-term moisture content can be compared with present *in situ* values to assure that the assumed long-term value does not exceed the present field value. Borrow samples can be taken at a depth of 120 to 500 cm (3.9 to 16.4 ft), but not close to the water table, and the borrow site conditions should be correlated to conditions at the disposal site.

The following methods are acceptable for estimating the long-term soil moisture, but each has limitations:

(a) Laboratory procedures American Society for Testing and Materials D 3152 (fine-textured soils) and American Society for Testing and Materials D 2325 (coarse and medium-textured soils) for capillary moisture test (15-bar suction) corresponding to the moisture content at which permanent wilting of plants occurs (Baver, 1956).

(b) The empirical relationship (Rawls and Brakensiek, 1982) that predicts water retention values of a soil on a volume basis (appears to be more suitable to sandy and silty soil than to clayey soil) and is represented by:

$$c = 0.026 + 0.005x + 0.0158y$$

where

c = predicted 15-bar soil water-retention value (volumetric moisture content)
x = percent clay in the soil
y = percent organic matter in the soil

This method takes into consideration the particle-size distribution of the soil. Clay particle sizes are defined here as those less than 0.002 mm in diameter. Organic content measurement is generally determined by reaction with hydrogen peroxide or by exposure to elevated temperature. The volumetric moisture content value derived from this equation should be converted to a weight percentage for application in the RAECOM and RADON codes. Other empirical correlations (Section 7.1.3 of DOE, 1989), if adequately justified, may be acceptable.

(7) Values for Ra-226 activity (pCi/g) are measured directly from tailings samples and other large volume sources of contaminated material, by radon equilibrium gamma spectroscopy (allow at least 10 days for the sealed sample to equilibrate), wet chemistry alpha spectrometry, or an equivalent procedure. If the tailings are fairly uniform in Ra-226 content and the Ra-226 and uranium (U-238) in the ore were approximately in equilibrium, the Ra-226 activity can be estimated from the average ore grade processed at the site, as discussed in Regulatory Guide 3.64 (NRC, 1989). Generally, tailings should be sampled at 90-cm [3-ft] intervals to a depth of 366 cm [12 ft], including representative sampling of slime tailings. More than one layer of contaminated material is represented in the flux model if there are significant differences in Ra-226 content with depth.

Since the disposal cell performance standard deals only with radon generated by the contaminated material, it is acceptable to neglect the Ra-226 activity in the cover soils for modeling flux, provided the cover soils are obtained from materials not associated with ore formations or other radium-enriched materials. If deep {below 61 cm [2 ft]} cover layers contain elevated Ra-226 or Th-230, that material layer and its Ra-226 level is represented in the flux model.

(8) The emanation coefficient has been obtained by using methods provided in Nielson, et al. (1982) and properly documented, or otherwise set to the reasonably conservative (for most soils) code default value of 0.35. A value of 0.20 may be estimated for tailings based on the literature, if supported by limited site-specific measurements.

(9) The radon diffusion coefficient, D, represents the long-term properties of the materials. The D value is determined from direct measurements or appropriately calculated. The soil should be tested at the design compaction density, with a range of moisture content values that includes the lower moisture retention capacity of the soil so that a radon breakthrough curve can be obtained (DOE, 1989). The calculation of the diffusion coefficient, based on the long-term moisture saturation, and porosity, as proposed in Regulatory Guide 3.64, Section C.1.1.5 (NRC, 1989), and the optional calculation in the RADON code, are acceptable.

(10) The soil cover thickness proposed in the reclamation design is such that the calculated average long-term radon flux is reduced to a level that meets the requirement in 10 CFR Part 40, Appendix A, Criterion 6(1).

5.1.3.2 Gamma Attenuation

The proposed cover will reduce the gamma radiation from the byproduct material to local soil background levels, and the licensee proposed an acceptable method to demonstrate this. The data will appear in the reclamation completion report.

5.1.3.3 Cover Radioactivity Content

At least the upper 61 cm [2 ft] of the disposal cell cover will contain levels of radioactivity essentially the same as surrounding soils, as demonstrated by an appropriate procedure. The data will be in the reclamation completion report if not available for the reclamation plan.

5.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radon and gamma attenuation and cover radioactivity content assessments, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the disposal cell cover radiation control at the _____ uranium mill facility. This review included an evaluation using the review procedures in Section 5.1.2, and the acceptance criteria outlined in Section 5.1.3 of this standard review plan.

The licensee has presented an acceptable radon attenuation design, and the staff evaluation determines that (1) the method used for calculating radon flux or minimum cover thickness is based on the one-dimensional, steady-state gas diffusion theory and appropriate input values; (2) input values of the material parameters lead to a reasonably conservative estimate of the long-term radon flux; (3) material parameters are consistent with construction specifications and expected long-term conditions; (4) the long-term attenuating capability of cover materials is justified using acceptable results of relevant tests or conservative estimates; (5) estimates of contaminated materials thickness are determined utilizing a sufficient number of data or by use of the default value; (6) if not measured, the estimated porosity of cover soils and tailings materials is based on the method in Regulatory Guide 3.64; (7) soil moisture values represent long-term moisture retention capacities; (8) Ra-226 activity has been measured in the tailings and other large volume sources of contaminated materials using acceptable procedures; (9) the emanation coefficient is obtained by either the equilibration method or the prediction method, or is set to a reasonably conservative value of 0.35; (10) the radon diffusion coefficient of the cover soil is determined from direct measurements or from a calculation based on Regulatory Guide 3.64; and (11) the cover gamma level and radioactivity content will be correctly determined and documented.

On the basis of the information presented in the application and in detailed review conducted of the site characterization for the _____ uranium mill facility, the NRC staff concludes that the disposal cell cover radon and gamma attenuation and radioactivity content are in compliance with 10 CFR Part 40, Appendix A, Criterion 6(1), which requires placement of an earthen cover (or approved alternative) over tailings and wastes at the end of the milling operations while providing assurance of control of radiological hazards for 1,000 years, to the extent reasonably achievable (but no less than 200 years); and which limits releases of radon-222 from uranium byproduct materials to the atmosphere so as not to exceed an average rate of 20 picocuries per square meter per second (pCi/m^2-s); Criterion 6(2), which requires demonstration of the effectiveness of the final radon barrier prior to emplacement of erosion protection measures or other features; Criterion 6(3), which requires demonstration of the

effectiveness of phased placement of radon barriers as each phase is completed if phased placement is in the plan; and Criterion 6(5), which requires that radon exhalation is not significantly above background because of the cover material.

5.1.5 References

American Society for Testing and Materials Standards:

D 698-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."

D 1557-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort."

D 2325-68, "Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus."

D 3152-72, "Standard Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-membrane Apparatus."

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DOE. 1988. "Effect of Freezing and Thawing on UMTRA Covers." Albuquerque, New Mexico: DOE, Uranium Mill Tailings Remedial Action Project. 1988.

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Nielson, K.K., et al. "Radon Emanation Characteristics of Uranium Mill Tailings." Proceedings of the Symposium on Uranium Mill Tailings Management December 9–10. Ft. Collins, Colorado: Colorado State University. 1982.

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Rawls, W.J. and D.L. Brakensiek. "Estimating Soil Water Retention From Soil Properties." Proceedings of the American Society of Civil Engineers. *Journal of the Irrigation and Drainage Division*. Vol. 108, No. IR2. 1982.

U.S. Army Corps of Engineers. “Effects of Freezing and Thawing on the Permeability of Compacted Clay.” Hanover, New Hampshire: Cold Regions Research and Engineering Laboratory. 1988.

5.2 Decommissioning Plan for Land and Structures

5.2.1 Areas of Review

The areas of review for the decommissioning (radiological cleanup and restoration) of land and structures (e.g., towers and buildings) are the site conditions (nature and extent of the contamination, soil background radioactivity, etc.); planned decommissioning activities (how and what measurements will be made, quality assurance quality control program, gamma guideline levels for soil cleanup, how “as low as is reasonably achievable” will be demonstrated); methods to be used to protect workers, the public, and the environment; verification (final status survey) plan with procedures; and the decommissioning cost estimate and surety amount. Often, the detailed mill decommissioning plan and the soil cleanup and verification plan are submitted for NRC approval a year before decommissioning is scheduled to begin. However, the reclamation plan must describe the expected decommissioning activities in enough detail to support the cost estimate needed for surety purposes. The preliminary decommissioning plan in the reclamation plan should include commitments to provide a detailed plan and cost estimate for NRC approval at least 9 months before decommissioning is expected to begin.

5.2.2 Review Procedures

(1) Site Conditions (Characterization)

Based on the operational history (including radiation surveys) of the facility, the reviewer determines that the plan describes the likely source and locations of residual byproduct material such as spills, releases, waste burial, haul roads, diversion ditches, process and yellowcake storage areas, ore stockpile areas, areas likely to be affected by windblown tailings, and tailings solution evaporation ponds. Determine that the extent of contamination (area and depth for soil) has been or will be established from adequate representative sampling and surveying. Sample analysis should include uranium where yellowcake or ore dust was present and thorium (Th-230) for acidic tailings pond residue. The radiological analysis for the ore processed at the site should also be reviewed for the ratios of Ra-226/U-238 and Ra-226/Th-230 to determine if non-equilibrium conditions could exist in the contaminated soil. The U-238 activity can be estimated by dividing the U-nat (total uranium) value by two. The reviewer should also determine from this data if Th-232 could be elevated above background due to windblown tailings and whether additional characterization data should be provided.

(2) Soil Background Radioactivity

Determine that the background level of Ra-226 (and U-nat, Th-230 and Th-232, as needed) in surface {15 cm [6 in.]} soil has been estimated using representative soil

samples from nearby {within 3.2 km [2 mi] of site boundary} undisturbed areas that are not affected by site activities and are geologically and chemically similar to the contaminated areas. The number of samples will depend partly on the variability in background values, but at least 30 samples should be obtained at the typical site to determine the average value, standard deviation, and distribution. The arithmetic mean of the sample data is used in the cleanup criteria unless appropriate statistical analysis demonstrates a log normal distribution (three tests) of the data.

Several different background values may be required if contaminated areas have distinctly different soil types. For example, if a portion of the site has a natural uranium and/or radium mineralization zone in/near the surface, the cleanup criterion for that area would use a background (reference) U-238 or Ra-226 value from a similarly mineralized area. A geologic site map with the background values placed on the sample location can be used to help identify whether more than one background value should be considered.

If the plan indicates that *in situ* ore is in the clean-up area, it should be characterized by Ra-226/U-238 ratios, visual criteria, and/or other means.

(3) Cleanup Requirements

For land cleanup, the residual Ra-226 [and/or Ra-228 if thorium (Th-232) byproduct material is present] in soil must meet the concentration limits in 10 CFR Part 40, Appendix A, Criterion 6(6), in areas that are not evaluated by the radon flux criterion (i.e., areas other than the disposal cell). If the plan indicates that the subsurface 15 pCi/g Ra-226 standard will be used, its use should be justified. For structures to remain on site, the staff reviews the proposed cleanup of mill-related radionuclides (byproduct material) on surfaces (e.g., walls, floors, drains) as well as in underlying soil.

For NRC uranium recovery licensees that did not have a decommissioning plan approved by June 11, 1999, [Appendix A, Criterion 6(6) was expanded effective that date], or that subsequently submit a revised plan, the radium benchmark dose applies for cleanup of residual radionuclides other than radium [primarily uranium (U-nat) and thorium (Th-230)] in soil and for surface activity on structures. For such licensees, the reviewer should refer to Appendix H of this document for guidance on the benchmark approach. This approach would also be evaluated if proposed by other uranium recovery licensees to derive cleanup limits in order to demonstrate compliance with 10 CFR 40.42(k)(2).

Determine that the plan indicates that residual contamination will be reduced to “as low as is reasonably achievable levels.” Usually, a low gamma guideline level is chosen so that most grids are cleaned to near background levels of radiation, an approach that has proven less costly for licensees than more extensive soil sampling and analysis. It is a method acceptable to the staff to demonstrate compliance with the “as low as is reasonably achievable” principle. The administrative limit for surface activity (10 to

25 percent of the criteria) has been considered an “as low as is reasonably achievable” level in the past but current policy should be confirmed by staff. The “as low as is reasonably achievable” approach discussed in NUREG–1727 (NRC, 2000b), also may be considered.

(4) Gamma Guideline Level

Because gamma measurements (in terms of exposure or count rates) can substitute for some Ra-226 analyses [as recommended in 40 CFR 192.20(b)(1)] and such measurements are not very reliable, the reviewer must be sure that the proposed gamma guideline value is conservative, considering the measurement uncertainties involved. Determine that the radium-gamma correlation that is used to derive the gamma guideline was performed with at least 30 soil Ra-226 values from approximately 2 to 25 pCi/g and that the corresponding gamma values adequately represent the grid (100-square-meter area) sampled. The proposed gamma guideline level must reliably (95 percent confidence) result in grids meeting the 5 pCi/g [0.19 Bq/g] Ra-226 plus background standard.

Confirm that the plan contains a commitment to perform a radium-gamma correlation on the verification data, to track soil samples that fail the Ra-226 criteria, and to perform additional cleanup after a verification soil sample exceeds the Ra-226 standard. Just cleaning the failed grid is not adequate because the failed sample could indicate that the gamma value may not be conservative and that some of the unsampled grids may also fail to meet the standard. For example, the plan could indicate that neighboring grids would also be analyzed for Ra-226 or, if the number of failed grids is excessive, the gamma guideline would be adjusted downward and areas further remediated, as necessary.

(5) Instruments and Procedures

Determine that the instruments and procedures used to determine the soil background radioactivity and the radium-gamma correlation are the same or very similar to those proposed for verification of compliance with Criterion 6(6) (final status survey). See NUREG–1505, Section 4.5 (NRC, 1998a). Instrument sensitivity should be adequate to reliably identify the proposed guideline levels [NUREG–1507 (NRC, 1998b)]. Survey instruments are specified and will be properly calibrated and tested, including daily checks during operations. The reviewer considers national standards (American Society for Testing and Materials, American National Standards Institute, and National Council on Radiation Protection as listed in Section 5.2.5) and the “Multi-Agency Radiation Survey and Site Investigation Manual” [NUREG–1575 (NRC, 2000a)] that contains general principles of soil sampling, determination of background, and gamma surveying to be acceptable.

Soil samples for uranium recovery sites can be composite samples (5 to 11 samples per grid have been approved). Evaluate sampling procedures for completeness (ensure proper depth, identification of sample and location, cleaning of equipment, chain-of-custody, etc). Determine that soil preparation procedures indicate that rocks and

vegetation should not be included in the sample to the extent that the additional volume would dilute the soil sample. Generally, rocks greater than or equal to 1.27 cm [0.5 in.] in diameter are excluded. Acceptable sample mixing, drying, and splitting methods are specified.

Evaluate the methods for soil radionuclide analysis. Standard analytical methods should be used. Portions of each sample verifying compliance should be archived until the NRC approves the decommissioning completion (final survey) report, as staff may want to do confirmatory analysis on selected soil samples. The plan for the final disposal of these archived samples should also be reviewed.

As required by 10 CFR 40.42(j)(2)(i), the gamma levels to be reported in the final survey are as mSv (μR) per hour at 1m [39.4 in.] from the surface. Measurements at 1 m [39.4 in.] would allow calculation of an exposure dose, but the goal of the gamma survey is to demonstrate compliance with the radium in soil criterion. Therefore, the staff has approved alternate methods such as meter readings (counts/minute) taken near the ground or at 0.45 m [18 in.]. These methods improve the quality of the gamma-radium correlation by reducing "shine" and they allow the survey meter and equipment associated with a global positioning system to be mounted on an all-terrain vehicle. Typically, measurements are made over the spot to be sampled, or the grid (100 m^2) is scanned with 9 to 12 measurements. Integrated count rate gamma scan values have also been approved if taken for at least one (1) minute within each grid.

Determine that gamma survey procedures indicate the speed, pattern, and spacing of the measurements or scan path. The procedure should allow demonstration of compliance with the radium standard. The reviewer should consider the thoroughness of the gamma scan (remedial action survey) to be done during soil removal, such as 1.5-m [5-ft] scan path, when evaluating the final survey procedures and the percentage of grids proposed for soil sampling.

Determine that procedures for measuring alpha or beta-gamma radiation on structure surfaces are detailed, reflect industry standards, and consider that smears for alpha activity generally have an efficiency of 10 percent or less. Measurements of smears are difficult to interpret quantitatively and should not be used for determining compliance but for determining if further investigation is necessary [NUREG–1575, Sections 6.4.2 and 8.5.3 (NRC, 2000a)].

(6) Quality Assurance and Quality Control

Determine that the quality assurance/quality control program addresses all aspects of decommissioning. The plan should indicate a confidence interval or that one will be specified before collection of samples. At least 10 percent of the soil samples should be split and a portion sent to an outside laboratory for quality assurance. To properly assess the adequacy of radiological data, the uncertainties associated with the data should be estimated statistically [NUREG–1501, Sections 3.2 and 5.2 (NRC, 1994)].

Evaluate the criteria for validating that the data to be used to demonstrate compliance and the quality assurance procedures to confirm that compliance data are precise and

accurate (e.g., laboratory will analyze spiked and duplicate samples, etc.). Confirm that management will ensure that approved procedures are followed (e.g., commitment to check gamma surveyor and data management).

(7) Final Status Survey

Evaluate the details of the proposed final status survey (radiation surveys and soil analyses) as discussed in Items 3–6 above, and determine whether the survey plan complies with 10 CFR 40.42(j)(2). The reviewer should also determine that enough data of the proper quality can be provided after decommissioning to demonstrate compliance with Criterion 6(6) of Appendix A and 10 CFR 40.42(k)(2). For example, determine that the proposed number and pattern of grids to be soil sampled and analyzed for Ra-226 are justified. Based on the degree of uncertainty (level of error in the measurements, number of measurements), the gamma guideline level, and implementation procedures, the staff has considered soil samples from 0.5 to 10 percent of the grids acceptable. Some verification soil sampling and surveying should be planned in presumably uncontaminated areas (buffer zone of about 30 meters beyond excavated areas). [Refer to Section 3 in Inspection Procedure 87654 (NRC, 2002) for additional information.]

Confirm that the licensee proposes to use the same instruments and procedures for the verification (final status) survey as were used in determining background and for the radium-gamma correlation, or justifies that they are comparable.

If buildings or other structures are to remain on site after license termination, determine whether adequate measurement of the surface activity is planned. Preliminary modeling by staff has indicated, that for habitable buildings, the average total (fixed plus removable) alpha level should be below 2,000 dpm/100 cm^2 in order to achieve 0.25 mSv/yr [25 mrem/yr].

(8) Preliminary Versus Final Decommissioning Plan

A preliminary decommissioning plan shall be submitted with the reclamation plan and may be updated for license renewal in order for the staff to better evaluate the decommissioning cost estimate provided for surety purposes. Since the actual site decommissioning may be years in the future and continued operation could change the cleanup design, or evolving technology and Agency rules or guidance could change the evaluation of procedures, the review of the preliminary plan should not be technically rigorous. However, the reviewer should determine whether sufficient detail has been provided in the plan to justify that the surety amount for decommissioning activities is adequate.

Confirm that both the preliminary and final plans identify a location to keep the records of information important to the decommissioning, as required by 10 CFR 40.36(f). These records would include documentation of spills or cleanup of contamination, drawings or descriptions of modification of structures in the restricted area, and locations of possible inaccessible contamination.

When a final decommissioning plan is submitted, the reviewer should determine whether the plan addresses the technical aspects discussed above [basically 10 CFR 40.42(g)(4) requirements] and whether it indicates that decommissioning will be completed as soon as practicable. The reviewer follows Section 5.3 of this standard review plan for the evaluation of the health and safety protection aspects of decommissioning. The reviewer should also consider recommendations in Regulatory Guide 3.65 (NRC, 1989) during the evaluation of the final decommissioning plan.

(9) Non-Radiological Hazardous Constituents

The decommissioning plan must address the non-radiological hazardous constituents of the byproduct material according to 10 CFR Part 40, Appendix A, Criterion 6(7). For windblown tailings areas, meeting the surface Ra-226 standard should be adequate to control these constituents in soil. A tailings cell cover that meets Appendix A criteria should control, minimize, or eliminate postclosure escape of non-radiological hazardous constituents into surface water and the atmosphere. However, any unusual or extenuating circumstances related to such constituents should be discussed in the reclamation plan or decommissioning plan in relation to protection of public health and the environment and should be evaluated by staff. The control of these substances in ground water is addressed under Chapter 4.0 of this standard review plan.

(10) Decommissioning Cost Estimate

Determine whether the cost estimate is itemized in sufficient detail such that values for soil sampling and preparation, Ra-226 analysis, gamma surveying, and data management are presented. The items should reflect the proposed activities in the plan. Also, the basis for each cost should be provided and verified by staff to be within the range of current charges for such activities in the site region. The staff should verify that adequate surety funds will be provided to cover these costs. Guidance on cost estimates for sureties is provided in Appendix C of this standard review plan.

5.2.3 Acceptance Criteria

The decommissioning plan will be acceptable if it meets the following criteria:

(1) The plan contains procedures to identify and place within the disposal cell, all soils on and adjacent to the processing site that are in excess of the standards in 10 CFR Part 40, Appendix A, Criterion 6(6), due to site activities. The plan is substantiated by the radiological characterization data and site history.

(2) Appropriate soil background values (different geological areas may need separate background values) for Ra-226, and for U-nat, Th-230, and/or Th-232, as appropriate, have been proposed with supporting data.

(3) If elevated levels of uranium or thorium are expected to remain in the soil after the Ra-226 criteria have been met, the licensee has used the radium benchmark dose approach in Appendix H for developing decommissioning criteria for these radionuclides.

(4) To ensure consistency of measurement data, instrumentation and procedures used for soil background analyses and the radium-gamma correlation are the same or very similar to those proposed to provide verification data. The instrumentation has the appropriate sensitivity, and procedures are adequate to provide reliable data.

(5) A detailed quality assurance and quality control plan for all aspects of decommissioning is provided. In addition to the basis for accepting or rejecting data, a procedure for sampling additional grids when a verification Ra-226 sample fails to meet the standard is provided.

(6) Final verification (status survey) procedures are adequate to demonstrate compliance with the soil and structure cleanup standards. Survey instruments are specified and will be properly calibrated and tested. The proposed verification soil sampling density takes into consideration detection limits of sample analyses, the extent of expected contamination (unaffected area could have fewer measurements than affected areas), and limits to the gamma survey for the potentially contaminated area to be sampled. The gamma guideline value to be used for verification has been appropriately chosen. Also, there is a commitment to provide the verification soil radium-gamma correlation and the number of verification grids that had additional removal because of excessive Ra-226 values, to confirm that the gamma guideline value was adequate. The plan provides for adequate data collection beyond the excavation boundary (buffer zone).

For structures to remain onsite, adequate plans/procedures to demonstrate compliance with the limits for the surface activity dose in Appendix H of this standard review plan have been developed.

(7) The plan indicates the location of records important to decommissioning procedures for protection of health and safety and demonstrates that decommissioning will be completed as soon as practicable, as required by 10 CFR 40.42 and Appendix A, Criterion 6A.

(8) The decommissioning cost estimate is itemized in sufficient detail and a basis (source) for each cost is provided. The total cost is reasonable for the area of the site and the expected decommissioning activities.

(9) The plan adequately describes the control of non-radiological hazards associated with the wastes as required by 10 CFR Part 40, Appendix A, Criterion 6(7).

(10) As required by Appendix A, Criteria 9 and 10, the licensee must maintain a financial surety, within the specific license, for the surface reclamation and decommissioning, with the surety sufficient to recover the anticipated cost and time frame for achieving compliance, and include the long-term surveillance. Guidance on establishing financial surety is presented in NRC (1988, 1997). Appendix C to this standard review plan provides an outline of the cost elements appropriate for establishing surety amounts for conventional uranium mills. Any staff assessment of surety amounts is reasonably consistent with the applicant's assessment.

5.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the processing site (soil and structures) decommissioning plan, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the site decommissioning plan for soil and structures at the _____ uranium mill facility. This review included an evaluation using the review procedures in Section 5.2.2, and the acceptance criteria outlined in Section 5.2.3 of this standard review plan.

The licensee has provided an acceptable site decommissioning plan, including (1) appropriately substantiated site characterization data or plans to identify contaminated areas; (2) plans to clean up and place within the disposal cell, all materials that are in excess of the standards and approved guidelines, including hazardous material; (3) sufficient information concerning instrumentation and procedures; (4) plans for post-reclamation survey and sampling for verification that the soil and structures meet radiological limits; (5) location for retention of records important to decommissioning; (6) methods to protect workers, the public, and the environment; and (7) a cost estimate for all proposed decommissioning activities.

On the basis of the information presented in the reclamation plan and the detailed review conducted of proposed decommissioning activities for the _____ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(6), which requires that any portion of a licensed uranium mill site not designed to control radon releases, contain a concentration of radium in land, averaged over areas of 100 square meters, which, as a result of byproduct material, does not exceed the background levels by more than (i) 5 pCi/g of Ra-226 averaged over the first 15 cm [6 in.] below the surface, and (ii) 15 pCi/g of Ra-226 averaged over 15-cm-thick layers more than 15 cm below the surface. Also, the cleanup of other residual radionuclides in soil and residual surface activity on structures to remain on site, meet the criteria developed with the radium benchmark dose approach, including a demonstration of “as low as is reasonably achievable” radiation levels and application of the unity test where applicable. For cases in which the licensee has proposed an alternative to the requirements of Criterion 6(6) or the approved guidance, the staff determines that the resulting level of protection is equivalent to that required by this criterion. In addition, the plan demonstrates compliance with 10 CFR Part 40, Appendix A, Criterion 6(7), which requires prevention of threats to human health and the environment from non-radiological hazards associated with the wastes.

The decommissioning plan specifies the location of records of information important to the decommissioning as required by 10 CFR 40.36(f) and meets the criteria of 10 CFR 40.42(g)(4) and (5). The plan sufficiently demonstrates that the proposed decommissioning activities will result in compliance with 10 CFR 40.42(j)(2) requirements to conduct a radiation survey. The plan complies with the 10 CFR 40.42(k)(1) and (2) requirements that source material be properly disposed of and reasonable effort be made to eliminate residual radioactive contamination. The decommissioning cost estimate meets the requirements of 10 CFR 40.42(g)(4)(v) and Appendix A, Criterion 9.

5.2.5 References

American National Standards Institute Standards:

N42.17A–1989, "Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Normal Environmental Conditions."

N42.12–1994, "American National Standard Calibration and Usage of Thallium-Activated Sodium Iodide Detector Systems for Assay of Radionuclides."

American Society for Testing and Materials Standards:

C 998-90 (reaffirmed 1995), "Standard Practice for Sampling Surface Soil for Radionuclides."

D 5283-92, "Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation."

E 181-93, "Standard Test Methods for Detector Calibration and Analysis of Radionuclides."

E 1893-97, "Standard Guide for Selection and Use of Portable Survey Instruments for Performing *In Situ* Radiological Assessments in Support of Decommissioning."

National Council on Radiation Protection and Measurements. "Calibration of Survey Instruments Used in Radiation Protection for the Assessment of Ionizing Radiation Fields and Radioactive Surface Contamination." Report No. 112. 1991.

NRC. "Uranium Mill *In-Situ* Leach Uranium Recovery, and 11e(2) byproduct Material Disposal Site Decommissioning Inspection." Inspection Manual—Inspection Procedure 87654. Washington DC: NRC. March 2002.

———. NUREG–1575, "Multi-Agency Radiation Survey and Site Investigation Manual." Rev. 1. Washington DC: NRC. 2000a.

———. NUREG–1727, "NMSS Decommissioning Standard Review Plan." Washington, DC: NRC. 2000b.

———. NUREG–1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys." Rev. 1. Washington DC: NRC. 1998a.

———. NUREG–1507, "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions." Washington DC: NRC. 1998b.

———. "Annual Financial Surety Update Requirements for Uranium Recovery Licensees." Generic Letter 97-03. Washington, DC: NRC. July 9, 1997.

———. Regulatory Guide 3.65, "Standard Format and Content of Decommissioning Plans Under 10 CFR Parts 30, 40, and 70." Washington DC: NRC, Office of Standards Development. 1989.

———. "Technical Position on Financial Assurances for Restoration, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities." Washington, DC: NRC. 1988.

5.3 Radiation Safety Controls and Monitoring

5.3.1 Areas of Review

The areas of review for radiation safety for protecting the site worker, the public, and the environment during reclamation and decommissioning are the control of releases, the radiation exposure and environmental monitoring programs, and the contamination control program. Decommissioning activities at mill sites involve occupational, and possibly public, exposures to radioactive materials that may require different or additional monitoring and control procedures than during site operation or standby status. Potential sources of exposure from working with tailings material are caused by airborne particulate contamination, radon gas, and external gamma radiation. Surface activity or dust on equipment and structures to be dismantled or decontaminated could also be a source of exposure.

The reclamation and final decommissioning plans should contain the licensee's evaluation of the site current radiation safety/protection plan or program and any proposed changes to the program for reclamation and decommissioning operations. The proposed measures should keep exposures as low as is reasonably achievable and in compliance with the requirements of 10 CFR Part 20. Key components of the program should address hazards unique to the reclamation or decommissioning work environment. Any new activities that could increase hazards to general health and safety (e.g., cleanup in confined spaces, or removal of hazardous or flammable chemicals) should be identified, considering the NRC Memorandum of Understanding with the Occupational Safety and Health Administration.

5.3.2 Review Procedures

Determine that the proposed radiation safety controls and all monitoring programs and procedures are sufficient to comply with the regulatory requirements during decommissioning and reclamation. A licensee will already have an approved radiation safety program in place; therefore, the focus of the review should be to ensure that the reclamation plan addresses those aspects of worker and public protection that require special consideration in planning reclamation and decommissioning activities. The environmental impacts of these activities will be addressed in the environmental assessment, but any concerns requiring mitigation should be addressed in the reclamation plan. The reclamation plan should confirm the applicability of the radiation protection and monitoring programs to reclamation and decommissioning activities or should propose changes to address new program needs based on review of the following:

(1) Control of Releases

Determine whether the proposed systems and procedures (e.g., tailings stabilization, dust control) are sufficient to minimize environmental emissions from the tailings impoundment construction activities or structure demolition, taking into consideration important release mechanisms such as wind resuspension and surface erosion. Radon gas emanating from the tailings pile is also a radiation safety concern for workers and downwind off-site populations. However, because control of the source is not possible during tailings recontouring or cleanup, the reviewer should examine the means proposed to limit the worker inhalation hazard (i.e., limiting exposure time, or using dust masks or respirators if required) and to establish an acceptable environmental monitoring program for measuring off-site airborne concentrations. Also, liquid releases can be created by rainwater runoff. Therefore, the review of the reclamation plan should include an evaluation, taking all exposure pathways into account, of proposals for ensuring off-site exposures are as low as is reasonably achievable.

(2) External Radiation Exposure Monitoring Program

Determine if changes to the existing program are needed or if proposed changes are adequate. The reviewer should consider the types of surveys conducted, criteria for determining survey locations, frequency of surveys, action levels, management audits, and corrective action requirements. Also, consider if changes are required in the program for personal/personnel monitoring (dosimeters and air samplers), including the criteria for placing workers in the program.

(3) Airborne Radiation Monitoring Program for Work Areas

Evaluate whether the proposed sampling locations, frequencies, procedures, and equipment are adequate to determine concentrations of airborne radioactive materials (including radon) in work areas during construction, demolition, and cleanup activities. Action levels, audits, and corrective action requirements should also be evaluated.

(4) Bioassay Program

Review the existing bioassay program or proposed changes to determine whether the proposed bioassay program is sufficient to protect employees performing decommissioning activities in yellowcake processing areas.

(5) Contamination Control Program

Evaluate the occupational radiation survey program. This review should include proposed housekeeping and cleanup requirements and specifications for clean areas to control contamination. Action levels for clean areas and for the release of materials, equipment, and work clothes from clean areas and/or the site should be evaluated.

(6) Environmental Monitoring Program

Determine whether the environmental monitoring program proposed for measuring concentrations and quantities of both radioactive and non-radioactive materials released to, and in, the environs of the proposed facility, are sufficient to protect employees and the public. Potential releases during disposal cell construction and cleanup activities will be primarily from resuspended tailings material and radon gas. The reviewer should focus on the frequency of sampling and analysis, the types and sensitivity of analyses, action levels, corrective action requirements, and the required number of effluent and environmental monitoring stations (including criteria for determining monitor station locations considering the reclamation work). The guidance in Regulatory Guide 4.20 (NRC, 1996) should be considered.

(7) Record Keeping

Determine whether the record keeping requirements for the radiation protection program have been addressed; that is, records of the provisions of the program and audits or other reviews of content and implementation are maintained for at least 3 years. Other records are maintained according to Subpart L of 10 CFR Part 20 and 10 CFR Part 40, Appendix A, Criterion 6(4).

5.3.3 Acceptance Criteria

The radiation safety controls and monitoring for site worker, public, and environmental protection during reclamation and decommissioning will be acceptable if they meet the following criteria:

(1) The reclamation plan identifies the radiation safety concerns that are unique to reclamation and decommissioning activities. These concerns include characterization of radiation hazards associated with inhalation of resuspended tailings material or yellowcake, gamma exposure from working close to tailings, and inhalation of radon gas and its progeny (decay products) emanating from tailings material.

(2) The reclamation plan describes any changes to an existing radiation safety or monitoring program that would be necessary to ensure worker or public safety during reclamation or decommissioning activities.

(3) Standard dust control measures such as regular wetting and/or phased stabilization are to be used for control of windblown tailings material or yellowcake dust.

(4) Any proposed changes to the established bioassay program will meet criteria of the applicable parts of Regulatory Guide 8.22, “Bioassay at Uranium Mills” (NRC, 1988) and Regulatory Guide 8.9, Revision 1, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program” (NRC, 1993), or an acceptable justification is provided for selecting an alternate approach.

(5) Any proposed workplace airborne radiological monitoring program will support the proposed bioassay program and is consistent with applicable parts of Regulatory Guide 8.25, “Air Sampling in the Workplace” (NRC, 1992) and Regulatory Guide 8.30, “Health

Physics Surveys in Uranium Mills" (NRC, 2002), or an acceptable justification is provided for selecting an alternate approach. The monitoring program will provide adequate protection of workers from radon gas or particulate exposures to maintain compliance with the inhalation limits in 10 CFR Part 20. If sampling locations will be revised, the reclamation plan contains one or more maps of the site that indicate the location of samplers for airborne radiation and provide the justification for determining the revised locations.

(6) Any proposed contamination control program is consistent with the guidance on conducting surveys for contamination of skin and of personal clothing presented in Regulatory Guide 8.30 (NRC, 2002).

(7) Any proposed environmental radiological monitoring program is consistent with applicable parts of Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC, 1980), or an acceptable justification is provided for selecting an alternate approach. The licensee has adequately considered site-specific aspects of climate and topography in determining locations of off-site airborne monitoring stations and environmental sampling areas so that detection of maximum off-site concentrations of windblown tailings material and contamination from any other significant transport pathways applicable to the site is ensured.

(8) Any proposed radiation protection program contains plans for documentation of exposures to all monitored workers and contractors and for availability of exposure records in a single location for inspection. The program provides for recordkeeping that meets the requirements of 10 CFR 20.2102; at least annual review of the program content and implementation; and implementation of the "as low as is reasonably achievable" requirements of 20.1101(d).

5.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiation safety controls and monitoring for site worker, public, and environmental protection during disposal cell construction and site cleanup, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the radiation safety controls and monitoring for site worker, public, and environmental protection during reclamation and decommissioning at the _____ uranium mill facility. This review included an evaluation using the review procedures in Section 5.3.2 and the acceptance criteria outlined in Section 5.3.3 of this standard review plan.

The licensee has provided an acceptable evaluation of radiation safety controls and monitoring required for worker, public, and environmental protection during reclamation and decommissioning activities, including (1) identification of the radiation safety concerns that are unique or likely to increase during reclamation construction and site decommissioning; (2) any necessary changes and associated justifications in the radiation safety program, such as personnel and environmental monitoring; (3) identification and discussion of any changes in an

existing radiation protection program; (4) control of potential contamination from windblown tailings by regular wetting and/or phased stabilization; and (5) the monitoring and contamination control programs will allow compliance with applicable portions of 10 CFR Parts 20 and 40.

On the basis of the information presented in the reclamation plan and the detailed review conducted of the radiation safety controls and monitoring for worker, public, and environment protection during reclamation and decommissioning for the _____ uranium mill facility, the NRC staff concludes that the information is acceptable and is in compliance with 10 CFR 20.1101, which requires development, documentation, and implementation of a radiation protection program ensuring compliance with 10 CFR Part 20 requirements and the use of procedures and engineering controls to achieve occupational and public doses that are as low as is reasonably achievable. The 10 CFR Part 40, Appendix A, Criterion 8, requirements for implementation of control measures to limit dust emissions from tailings that are not covered by standing liquids, including wetting or chemical stabilization, will be met. [This requirement may be relaxed for tailings impoundments that have surfaces that are sheltered from wind exposure (i.e., below grade) or that have an interim cover.] The requirements in 10 CFR 40.42(g)(4)(iii), to describe methods that ensure protection of workers and the environment against radiation hazards during decommissioning, have been met.

5.3.5 References

NRC. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Mills." Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002

———. Regulatory Guide 4.20, "Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors." Washington, DC: NRC, Office of Standards Development. 1996.

———. Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program." Rev. 1. Washington DC: NRC, Office of Standards Development. 1993.

———. Regulatory Guide 8.25, "Air Sampling in the Workplace." Rev. 1. Washington, DC: NRC, Office of Standards Development. 1992.

———. Regulatory Guide 8.22, "Bioassay at Uranium Mills." Rev. 1. Washington, DC: NRC, Office of Standards Development. 1988.

———. Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills." Rev. 1. Washington, DC: NRC, Office of Standards Development. 1980.