Umetco Minerals Corporation

GAS HILLS RECLAMATION PROJECT

Docket No. 40-0299
License No. SUA-648

FINAL DESIGN and RECLAMATION PLAN

for

GHP No. 2/Mill Area

May 2003
Revision 1, September 2003

Umetco Minerals Corporation
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Response to NRC Request for Additional Information
Final Reclamation Plan for Pond No. 2
Umetco Minerals Corporation's Gas Hills Uranium Mill Site

NRC Comment No. 1

Discussion: Part 40, Appendix A, Criterion 6(5) requires that near surface cover material to be essentially the same radioactivity as surrounding surface soil. Page 2 of the plan indicates that continuous gamma scans will be done during excavation of the clay soil to be used in the cell cover, to assure there is no radiological contamination.

Request: Umetco should provide the basis for choosing the gamma level that will allow use of the clay material, such as a gamma-radium correlation and survey procedure. In addition, some confirmatory soil sample analysis should be performed unless there is adequate conservatism in the correlation and survey procedure to ensure that background levels of radioactivity are achieved for the cover.

Response to Comment No. 1

The radium attenuation design for the radon barrier is based on an average radium activity of 2 pCi/g. This value was conservatively selected from samples of the clay soil obtained in the borrow source located approximately 6 miles west of the site and used for construction of the pond liner and radon barriers. These sample results are as follows:

Sample I.D.	^{226}Ra (pCi/g)	Reference
A	1.4	October 15, 1997 Heap Leach Submittal
B	2.0	October 15, 1997 Heap Leach Submittal
C	1.8	October 15, 1997 Heap Leach Submittal
D	1.2	October 15, 1997 Heap Leach Submittal
E	2.3	October 15, 1997 Heap Leach Submittal
HRE-1	3.6	September 25, 1996 Heap Leach Submittal
HRE-2	2.4	September 25, 1996 Heap Leach Submittal
HRE-3	2.6	September 25, 1996 Heap Leach Submittal
HRE-4	1.9	September 25, 1996 Heap Leach Submittal
Average =	2.1	

Umetco will verify by collimated field gamma survey that clay soils excavated from the GHP No. 2 liner and used for construction of the radon barrier are within a range of reasonably anticipated ^{226}Ra activities and averaging less than 2 pCi/g used in the radon attenuation design.

During construction, continuous gamma scans will be performed in accordance with site procedures E14 and E17 to ensure potentially ^{226}Ra contaminated soils are not used in cover construction. A gamma-radium correlation for the clay soil will be developed by obtaining at least six clay soil samples and associated collimated gamma measurements.

In addition to continuous gamma scans, soil samples will be obtained from the constructed radon barrier at a frequency of 1 sample per 800 CY which is approximately 1 sample per acre per lift of radon barrier soils. Laboratory ^{226}Ra analysis by gamma spectrometry shall be performed on each sample in accordance with Gas Hills site procedure.

Comment 1 - Plan Revisions	
Section 1.3.2, paragraph 4	Correct reference to site procedures; include requirement for soil sampling of liner materials; add paragraph 5 describing radiological survey and soil sampling.
Table 6-3	Add testing requirement and frequency for ^{226}Ra sampling and testing.

NRC Comment No. 2

Discussion: The Standard Review Plan (NUREG 1620 Section 5.1.3.1 (7)) indicates that more than one layer of contaminated material should be represented in the radon model if there are significant differences in Ra-226 with depth. Page 6 of the plan indicates that the radium activity concentration of the upper 500 cm of the pond soil will be determined by analysis of one borehole composite sample per acre. However, if the radium activity is not fairly homogeneous, the radon flux would be higher than your estimate if there were higher activity material in the upper layer of the soil.

Request: Provide evidence of radium activity concentration homogeneity or provide a plan to divide the borehole core into 3-foot segments for the upper 9 feet and perform Ra-226 laboratory analysis on each segment.

Response to Comment No. 2

Review of existing data indicates some degree of non-homogeneity in subsurface radium concentrations. Applicable portions of the downhole data averaged in 3-foot segments results in the following distribution by depth.

Segment (ft)	Segment (cm)	Arithmetic Mean ^{226}Ra (pCi/g)
0 - 3	0 - 91.44	69.01
3 - 6	91.44 - 182.88	62.12
6 - 9	182.88 - 274.32	54.63

Accordingly, the radon model has been revised to account for the segmented radium concentrations. Field verification of radium concentrations will also be accomplished in 3-foot segments at a minimum density of one borehole per acre. Specific revisions to the radon model are contained in the response to Comment 3.

Comment 2 - Plan Revisions	
Table 2-1	Modify Table 2-1 to include segmented waste layers.
Table 2-2	Modify Table 2-2 to show ^{226}Ra concentrations in 3-foot segments.
Section 2.3.1, paragraph 6	Revise paragraph to discuss segmented waste layers.
Section 2.3.1, paragraph 7	Revise paragraph to discuss segmented sampling to verify ^{226}Ra activity of waste material.

NRC Comment 3

Discussion: Page 6 of the plan indicates that the radon barrier emanation coefficient (0.14) used in the model was the average of five test results. However, the test results in the submittal of September 25, 1996, indicate that 0.14 was the lowest value and the average was 0.20. The value of 0.20 was used for the Heap Leach and A-9 radon barrier models.

Request: To resolve this inconsistency, provide test results referred to, or revise the emanation coefficient in the radon model for Pond 2.

Response to Comment 3

Comment 3 refers to Umetco's September 25, 1996 submittal, which provided emanation coefficient test results and used an input value of 0.20 for the RADON model contained in that submittal. The reference on page 6 of the GHP No. 2 design is Umetco's October 15, 1997 heap leach submittal providing additional test data (including emanation coefficient values) of 5 samples of radon barrier soils. However, the NRC is correct as the RADON model contained in the September 25, 1996 submittal using an emanation coefficient of 0.20 was not modified by the supplemental data provided in the October 15, 1997 submittal. The following table summarizes values presented in Umetco's September 25, 1996 and October 15, 1997 submittals.

Summary of Radon Barrier (Clay Soil) Test Results				
Sample ID	^{226}Ra (pCi/g)	Emanation Coefficient	Diffusion Coefficient (cm^2/sec)	Comment
A	1.4	0.18	0.0016	October 15, 1997 Submittal
B	2.0	0.23	0.0034	October 15, 1997 Submittal
C	1.8	0.07	0.0042	October 15, 1997 Submittal
C	1.2	0.13	0.0034	October 15, 1997 Submittal
E	2.3	0.09	0.0017	October 15, 1997 Submittal
HRE-1	3.6	0.261	Composite of 4 Samples = 0.0041	September 25, 1996 Submittal
HRE-2	2.4	0.143		September 25, 1996 Submittal
HRE-3	2.6	1.191		September 25, 1996 Submittal
HRE-4	1.9	0.207		September 25, 1996 Submittal
Average =	2.1	0.17	0.0031	
Values Selected for Revised Modeling				
RUN 1	2.0	0.20	Code Calculation	
RUN 2	2.0	0.17	0.0031	

The radon attenuation design as modified in this response consists of 2 RADON models. RUN 1 provides a conservative model with the following input modifications:

- 3-foot segmented waste layers for the upper 9-feet of waste material as discussed in the response to Comment 2.
- Emanation coefficient of 0.20 for the radon barrier as previously approved in Umetco's September 25, 1996 submittal.
- Default or code calculated diffusion coefficient for all waste and cover layers.

RUN 2 demonstrates the conservative attributes of the radon attenuation design by:

- Input emanation coefficient of 0.17 for the radon barrier, which is the average of 9 samples tested.
- Input diffusion coefficient of 0.0031 cm^2/sec for the radon barrier layer, which is the average of 6 samples tested instead of code calculated diffusion coefficient.

The following table summarizes the input values used in the RADON models.

SUMMARY OF RADON MODEL INPUT PARAMETERS - RUN 1

Layer No.	Thickness (cm)	Porosity	Mass Density (g/cm^3)	^{226}Ra Activity (pCi/g)	Emanation Coefficient	Moisture Content (dry wt. %)	Diffusion Coefficient (cm^2/sec)
Layer 1 - Waste	225.68	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 2 - Waste	91.44	Code Calc.	1.75	55	0.262	6	Code Calc.
Layer 3 - Waste	91.44	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 4 - Waste	91.44	Code Calc.	1.75	69	0.262	6	Code Calc.
Layer 5 - Radon Barrier	30.48	Code Calc.	1.59	2	0.20	12	Code Calc.
Layer 6 - Frost Protection	137.16	Code Calc.	1.75	10	0.262	6	Code Calc.

1) Upper 9-feet (0 cm to 274.32 cm) of waste material is divided into 3-foot segments. Waste layer 4 (274.32 cm to 500 cm) assumes the average ^{226}Ra activity from the existing subsurface data.
2) Previously approved emanation coefficient of 0.20 used for RUN 1.
3) Default (code calculated) diffusion coefficient used for all layers of waste and cover.

SUMMARY OF RADON MODEL INPUT PARAMETERS - RUN 2

Layer No.	Thickness (cm)	Porosity	Mass Density (g/cm^3)	^{226}Ra Activity (pCi/g)	Emanation Coefficient	Moisture Content (dry wt. %)	Diffusion Coefficient (cm^2/sec)
Layer 1 - Waste	225.68	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 2 - Waste	91.44	Code Calc.	1.75	55	0.262	6	Code Calc.
Layer 3 - Waste	91.44	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 4 - Waste	91.44	Code Calc.	1.75	69	0.262	6	Code Calc.
Layer 5 - Radon Barrier	30.48	Code Calc.	1.59	2	0.17	12	0.0031
Layer 6 - Frost Protection	137.16	Code Calc.	1.75	10	0.262	6	Code Calc.

1) Emanation coefficient of 0.17 used for radon barrier layer (average of 9 samples tested).
2) Diffusion coefficient of 0.0031 cm2/sec input for radon barrier layer (average value of 6 samples tested).

The RADON models described above resulted in an exit flux of 19.40 pCi/m^2/sec. for RUN 1 and 14.30 pCi/m^2/sec. for RUN 2. These results are below the 20 pCi/m^2/sec. exit flux limit established in 10 CFR 40, Appendix A, Criterion 6. Both of the model runs are conservative because:

- Diffusion coefficients for all waste and cover layers except RUN 2 radon barrier are code calculated.
- Conservative 6 percent moisture content values are assumed for waste and frost protection.
- The long-term moisture content for the radon barrier soils is assumed to be 12 percent, measured equilibrium moisture content at 15-bars for this soil ranges from 16.1 percent to 19.7 percent.
- The radium activity for the frost protection soil assumes 10 pCi/g ^{226}Ra. Field measurement of ^{226}Ra during construction will control and verify that ^{226}Ra concentrations are less than 10 pCi/g ^{226}Ra.

Comment 3 - Plan Revisions	
Section 2.3.2, paragraph 2	Revise paragraph to clarify source of data and correct reference to Section 1.3.2.
Section 2.3.2, paragraph 3	Revise paragraph to use emanation coefficient of 0.20 with appropriate reference to source of information.
Section 2.4	Revised to reflect results of new RADON attenuation models.
Appendix A	Revised RADON attenuation models.

NRC Comment 4

Discussion: NRC guidance recommends that the thickness of the embankment apron be at least three times the rock protection D_{50}, to account for erosive forces that are created from the embankment flow. Drawing "GHP No. 2 Sections and Details" shows TYPE C riprap to have a D_{50} of 6 inches for the apron. However, Detail 1 shows 10 inches of Type C erosion protection will be placed in this area (on top of 3 inches of Type A riprap), not 18 inches (3 x 6 inches).

Request: Justify that the thickness of erosion protection along the embankment apron is adequate.

Response to Comment 4

The buried embankment toe apron for GHP No. 2 has been modified to a flatter 6(H):1(V) slope (17% slope). In this configuration the maximum D_{50} calculated at the toe of the 20% embankment slope is 4.00 inches and at the toe of the buried 17% apron 3.7 inches. The specified erosion protection for this application has a D_{50} of 6 inches which results in a conservative 33% oversizing of the required rock size at the most

critical area of the apron toe. The size of the erosion protection for the toe apron was determined along 4 profiles as shown on Figure 4-1. The resulting design D_{50}s at the toe of the 17% buried apron are as follows:

Profile 1: D_{50} = 3.23 inches
Profile 2: D_{50} = 3.03 inches
Profile 3: D_{50} = 3.30 inches
Profile 4: D_{50} = 3.73 inches

As stated above, this represents a 33% to 39% oversizing at the toe of the embankment slope and a 37% to 50% oversizing at the toe of the buried apron. Using 3 times the nominal calculated D_{50} at the toe of the buried apron, i.e., 3.3 inches x 3 = 9 inches, a layer thickness of 10 inches is adequate.

NRC guidance (Draft NUREG 1623) indicates that the erosion protection for the toe apron should extend a minimum of 15 median rock sizes. This would indicate that the minimum apron length should be 7.5 feet whereas the proposed apron length is 36 feet. NUREG 1623 also indicates that if the flow discharges onto relatively flat ground with little or no potential for gully intrusion, the design procedure is not needed and riprap sizing at the toe of the embankment toe only needs to be about 50% larger than the sideslope. The buried apron will be backfilled with compacted soils to a minimum 95% standard Proctor density and graded to a flat slope in accordance with the site wide grading plan. The specified erosion protection has a minimum D_{50} range of 6 inches to 9 inches. Quality control gradation testing of erosion protection material during processing demonstrates the actual D_{50} of the Type C erosion protection is well within the specified D_{50} range, i.e., actual D_{50} is greater than 6 inches. Consequently, the proposed design provides riprap about 50 percent larger than the minimum calculated D_{50} for this application.

Considering,

- the conservative oversizing of the specified erosion protection on the modified apron slope;
- the discharges from the cover to a compacted, graded ground surface;
- and the actual gradation of the erosion protection material that has been produced for this application, i.e., D_{50}, is about 2 inches larger than the minimum specified,

the 10 inch thickness of the modified toe apron is conservative for this application.

Comment 4 - Plan Revisions	
Table 4-1	Revise table to show modified toe apron slope.
Table 4-2	Revise table to show modified toe apron erosion protection calculations.
Appendix B, page 6	Revise calculation to show modified toe apron design.
Section 4.2.2	Add 2nd paragraph to discuss toe apron design.
Drawings 4 of 5 and 5 of 5	Revise to show modified toe apron slope.

NRC Comment 5

Discussion: The Standard Review Plan (NUREG-1620 Section 3.4.2(4)) provides evaluation criteria for diversion channels that have not been completely addressed by the plan. The intersection of the Heap Leach Pile and the diversion channel may be a location where turbulence can occur when flow along the heap leach embankment and the concentrated flow from the diversion channel intersect. Plan Section L-L' shows that one layer of Type B erosion protection will be placed at the toe of the Heap Leach embankment.

Request: Discuss how embankment flow was considered in the erosion protection design for the diversion channel.

Response to Comment 5

The channel flow at peak discharge is subcritical with an interstitial flow velocity of 0.14 feet/second. NRC guidance states that if the velocity at the soil/rock interface is less than 0.5 feet/second, a filter layer will not be needed.

Flows discharging into the channel from the Heap Leach and Above-Grade Tailings embankment covers have very shallow flow depth. However, the interstitial flow velocity is 0.55 feet/second at the toe of the slope. The calculated D_{50} size of the riprap at the toe of the slope is 1.74 inches. The specified TYPE B erosion protection has a minimum D_{50} of 3 inches indicating a minimum 42 percent oversizing of erosion protection at the toe of the slope. Since the interstitial flow velocity at this point is in excess of 0.5 feet/second, the design has been modified to include a bedding layer for the channel side slope and extending into the channel bottom for a distance of 15 feet as shown on the revised Drawings.

Comment 5 - Plan Revisions	
Section 4.2.4	Add 5th paragraph to discuss modification to channel design.
Drawing 4 of 5	Revised to show bedding layer in channel.

NRC Comment 6

Discussion: The Standard Review Plan (NUREG-1620 Section 3.4.2) provides evaluation criteria for diversion channels including sediment accumulations. Sedimentation in the diversion channel was not discussed in the plan.

Request: Address sedimentation issues or provide a short discussion indicating why it is not necessary.

Response to Comment 6

Sedimentation of diversion channels can be a significant problem primarily because diversion channels are usually designed to a milder slope than natural channels resulting in sediment deposition. For the GHP No. 2 channel design, all drainage basins contributing to channel flows are on the reclaimed Heap Leach and Above-Grade embankments. The reclamation covers for these embankments have been constructed with erosion protection designed for PMF flow conditions. Consequently, there is no significant source of sediment in the drainage basin, which contributes to the GHP No. 2 channel.

Comment 6 - Plan Revisions	
Section 4.2.6	Section 4.2.6 has been added to discuss sedimentation.

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Contents

1.0 INTRODUCTION **1**
1.1 Background 1
1.2 GHP No. 2 Setting 1
1.3 Design Overview 1
1.3.1 Solidifying Remaining Liquids and Residue 1
1.3.2 Removing and Disposing of the Existing Pond Liner 2
1.3.3 Reclamation Cover Design 3
2.0 RADON ATTENUATION DESIGN **3**
2.1 General 3
2.2 Cover Design 4
2.3 Soil Properties/Input Parameters 4
2.3.1 Waste Material Input Parameters 4
2.3.2 Radon Barrier Input Parameters 7
2.3.3 Frost Protection Input Parameters 8
2.4 Radon Attenuation Model Results 9
3.0 GEOTECHNICAL DESIGN **10**
3.1 Cover Design 10
3.2 Slope Stability Analysis 10
3.2.1 Material Properties 10
3.2.2 Model Results 12
3.2.3 Model Graphics 12
3.3 Settlement and Cover Cracking 12
3.4 Liquefaction 13
3.5 Frost Protection 13
4.0 EROSION PROTECTION **13**
4.1 Design Storm 13
4.2 Erosion Protection Design 13
4.2.1 Layer Thickness 15
4.2.2 Scour Depth and Toe Apron 15
4.2.3 Filter Requirements 16
4.2.4 GHP No. 2 Channel 16
4.2.5 Erosion Protection Gradations 17
4.2.6 Sedimentation 17
5.0 GHP No. 2 RECLAMATION SPECIFICATIONS **17**
5.1 Scope of Work 17
5.1.1 Specifications and Drawings 18
5.2 Liner Removal 18
5.2.1 Solidifying Remaining Liquids 18
5.2.2 Disposing of Synthetic Lining Materials 19
5.3 Site Grading 19
5.4 Radon Barrier 19
5.4.1 Materials 19
5.4.2 Placement 19
5.5 Frost Protection Layer 20
5.5.1 Materials 20
5.5.2 Placement 21
5.6 Erosion Protection 21
5.6.1 Quality Requirements 21
5.6.2 Gradation Requirements 24
5.6.3 Erosion Protection Placement 24
6.0 QUALITY CONTROL PLAN **26**
6.1 Quality Control/Quality Assurance Personnel 26
6.2 Test Procedures and Documentation 26
6.3 Test Frequencies 27

Tables

Table 2-1 Radon Model Input Parameters 4
Table 2-2 Average Radium Activity 5
Table 3-1 Summary of Shear Strength Tests 9
Table 3-2 Results of Slope Stability Analysis 10
Table 4-1 Summary of Flow Segments 12
Table 4-2 Summary of Erosion Protection Design Calculations 13
Table 4-3 Summary of Channel Erosion Protection Design Calculations 14
Table 4-4 Erosion Protection Gradation Requirements 14
Table 5-1 Required Quality Control Tests 19
Table 5-2 Erosion Protection Scoring Criteria 20
Table 5-3 Erosion Protection Gradation Requirements 21
Table 6-1 Summary of QC Test and Inspection Procedures 24
Table 6-2 Summary of QC Test and Inspection Forms 24
Table 6-3 Minimum Test Frequencies 25

Appendices

Appendix A Radon Attenuation Design
Appendix B Erosion Protection Calculations

Figures

Figure 2-1 Location of Boreholes
Figure 3-1 Static Slope Stability Analysis
Figure 3-2 Seismic Slope Stability Analysis
Figure 4-1 Surface Profiles, Drainage Basin

Drawings

GH-198 Site Plan and Location Maps ..... Sheet 1 of 5
GH-199 GHP-2 Pre-Cover Grading Plan ..... Sheet 2 of 5
GH-200 GHP-2 Frost Protection Plan ..... Sheet 3 of 5
GH-201 GHP-2 Erosion Protection Plan ..... Sheet 4 of 5
GH-202 GHP-2 Sections and Details ..... Sheet 5 of 5

1.0 INTRODUCTION

This submittal provides the final reclamation design detail for the Gas Hills Pond (GHP) No. 2 area of Umetco Minerals Corporation's (Umetco), Gas Hills, Wyoming site.

1.1 Background

In a September 25, 1996 submittal, Umetco requested approval of a revised reclamation plan for the Heap Leach area including the GHP No. 2 pond area. Minimal site data was provided for reclaiming GHP No. 2 since disposal of liquid waste (evaporation of liquids from groundwater extraction) was not complete and duration of the Groundwater Corrective Action Plan (CAP) unknown. In response to NRC staff concerns regarding the limited data, Umetco acknowledged (February 11, 1998 letter) that the provided design was preliminary. Umetco committed to providing a final design for closure of GHP No. 2 when the necessary data were available.

1.2 GHP No. 2 Setting

GHP No. 2 is a 17-acre evaporation pond constructed in the former mill process and or stockpile area of the Gas Hills facility. Subsurface site characterization data obtained prior to constructing GHP No. 2 indicate that soils in the area (beneath the existing pond) contain, at depth, elevated concentrations of radionuclides which appear to occur from natural mineralization and mill related impacts. Considering the volume of potentially impacted soils and the difficulty in distinguishing 11e.(2) affected soils from naturally elevated soils in this area, the pond will be reclaimed in place.

1.3 Design Overview

The reclamation design for the GHP No. 2 pond area was developed to provide long-term closure and stabilization of the area in accordance with the requirements of NRC regulations stated in 10 CFR Part 40, Appendix A. The key components of this design include the following:

- Solidifying remaining liquids and evaporative residue
- Removing, disposing and utilizing the existing pond lining system
- Reclamation cover design

1.3.1 Solidifying Remaining Liquids and Residue

Umetco's groundwater CAP was terminated on March 29, 2002 by NRC approval (Amendment 48) of Alternate Concentrations Limits (ACLs) for the Gas Hills site. Coinciding with ACL approval, reclamation activities at the site have progressed to a point in which soil cleanup activities have been completed with the Final Status Survey Plan (FSSP) report to be submitted in September 2003 and completion of the A-9 radon barrier in 2003. Consequently, discharge of liquid 11e.(2) byproduct liquids into the GHP No. 2 pond have terminated with the exception of solutions removed from the A-9 decant tower and contaminated storm flows, i.e., runoff from uncovered portion of A-9 disposal cell.

Reclamation of the GHP No. 2 area will begin once the evaporation of liquids has progressed to a point in which adequate solidification with soil can occur. Local borrow soils will be mixed with remaining pond solutions to a point which does not exceed a soil moisture content that prohibits compaction of the soil at 95 percent of standard Proctor density. Once the pond liquid decreases to a level in which 1.5 million gallons or less remain, reclamation activities will be initiated. Umetco estimates that local site soils (mine spoil soils) will be used to solidify the remaining pond liquids at a rate of approximately 30 gallons per cubic yard of soil, assuming the borrow material has an initial moisture content of 6 percent or less by dry weight. Accordingly, approximately 30,000 to 50,000 cubic yards of soil will be utilized to solidify the remaining liquids and pond residue.

Once the liquids and residues have been solidified and the pond liner removed as described in Section 1.3.2, the material will be placed and compacted to 95 percent standard Proctor density (ASTM D698). This material will be placed in a thin layer between the existing pond subgrade and the bottom of the GHP No. 2 reclamation cover as shown on the drawings.

1.3.2 Removing and Disposing of the Existing Pond Liner

The existing GHP No. 2 pond liner consists of the following components:

- Primary (top) Liner - 60 mil High-Density Polyethylene (HDPE) geomembrane.
- Leachate/Collection/Leak Detection Layer - HDPE geonet with transmissivity of 3E-4 m^2/sec. or higher.
- Secondary (bottom) Liner – two-component layer consisting of an upper 60-mil HDPE geomembrane and lower layer of compacted clay soil (18 inches thick) with a hydraulic conductivity of less than 1E-7 cm^3/sec.

The bottom of the evaporation pond is constructed at a one-percent slope to a central point at the west end where the leachate collection/leak detection facilities are located. The entire pond lining system will be removed and/or disrupted to eliminate a potential "bathtub" effect, which could result from reclaiming the pond area with the lining system in place. Umetco does not anticipate a significant volume or thickness of post-evaporation residue remaining on the synthetic liner as indicated by portions of the liner currently exposed. The synthetic liner will be removed in a manner that prevents contamination of the underlying clay soil, i.e., upper geomembrane removed while the secondary membrane protects the soil liner. The secondary geomembrane will be removed by rolling or folding to prevent contamination of the clay liner soils.

All synthetic materials removed from the lining system shall be shredded into pieces not exceeding 3-feet in width and 20-feet in length. Synthetic materials shall be placed with the compacted soils used to solidify remaining pond liquids.

The 18-inch clay soil liner is constructed of the same soil, i.e., the same borrow source and same characteristics, used for the radon barrier on the Heap Leach and A-9 Repository. Umetco anticipates using a significant portion of the liner soil for constructing the radon barrier layer of the closure cover. Continuous radiological scans (Procedure No. E-14 and E-17) and soil sampling (refer to Table 6-3) will verify that pond solutions or residual material from removing the synthetic portion of the liner have not impacted the soil. The clay soil liner will be excavated

to within a few inches of the pond/liner subgrade to account for potential impact to the affected subgrade soils. Once the usable portion of the clay liner material has been removed, the bottom of the pond will be regraded to provide the appropriate subgrade slope for constructing the reclamation cover. Regrading the pond bottom shall be accomplished in a manner that avoids a continuous low permeability layer in the bottom of the GHP No. 2 disposal cell.

Umetco will verify by collimated field gamma survey that clay soils excavated from the GHP No. 2 liner and used for construction of the radon barrier are within a range of reasonably anticipated ^{226}Ra activities, i.e., as shown on Table 2-3, and average less than 2 pCi/g as used in the radon attenuation design. A gamma-radium correlation for the clay soil will be developed by obtaining at least six clay soil samples and associated collimated gamma measurements. In addition to continuous gamma scans, soil samples will be obtained from the constructed radon barrier at a frequency of 1 sample per 800 cubic yards which is approximately 1 sample per acre per lift of radon barrier soils. Laboratory ^{226}Ra analysis by gamma spectrometry shall be performed on each sample in accordance with Gas Hills site procedure.

1.3.3 Reclamation Cover Design

The GHP No. 2 reclamation cover consists of a 12-inch thick radon barrier layer, 54-inch thick frost protection layer, and an erosion protection layer. The reclamation cover for the GHP No. 2/Mill Area has been designed with a gentle one-percent top slope and 20 percent side slope as shown on the drawings. Depending on the final volume of soil used to solidify the remaining liquids, it may be necessary to increase the elevation of the top cover by a few feet. The hydraulic calculations provided in Section 4.0 account for the worst case cell height in the design of erosion protection materials.

2.0 RADON ATTENUATION DESIGN

This section details the radon attenuation design for the GHP No. 2/Mill Area. The reclamation cover for GHP No. 2 has been designed to limit the release of Radon (^{222}Rn) from uranium byproduct materials to a rate of 20 pCi/m^2/sec. from the surface of the cell as required by 10 CFR Part 40, Appendix A.

2.1 General

GHP No. 2 was constructed in the former mill process area at the Gas Hills site. Site characterization, studied in the summer and fall of 1995, indicate that this area contained a significant volume of contaminated soil and foundation debris that were not removed during the initial mill demolition activities at the site. Construction activities associated with constructing GHP No. 2 included removing remaining mill foundations, process facilities, and related mill utilities. However, the soil beneath the existing pond contains elevated concentrations of radionuclides, which appear to occur from both natural mineralization, and mill related impacts, i.e., elevated sulfates and high concentrations of uranium and thorium. Accordingly, Umetco has elected to reclaim the GHP No. 2/Mill Area in place with a closure cover designed and constructed in accordance with 10 CFR Part 40, Appendix A.

2.2 Cover Design

The conceptual design for closing the GHP No. 2/Mill Area was provided with the Heap Leach design approved by May 28, 1998 License Amendment 38. That conceptual design assumed a significant volume of 11e.(2) material to be placed in the cell prior to final closure. However, the sequence of reclamation activities at the site resulted in a situation in which the previously assumed volume of contaminated material may be significantly reduced.

2.3 Soil Properties/Input Parameters

The radon attenuation design for the cover was evaluated using the RADON computer code, Version 1.2, February 2, 1989. Table 2-1 is a summary of model input parameters used for the attenuation design. The following sections provide the rationale for selecting model input parameters.

2.3.1 Waste Material Input Parameters

Mass Density – The remaining pond liquids and residue will be solidified by mixing with mine spoil material, then placed and compacted within the disposal cell. The soil to be used for solidifying the remaining liquids has the same characteristics as the frost protection soils used for constructing the heap cover. These soils are clayey sand and/or silty-clayey sand and classify as SC and/or SC-SM. The maximum standard Proctor density ranges from 109 pcf to 121 pcf with optimum moisture content of 11 to 14 percent (NRC Heap Leach TER). Since the waste material placed within the disposal cell will be compacted to a minimum 95 percent standard Proctor maximum density, 95 percent of the average density (or 1.75 g/cm^3) was used for the mass dry density of waste material.

The GHP No. 2/Mill Area is underlain with the same natural soils that are beneath the adjacent Heap Leach and comprise the major portion of the upper 500 cm of waste material. Details of the adjacent subsurface geotechnical investigation are contained in Umetco's August 19, 1997 letter, referenced in LC 61. These soils consist mainly of yellowish-brown, fine-to-coarse sand and gravel, with some cobbles up to 8 inches in diameter with occasional layers/lenses of brown-to-gray silty clay and sandy clay. The sands and gravels are medium dense to very dense. The lenses of silty clay and sandy clay are very stiff. Laboratory tests for this material include moisture, density, grain size distribution, compaction and strength tests. The unit weight of the foundation soils ranges from 107 pcf to 128 pcf.

To be conservative in selecting the mass density input for the model, a value of 1.75 g/cm^3 was selected which represents 95 percent of the average density for placed and compacted material and the lower range of densities for the foundation soils.

Radium Activity – Waste material in the upper 500 cm (equivalent to infinitely thick source of radon) is comprised of a thin layer or thin concentration of soils used to solidify remaining pond liquids and the GHP No. 2 subgrade (former mill process area). Accurate determination of the ^{226}Ra activity of the placed waste materials can not be made until soil mixing has occurred and will be dependent upon the ^{226}Ra activity of the remaining liquids and mine spoil material. The residual pond liquids and residue when mixed with soil (approximately 30 to 50 gallons per

Table 2-1

SUMMARY OF RADON MODEL INPUT PARAMETERS - RUN 1

Layer No.	Thickness (cm)	Porosity	Mass Density (g/cm^3)	^{226}Ra Activity (pCi/g)	Emanation Coefficient	Moisture Content (dry wt. %)	Diffusion Coefficient (cm^2/sec)
Layer 1 - Waste	225.68	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 2 - Waste	91.44	Code Calc.	1.75	55	0.262	6	Code Calc.
Layer 3 - Waste	91.44	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 4 - Waste	91.44	Code Calc.	1.75	69	0.262	6	Code Calc.
Layer 5 - Radon Barrier	30.48	Code Calc.	1.59	2	0.20	12	Code Calc.
Layer 6 - Frost Protection	137.16	Code Calc.	1.75	10	0.262	6	Code Calc.

1) Upper 9-feet (0 cm to 274.32 cm) of waste material is divided into 3-foot segments. Waste layer 4 (274.32 cm to 500 cm) assumes the average ^{226}Ra activity from the existing subsurface data.
2) Previously approved emanation coefficient of 0.20 used for RUN 1.
3) Default (code calculated) diffusion coefficient used for all layers of waste and cover.

SUMMARY OF RADON MODEL INPUT PARAMETERS - RUN 2

Layer No.	Thickness (cm)	Porosity	Mass Density (g/cm^3)	^{226}Ra Activity (pCi/g)	Emanation Coefficient	Moisture Content (dry wt. %)	Diffusion Coefficient (cm^2/sec)
Layer 1 - Waste	225.68	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 2 - Waste	91.44	Code Calc.	1.75	55	0.262	6	Code Calc.
Layer 3 - Waste	91.44	Code Calc.	1.75	62	0.262	6	Code Calc.
Layer 4 - Waste	91.44	Code Calc.	1.75	69	0.262	6	Code Calc.
Layer 5 - Radon Barrier	30.48	Code Calc.	1.59	2	0.17	12	0.0031
Layer 6 - Frost Protection	137.16	Code Calc.	1.75	10	0.262	6	Code Calc.

1) Emanation coefficient of 0.17 used for radon barrier layer (average of 9 samples tested).
2) Diffusion coefficient of 0.0031 cm2/sec input for radon barrier layer (average value of 6 samples tested).

cubic yard of soil) is anticipated to have a relatively low radium content. Although the radium content of the placed waste material will be low (average < 50 pCi/g) the ^{226}Ra of the subgrade soils which exist beneath the existing liner will be the controlling factor in designing the reclamation cover.

The soil ^{226}Ra concentration for the former mill area soils was obtained during the 1995 characterization work conducted prior to constructing GHP No. 2 over the former mill area. Subsequent to radiological characterization of this area, GHP No. 2 was constructed, resulting in removing a portion of the soils represented by the downhole measurements. A summary of the average ^{226}Ra activity of the applicable portions, i.e., measurements which exist in the upper 500 cm, are provided in Table 2-2. Complete borehole logs showing all ^{226}Ra measurements and portions removed during construction of GHP No. 2 are provided in Appendix A. Borehole locations are shown on Figure 2-1. ^{226}Ra measurements were taken using downhole gamma logging methods at 0.5-foot intervals.

Table 2-2 Average Radium Activity

Borehole No.	Avg. ^{226}Ra of Applicable Portion (pCi/g)	Avg. ^{226}Ra of 0' - 3' (0 to 91.44 cm) (pCi/g)	Avg. ^{226}Ra of 3' - 6' (91 - 183 cm) (pCi/g)	Avg. ^{226}Ra of 6' - 9' (183 - 274 cm) (pCi/g)
MB-01	N/A			
MB-02	23.3	23.3		
MB-03	23.9	46.4	15.5	17.4
MB-04	N/A			
MB-05	20.6	24.7	21.0	18.1
MB-06	47.0	95.6	73.6	18.8
MB-07	N/A			
MB-08	N/A			
MB-09	N/A			
MB-10	30.4	30.4		
MB-11	N/A			
MB-12	N/A			
MB-13	30.4	35.3	22.4	33.7
MB-14	84.8	31.2	40.4	105.9
MB-15	12.2	12.2		
MB-16	28.0	28.0		
MB-17	49.4	61.3	41.4	22.2
MB-18	97.6	86.3	100.9	101.1
MB-19	38.8	63.2	43.6	29.7
MB-20	318.5	318.5		
MB-21	104.5	190.0	274.7	80.2
MB-22	91.7	95.9	107.7	
MB-23	56.6	49.4	54.9	65.4
MB-24	49.8	82.4	31.1	26.7
MB-25	68.6	62.9	29.1	23.3
RB-08	79.6	28.7	69.6	125.0
RB-10	N/A			
RB-12	N/A			
RB-24	22.5	34.0	16.9	11.9
	Avg. of applicable values = 61.4 pCi/g	Avg. of all segment measurements = 69 pCi/g	Avg. of all segment measurements = 62 pCi/g	Avg. of all segment measurements = 54 pCi/g

The radium concentration input is based on the average ^{226}Ra concentration in 3-foot segments for the upper 9-feet (274.32 cm) of waste material. The average of all subsurface ^{226}Ra measurements was input for the 9 feet to 16.4 feet (274.32 cm to 500 cm) layer of waste material.

Prior to cover construction, Umetco will verify the ^{226}Ra activity of the upper 500 cm below the radon barrier. Subsurface borings will be made at a density of one borehole per acre to a depth of 500 cm. Composite samples for each 3-foot segment of the borehole will be obtained with subsequent onsite laboratory analysis of ^{226} Ra.

Emanation Coefficient – As discussed above, the mine spoil material that will be utilized in solidifying residual liquids has the same physical characteristics as the frost protection soil used for constructing the Heap Leach cover. The measured emanation coefficient for this soil is 0.262. This value also coincides well with the average value for the heap filter layer, as these soils are essentially the same.

Moisture Content – The long-term moisture content of the soil used for solidification as well as the foundation soils may be impacted by the characteristics of the remaining pond liquids and former mill processing activities. Accordingly, conservative moisture content of 6 percent was included in the model.

Diffusion Coefficient – To provide a conservative model, the code calculated diffusion coefficient was used for the placed waste materials and foundation soils.

2.3.2 Radon Barrier Input Parameters

Mass Density – The mass density of the radon barrier soils was estimated from standard Proctor tests on 5 samples of clay soil used in constructing the Heap Leach radon barrier. The maximum dry density of the samples rage from 103.3 pcf to 105.7 pcf with an average of 104.28 pcf. Since the radon barrier soil will be compacted to at least 95 percent of standard Proctor maximum density, 95 percent of the average maximum density was used, i.e., 95 percent of 104.8 = 1.59 g/cm^3. This value is conservative since 95 percent of the standard Proctor density is the minimum allowable dry density accepted during placement and additional consolidation of the radon barrier will occur over time.

Radium Activity – A ^{226}Ra activity of 2 pCi/g was input for the radon barrier layer based on the average of 9 samples tested by Rodgers and Associates for the borrow source. Test results are contained in Umetco's September 25, 1996 and October 15, 1997 Heap Leach submittals and summarized in Table 2-3. The radium activity of the radon barrier soils borrowed from the existing GHP No. 2 liner will be verified as discussed in Section 1.3.2.

Table 2-3

Summary of Radon Barrier (Clay Soil) Test Results				
Sample ID	^{226}Ra (pCi/g)	Emanation Coefficient	Diffusion Coefficient (cm^2/sec)	Comment
A	1.4	0.18	0.0016	October 15, 1997 Submittal
B	2.0	0.23	0.0034	October 15, 1997 Submittal
C	1.8	0.07	0.0042	October 15, 1997 Submittal
C	1.2	0.13	0.0034	October 15, 1997 Submittal
E	2.3	0.09	0.0017	October 15, 1997 Submittal
HRE-1	3.6	0.261	Composite of 4 Samples = 0.0041	September 25, 1996 Submittal
HRE-2	2.4	0.143		September 25, 1996 Submittal
HRE-3	2.6	1.191		September 25, 1996 Submittal
HRE-4	1.9	0.207		September 25, 1996 Submittal
Average =	2.1	0.17	0.0031	
Values Selected for Modeling				
RUN 1	2.0	0.20	Code Calculation	
RUN 2	2.0	0.17	0.0031	

Emanation Coefficient – Emanation coefficient tests previously provided by Umetco's September 25, 1996 and October 15, 1997 submittals are shown on Table 2-3. An emanation coefficient of 0.20 was approved for Umetco's Heap Leach RADON models in the September 25, 1996 submittal.

Moisture Content – Capillary moisture tests were performed on 5 samples of radon barrier soil to determine the long-term moisture content of the soil. The equilibrium moisture content at 15-bars ranges from 16.1 percent to 19.7 percent with an average of 17.6 percent. NRC review (NRC Heap Leach TER) of this test data indicated that 15-bar capillary moisture tests are not always conservative for determining long-term moisture content. Subsequent modeling by NRC staff used a moisture content of 12 percent for the radon barrier soils. Accordingly, an input value of 12 percent is used for the GHP No. 2 model.

Diffusion Coefficient – To provide a conservative model, the code calculated diffusion coefficient was used for the waste material.

2.3.3 Frost Protection Input Parameters

Mass Density – The soil to be used for constructing the frost protection layer has the same characteristics as the frost protection soils used for constructing the Heap Leach cover. These soils are clayey sand and/or silty-clayey sand and classify as SC and/or SM. The maximum standard Proctor density ranges from 109 pcf to 121 pcf with optimum moisture content ranging from 11 to 14 percent (NRC Heap Leach TER). Since the frost protection soils will be compacted to 95 percent of the standard Proctor maximum density, 95 percent of the average density range (or 1.75 g/cm^3) was used for the mass dry density of the frost protection material.

Radium Activity – The radium activity input for the frost protection layer assumes the approved ^{226}Ra site-wide background value of 10 pCi/g.

Emanation Coefficient – As discussed above, the mine spoil material that will be utilized in constructing the frost protection layer has the same characteristics as the frost protection soil used for constructing the Heap Leach cover. The measured emanation coefficient for this soil is 0.262. This value also coincides well with the average value for the heap filter layer, as these soil types are essentially the same.

Moisture Content – The long-term moisture content of the soil used for solidification may be impacted by the characteristics of the pond solutions. Accordingly, conservative moisture content of 6 percent was input into the model.

Diffusion Coefficient – To provide a conservative model, the default code calculated diffusion coefficient was used for the frost protection layer.

2.4 Radon Attenuation Model Results

The radon attenuation design for the cell cover was modeled using the RADON computer code, Version 1.2, February 2, 1989. The radon attenuation model consists of two RADON models. RUN 1 provides a conservative model with the following input conditions.

- 3-foot segmented waste layers for the upper 9 feet of waste material.
- Radon barrier emanation coefficient of 0.20 as previously approved in Umetco's September 25, 1996 Heap Leach submittal.
- Conservative 12 percent long-term moisture content for radon barrier soils.

RUN 2 is provided to demonstrate the conservative attributes of the radon attenuation design by:

- input of an emanation coefficient of 0.17 for the radon barrier, which is the average of 9 samples tested, as shown on Table 2-3.
- input diffusion coefficient of 0.0031 cm^2/sec. for the radon barrier layer, which is the average of 6 samples tested as shown on Table 2-3.

The RADON models described above resulted in an exit flux of 19.40 pCi/m^2/sec. for RUN 1 and 14.30 pCi/m^2/sec. for RUN 2. The results of both of the RADON models are below the 20 pCi/m^2/sec. exit flux limit established in 10 CFR 40, Appendix A, Criterion 6. Both of the models used to evaluate the design are conservative because:

- diffusion coefficients for all waste and cover layers, except RUN 2 radon barrier, are code calculated.
- conservative 6 percent moisture content values are assumed for waste and frost protection layers.
- long-term moisture content for the radon barrier soils is assumed to be 12 percent, whereas the measured equilibrium moisture content at 15-bars for this soil ranges from 16.1 to 19.7 percent.

- radium activity for the frost protection soil assumes 10 pCi/g ^{226}Ra. Field measurements of ^{226}Ra during construction will control and verify that ^{226}Ra concentrations are less than 10 pCi/g ^{226}Ra.

3.0 GEOTECHNICAL DESIGN

This section provides the geotechnical considerations for closing the GHP No. 2 area of the Gas Hills site. Geotechnical design elements for this reclamation plan include slope stability, settlement, liquefaction, and frost penetration.

3.1 Cover Design

The GHP No. 2 reclamation cover consists of a 12-inch thick radon barrier layer, 54-inch thick frost penetration layer, and an erosion protection layer. The cover for the GHP No. 2 area has been designed with a gentle 1 percent top slope and 20 percent out slope as shown on the drawings.

3.2 Slope Stability Analysis

The long-term stability of the reclaimed GHP No. 2 embankment was evaluated using SLOPE/W, Version 5, GEO-SLOPE International Ltd. SLOPE/W is a slope stability software product that uses limit equilibrium theory to compute the factor of safety of earth and rock slopes.

3.2.1 Material Properties

The foundation and cover soil properties used in the Heap Leach analysis are the same as those that exist and are proposed for the GHP No. 2 reclamation cover. Accordingly, the material properties approved for the Heap Leach were used for the stability analysis. The following is a summary of material types and properties used for this analysis. Test results used are contained in the approved design for the Heap Leach facility and summarized in Table 3-1.

Frost Protection Soil – These soils are clayey sand and/or silty-clayey sand that classify as SC or SC-SM. The maximum standard Proctor density ranges from 109 to 121 pcf with and optimum moisture content of 11 percent to 14 percent. Consolidated undrained triaxial shear testing of these soils resulted in an average internal angle of friction (total stress) of 22 degrees and cohesion of 200 psf.

Radon Barrier Material – The clay material proposed for the radon barrier is obtained from a borrow source located 6 miles northeast of the East Gas Hills facility. Radon barrier soil generally consists of fat clays (CH) and some lean clays (CL) with generally greater than 95 percent passing the No. 200 sieve. The maximum standard Proctor density ranges from 100 to 105 psf with an optimum moisture content ranging from 19 to 22 percent. Consolidated undrained triaxial shear testing of this soil resulted in an average internal angle of friction (total stress) of 15 degrees and cohesion of 16 psf. Field hydraulic conductivity tests of this material, when compacted in place results in a coefficient of permeability of 3E-9 to 7E-9 cm/sec.

Table 3-1 Summary of Shear Strength Tests
(Data from August 19, 1997 Heap Leach Submittal)

Soil Type	Triaxial Shear Testing				Direct Shear Testing		Unit Weight	Sample ID
	Effective Stress		Total Stress					
	PHI	C	PHI	C	PHI	C	(pcf)	
Frost Protection	34	0	32	0				Sample 12
	29	175	12.5	450			125	HB-5 @ 0-3.7'
Average	31.5	87.5	22.2	225.0				
Mean	31.5	87.5	22.2	225.0				
Standard Deviation	3.54	123.7	13.8	318.2				
Use for Stability Analysis			22	200			125	
Radon Barrier	23.2	141.1	14.8	112.3			120	Sample No. A
	21.4	36	14.1	15.8			119	Sample No. B
	24.3	14	15	7.2			120	Sample No. C
	22.7	154	14.8	66.2			119	Sample No. D
	26	14.4	16.1	7.2			120	Sample No. E
Average	23.5	71.9	15.0	41.7			120	
Mean	23.2	36.0	14.8	15.8			120	
Standard Deviation	1.73	69.8	0.7	46.5			1	
Use for Stability Analysis			15	16			120	
Foundation					24.1	1700	128	DH2-11
					18.1	2200	128	DH2-12
					23.6	1800	119	DH2-13
					21.1	1100	112	DH3-2
					21.9	1100	112	DH3-3
					31.9	300	111	DH3-5
					20.5	1050	112	DH3-6
					21.5	1100	107	DH3-7
					18.3	1400	111	DH4-9
Average					22.3	1306	116	
Mean					21.5	1100	112	
Standard Deviation					4.1	549	8	
Use for Stability Analysis					20	1100	112	

Pond Contaminated Soil – Residual liquids and sludges in GHP No. 2 will be solidified using frost protection soil. To provide a conservative analysis, a unit weight of 115 pcf, internal angle of friction of 15 degrees, and cohesion of 0 were assumed for this analysis.

Foundation Materials – The GHP No. 2 site is underlain with natural soils consisting mainly of yellowish-brown, fine-to-coarse sand and gravel, with some cobbles up to 8 inches in diameter, with occasional layers/lenses of brown-to-gray silty clay and sandy clay. The sands and gravels are medium dense to very dense. The lenses of silty clay and sandy clay are very stiff. Laboratory tests for this material include moisture, density, grain size distribution, compaction and direct shear strength tests. A unit weight of 112 pcf, friction angle of 20 degrees, and cohesion of 110 psf were used for the foundation material.

3.2.2 Model Results

Factors of Safety (FS) against failure of the slope for seismic and static loading conditions were evaluated. The NRC has completed the seismic design evaluation of Umetco's Gas Hills site. The seismic coefficient selected by the NRC for the site was based on the June 26, 1994 LLNL report "Seismic Hazard Analysis of Title II Reclamation Plans." A PGA of 0.3g resulting from the maximum credible earthquake (i.e., deterministic method 1-sigma PGA) was used. As recommended in the NRC Standard Review Plan (SRP), a horizontal seismic coefficient equal to two-thirds of the PGA or 0.2g has been determined appropriate for pseudostatic analysis at this site.

The minimum safety factor was determined for the maximum section of the GHP No. 2 embankment and cover. The methods chosen for use in this analysis include Spencer, Ordinary Fellenius, Bishop, and Janbu. Interactive searches determined the most critical failure surface on each of the sections analyzed. Table 3-2 provides the results of this analysis and the minimum factor of safety established for long-term stabilization of the embankment.

Table 3-2 Results of Slope Stability Analysis

Analysis Method	Static (FS minimum = 1.5)		Pseudostatic (FS minimum = 1.0)	
Ordinary	2.77	---	1.34	---
Bishop	2.82	---	1.36	---
Janbu	---	2.76	---	1.34
Spencer	2.82	2.82	1.36	1.36

3.2.3 Model Graphics

Sheet 2 of 5 of the drawings, Section CC', shows the location of the maximum section selected for the stability analysis. Graphical stability model results are shown in Figures 3-1 and 3-2.

3.3 Settlement and Cover Cracking

The GHP No. 2 site is underlain with natural soils consisting mainly of yellowish-brown, fine-to-coarse sand and gravel, with some cobbles up to 8-inches in diameter, with occasional layers/lenses of brown-to-gray silty clay and sandy clay. The sands and gravels are medium to very dense. The lenses of silty clay and sandy clay are very stiff.

As discussed in Section 1.3.2, once the lining materials are removed, residual pond liquids and waste materials will be solidified with local mine overburden soils. These soils consist of clayey sand and/or silty-clayey sand that mostly classify as SC or SC-SM. Solidified soils will be placed and compacted to a minimum 95 percent of the standard Proctor density at a moisture content of less than 3 percent above optimum.

Since all residual pond liquids and residue will be mixed with mostly granular (SC-SM) soil and compacted prior to cover construction, long-term (time dependent) settlement will be very low or negligible. Additional loading from cover construction will likely result in settlement. However, this is expected to be mostly instantaneous settlement that will occur during cover placement and is not expected to have any adverse impact on the cover. Therefore, there is no potential for cracking of the radon barrier as a result of settlement.

3.4 Liquefaction

The closed disposal cell will consist of a low permeability reclamation cover, unsaturated compacted waste material underlain by natural foundation soils. The water table below the site is very deep (approximately 100 feet) and the pond lining system will be removed as discussed in Section 1.3.2, to prevent a potential "bathtub" condition within the cell.

For liquefaction to occur, a soil must be saturated, loose, and cohesionless. The pond waste material will be compacted, granular material in an unsaturated condition, and is therefore not susceptible to liquefaction. The foundation materials, SC-SM, are in a dense unsaturated state and are also not susceptible to liquefaction.

3.5 Frost Protection

Frost penetration models for this cover configuration have previously been reviewed and accepted by the NRC for the Heap Leach, Above-Grade, and A-9 disposal cells. Since the cover soils for the GHP No. 2 area are the same, a frost penetration depth of 54-inches has been incorporated into the final cover design.

4.0 EROSION PROTECTION

This section provides design details associated with surface water hydrology and erosion protection for the GHP No. 2 area of the Gas Hills site.

The final configuration of the GHP No. 2 reclamation cover has been modified from the conceptual design provided in the approved Heap Leach design. The adjacent reclamation designs, i.e., Heap Leach and Above-Grade Tailings, are not affected by the modifications to the GHP No. 2 cover design.

4.1 Design Storm

The hydrologic basis for design of erosion protection of the GHP No. 2 area is the probable maximum precipitation (PMP) event computed for the Gas Hills site. A PMP rainfall depth of 9.3 inches in one hour has been accepted (NRC TER, Umetco Heap Leach Reclamation Plan, Amendment 38 to SUA-648, May 28, 1998) to estimate PMFs for small drainage areas associated with the Gas Hills site. This estimate was developed using Hydrometeorological Report (HMR) 55A.

4.2 Erosion Protection Design

The erosion protection design for the GHP No. 2 reclamation cover is based on four finished-grade surface profiles as shown on Figure 4-1. The surface profiles were selected to depict flow paths on the final surface configuration, which would result in maximum discharges off of the reclamation cover. Each surface profile has been divided into segments that identify slope change. Table 4-1 provides a summary of slope profiles, slope lengths and elevation changes used in the erosion protection design.

Table 4-1 Summary of Flow Segments

Profile 1	Length (feet)	Height (feet)	Slope (%)
Segment 1 - Top Slope of Heap	520	3	0.58
Segment 2 - Heap Side Slope	210	42	20
Segment 3 - GHP No. 2, Top Slope	390	3.9	1
Segment 4 - GHP No. 2, Out Slope	110	22	20
Segment 5 - GHP No. 2, Toe Apron	36	6	17
Profile 2	**Length (feet)**	**Height (feet)**	**Slope (%)**
Segment 1 - GHP No. 2, Top Dike	10	0.1	1
Segment 2 - GHP No. 2, Dike Out Slope	80	16	20
Segment 3 - GHP No. 2, Top Slope	600	6	1
Segment 4 - GHP No. 2, Out Slope	150	30	20
Segment 5 - GHP No. 2, Toe Apron	36	6	17
Profile 3	**Length (feet)**	**Height (feet)**	**Slope (%)**
Segment 1 - GHP No. 2, Top Dike	10	0.1	1
Segment 2 - GHP No. 2, Dike Out Slope	55	11	20
Segment 3 - GHP No. 2, Top Slope	810	8.1	1
Segment 4 - GHP No. 2, Out Slope	180	36	20
Segment 5 - GHP No. 2, Toe Apron	36	6	17
Profile 4	**Length (feet)**	**Height (feet)**	**Slope (%)**
Segment 1 - GHP No. 2, Top Dike	10	0.1	1
Segment 2 - GHP No. 2, Dike Out Slope	55	11	20
Segment 3 - GHP No. 2, Top Slope	810	8.1	1
Segment 4 - GHP No. 2, Out Slope	50	10	20
Segment 5 - GHP No. 2, Toe Apron	36	6	17

Unit width peak flow rates were calculated for each surface profile using procedures recommended in Draft NUREG-1623. Peak flow rates were conservatively estimated using PMP of 9.3 inches and a runoff coefficient of 1.

Erosion protection rock size calculations were made for each flow segment using the Stephenson Method for slopes greater than 10 percent and the Safety Factors Method for slopes less than 10 percent. Table 4-2 provides a summary of erosion protection design calculations. Detailed hydrology and riprap size calculations are provided in Appendix B.

Table 4-2 Summary of Erosion Protection Design Calculations

Flow Segment	Profile 1	Profile 2	Profile 3	Profile 4
Flow Segment 2 - Dike Out Slope				
D_{50} Calculated (inches)	N/A	1.17	0.94	0.94
D_{50} Specified (inches)	N/A	3	3	3
Layer Thickness (inches)	N/A	6	6	6
Interstitial Flow (feet/second)	N/A	0.69	0.69	0.69
Bedding Layer	N/A	No	No	No
Flow Segment 3 - Top GHP No. 2 Cover				
D_{50} Calculated (inches)	0.5	0.5	0.5	0.5
Safety Factor	1.04	1.15	1.06	1.06
Layer Thickness (inches)	6	6	6	6
Interstitial Flow (feet/second)	0.49	0.49	0.49	0.49
Bedding Layer	No	No	No	No
Flow Segment 4 - 5(H):1(V) Out Slope				
D_{50} Calculated (inches)	3.92	3.66	4.00	3.73
D_{50} Specified (inches)	6	6	6	6
Layer Thickness (inches)	10	10	10	10
Interstitial Flow (feet/second)	0.99	0.99	0.99	0.99
Bedding Layer	3" Type A	3" Type A	3" Type A	3" Type A
Flow Segment 5 - 6(H):1(V) Toe Apron				
D_{50} Calculated (inches)	3.23	3.03	3.30	3.73
D_{50} Specified (inches)	6	6	6	6
Layer Thickness (inches)	10	10	10	10
Interstitial Flow (feet/second)	0.90	0.90	0.90	0.99
Bedding Layer	3" Type A	3" Type A	3" Type A	3" Type A

4.2.1 Layer Thickness

Erosion protection layer thickness was determined using criteria in Draft NUREG-1623 which recommends a layer thickness of not less than 1.5 times the median stone diameter (D_{50}) or the maximum stone size (D_{100}), whichever is greater. The design thickness for the erosion protection materials is shown in Table 4-2.

4.2.2 Scour Depth and Toe Apron

Umetco has previously conducted and submitted (August 19, 1997) an extensive geomorphic investigation of gullying in site area to determine expected depths of gullying that would occur, based on drainage areas and other conditions. It was determined that the maximum depth of gullying in the site area is about 6 feet, for gullying with significant associated drainage areas. The NRC (NRC TER, Umetco Heap Leach Reclamation Plan, Amendment 38 to SUA-648, May 28, 1998) subsequently accepted this value. Accordingly, the toe aprons for the GHP No. 2 cover have been extended to a depth of 6 feet.

The buried embankment toe apron for GHP No. 2 consists of a 17 percent (6(H):1(V)) slope. In this configuration, the maximum D_{50} calculated at the toe of the 20 percent embankment slope is 4.00 inches and at the toe of the buried 17 percent apron is 3.7 inches. The specified erosion protection for this application has a minimum D_{50} of 6 inches, which results in a 33 percent oversizing of the riprap at the most critical area of the apron toe. Using 3 times the nominal

calculated D_{50} at the toe of the buried apron, i.e., 3.3 inches x 3 = 9.9 inches, a layer thickness of 10 inches is adequate considering the oversizing of the erosion protection layer. Draft NUREG-1623 indicates that if embankment flows discharge onto relatively flat ground with little or no potential for gully intrusion, the embankment toe only needs to be about 50 percent larger than the sideslope. The buried apron will be backfilled with soils compacted to 95 percent standard Proctor density and graded to a flat slope in accordance with the site wide grading plan. The specified erosion protection has a D_{50} range of 6 inches to 9 inches. Consequently the proposed design provides a riprap about 50 percent larger than the maximum calculated D_{50} for this application.

4.2.3 Filter Requirements

Filter requirements for erosion protection has been evaluated by computing the interstitial flow velocity at the soil/rock interface using the procedure presented in Draft NUREG-1623. For the GHP No. 2 design, the calculated interstitial velocities become critical for the 20 percent out slope and toe apron. Accordingly, a 3-inch thick layer of Type A (D_{50} = 0.5 inch) will be used as a bedding layer below the Type C (D_{50} = 6 inch) erosion protection material.

4.2.4 GHP No. 2 Channel

This section describes the erosion protection design for the GHP No. 2 channel, located between the Above-Grade Tailings embankment and the GHP No. 2 cell. The channel receives flows from a portion of the Above-Grade Tailings embankment to prevent flows from impacting the GHP No. 2 cover.

The peak channel discharge was computed assuming a 9.3 inch PMP event over the 17.5-acre drainage basin as shown on Figure 4-1. The peak flow rate for the GHP No. 2 channel was computed using the Rational Formula, which resulted in a peak flow rate of 700 cfs.

Erosion protection rock size for the channel was evaluated for the upper 1 percent sloping channel segment using the Safety Factors Method. Rock size for the 10 percent out slope and buried apron was determined using the Stephenson Method. Results of these calculations are summarized in Table 4-3. Detailed calculations are provided in Appendix B.

Table 4-3 Summary of Channel Erosion Protection Design Calculations

Flow Segment	Channel Slope	Channel Width	Minimum D_{50}	Specified D_{50}
Segment 1	1% or 0.01 ft/ft	100-feet	2.4 inches	3 inches
Segment 2	10% or 0.1 ft/ft	200-feet	4.75 inches	6 inches

Interstitial flow velocities were evaluated for both channel segments. The interstitial velocity for segment 1 was calculated at 0.14 feet per second which is substantially less than 0.5 feet per second recommended for a bedding/filter layer requirement (Draft NUREG-1623). The interstitial flow velocity of the 10(H):1(V) channel out slope and buried apron is 0.68 feet/second. Accordingly, a 3-inch thick bedding layer of Type A (D_{50} = 0.5 inch) will be placed on the channel out slope and buried apron.

Flows discharging into the channel from the Heap Leach and Above-Grade Tailings embankment covers have very shallow flow depths but a relatively high interstitial flow velocity of 0.55 feet/second at the toe of the slope. The calculated D_{50} size of the riprap at the toe of the

slope is 1.74 inches. The specified Type B erosion protection has a minimum D_{50} of 3 inches, indicating a minimum 42 percent oversizing at the toe of the slope. Since the interstitial flow velocity at this point is in excess of 0.5 feet/second, the design provides a bedding layer for the channel sideslope extending into the channel bottom a distance of 15 feet as shown on Sheet 4 of 5 of the drawings.

4.2.5 Erosion Protection Gradations

The following gradations are specified for use as erosion protection for the GHP No. 2 closure cover.

Table 4-4 Erosion Protection Gradation Requirements

Type A (D_{50} = 0.5")		Type B (D_{50} = 3")		Type C (D_{50} = 6")	
Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing
3"	100	6"	100	10"	100
1.5"	60 - 100	5"	50 - 100	9"	50 - 100
1"	40 - 100	4"	30 - 100	8"	20 - 100
3/4"	20 - 100	3"	0 - 50	6"	0 - 50
1/2"	5 - 50	2"	0 - 15	4"	0 - 15
3/8"	0 - 25				
No. 4	0 - 5				

4.2.6 Sedimentation

Sedimentation of diversion channels can be a significant problem primarily because diversion channels are usually designed to a milder slope than natural channels resulting in sediment deposition. For the GHP No. 2 channel design, all drainage basins contributing to channel flows are on the reclaimed Heap Leach and Above-Grade embankments. The reclamation covers for these embankments have been constructed with erosion protection designed for PMF flow conditions. Consequently, there is no source of sediment in the drainage basin, which contributes flows to the GHP No. 2 channel.

5.0 GHP No. 2 RECLAMATION SPECIFICATIONS

This section details the construction specifications for reclamation construction.

All work shall be in accordance with these specifications, the reclamation plan drawings, and shall be documented in accordance with the Quality Control Plan described in Section 6.0.

Work shall be conducted in compliance with Umetco's Health and Safety Plan, NRC License SUA-648, and applicable site procedures. Materials and products used shall be as specified herein for services intended. The method used in performance of the work shall produce satisfactory results for the services intended and shall be in accordance with standard construction industry practices.

5.1 Scope of Work

The scope of work consists of the following:

- Solidifying remaining liquids and evaporative residue.
- Removing, disposing, and utilizing existing pond lining system.
- Reclamation cover construction.

5.1.1 Specifications and Drawings

Technical specifications and construction drawings for reclaiming the GHP No. 2 area are provided herein. The construction drawings are attached to the specifications. Anything mentioned in the specifications and not shown on the drawings, or shown on the drawings and not detailed in the specifications, shall be of like effect as if showing and detailed in both.

5.2 Liner Removal

The existing GHP No. 2 liner consists of the following components:

- Primary (top) Liner - 60 mil High-Density Polyethylene (HDPE) geomembrane.
- Leachate Collection/Leak Detection Layer - HDPE geonet with transmissivity of 3E-4 m^2/sec or higher.
- Secondary (bottom) Liner - two component composite liner consisting of an upper 60-mil HDPE geomembrane and lower layer of compacted clay soil (18-inches in thickness) with hydraulic conductivity of less than 1E-7 cm^3/sec.

The bottom of the evaporation pond is constructed at a one-percent slope to a central point at the west end where the leachate collection/leak detection facilities are located. Umetco does not anticipate a significant volume or thickness of post-evaporation residue remaining on the synthetic liner as indicated by portions of the liner currently exposed.

The liner removal process shall be accomplished in a manner that prevents potential contamination of the clay portion of the liner. The synthetic portion of the liner in the upper (east end) of the pond will be removed first. Exposed clay liner material in this area will then be verified to ensure soil is uncontaminated, then excavated and placed as radon barrier soils on the side slopes of the GHP No. 2 embankment as specified in Section 5.4. After the clay soils have been removed, the upper portion of the pond area will be used for soil mixing of remaining pond liquids as discussed below.

5.2.1 Solidifying Remaining Liquids

Remaining liquid wastes will be solidified by mixing with soils obtained from local borrow sources. This process shall be accomplished by pumping remaining liquids from the lower pond area to a designated stockpile in the upper portion of the pond. Local borrow soils will be mixed with remaining pond solutions to a point which does not exceed a soil moisture content that prohibits compaction of the soil at 95 percent of standard Proctor density. Once the liquids have been solidified and the remaining pond liner removed, the material will be placed in a thin layer between the existing pond subgrade and the bottom of the GHP No. 2 reclamation cover and compacted to 95 percent standard Proctor density (ASTM D 698) as shown on the drawings.

5.2.2 Disposing of Synthetic Lining Materials

All synthetic lining materials and debris removed from the GHP No. 2 pond shall be shredded into pieces not exceeding 3 feet in width and 20 feet in length. Synthetic materials shall be placed with compacted soils used to solidify remaining pond liquids.

5.3 Site Grading

Required lines, levels, contours, and datum locations shall be identified in the field. Survey benchmarks and intended elevations for the work shall be verified before grading begins.

Subgrade fill at densities lower than the specified minimum density for subsequent fill placement shall be worked to meet the density requirements or removed and replaced by acceptable fill compacted to meet the specified compaction.

5.4 Radon Barrier

This section covers placement of the radon barrier layer of the reclamation cover.

5.4.1 Materials

Clayey soils for constructing the radon barrier layer has been borrowed from a permitted borrow source and stockpiled on site. The Cody shale (claystone) material contained in the stockpile shall be conditioned prior to excavation for placement in the radon barrier. The moisture content of the material shall be within 2 percent of the specified moisture prior to placement.

Conditioning of this material shall (at a minimum) require application of water, disking and desiccation to the extent necessary to provide a homogeneous borrow material prior to excavation and placement. Soils used in constructing the radon barrier shall conform to the following physical requirements:

- At least 50 percent passing the No. 200 sieve.
- Maximum particle size of 1 inch.
- Liquid limit of the material shall be at least 25 percent with a minimum plasticity index of 10.
- Maximum hydraulic conductivity of 1E-7 cm/sec when compacted to 95 percent of maximum standard Proctor density (ASTM D 698).

5.4.2 Placement

Radon barrier (clayey soil) shall be placed in equal continuous layers not exceeding 6 inches compacted thickness and shall be compacted to a minimum of 95 percent of the maximum standard Proctor density (ASTM D 698), at a moisture content of between optimum moisture content and 4 percent above optimum moisture content.

The placement areas and thickness for the radon barrier layer are shown on the drawings. Distribution and gradation of materials in each layer will be, as far as practicable, free of lenses,

pockets, streaks, or layers of material differing substantially in texture, gradation or moisture content from surrounding materials.

Compacting radon barrier soils shall be accomplished using tamping foot (sheepsfoot) roller. In placing the first lift of radon barrier material, care shall be taken to avoid mixing of underlying radiologically contaminated soils. The top surface of the compacted final lift of the radon barrier shall be bladed to the uniform and smooth grades established on the drawings or as modified by the engineer in the field.

If the compacted surface of any layer or fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it will be moistened and/or reworked with a harrow, scarifier, or suitable equipment, to a sufficient depth to provide relatively uniform moisture content and a satisfactory bonding surface before the next layer of fill is placed. If the compacted surface of any layer of the placed material is too wet to obtain the specified compaction of the fill material to be placed thereon, the material shall be allowed to dry out, reworked, or scarified to reduce the moisture content and recompacted to the specified density.

Fill soils shall not be placed when the subgrade is frozen, or when ambient temperatures do not permit placement or compaction of fill material to the specified density without developing frost lenses in the fill.

Construction surfaces, including lift surfaces, shall be protected from desiccation prior to placing subsequent lifts or frost protection materials.

The top of the radon barrier layer shall be graded to within +0.1 foot of the design grade shown on the drawings or as modified by the engineer in the field. The in-place thickness of the radon barrier layer shall be equal to or greater than 100 percent of the design thickness shown.

5.5 Frost Protection Layer

This section covers placement of the frost protection layer of the reclamation cover.

5.5.1 Materials

The frost protection layer of the cover extension shall be constructed with soils obtained from local mine spoil borrow sources. Suitable materials obtained from the borrow sources shall consist of clayey and/or silty sand, classified as SC and/or SC-SM, in accordance with the Unified Soil Classification System. Soils used for constructing the frost protection layer shall be free of brush, roots, sod, lumps or rocks larger than one-half of the lift thickness, or other perishable or unsuitable materials.

A significant volume of soils obtained from mine spoil borrow sources at the site have radiological characteristics which are naturally occurring but unsuitable for cover construction. Umetco will continuously monitor borrow excavations in the field. The radiological and characteristic suitability of borrow materials will be determined on a load-by-load basis. For the most part, radiologically elevated (naturally occurring) materials which are present in borrow areas, occur in isolated ponds and at times small clusters of loosely cemented rock. Upon initial scanning of this material it may appear that radiologically elevated materials are wide spread and

unsuitable for cover construction while post-handling measurements may indicate that the radiological characteristics of the material are suitable. Unsuitable materials excavated within the borrow area shall not be used for reclamation cover construction and will be incorporated into mine reclamation activities.

5.5.2 Placement

Frost protection soils shall be placed in equal continuous layers not exceeding 12 inches compacted depth and compacted to a minimum of 95 percent of maximum standard Proctor density (ASTM D 698), at a water content above minus 2 percent of optimum.

The placement areas and thickness for the frost protection layer are shown on the drawings. Distribution and gradations of materials in each layer will be, as far as practicable, free of lenses, pockets, streaks, or layers of material differing substantially in texture, gradation, or moisture content from surrounding materials.

If the compacted surface of any layer of fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it will be moistened and/or reworked with a harrow, scarifier, or other suitable equipment to a sufficient depth to provide a relatively uniform moisture content and a satisfactory bonding surface before the next layer of earthfill is placed.

No material will be placed in the fill layer when subgrade soils are frozen or when ambient temperatures do not permit placement or compaction of soils to the specified density without developing frost lenses in the fill.

The top of the frost protection layer shall be graded to within +0.1 foot of the design grade shown on the drawings or as modified by the engineer in the field. The in-place thickness of the frost protection layer shall be equal to or greater than 100 percent of the design thickness shown.

5.6 Erosion Protection

Erosion protection materials shall be obtained from Umetco's Rattlesnake Quarry located approximately 6 miles east of the Gas Hills site. Erosion protection materials from this quarry site have been approved for use as erosion protection for repositories at the Gas Hills site, i.e., Above-Grade Tailings, A-9 Repository, Heap Leach.

5.6.1 Quality Requirements

Umetco will perform quality control testing of erosion protection material to insure and provide the necessary documentation that processed material meets the durability and gradations requirements specified herein.

Erosion protection materials will initially be tested when each type of material is produced. Thereafter, the testing shall be performed at a minimum frequency of one test for each 10,000 cubic yards or fraction thereof produced or placed.

The required quality control tests are shown in Table 5-1. The scoring criterion to determine rock quality is shown in Table 5-2.

Table 5-1 Required Quality Control Tests

Gradation	ASTM C117, ASTM C136
Specific Gravity (Saturated Surface Dry)	ASTM C127
Absorption	ASTM C127
Sodium Sulfate Soundness	ASTM C88 (5 cycles)
Abrasion	ASTM C131 (100 revolutions)
Schmidt Rebound Hardness	ISMR Method
Petrographic Examination	ASTM C295

The score for each test will be determined by multiplying the appropriate weighting factor by the score (0 to 10) based on the specific test result. The final score for each sample is the ration of the sum of the individual test scores (five tests) to the maximum possible score, expressed as a percentage. To be acceptable, the final score must be no less than 80 percent for riprap material.

Umetco's quality control staff will continuously inspect the quarried material prior to final processing of the material and shall notify the contractor of potential problematic durability issues.

Table 5-2 Erosion Protection Scoring Criteria

Laboratory Test	Weighting Factor			Score										
				10	9	8	7	6	5	4	3	2	1	0
	Limestone	Sandstone	Igneous	Good				Fair			Poor			
Sp. Gravity	12	6	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.40	2.25
Absorption, %	13	5	2	0.10	.30	.50	.67	.83	1.0	1.5	2.0	2.5	3.0	3.5
Sodium Sulfate, %	4	3	11	1	3	5	6.7	8.3	10	12.5	15	20	25	30
L/A Abrasion (100 revs), %	1	8	1	1	3	5	6.7	8.3	10	12.5	15	20	25	30
Schmidt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	0

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

5.6.2 Gradation Requirements

Erosion protection (rock riprap) materials shall be reasonably well graded within the limits presented in Table 5-3. The sizes are specified in terms of square opening of U. S. Standard Sieves or by the nominal sizes of the materials.

Table 5-3 Erosion Protection Gradation Requirements

Type A (D_{50} = 0.5")		Type B (D_{50} = 3")		Type C (D_{50} = 6")	
Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing
3"	100	6"	100	10"	100
1.5"	60 - 100	5"	50 - 100	9"	50 - 100
1"	40 - 100	4"	30 - 100	8"	20 - 100
3/4"	20 - 100	3"	0 - 50	6"	0 - 50
1/2"	5 - 50	2"	0 - 15	4"	0 - 15
3/8"	0 - 25				
No. 4	0 - 5				

5.6.3 Erosion Protection Placement

This section covers construction (placement) of the erosion protection layer(s) portion of the reclamation covers and associated hydraulic structures, e.g., toe aprons, channels, etc., for the GHP No. 2 area.

5.6.3.1 Subgrade Preparation

Surfaces to be prepared for placing erosion protection shall be cleared of rubbish and any deleterious material. Prior to placing erosion protection materials, the subsurface shall be graded to within +0.1 foot of the final design grade established on the drawings or as modified by the engineer in the field. All surfaces prepared to receive erosion protection materials and/or bedding material shall be proof rolled with a smooth drum roller or approved equivalent. A designated representative of the QC staff shall witness proof rolling. Damage to the prepared subgrade by construction activities or erosional forces, i.e., storm runoff, etc., shall be repaired in accordance with these specifications prior to placing erosion protection materials.

Frozen or unsuitable materials shall not be used for subgrade preparation. Preparing the subgrade surface shall occur when ambient temperatures permit adequate grading and proof rolling of the subgrade. Placing erosion protection materials shall not be allowed when snow is present on the subgrade.

5.6.3.2 Placement and Compaction

Erosion protection materials shall be placed to the lines and grades established on the drawings or as established by the engineer in the field.

Type A erosion protection also serves as bedding material for the larger riprap as shown on the drawings. Type A erosion protection shall be placed and graded to the designated lift thickness and shall be rolled with a smooth drum roller or approved equivalent.

Erosion protection materials shall be handled, loaded, transported, stockpiled, and placed in a manner that avoids nonconformance with the specifications due to segregation and degradation, including materials moved to and from stockpiles. Various placement methods used by the contractor that tend to segregate particle sizes within the layer will not be permitted.

Erosion protection material, up to a maximum nominal size of 12-inches, may be placed by end dumping and spread by bulldozer, hydraulic excavator, or approved equivalent. Dumped riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the bedding material or subgrade. The finished erosion protection layer shall be free from pockets of small stones and clusters of larger stones. Placing stone by dumping into chutes or by similar methods will likely cause segregation of the various sizes and will not be permitted. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry, by controlled dumping of successive loads during final placement, or by other methods of placement that produce the specified results. Rearranging of individual stones by mechanical equipment or by hand may be required to the extent necessary to obtain a well-keyed and reasonably well graded distribution of stone sizes as specified above. Larger pieces of riprap may require individual placement. Hand arrangement will be required only to the extent necessary to secure acceptable results. Stones shall be selected and positioned so as to produce an essentially solid, densely placed face of rock with all stones firmly wedged in place. Any stones that are not firmly wedged shall be adjusted and additional selected stones inserted or existing stones replaced to achieve solid interlock.

Each layer of erosion protection materials shall be track-walked by two passes of Caterpillar D6 bulldozer, smooth drum roller, or approved equivalent. Erosion protection materials shall be spread in a manner that will achieve full coverage and a uniformly distributed well-keyed, densely placed layer.

Construction equipment other than spreading and compaction equipment shall not be allowed to move over the placed erosion protection and bedding layers except at equipment crossovers as designated by the QC representative.

5.6.3.3 Tolerances

The erosion protection (riprap) layers shall be placed to the limits and thickness shown on the drawings and within the following tolerances.

1) The top of the frost protection or subgrade shall be within $\pm$ 0.1 foot of the design elevation or grade established on the drawing or as modified by the engineer in the field.
2) The thickness of erosion protection and bedding layers shall be no less than 90 percent of the design thickness shown on the drawings.
3) Local irregularities not exceeding the tolerances above will be permitted, provided that such irregularities do not form mounds, ridges, swales, or depressions that in the opinion of the QC Officer could cause concentrations of surface runoff.

6.0 QUALITY CONTROL PLAN

This section details the quality control and quality assurance activities to be performed for reclaiming the GHP No. 2 area.

The objectives of the quality control plan are to effectively control the quality of work performed, to verify that construction activities are performed in accordance with the approved plans and specifications, and provide adequate checks and audits to assure proper implementation of the quality control activities. Proper implementation of these activities will provide detailed documentation of the project and assure construction reclamation activities have been performed in accordance with the approved plans and specifications.

6.1 Quality Control/Quality Assurance Personnel

Quality control activities shall be implemented and managed by the QC Officer. These activities include field sampling, construction inspection, field testing, and laboratory testing. The QC Officer, appointed by the engineer, shall supervise field and laboratory QC technicians and control documentation of construction and quality control activities. The QC Officer shall have the specific authority and responsibility to reject work or material, to stop work, to require removal or placement, to specify and require appropriate corrective actions if it is determined work is not in conformance with the approved plans and specifications.

Quality assurance activities shall be implemented by the QA Officer who is an independent consultant and/or Umetco technical staff member with expertise in a specific aspect of reclamation work being performed. Quality assurance functions include pre-qualification of QC personnel, verification of test procedures and results, equipment checks, and review of calculations and associated documentation.

6.2 Test Procedures and Documentation

QC procedures and report forms have been developed, approved, and utilized for reclamation activities associated with Gas Hills disposal cells, i.e., Above-Grade Tailings, Heap Leach, and A-9 Repository. These procedures and report forms (summarized below) will be used in the QC activities for the GHP No. 2 area. Table 6-1 summarizes previously approved test procedures. Table 6-2 provides a summary of QC forms to be used in documenting QC sampling, testing, and inspection activities. Modification to these procedures and forms (from those previously reviewed and accepted) will be made only to the extent that reflects modification of ASTM standards or enhances/clarifies documentation associated with construction inspection and testing activities.

Table 6-1 Summary of QC Test Procedures

Procedure No.	QC Procedure Title
QC GHP - 1	Field Inspections
QC GHP - 2	Sampling of Aggregates and Soils
QC GHP - 3	Field Description of Soils
QC GHP - 4	Particle Size Analysis
QC GHP - 5	Size Analysis of Soil Finer Than No. 200 Sieve
QC GHP - 6	Moisture Content of Soils
QC GHP - 7	Atterberg Tests
QC GHP - 8	Soil Classification for Engineering Purposes
QC GHP - 9	Laboratory Compaction Test
QC GHP - 10	In-Place Density Tests
QC GHP - 11	Compacted Soil Layer Thickness
QC GHP - 12	Particle Size Analysis of Natural and Man-Made Riprap Materials
QC GHP - 13	Rock Protection Layer Thickness

Table 6-2 Summary of QC Test and Inspection Forms

Form No.	QC Form Title
F-1	Construction Activities Report
F-2	Soil Sampling Log
F-3	Gradation Analysis Worksheet
F-4	Gradation Analysis with Hydrometer Worksheet
F-5	Gradation Test Results
F-6	Moisture & Density Worksheet
F-7	Atterberg Limits 1-Point Worksheet
F-8	Atterberg, -200, Moisture Density Worksheet
F-9	Atterberg Limits 3-Point Worksheet
F-10	Summary of Laboratory Tests
F-11	Field Density (Sand Cone, Balloon)
F-12	Laboratory Compaction Test
F-13	Rock and Moisture Correction Calculations
F-14	Moisture-Density Relationships - 1
F-15	Moisture-Density Relationships - 2
F-16	Nuclear Test Data
F-17	Grouting Logs
F-18	Compliance Report
F-19	Field Change Order
F-20	Design Change Order

6.3 Test Frequencies

The minimum test frequencies performed as part of the QC program are detailed below in Table 6-3.

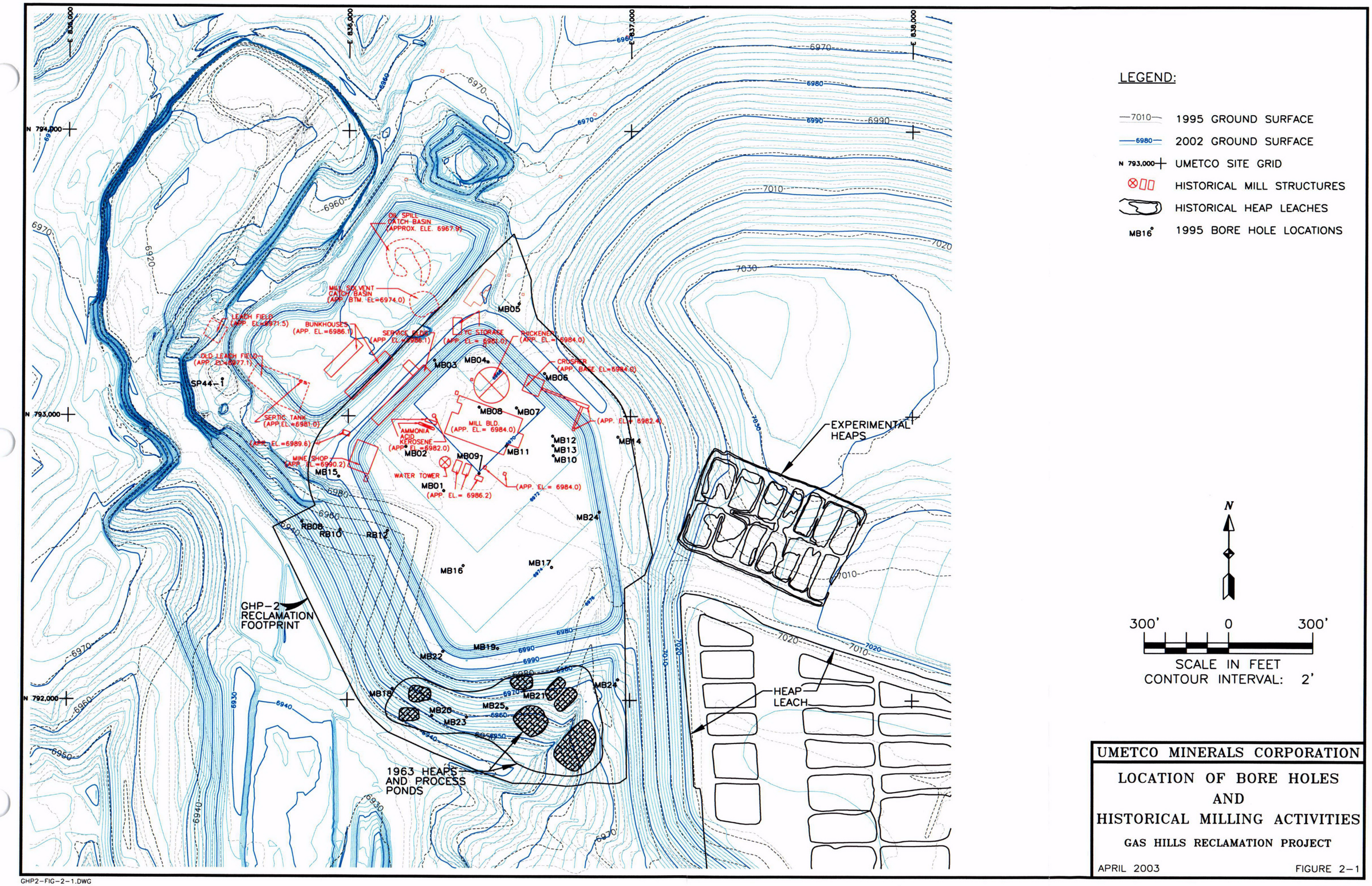
Table 6-3 Minimum Test Frequencies

Test	Procedure	Standard	Frequency
Radon Barrier, Frost Protection Layer and Erosion Protection			
Field Moisture and Density	QC GHP - 10	ASTM D2922 ASTM D3017	1 test per 500 CY
Sand Cone Correlation	QC GHP - 10	ASTM D1556 ASTM D2216	1 test for every 10 nuclear gauge tests
Laboratory Compaction	QC GHP - 9	ASTM D698	1 test for every 10 or 15 field tests depending on variability of soils.
Soil Classification • Particle Size Analysis • Atterberg Limits	QC GHP - 7 QC GHP - 8 QC GHP - 12	ASTM D2487 ASTM D4318 ASTM D1140 ASTM D422	1 test per 1000 CY
^{226}Ra Activity [1)]	Gamma Spectrometry		1 Test per 800 CY
Rock Durability • Gradation • Specific Gravity (SSD) • Absorption • Sodium Sulfate (5 cycles) • Abrasion (100 rev) • Schmidt Hardness • Petrographic Analysis	QC GHP - 12	 ASTM C117,C136 ASTM C127 ASTM C127 ASTM C88 ASTM C131 ISMR Method ASTM C295	1 test per 10,000 CY
Subgrade, Waste Soils, Grading			
Field Moisture and Density	QC GHP - 10	ASTM D2922 ASTM D3017	1 test per 1000 CY
Sand Cone Correlation	QC GHP - 10	ASTM D1556 ASTM D2216	1 test for every 10 nuclear gauge tests
Laboratory Compaction	QC GHP - 9	ASTM D698	1 test for every 10 or 15 field tests depending on variability of soils.
Soil Classification • Particle Size Analysis • Atterberg Limits	QC GHP - 7 QC GHP - 8 QC GHP - 12	ASTM D2487 ASTM D4318 ASTM D1140 ASTM D422	1 test per 2000 CY

1) Soil samples will be obtained from the constructed radon barrier at a frequency of 1 sample per 800 CY which is approximately 1 sample per acre per lift of radon barrier soils. Laboratory ^{226}Ra analysis by gamma spectrometry shall be performed on each sample.

FIGURES

Figure 2-1	Location of Boreholes
Figure 3-1	Static Slope Stability Analysis
Figure 3-2	Seismic Slope Stability Analysis
Figure 4-1	Surface Profiles, Drainage Basin



UMETCO MINERALS CORPORATION

LOCATION OF BORE HOLES
AND
HISTORICAL MILLING ACTIVITIES

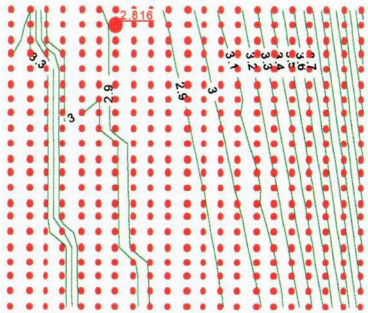
GAS HILLS RECLAMATION PROJECT

APRIL 2003 FIGURE 2-1

GHP2-FIG-2-1.DWG

C01

Figure 3-1 GHP No. 2 – Static Slope Stability Analysis



Soil Properties

Soil 1: Frost Protection
Soil Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 22 degrees

Soil 2: Radon Barrier
Soil Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 16 psf
Phi: 15 degrees

Soil 3: Pond Contaminated Soils
Soil Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 15 degrees

Soil 4: Fill Soils
Soil Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 22 degrees

Soil 5: Foundation
Soil Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion: 1100 psf
Phi: 20 degrees

Description: GHP No. 2
Comments: Maximum Section
File Name: GHP No. 2 Maximum Section.slp
Last Saved Date: 4/15/2003
Last Saved Time: 10:32:34 AM
Analysis Method: Spencer
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric Lines / Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

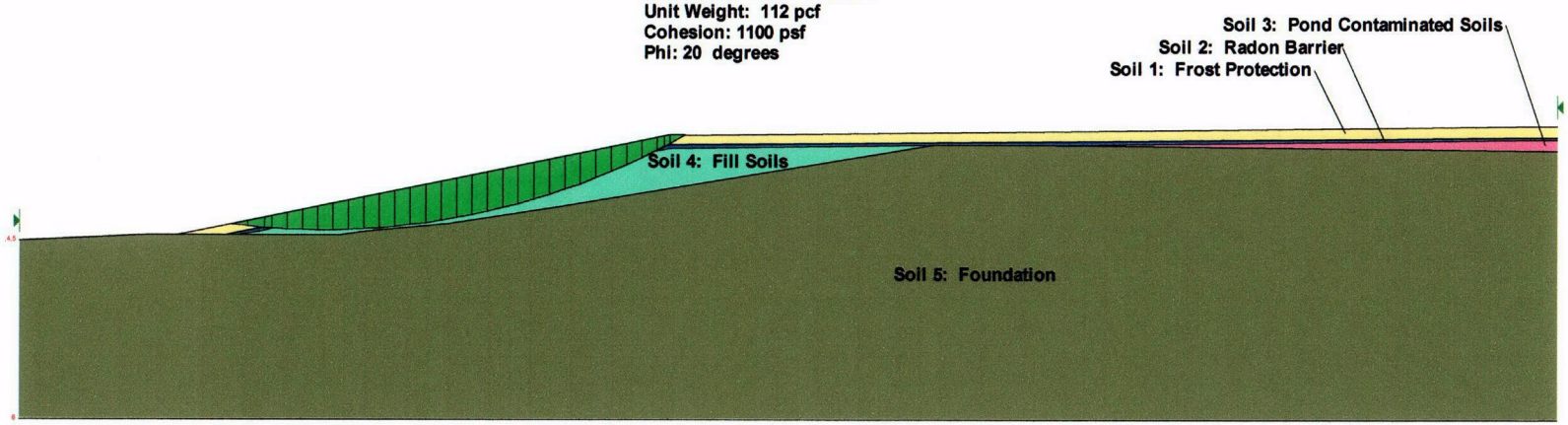
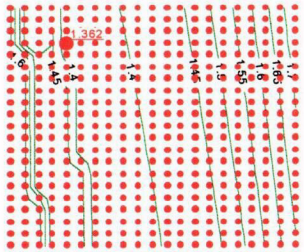


Figure 3-2 GHP No. 2 - Seismic Slope Stability Analysis



Soil Properties

Soil 1: Frost Protection
Soil Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 22 degrees

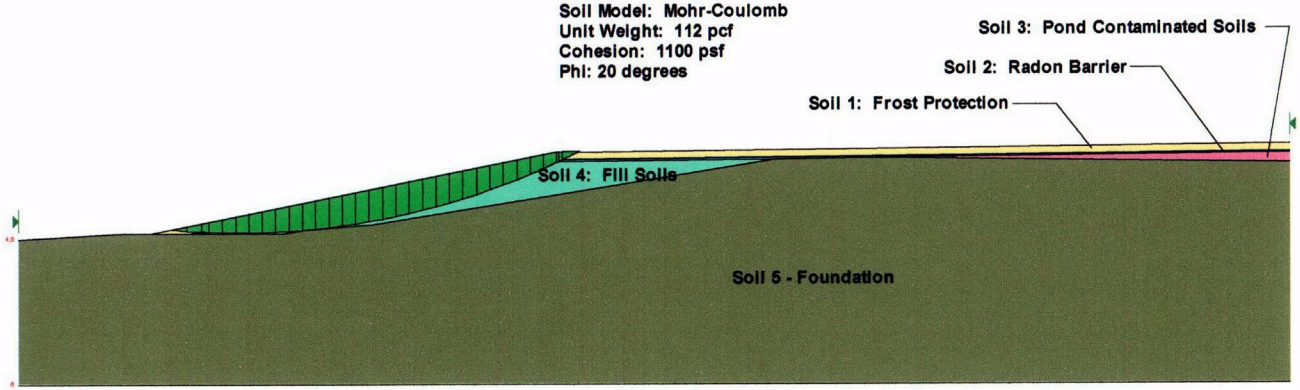
Soil 2: Radon Barrier
Soil Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 16 psf
Phi: 15 degrees

Soil 3: Pond Contaminated Soils
Soil Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 15 degrees

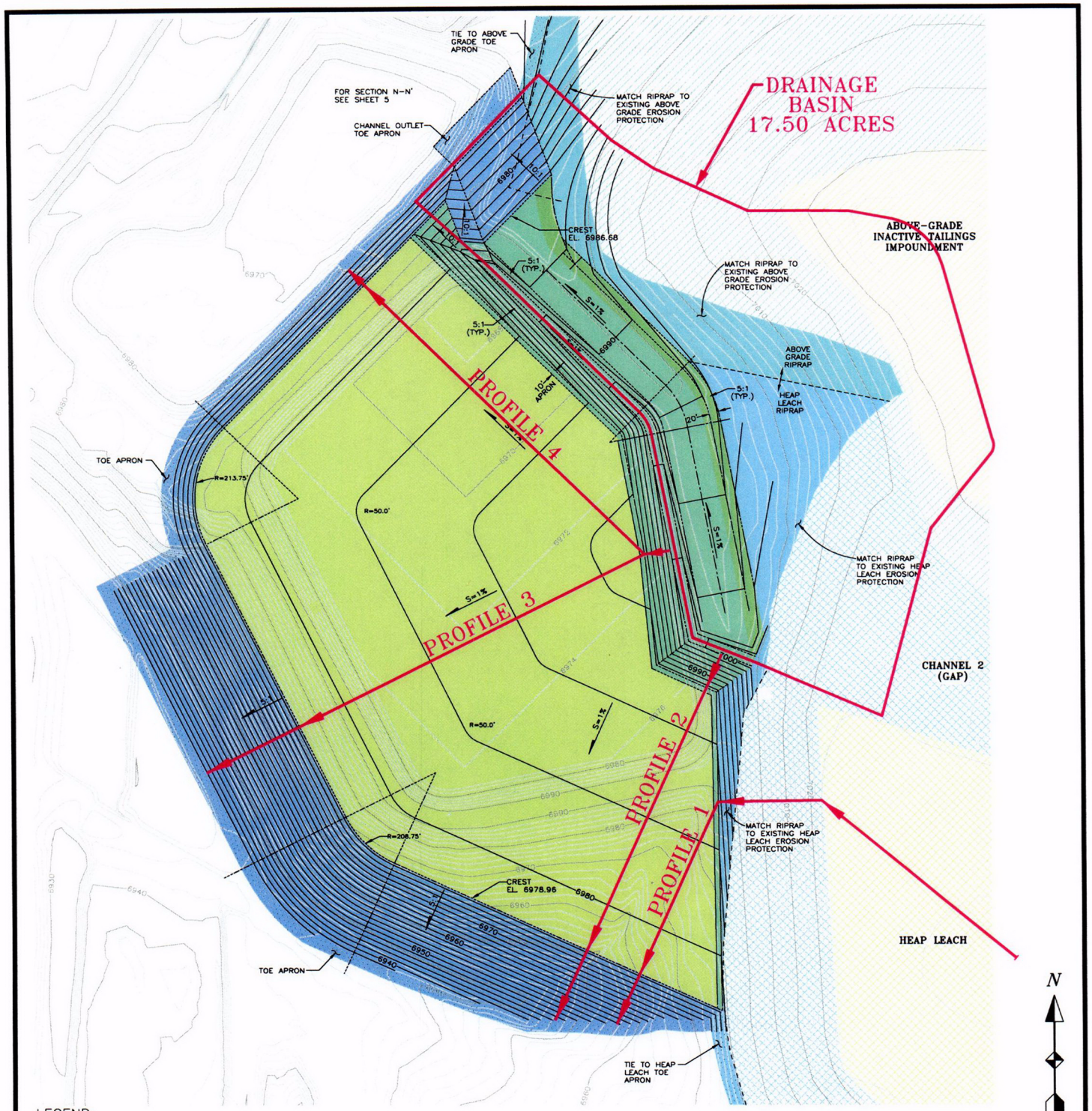
Soil 4: Pond Contaminated Soils
Soil Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 22 degrees

Soil 5: Foundation
Soil Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion: 1100 psf
Phi: 20 degrees

Description: GHP No. 2
Comments: Maximum Section
File Name: GHP No. 2 Maximum Section Seismic.slp
Last Saved Date: 4/15/2003
Last Saved Time: 12:49:03 PM
Analysis Method: Spencer
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric Lines / Ru
Tension Crack Option: (none)
Seismic Coefficient: Horizontal



C03



LEGEND:

- EXISTING 2002 CONTOURS
- PROPOSED FINISHED GRADING

GHP-2 RIPRAP:
- 6-INCHES OF RIPRAP TYPE "A" D_{50} = 0.5 INCH
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH WITH 3-INCHES OF FILTER TYPE "A" D_{50} = 0.5 INCH
- 10-INCHES OF RIPRAP TYPE "C" D_{50} = 6.0 INCH WITH 3-INCHES OF FILTER TYPE "A" D_{50} = 0.5 INCH

TIE TO HEAP LEACH:
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH WITH 6-INCHES OF FILTER TYPE "A" D_{50} = 0.5 INCH

TIE TO ABOVE GRADE:
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH

EXISTING HEAP LEACH:
- 6-INCHES OF RIPRAP TYPE "A" D_{50} = 0.5 INCH
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH WITH 6-INCHES OF FILTER TYPE "A" D_{50} = 0.5 INCH

EXISTING ABOVE-GRADE:
- 6-INCHES OF RIPRAP TYPE "A" D_{50} = 0.5 INCH
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH

- BELOW-GRADE APRON

0 100' 200' 300'

SCALE IN FEET
CONTOUR INTERVAL: 2'

REVISED 9/5/03 - TOE APRON
REVISED 9/5/03 - CHANNEL RIPRAP

UMETCO MINERALS CORPORATION

SURFACE PROFILES

DRAINAGE BASIN

GAS HILLS RECLAMATION PROJECT

APRIL 2003

FIGURE 4-1

GHP2-FIG-4-1.DWG

C04

APPENDIX A

RADON ATTENUATION DESIGN

Radon Attenuation Model
Subsurface Radium Data

Radon Attenuation Model

-----*****! RADON !*****-----

Version 1.2 - Feb. 2, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

GHP No. 2 - RUN 1 - 8/27/03

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.01	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1

THICKNESS	225.68	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	62	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.758D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 2

THICKNESS	91.44	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	55	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.559D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 3

THICKNESS	91.44	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	62	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.758D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 4

THICKNESS	91.44	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	69	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.956D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 5

THICKNESS	30.48	cm
CALCULATED POROSITY	0.400	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	2	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.2	
CALCULATED SOURCE TERM CONCENTRATION	3.339D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	12	%
MOISTURE SATURATION FRACTION	.477	
CALCULATED DIFFUSION COEFFICIENT	1.277D-02	cm^2 s^-1

LAYER 6

THICKNESS	137.16	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	10	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	2.835D-05	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

BARE SOURCE FLUX FROM LAYER 1: 5.488D+01 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	2.257D+02	5.648D-01	7.449D+04
2	9.144D+01	6.135D-01	7.385D+04
3	9.144D+01	8.128D+00	6.907D+04
4	9.144D+01	2.917D+01	4.868D+04
5	3.048D+01	2.112D+01	2.602D+04
6	1.372D+02	1.940D+01	0.000D+00

-----*****! RADON !*****-----

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RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

GHP No. 2 - RUN 2 - 8/27/03

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.01	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1

THICKNESS	225.68	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	62	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.758D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 2

THICKNESS	91.44	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	55	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.559D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 3

THICKNESS	91.44	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	62	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.758D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 4

THICKNESS	91.44	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	69	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	1.956D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

LAYER 5

THICKNESS	30.48	cm
CALCULATED POROSITY	0.400	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	2	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.17	
CALCULATED SOURCE TERM CONCENTRATION	2.838D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	12	%
MOISTURE SATURATION FRACTION	.477	
MEASURED DIFFUSION COEFFICIENT	.0031	cm^2 s^-1

LAYER 6

THICKNESS	137.16	cm
CALCULATED POROSITY	0.340	
MEASURED MASS DENSITY	1.75	g cm^-3
MEASURED RADIUM ACTIVITY	10	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.262	
CALCULATED SOURCE TERM CONCENTRATION	2.835D-05	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.309	
CALCULATED DIFFUSION COEFFICIENT	2.318D-02	cm^2 s^-1

BARE SOURCE FLUX FROM LAYER 1: 5.488D+01 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	2.257D+02	-1.567D-01	7.548D+04
2	9.144D+01	-1.129D+00	7.619D+04
3	9.144D+01	3.959D+00	7.464D+04
4	9.144D+01	1.921D+01	6.197D+04
5	3.048D+01	1.121D+01	1.644D+04
6	1.372D+02	1.439D+01	0.000D+00

Subsurface Radium Data

Borehole MB-01		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	31.4	Removed
1.5	24.6	Removed
2.0	26.9	Removed
2.5	28.3	Removed
3.0	29.3	Removed
3.5	27.2	Removed
4.0	36.3	Removed
4.5	38.2	Removed
5.0	31.8	Removed
5.5	28.2	Removed
6.0	26.4	Removed
6.5	34.2	Removed
7.0	33.6	Removed
7.5	27.2	Removed
8.0	24.1	Removed
8.5	23.9	Removed
9.0	21.7	Removed
9.5	20.2	Removed
10.0	19.2	Removed
Average ^{226}Ra (pCi/g) =	28.0	0
Number of Measurements =	19	0

Borehole MB-02		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	40.1	Removed
1.5	37.8	Removed
2.0	29	Removed
2.5	26.1	Removed
3.0	22.8	Removed
3.5	21.1	Removed
4.0	22.4	Removed
4.5	23.4	Removed
5.0	23.4	Removed
5.5	23.8	Removed
6.0	23.4	Removed
6.5	23.8	Removed
7.0	22.2	Removed
7.5	22.4	Removed
8.0	22	Removed
8.5	22.8	Removed
9.0	22.6	Removed
9.5	22.2	Removed
10.0	22.8	Removed
10.5	23	Removed
11.0	21.6	Removed
11.5	22	Removed
12.0	22.4	Removed
12.5	23.4	Removed
13.0	23.2	Removed
13.5	21.1	Removed
14.0	21.1	Removed
14.5	22.4	Removed
15.0	23.4	Removed
15.5	23.6	Removed
16.0	23.8	Removed
16.5	23.2	23.2
17.0	23.4	23.4
Average ^{226}Ra (pCi/g) =	24.0	23.3
Number of Measurements =	33	2

Borehole MB-03		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	67	67
1.5	64.2	64.2
2.0	46.6	46.6
2.5	32.1	32.1
3.0	22.3	22.3
3.5	18.3	18.3
4.0	14.9	14.9
4.5	14.3	14.3
5.0	14	14
5.5	14.4	14.4
6.0	16.8	16.8
6.5	16.2	16.2
7.0	16.5	16.5
7.5	16.8	16.8
8.0	17.8	17.8
8.5	18.1	18.1
9.0	18.8	18.8
9.5	12.1	12.1
10.0	12	12
Average ^{226}Ra (pCi/g) =	23.9	23.9
Number of Measurements =	19	19

Borehole MB-04		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	74.8	Removed
1.5	45.7	Removed
2.0	27.4	Removed
2.5	17.4	Removed
3.0	12.8	Removed
3.5	11.5	Removed
4.0	11.8	Removed
4.5	11.6	Removed
5.0	11.5	Removed
5.5	11.8	Removed
6.0	11.2	Removed
6.5	11.3	Removed
7.0	11.9	Removed
7.5	12.6	Removed
8.0	14.9	Removed
8.5	15.5	Removed
9.0	13.3	Removed
9.5	13.8	Removed
Average ^{226}Ra (pCi/g) =	16.9	
Number of Measurements =	18	

Borehole MB-05		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	18.55	18.55
1.5	25.8	25.8
2.0	27.17	27.17
2.5	27.49	27.49
3.0	24.67	24.67
3.5	23.14	23.14
4.0	23.22	23.22
4.5	21.93	21.93
5.0	19.6	19.6
5.5	19.44	19.44
6.0	18.8	18.8
6.5	17.27	17.27
7.0	18.8	18.8
7.5	17.75	17.75
8.0	18.31	18.31
8.5	18.07	18.07
9.0	18.63	18.63
9.5	16.94	16.94
10.0	16.38	16.38
Average ^{226}Ra (pCi/g) =	20.6	20.6
Number of Measurements =	19	19

Borehole MB-06		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	224.6	224.6
1.5	32.2	32.2
2.0	43.5	43.5
2.5	82.6	82.6
3.0	95.3	95.3
3.5	104.9	104.9
4.0	107.3	107.3
4.5	104.1	104.1
5.0	68.1	68.1
5.5	36.3	36.3
6.0	20.6	20.6
6.5	16.7	16.7
7.0	16.8	16.8
7.5	18	18
8.0	18.9	18.9
8.5	20.2	20.2
9.0	22	22
9.5	25.3	25.3
10.0	29.2	29.2
10.5	30.5	30.5
11.0	28.1	28.1
11.5	24.3	24.3
12.0	22.7	22.7
12.5	23	23
13.0	23.8	23.8
13.5	25.3	25.3
14.0	26.8	26.8
14.5	24.7	24.7

Borehole MB-06 (Cont'd)		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
15.0	22.8	>500 cm
15.5	25	>500 cm
16.0	25.6	>500 cm
16.5	30.1	>500 cm
17.0	34.1	>500 cm
17.5	44.1	>500 cm
18.0	49.8	>500 cm
18.5	43.3	>500 cm
19.0	31.6	>500 cm
19.5	23.5	>500 cm
Average ^{226}Ra (pCi/g) =	43.3	47.0
Number of Measurements =	38.0	28.0

Borehole MB-07		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	16.14	Removed
1.5	20.65	Removed
2.0	26.04	Removed
2.5	30.95	Removed
3.0	36.83	Removed
3.5	61.22	Removed
4.0	92.86	Removed
4.5	140.35	Removed
5.0	170.14	Removed
5.5	185.43	Removed
6.0	188.65	Removed
6.5	187.04	Removed
7.0	196.7	Removed
7.5	205.56	Removed
8.0	199.92	Removed
8.5	191.87	Removed
9.0	206.36	Removed
9.5	243.39	Removed
10.0	291.69	Removed
10.5	310.21	Removed
11.0	273.18	Removed
11.5	226.49	Removed
12.0	195.09	Removed
12.5	169.33	Removed
13.0	137.94	Removed
13.5	109.76	Removed
14.0	90.44	Removed
14.5	83.84	Removed
15.0	82	Removed
15.5	76	Removed
16.0	72.4	Removed
16.5	68.1	Removed
17.0	71.2	Removed
17.5	63.3	Removed
18.0	58	Removed
18.5	65.9	Removed
19.0	67	Removed
19.5	48.1	Removed
20.0	29.7	Removed
Average ^{226}Ra (pCi/g) =	127.9	
Number of Measurements =	39	

Borehole MB-08		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	37	Removed
1.5	75	Removed
2.0	96.9	Removed
2.5	77.6	Removed
3.0	43	Removed
3.5	22	Removed
4.0	16.5	Removed
4.5	14.4	Removed
5.0	14.6	Removed
5.5	15.7	Removed
6.0	14.8	Removed
6.5	14	Removed
7.0	12.8	Removed
7.5	11.9	Removed
8.0	11.7	Removed
8.5	11.6	Removed
9.0	11.9	Removed
9.5	11.9	Removed
10.0	11.9	Removed
10.5	11.7	Removed
11.0	12.1	Removed
11.5	13.3	Removed
12.0	14.4	Removed
12.5	17.4	Removed
13.0	20.9	Removed
13.5	22.3	Removed
14.0	22.6	Removed
14.5	20.5	Removed
15.0	20.2	Removed
15.5	20.1	Removed
16.0	19.7	Removed
Average ^{226}Ra (pCi/g) =	23.9	
Number of Measurements =	31	

Borehole MB-09		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	24.2	Removed
1.5	32.1	Removed
2.0	33.1	Removed
2.5	34.1	Removed
3.0	50.6	Removed
3.5	58	Removed
4.0	52	Removed
4.5	33.9	Removed
5.0	20.1	Removed
5.5	15.3	Removed
6.0	13.6	Removed
6.5	12.6	Removed
7.0	11.3	Removed
7.5	10.4	Removed
8.0	10	Removed
8.5	9.9	Removed
9.0	11.2	Removed
9.5	13.4	Removed
10.0	14.5	Removed
10.5	14.2	Removed
11.0	14.1	Removed
11.5	15.1	Removed
12.0	16.1	Removed
12.5	17.6	Removed
13.0	18.5	Removed
13.5	18.3	Removed
14.0	18	Removed
14.5	18	Removed
15.0	18.3	Removed
15.5	19.8	Removed
16.0	20.5	Removed
16.5	21.4	Removed
17.0	21.1	Removed
Average ^{226}Ra (pCi/g) =	21.6	
Number of Measurements =	33	

Borehole MB-10		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	17.4	Removed
1.5	23.2	Removed
2.0	26.3	Removed
2.5	28.2	Removed
3.0	38	Removed
3.5	73.1	Removed
4.0	136.1	Removed
4.5	193.4	Removed
5.0	244.5	Removed
5.5	267.9	Removed
6.0	301.1	Removed
6.5	302.1	Removed
7.0	189.9	Removed
7.5	77	Removed
8.0	40.7	Removed
8.5	29.4	Removed
9.0	27.3	Removed
9.5	25.3	Removed
10.0	23.6	Removed
10.5	20.9	Removed
11.0	20.5	Removed
11.5	20.1	Removed
12.0	19.5	Removed
12.5	20.1	Removed
13.0	21.4	Removed
13.5	22.4	Removed
14.0	23.6	Removed
14.5	24.4	Removed
15.0	29.4	Removed
15.5	36.8	Removed
16.0	40.7	Removed
16.5	55.1	Removed
17.0	47.5	Removed
17.5	29.6	Removed
18.0	26.3	26.3
18.5	27.7	27.7
19.0	33.1	33.1
19.5	34.9	34.9
20.0	30.2	30.2
Average ^{226}Ra (pCi/g) =	67.9	30.4
Number of Measurements =	39	5

Borehole MB-11		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	17.6	Removed
1.5	23.6	Removed
2.0	24.9	Removed
2.5	22.4	Removed
3.0	25.1	Removed
3.5	26.9	Removed
4.0	29.6	Removed
4.5	30	Removed
5.0	22.6	Removed
5.5	13.7	Removed
6.0	10.6	Removed
6.5	11	Removed
7.0	11.1	Removed
7.5	11.4	Removed
8.0	11.3	Removed
8.5	10.8	Removed
9.0	10.4	Removed
Average ^{226}Ra (pCi/g) =	18.4	
Number of Measurements =	17	

Borehole MB-12		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	33.3	Removed
1.5	39.5	Removed
2.0	43.2	Removed
2.5	40.9	Removed
3.0	40.3	Removed
3.5	48.5	Removed
4.0	92.6	Removed
4.5	148.7	Removed
5.0	203	Removed
5.5	291.2	Removed
6.0	347.9	Removed
6.5	304.6	Removed
7.0	144.1	Removed
7.5	75.5	Removed
8.0	43	Removed
8.5	32.5	Removed
9.0	26.7	Removed
9.5	24.9	Removed
10.0	24.6	Removed
10.5	26.5	Removed
11.0	27.3	Removed
11.5	28.2	Removed
12.0	26.9	Removed
12.5	26.7	Removed
13.0	28.6	Removed
13.5	28.4	Removed
14.0	30.2	Removed
14.5	34.3	Removed
15.0	38	Removed
15.5	38.7	Removed
16.0	42.6	Removed
16.5	53.1	Removed
Average ^{226}Ra (pCi/g) =	76.1	
Number of Measurements =	32	

Borehole MB-13		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	35.2	Removed
1.5	38.5	Removed
2.0	45.5	Removed
2.5	61.7	Removed
3.0	62.1	Removed
3.5	103.8	Removed
4.0	141.7	Removed
4.5	170.7	Removed
5.0	251.9	Removed
5.5	348.3	Removed
6.0	357.8	Removed
6.5	264.4	Removed
7.0	108.1	Removed
7.5	50.6	Removed
8.0	32.7	Removed
8.5	26.9	Removed
9.0	25.1	Removed
9.5	24.6	Removed
10.0	22.2	Removed
10.5	20.1	Removed
11.0	18.6	Removed
11.5	18.1	Removed
12.0	17.9	Removed
12.5	19	Removed
13.0	19	Removed
13.5	19.4	Removed
14.0	19.8	Removed
14.5	20.5	Removed
15.0	22.2	Removed
15.5	2302	Removed
16.0	25.9	Removed
16.5	29	Removed
17.0	31.2	31.2
17.5	31.7	31.7
18.0	35.8	35.8
18.5	40.7	40.7
19.0	42.6	42.6
19.5	36	36
20.0	28.8	28.8
20.5	27.3	27.3
21.0	26.7	26.7
21.5	23	23
22.0	19.1	19.1
22.5	18.1	18.1
23.0	20.3	20.3
23.5	42.4	42.4
24.0	51	51
24.5	23	23
25.0	18.3	18.3
Average ^{226}Ra (pCi/g) =	106.9	30.4
Number of Measurements =	49	17

Borehole MB-14		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	27.5	27.5
1.5	32.9	32.9
2.0	33.7	33.7
2.5	31.2	31.2
3.0	30.6	30.6
3.5	27.3	27.3
4.0	26.3	26.3
4.5	27.5	27.5
5.0	31.7	31.7
5.5	45.5	45.5
6.0	83.8	83.8
6.5	130.7	130.7
7.0	114.7	114.7
7.5	84.4	84.4
8.0	80.7	80.7
8.5	95.9	95.9
9.0	129.1	129.1
9.5	179.6	179.6
10.0	213.1	213.1
10.5	205.3	205.3
11.0	190.3	190.3
11.5	137.3	137.3
12.0	70.8	70.8
12.5	49	49
13.0	41.3	41.3
13.5	38.7	>500 cm
14.0	35.2	>500 cm
14.5	33.5	>500 cm
15.0	32.7	>500 cm
15.5	32.7	>500 cm
16.0	25.7	>500 cm
16.5	20.7	>500 cm
17.0	20.1	>500 cm
17.5	19.8	>500 cm
18.0	20.5	>500 cm
18.5	21.1	>500 cm
19.0	22.2	>500 cm
19.5	22	>500 cm
20.0	22	>500 cm
20.5	25.1	>500 cm
21.0	29.6	>500 cm
21.5	34.7	>500 cm
22.0	38.7	>500 cm
22.5	39.1	>500 cm
23.0	30	>500 cm
23.5	27.1	>500 cm
24.0	26.9	>500 cm
24.5	23.6	>500 cm
25.0	22.4	>500 cm
Average ^{226}Ra (pCi/g) =	56.8	84.8
Number of Measurements =	49	25

Borehole MB-15		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	11.55	11.55
1.5	12.27	12.27
2.0	12.11	12.11
2.5	12.27	12.27
3.0	12.6	12.6
Average ^{226}Ra (pCi/g) =	12.2	12.2
Number of Measurements =	5	5

Borehole MB-17		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	39.7	Removed
1.5	41.3	Removed
2.0	43.3	Removed
2.5	42.1	Removed
3.0	41	Removed
3.5	40.9	Removed
4.0	41.2	Removed
4.5	41.7	Removed
5.0	42.8	Removed
5.5	36	Removed
6.0	24.8	Removed
6.5	19.3	Removed
7.0	16.7	Removed
7.5	15.5	Removed
8.0	15.8	Removed
8.5	16.6	Removed
9.0	19.1	Removed
9.5	22	Removed
10.0	25.4	Removed
10.5	27.9	Removed
11.0	31.4	Removed
11.5	36.3	Removed
12.0	44.2	Removed
12.5	56.9	Removed
13.0	65.3	65.3
13.5	64.3	64.3
14.0	61.9	61.9
14.5	53.3	53.3
15.0	52.8	52.8
15.5	64	64
16.0	67.7	67.7
16.5	71.6	71.6
17.0	64.5	64.5
17.5	45.9	45.9
18.0	29.3	29.3
18.5	26.9	26.9
19.0	25	25
19.5	26.9	26.9
20.0	22.2	22.2
Average ^{226}Ra (pCi/g) =	47.9	49.4
Number of Measurements =	39	15

Borehole MB-16		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	19.2	Removed
1.5	16.7	Removed
2.0	15.33	Removed
2.5	14.61	Removed
3.0	15.98	Removed
3.5	15.41	Removed
4.0	14.77	Removed
4.5	13.8	Removed
5.0	14.61	Removed
5.5	15.09	Removed
6.0	15.58	Removed
6.5	16.38	Removed
7.0	17.1	Removed
7.5	18.47	Removed
8.0	19.6	Removed
8.5	21.05	Removed
9.0	24.51	Removed
9.5	27.09	Removed
10.0	26.44	Removed
10.5	28.94	Removed
11.0	28.7	Removed
11.5	28.54	Removed
12.0	29.18	Removed
12.5	29.5	Removed
13.0	27.65	Removed
13.5	27.09	Removed
14.0	25.56	25.56
14.5	27.41	27.41
15.0	31	31
Average ^{226}Ra (pCi/g) =	21.6	28.0
Number of Measurements =	29	3

Borehole MB-18		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	71	71
1.5	81.3	81.3
2.0	88.1	88.1
2.5	94.9	94.9
3.0	96.3	96.3
3.5	99.4	99.4
4.0	101.7	101.7
4.5	102.7	102.7
5.0	101.1	101.1
5.5	97.8	97.8
6.0	102.7	102.7
6.5	107.7	107.7
7.0	105.2	105.2
7.5	98.6	98.6
8.0	97.6	97.6
8.5	98.2	98.2
9.0	99	99
9.5	102.5	102.5
10.0	108.5	108.5
Average ^{226}Ra (pCi/g) =	97.6	97.6
Number of Measurements =	19	19

Borehole MB-20		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	314	314
1.5	347	347
2.0	331	331
2.5	282	282
Average ^{226}Ra (pCi/g) =	318.5	318.5
Number of Measurements =	4	4

Borehole MB-19		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	50.6	Removed
1.5	73.5	Removed
2.0	98.8	Removed
2.5	116.5	Removed
3.0	90.2	Removed
3.5	76.4	Removed
4.0	70	70
4.5	67.7	67.7
5.0	64.6	64.6
5.5	61.1	61.1
6.0	64.8	64.8
6.5	60.3	60.3
7.0	53.9	53.9
7.5	49	49
8.0	44.2	44.2
8.5	43	43
9.0	41.7	41.7
9.5	41.5	41.5
10.0	42.2	42.2
10.5	37.6	37.6
11.0	31.9	31.9
11.5	26.7	26.7
12.0	27.7	27.7
12.5	27.5	27.5
13.0	26.9	26.9
13.5	24.2	24.2
14.0	23.2	23.2
14.5	23.4	23.4
15.0	22.6	22.6
15.5	18.9	18.9
16.0	19	19
16.5	21.1	21.1
17.0	24.2	24.2
17.5	32.7	32.7
18.0	38	38
18.5	39.5	39.5
19.0	36.8	36.8
19.5	36.2	36.2
20.0	38.2	38.2
20.5	40.5	>500 cm
21.0	45.5	>500 cm
21.5	54.1	>500 cm
22.0	57.6	>500 cm
22.5	64	>500 cm
23.0	63.8	>500 cm
23.5	68.1	>500 cm
24.0	74.9	>500 cm
24.5	79	>500 cm
25.0	100.9	>500 cm
25.5	105.8	>500 cm
26.0	104.8	>500 cm
Average ^{226}Ra (pCi/g) =	51.9	38.8
Number of Measurements =	51	33

Borehole MB-21		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	122	122
1.5	160	160
2.0	196	196
2.5	228	228
3.0	244	244
3.5	251	251
4.0	258	258
4.5	286	286
5.0	288	288
5.5	297	297
6.0	268	268
6.5	221	221
7.0	131	131
7.5	60	60
8.0	32	32
8.5	20	20
9.0	17	17
9.5	17	17
10.0	17	17
10.5	16	16
11.0	15	15
11.5	15	15
12.0	14	14
12.5	14	14
13.0	15	15
13.5	14	14
14.0	15	15
14.5	17	17
15.0	21	21
15.5	28.5	28.5
16.0	29.1	29.1
16.5	18.8	18.8
17.0	15.9	>500 cm
Average ^{226}Ra (pCi/g) =	101.9	104.5
Number of Measurements =	33	32

Borehole MB-22		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	71.4	71.4
1.5	105	105
2.0	120.4	120.4
2.5	124.8	124.8
3.0	58	58
3.5	110.6	110.6
4.0	103.5	103.5
4.5	92.6	92.6
5.0	99	99
5.5	118.4	118.4
6.0	122.3	122.3
6.5	112.4	112.4
7.0	85.6	85.6
7.5	66.5	66.5
8.0	44	44
8.5	32.9	32.9
9.0	30.8	>500 cm
9.5	39.7	>500 cm
10.0	27.3	>500 cm
10.5	26.1	>500 cm
11.0	25.9	>500 cm
11.5	22.4	>500 cm
12.0	20.1	>500 cm
12.5	18.1	>500 cm
13.0	16.4	>500 cm
13.5	16.5	>500 cm
14.0	16.7	>500 cm
14.5	18.8	>500 cm
15.0	22.6	>500 cm
15.5	26.3	>500 cm
16.0	27.7	>500 cm
16.5	26.5	>500 cm
17.0	25.1	>500 cm
17.5	23	>500 cm
18.0	18.6	>500 cm
18.5	18.1	>500 cm
19.0	14.8	>500 cm
19.5	14.6	>500 cm
20.0	14	>500 cm
20.5	13.2	>500 cm
21.0	12.7	>500 cm
21.5	13.1	>500 cm
22.0	15.9	>500 cm
22.5	18.6	>500 cm
Average ^{226}Ra (pCi/g) =	46.6	91.7
Number of Measurements =	44	16

Borehole MB-23		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	62.2	62.2
1.5	47	47
2.0	45	45
2.5	47.3	47.3
3.0	45.5	45.5
3.5	48.4	48.4
4.0	52.6	52.6
4.5	49.8	49.8
5.0	56.5	56.5
5.5	59.1	59.1
6.0	63.1	63.1
6.5	62.8	62.8
7.0	63.4	63.4
7.5	67.7	67.7
8.0	63	63
8.5	65.8	65.8
9.0	69.4	69.4
9.5	69.7	69.7
10.0	64	64
10.5	60.4	60.4
11.0	52.8	52.8
11.5	49.6	49.6
12.0	50.6	50.6
12.5	51.3	51.3
13.0	54.1	54.1
13.5	52.4	52.4
14.0	52.9	52.9
14.5	57.9	57.9
15.0	59.1	>500 cm
15.5	58.5	>500 cm
16.0	54.1	>500 cm
16.5	53.6	>500 cm
17.0	59.9	>500 cm
17.5	62.5	>500 cm
18.0	64.1	>500 cm
18.5	67.6	>500 cm
19.0	81.4	>500 cm
19.5	78.8	>500 cm
20.0	67.4	>500 cm
20.5	51.4	>500 cm
21.0	36.6	>500 cm
21.5	34.5	>500 cm
22.0	34.9	>500 cm
Average ^{226}Ra (pCi/g) =	56.9	56.6
Number of Measurements =	43	28

Borehole MB-24		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	14.72	Removed
1.5	24.03	Removed
2.0	39.8	Removed
2.5	20.94	Removed
3.0	22.79	Removed
3.5	28.97	Removed
4.0	47.1	Removed
4.5	74.09	Removed
5.0	92.83	Removed
5.5	104.16	Removed
6.0	106.43	Removed
6.5	98.19	Removed
7.0	84.39	Removed
7.5	103.13	Removed
8.0	124.15	Removed
8.5	126	Removed
9.0	141.45	141.45
9.5	137.95	137.95
10.0	69.35	69.35
10.5	58.64	58.64
11.0	56.58	56.58
11.5	57.2	57.2
12.0	55.55	55.55
12.5	51.02	51.02
13.0	41.95	41.95
13.5	32.06	32.06
14.0	21.97	21.97
14.5	20.12	20.12
15.0	19.4	19.4
15.5	22.4	22.4
16.0	25.3	25.3
16.5	26.9	26.9
17.0	27.7	27.7
17.5	31	31
Average ^{226}Ra (pCi/g) =	59.1	49.8
Number of Measurements =	34	18

Borehole MB-25		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	89.6	89.6
1.5	91.2	91.2
2.0	59.5	59.5
2.5	39.7	39.7
3.0	34.7	34.7
3.5	33.4	33.4
4.0	30.2	30.2
4.5	30.1	30.1
5.0	27.4	27.4
5.5	26.7	26.7
6.0	27.1	27.1
6.5	24.1	24.1
7.0	22	22
7.5	23.2	23.2
8.0	21.9	21.9
8.5	23.5	23.5
9.0	25.1	25.1
9.5	27.2	27.2
10.0	27.2	27.2
10.5	30.7	30.7
11.0	28.9	28.9
11.5	30	30
12.0	36	36
12.5	44.4	44.4
13.0	69.6	69.6
13.5	148.4	148.4
14.0	289.3	289.3
14.5	347.2	347.2
15.0	210	210
15.5	140	140
16.0	125	>500 cm
16.5	128	>500 cm
17.0	135	>500 cm
Average ^{226}Ra (pCi/g) =	74.1	68.6
Number of Measurements =	33	30

Borehole RB-08		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	26.1	26.1
1.5	27.3	27.3
2.0	28.6	28.6
2.5	31	31
3.0	30.4	30.4
3.5	33.7	33.7
4.0	38.7	38.7
4.5	49.2	49.2
5.0	72.6	72.6
5.5	94.7	94.7
6.0	128.7	128.7
6.5	146	146
7.0	140	140
7.5	127.6	127.6
8.0	117.3	117.3
8.5	109.7	109.7
9.0	109.1	109.1
9.5	103.5	103.5
10.0	97.4	97.4
10.5	83.6	83.6
11.0	84.6	84.6
11.5	75.3	75.3
12.0	75.1	75.1
12.5	84.8	84.8
13.0	82.1	82.1
13.5	75.9	75.9
14.0	75.7	75.7
14.5	78.8	78.8
15.0	81.1	>500 cm
15.5	83.4	>500 cm
16.0	88.5	>500 cm
16.5	90	>500 cm
17.0	85.2	>500 cm
17.5	76.8	>500 cm
18.0	66.5	>500 cm
18.5	61.1	>500 cm
19.0	54.3	>500 cm
19.5	52.5	>500 cm
20.0	46.3	>500 cm
20.5	45.9	>500 cm
21.0	51.2	>500 cm
21.5	39.9	>500 cm
22.0	36.2	>500 cm
22.5	33.1	>500 cm
23.0	31.4	>500 cm
23.5	30	>500 cm
24.0	29.6	>500 cm
24.5	30.2	>500 cm
25.0	30.4	>500 cm
25.5	30.4	>500 cm
26.0	31.2	>500 cm
26.5	31	>500 cm
27.0	30	>500 cm

Borehole RB-08 (Cont'dt)		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
27.5	28.8	>500 cm
28.0	28.2	>500 cm
28.5	28.4	>500 cm
29.0	29.4	>500 cm
29.5	30	>500 cm
30.0	29.8	>500 cm
30.5	30.6	>500 cm
31.0	30.2	>500 cm
31.5	30.4	>500 cm
32.0	29.6	>500 cm
32.5	29.6	>500 cm
33.0	29.8	>500 cm
33.5	29.6	>500 cm
34.0	29.4	>500 cm
34.5	29.2	>500 cm
35.0	30	>500 cm
35.5	30.8	>500 cm
36.0	31.9	>500 cm
36.5	33.9	>500 cm
37.0	36.4	>500 cm
37.5	39.1	>500 cm
38.0	42.2	>500 cm
38.5	42.8	>500 cm
39.0	39.5	>500 cm
39.5	37.2	>500 cm
40.0	35.8	>500 cm
40.5	36.4	>500 cm
41.0	36.2	>500 cm
41.5	36.6	>500 cm
42.0	37	>500 cm
42.5	43.6	>500 cm
43.0	43.4	>500 cm
43.5	39.5	>500 cm
44.0	37.2	>500 cm
Average ^{226}Ra (pCi/g) =	69.7	79.6
Number of Measurements =	83	28

Borehole RB-10		
Borehole Depth	^{226}Ra	Portion Existing within upper
(ft)	(pCi/g)	500 cm
1.0	25.3	>500 cm
1.5	25.1	>500 cm
2.0	26.1	>500 cm
2.5	28.6	>500 cm
3.0	29.6	>500 cm
3.5	32.5	>500 cm
4.0	40.1	>500 cm
4.5	52.9	>500 cm
5.0	65.4	>500 cm
5.5	70.6	>500 cm
6.0	75.9	>500 cm
6.5	85.4	>500 cm
7.0	93.9	>500 cm
7.5	94.5	>500 cm
8.0	95.9	>500 cm
8.5	109.7	>500 cm
9.0	118.2	>500 cm
9.5	118	>500 cm
10.0	108.3	>500 cm
10.5	103.3	>500 cm
11.0	119	>500 cm
11.5	121.7	>500 cm
12.0	105.4	>500 cm
12.5	92.4	>500 cm
13.0	82.9	>500 cm
13.5	75.7	>500 cm
14.0	65.6	>500 cm
14.5	64.6	>500 cm
15.0	78.6	>500 cm
15.5	84	>500 cm
16.0	65.2	>500 cm
16.5	57.8	>500 cm
17.0	56.6	>500 cm
17.5	56.4	>500 cm
18.0	49.2	>500 cm
18.5	54.1	>500 cm
19.0	68.3	>500 cm
19.5	73.9	>500 cm
20.0	78	>500 cm
20.5	74.9	>500 cm
21.0	72.4	>500 cm
21.5	66.3	>500 cm
22.0	58.2	>500 cm
22.5	45.7	>500 cm
23.0	37.6	>500 cm
23.5	33.3	>500 cm
24.0	32.5	>500 cm
24.5	31.7	>500 cm
25.0	31.7	>500 cm
25.5	31.2	>500 cm
26.0	29.2	>500 cm
26.5	31	>500 cm
27.0	31.7	>500 cm
27.5	30.2	>500 cm

Borehole RB-10 (Cont'd)		
Borehole Depth	^{226}Ra	Portion Existing within upper
(ft)	(pCi/g)	500 cm
28.0	30	>500 cm
28.5	30	>500 cm
29.0	30.6	>500 cm
29.5	32.5	>500 cm
30.0	43.2	>500 cm
30.5	55.1	>500 cm
31.0	52	>500 cm
31.5	46.9	>500 cm
Average ^{226}Ra (pCi/g) =	61.4	
Number of Measurements =	62	

Borehole RB-12		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	23.2	>500 cm
1.5	24.9	>500 cm
2.0	25.5	>500 cm
2.5	27.9	>500 cm
3.0	30.6	>500 cm
3.5	32.9	>500 cm
4.0	38.7	>500 cm
4.5	43.4	>500 cm
5.0	47.5	>500 cm
5.5	57.4	>500 cm
6.0	69.8	>500 cm
6.5	76.8	>500 cm
7.0	78.4	>500 cm
7.5	82.3	>500 cm
8.0	88.9	>500 cm
8.5	84.4	>500 cm
9.0	68.9	>500 cm
9.5	55.1	>500 cm
10.0	46.1	>500 cm
10.5	41.5	>500 cm
11.0	39.3	>500 cm
11.5	41.5	>500 cm
12.0	45.7	>500 cm
12.5	46.7	>500 cm
13.0	45.2	>500 cm
13.5	43.8	>500 cm
14.0	43.6	>500 cm
14.5	45.9	>500 cm
15.0	46.3	>500 cm
15.5	46.5	>500 cm
16.0	52.5	>500 cm
16.5	56	>500 cm
17.0	48.8	>500 cm
17.5	40.9	>500 cm
18.0	36.8	>500 cm
18.5	34.1	>500 cm
19.0	31.4	>500 cm
19.5	29	>500 cm
20.0	28.2	>500 cm
20.5	27.7	>500 cm
21.0	28.4	>500 cm
21.5	30.6	>500 cm
22.0	34.3	>500 cm
22.5	38	>500 cm
23.0	43.2	>500 cm
23.5	53.7	>500 cm
24.0	65	>500 cm
24.5	66.7	>500 cm
25.0	57.2	>500 cm
25.5	50.4	>500 cm
26.0	57.2	>500 cm
26.5	60.9	>500 cm
27.0	57.6	>500 cm
27.5	58.8	>500 cm

Borehole RB-12 (Cont'd)		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
28.0	56.2	>500 cm
28.5	51.8	>500 cm
29.0	43.8	>500 cm
29.5	33.7	>500 cm
30.0	30	>500 cm
30.5	29.2	>500 cm
31.0	30.4	>500 cm
31.5	29	>500 cm
32.0	27.7	>500 cm
32.5	28.6	>500 cm
33.0	34.3	>500 cm
33.5	38	>500 cm
34.0	36.4	>500 cm
34.5	34.5	>500 cm
Average ^{226}Ra (pCi/g) =	44.1	
Number of Measurements =	64	

Borehole RB-24		
Borehole Depth (ft)	^{226}Ra (pCi/g)	Portion Existing within upper 500 cm
1.0	34.3	34.3
1.5	36.2	36.2
2.0	34.2	34.2
2.5	34.9	34.9
3.0	30.2	30.2
3.5	22	22
4.0	16.6	16.6
4.5	13.3	13.3
5.0	12.5	12.5
5.5	12.3	12.3
6.0	11.3	11.3
6.5	11.9	11.9
7.0	11.7	>500 cm
7.5	11.5	>500 cm
8.0	11.1	>500 cm
8.5	11.3	>500 cm
9.0	11.7	>500 cm
9.5	13.1	>500 cm
10.0	16	>500 cm
10.5	19.7	>500 cm
11.0	33.1	>500 cm
11.5	57.6	>500 cm
12.0	79.7	>500 cm
12.5	74.5	>500 cm
13.0	54.9	>500 cm
13.5	31	>500 cm
14.0	20.1	>500 cm
14.5	16.6	>500 cm
15.0	15.8	>500 cm
15.5	13.5	>500 cm
16.0	11.5	>500 cm
16.5	12.9	>500 cm
17.0	14.3	>500 cm
17.5	14.1	>500 cm
18.0	13.9	>500 cm
18.5	15.2	>500 cm
19.0	17.6	>500 cm
19.5	18.1	>500 cm
20.0	19.5	>500 cm
20.5	18.3	>500 cm
21.0	19.3	>500 cm
21.5	18.1	>500 cm
22.0	17.2	>500 cm
Average ^{226}Ra (pCi/g) =	22.9	22.5
Number of Measurements =	43	12