# Final Construction Completion Report
## Gas Hills, Wyoming Site

# VOLUME II
# HEAP LEACH MODIFICATIONS

**June 2007**

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## Definition of Terms

| Acronym / Abbreviation | Definition |
|---|---|
| ASTM | American Society for Testing and Materials |
| CH | Fat Clay |
| CL | Lean Clay |
| cm/s | centimeter per second |
| $cm^2/s$ | centimeters squared per second |
| CY | cubic yards |
| $D_{50}$ | Minimum median particle size |
| FSSR | Final Status Survey Report |
| GHP | Gas Hills Pond (e.g., GHP-1) |
| $g/cm^3$ | grams per cubic centimeter |
| ISRM | International Society for Rock Mechanics |
| μR/hr | microRoentgens per hour |
| n | number |
| NA | Not Applicable |
| NESHAPS | National Emission Standards for Hazardous Air Pollutants |
| NP | non-plastic |
| NRC | U. S. Nuclear Regulatory Commission |
| pcf | pounds per cubic foot |
| pCi/g | picoCuries per gram |
| $pCi/m^2s$ | picoCuries per square meter per second |
| PI | plastic index |
| PM | percent moisture |
| Ra-226 | Radium-226 |
| SC | Clayey sand (ASTM designation) |
| SM | Silty sand (ASTM designation) |
| SSD | Saturated surface dry |
| TER | Technical Evaluation Report |
| Umetco | Umetco Minerals Corporation |

## 1.0 INTRODUCTION

This volume of the Construction Completion Report documents the conduct and completion of reclamation construction activities for the Heap Leach Design Enhancement at the Umetco Minerals Corporation (Umetco) former uranium mill site located in East Gas Hills, Wyoming (Figure 1.1). The Gas Hills site is licensed by the U.S. Nuclear Regulatory Commission (NRC) under Source Materials License SUA-648, Docket No. 40-0299 to possess byproduct material in the form of uranium tailings, as well as other radioactive wastes generated by past milling operations. All construction work described herein was performed in accordance with the specifications documented in the design report entitled *Heap Leach Reclamation Plan Modifications and Reclamation Plan for GHP No. 2/Mill Area*† (Umetco 1996) and subsequent submittals provided in response to NRC comments. This modified plan was approved by the NRC on May 28, 1998 (License Amendment 38). Drawing 1 shows the final as-built topography and erosion protection placement for the Heap Leach demonstrating construction completion.

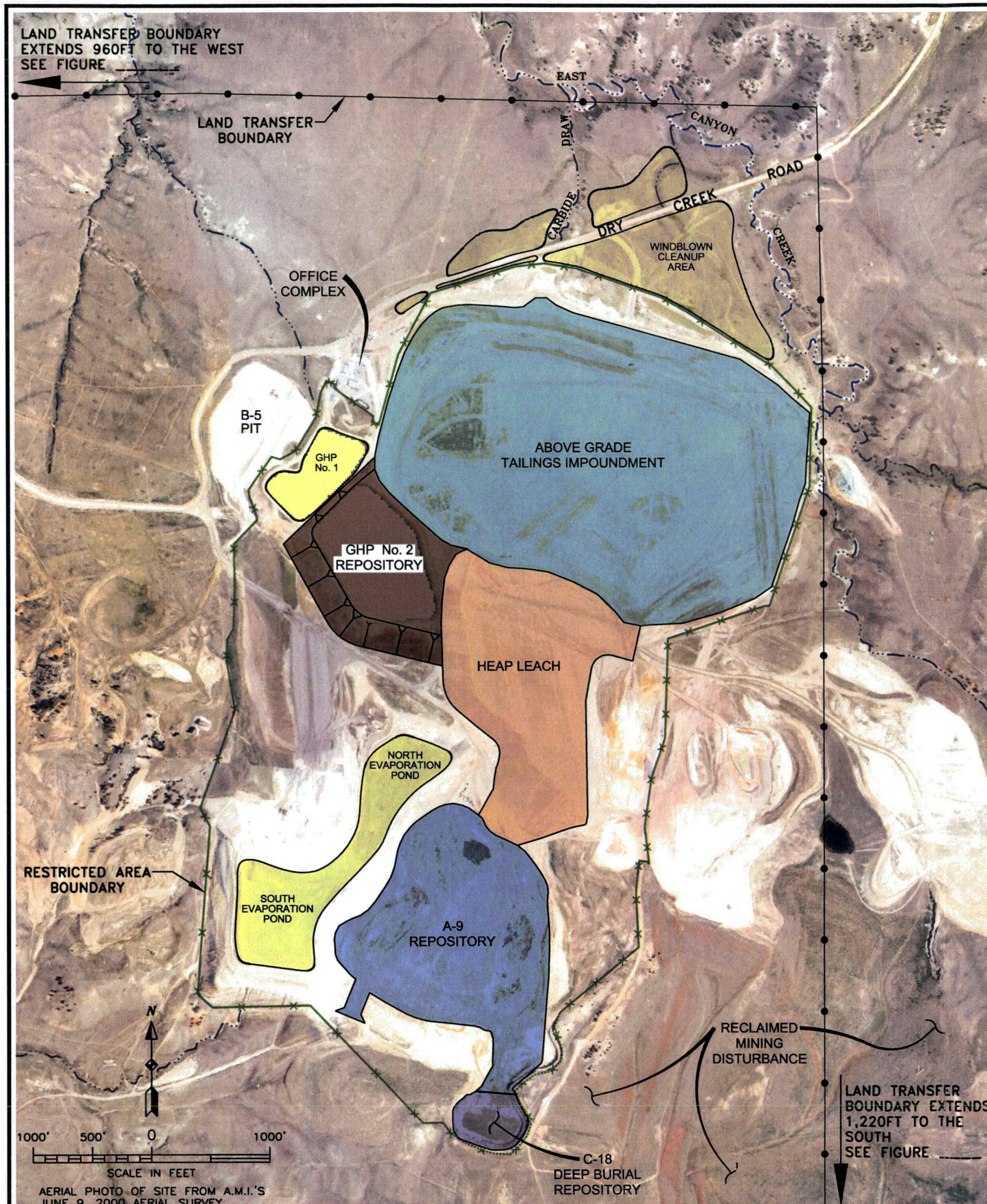
### 1.1 Area Description and Background

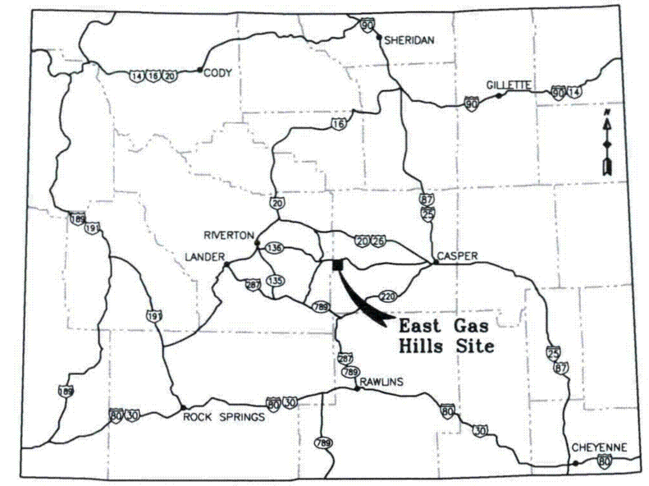
Heap leach operations at the site began in March 1980, under the authority of NRC License No. SUA-648, Amendment No. 11. The heap was extended in 1982 and operated until December 1984. Heap leach operations resumed in May 1987 and were finally terminated in January 1988.

In February, 1991, Umetco submitted a reclamation plan for the heap leach facility to the NRC for approval. This original cover design consisted of a 12-inch radon barrier, a 12-inch filter layer, a 30-inch frost protection layer, and 6 inches of topsoil. Sideslopes were to be reclaimed by construction of a multi-gradient sacrificial fill (nominal 5:1 slope) with a 6-inch topsoil layer and subsequent vegetation to control erosion. Electing to proceed with heap leach reclamation construction prior to NRC approval, the bulk of the Heap Leach reclamation work specified in the original design was substantially completed by 1992, with the exception of topsoil placement and seeding. In 1994, the NRC provided comments on the 1991 reclamation design.

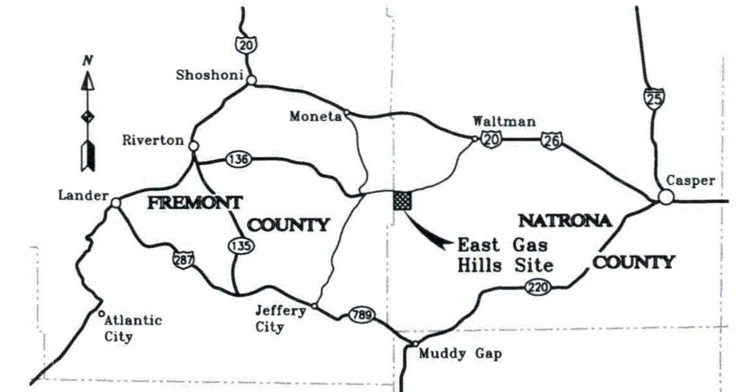
Umetco responded to NRC comments in series of submittals in 1994 and 1995 evaluating the previous construction activities. This comment response period culminated in the submittal of a revised plan in 1996 (*Heap Leach Reclamation Plan Modifications*) which, after modifications in response to NRC comments, represents the first design to be approved for the Heap Leach area. The design modifications included (with subsequent NRC approval) evaluation of the existing reclamation cover construction (i.e., that completed in 1992, shown on Drawing 2). Endpoints evaluated included seismic design, slope stability, liquefaction potential, settlement, radon barrier cover cracking potential, and radon attenuation. This plan was approved by the NRC on May 28, 1998, as amended by License Amendment 38. The corresponding TER is provided in Attachment 1.

† Although GHP-2 was initially addressed in this plan (its cover design was the same as that for the Heap Leach), in response to NRC questions, Umetco determined in February 1998 that data for the pond were limited because disposal there was not complete (i.e., the groundwater corrective action program was still ongoing). Umetco committed to submitting a final design for closure of Pond No. 2 when the required data were available. This occurred in 2003, as documented in the Final Construction Completion Report for GHP-2 (Volume V).

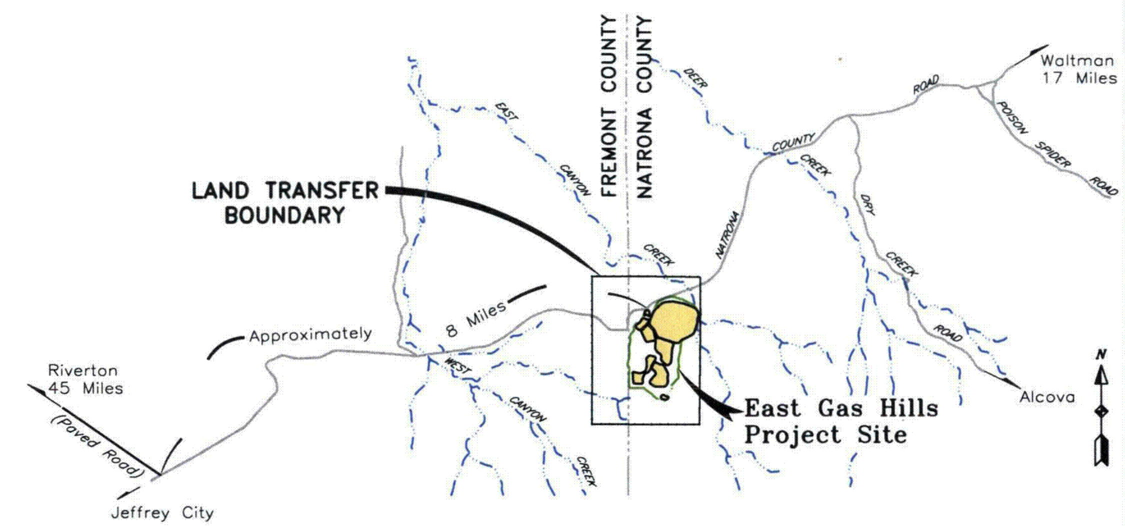



**STATE OF WYOMING**
NOT TO SCALE




**VICINITY MAP**
NOT TO SCALE




**LOCATION MAP**
NOT TO SCALE

**LEGEND:**

- ABOVE-GRADE TAILINGS IMPOUNDMENT
  RADON BARRIER LIMITS = 170.59 AC
  REPOSITORY LIMITS = 170.24 AC
- HEAP LEACH REPOSITORY
  RADON BARRIER LIMITS = 48.91 AC
  REPOSITORY LIMITS = 56.93 AC
- A-9 REPOSITORY
  RADON BARRIER LIMITS = 51.29 AC
  REPOSITORY LIMITS = 61.70 AC
- GHP No. 2 REPOSITORY
  RADON BARRIER LIMITS = 35.73 AC
  REPOSITORY LIMITS = 46.14 AC
- C-18 DEEP BURIAL REPOSITORY
  REPOSITORY LIMITS = 5.97 AC
- FINAL STATUS SURVEY AREAS
- LAND TRANSFER BOUNDARY
- RESTRICTED AREA BOUNDARY
- FEATURE BOUNDARIES
- DRAINAGEWAYS

**LEGAL DESCRIPTION OF LAND TRANSFER BOUNDARY:**

LAND TRANSFER BOUNDARY INCLUDES ALL OF SECTION 15, THE NORTH HALF OF SECTION 22, THE NORTHEAST QUARTER OF SECTION 21, THE EAST HALF OF SECTION 16, THE SOUTHEAST QUARTER OF SECTION 9 AND THE SOUTH HALF OF SECTION 10, ALL LOCATED IN TOWNSHIP 33 NORTH, RANGE 89 WEST OF THE SIXTH PRINCIPAL MERIDIAN. SAID LAND CONTAINS APPROXIMATELY 1920 ACRES.

UMETCO MINERALS CORPORATION

SITE PLAN
AND
LOCATION MAP

GAS HILLS, WYOMING

JUNE 2007 FIGURE 1.1

GH-Loc-Map-Fig-1-1.dwg

## 1.2 Scope of Work Addressed in this Report

The 1996 plan proposed major modifications to the initial 1991 plan, including:

1) Placement of additional frost protection soil on top of the existing cover;
2) Extension of the reclamation cover—i.e., 18-inch radon barrier, 54-inch frost protection layer and the erosion protection layer—down the sideslopes of the heap;
3) Extension of the reclamation cover over the gap between the heap and above-grade tailings impoundment; and
4) Replacement of the previously proposed vegetative cover surface with riprap erosion protection on both the top and sideslopes of the Heap Leach.

As discussed in Volume I, this Construction Completion Report is the final in a series of submittals demonstrating that the Gas Hills site meets the requirements for license termination. The other key submittal related to the Heap Leach area is the *Final Status Survey Report*, which was initially submitted in 2003 and then finalized on September 2, 2004 in response to NRC comments. This report documents the results of the gamma exposure survey for the Heap Leach cover. and approved on September 27, 2004 (see Volume I, Section 6).

At the outset, it is important to note that this report only addresses construction completed since development of the 1996 reclamation plan. All work performed before that time (i.e., that completed in 1992) is incorporated in the NRC-approved modified design. Drawing 2 shows the existing cover—i.e., that completed in 1992—along with the 1996 design modifications.

## 1.3 License Condition and Regulatory Framework

The requirements for reclamation of the Heap Leach construction reclamation are established in SUA-648 License Condition 61, which states the following:

> The final reclamation of the heap leach impoundment shall be in accordance with the reclamation plan submitted September 25, 1996, as supplemented or revised by submittals dated June 6, August 19, and October 15, 1997, and January 15, February 11 and 13, 1998, and December 20, 2000. [Applicable Amendments: 38, 44]

This report will demonstrate that the conditions of this license condition have been met and that the completed construction at the Heap Leach satisfies the requirements set forth in 10 CFR 40 Appendix A regarding stability and radon flux.

## 1.4 Volume II Organization

The completion of this work in accordance with the approved plan is demonstrated primarily in the quality assurance/quality control test records provided in the appendices and the as-built drawings. To facilitate review, final as-built drawings are provided in two formats—standard plates (provided in the following binder), allowing examination of all construction details and final topography and, for easier access and reference, 11 x 17 inch format. Plates are provided separately in the following binder.

Although this volume is intended to serve largely as a stand-alone report, Volume I is requisite reading, as it presents important information regarding the quality and placement of erosion protection materials for all repository areas, including the results of rock durability and gradation tests and in-place visual depth checks (Volume I, Section 5). Volume I also presents detailed historical information and summarizes the issues and reports most germane to license termination.

Following this introduction, Section 2 summarizes the Heap Leach history and the evolution of reclamation plans preceding the enhanced reclamation plan addressed herein. Section 3 provides an overview of the reclamation plan, including a summary of all related submittals and NRC comments. Section 4 summarizes the construction activities, documenting volumes of material placed and corresponding quality control testing procedures. Section 5 summarizes the results of the quality control testing for all soil placement (contaminated fill placement, radon barrier, and frost protection).

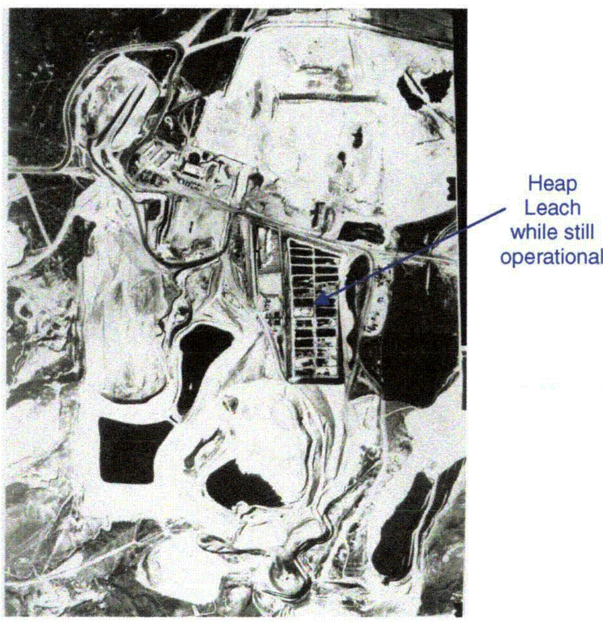
Section 6 documents the erosion protection placement, referencing Volume I for additional details. Section 7 documents the final radiological status of the Heap Leach, including the frost protection Ra-226 content, results of radon flux (NESHAPs) measurements, and gamma exposure survey results. Section 8 summarizes the findings of this construction completion report. References are provided in Section 9. Quality control test results are provided in the appendices, which are organized as follows:

Appendix A – Contaminated Fill Quality Control Test Results
Appendix B – Radon Barrier Quality Control Test Results
Appendix C – Frost Protection Quality Control Test Results
Appendix D – Toe Protection Quality Control Test Results

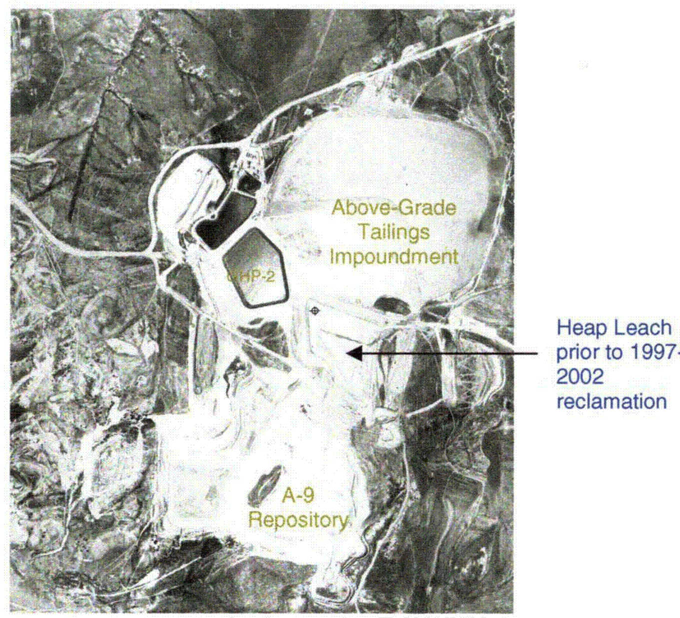
## 2.0 BACKGROUND

Heap leach operations at the Gas Hills site began in March 1980 under SUA-648 Amendment No. 11. The operations were extended in November 1982, as permitted by Amendment No. 17 of the license, and operated until December 1984. Operations were restarted in May 1987 and finally shut down in January 1988.

The two insets below show historical aerial photographs of the Gas Hills site, Heap Leach. In the first, taken in September 1983, the 1982 expansions of the Heap are evident. The second photograph, taken in June 1997, shows the layout of the site at onset of the reclamation construction activities addressed herein.




Aerial Photo: September 12, 1983




Aerial Photo: June 11, 1987

### 2.1 1991 Reclamation Plan and Construction Activities

In February, 1991, Umetco submitted a reclamation plan for the heap leach facility to the NRC for approval. The NRC provided review comments to the proposed reclamation plan on May 22, 1991. Response to these comments were submitted on December 2, 1991, providing additional geotechnical borrow area data and proposed cost justification for the proposed design.

The original 1991 reclamation design consisted of a 12-inch radon barrier, 12-inch filter layer, 30-inch frost protection layer, and 6-inch topsoil to be constructed on the top of the heap. Sideslopes were to be reclaimed by construction of a multi-gradient sacrificial fill (nominal 5:1 slope) with a 6-inch topsoil layer and subsequent vegetation to control erosion. Umetco elected to proceed with heap leach reclamation construction prior to formal NRC approval. This work was substantially completed by 1992 with the exception of topsoil placement and seeding.

## 2.2 NRC Evaluation and Comments: 1994-1995

In 1994, the NRC provided technical comments on the 1991 reclamation design. Umetco responded to NRC comments in 1994 and 1995 discussing the reclamation plan and evaluation of reclamation construction activities performed to date. Responses to the NRC comments were contained in a series of documents prepared by James L. Grant and Associates (see 1996 plan and references in Section 9).

On February 6, 1995, Umetco submitted a response to verbal comments provided by the NRC addressing seismicity, slope stability, permeability of the radon barrier and frost penetration depth. In this submittal Umetco committed to evaluate the permeability of the constructed radon barrier with field measurements and to increase the thickness of the frost protection soils over the radon barrier. The 1994 evaluation of the previous reclamation work also indicated that some of the soils utilized to construct the top cover of the heap had elevated radium concentrations (naturally occurring mine spoil). Therefore, in the summer of 1995, Umetco conducted an extensive radiological background and site characterization study. This study also evaluated the radiological suitability of the existing cover soils placed on the heap leach facility in 1991 and 1992. Results of this study indicate that the radium content of the filter layer was elevated and that the near surface and sideslope cover soils were slightly elevated.

The above submittals coincided with the NRC's establishment of a new policy regarding previously-approved reclamation plans dated July 18, 1995. Although an approved plan was not yet in place for the Heap, this new policy did influence the enhancements proposed in the 1996 plan, in particular regarding radon attenuation and erosion protection. The 1996 reclamation plan modifications and subsequent submittals proposed design revisions to address these concerns, as discussed in the following section.

## 3.0 1996 HEAP LEACH RECLAMATION PLAN OVERVIEW

This section presents an overview of the 1996 enhanced reclamation plan—*Heap Leach Reclamation Plan Modifications*—on which the design and construction documented herein was based. This plan was submitted by letter dated September 25, 1996 and was amended by six submittals prior to the NRC's approval of the enhanced reclamation plan in May 1998. To facilitate review, Table 3.1 provides a cross-reference to this plan identifying where various aspects of the modeling underlying the design (e.g., settlement analyses) are addressed. Table 3.1 provides a cross-reference to the enhanced reclamation plan. Table 3.2 documents the plan submittal history, including revisions and NRC approvals. Table 3.3 summarizes the parameters used for the Heap Leach radon flux modeling for the cover and sideslopes respectively.

### 3.1 Scope of Work

The modifications included in the enhanced design plan were developed to satisfy the NRC's review comments on the reclamation design. These modifications included:

- Placement of additional frost protection soils on the top cover, increasing the thickness to 54 inches (4.5 feet).
- Extension of the reclamation cover—i.e., 18-inch radon barrier, 54-inch frost protection layer and erosion protection layer—down the sideslopes of the heap.
- Extension of the reclamation cover over the gap between the heap and above-grade tailings impoundment (addressing areas where elevated radium levels were measured); and
- Replacement of the previously proposed vegetative cover surface with riprap erosion protection on both the top and sideslopes of the heap leach facility.

### 3.2 Plan Modifications and NRC Approval(s)

The revised Heap Leach reclamation plan was submitted by letter on September 25, 1996. The NRC's responses (dated May 9, 1997) identified four primary issues: 1) concerns about gully headcutting; 2) the strength parameters used for slope stability analysis; 3) radon attenuation (assumptions used in model); and 4) the radium content of the remaining cover to be placed. These concerns were addressed in Umetco's submittals in response to these comments are summarized in Table 3.2.

In the TER supporting the plan approval (provided in Attachment 1), the NRC concluded that the heap leach site design, as proposed, would meet NRC regulations stated in 10 CFR 40, Appendix A, Criteria 4 (c), (d), (e), and 6(1), with regard to reasonable assurance of stability and control of the contaminated material; and limitation of radon flux. In December 2000, Umetco submitted the *Proposal for Erosion Protection Modification for the Above-Grade Tailings Impoundment and Heap Leach.* This submittal documented proposed changes for erosion protection, discussed in Section 6, and was approved by the NRC (License Amendment 44) in April 2001 (TER provided in Attachment 2).

**Table 3.1 1996 Heap Leach Reclamation Plan Modifications Report: Summary of Contents**

***Preface*:** The reclamation plan, entitled *Heap Leach Reclamation Plan Modifications and Reclamation Plan for GHP No. 2/Mill Area* was submitted in September 1996 and was approved by the NRC with modifications on May 28, 1998 (Amendment No. 38, License Condition 61).

| **Part or Section No.** | **Title** | **Description of Contents** (left blank if section title is sufficiently descriptive) |
|---|---|---|
| **PART I** | **Design and Technical Approach** | |
| Nine sections, presenting background information and documenting the geotechnical bases for the design specifications presented in Part II. Sections 1 and 2 provide background information. Section 3 identifies the design modifications. Sections 4 and 5 document analyses for radon attenuation and infiltration, respectively. Section 6 addresses frost penetration. Sections 7 and 8 document slope stability and liquefaction and settlement analyses. The erosion protection design is detailed in Section 9. | | |
| **PART II** | **Technical Specifications** | |
| Sections 1, 2, and 3 | General, Administrative Instructions, Mobilization and Demobilization | Section 2.8 (Quality Control/Quality Assurance) documents the required geotechnical testing frequencies, which were later modified by Umetco letter dated 2/13/98 (see Table 3.2). |
| Section 4 | Contaminated Soils | Section 4.5 presents the placement specifications. |
| Section 5 | Radon Barrier<br>Requirements were later amended by Umetco letter dated 2/11/98. | Section 5.3 describes the material requirements and borrow source; placement and compaction requirements are documented in Section 5.4. |
| Section 6 | Frost Protection Layer | Sections 6.3 and 6.4 document the key requirements. |
| Section 7 | Erosion Protection | Quality control test requirements are documented in Section 7.4; Section 7.5 documents gradation requirements. |
| **PART III** | **Quality Plan** | |
| Sections 1-3 | Quality Plan introductory material | Quality plan scope, objectives, and definitions |
| Section 4 | Quality Control/Quality Assurance | Describes general QA/QC activities and reporting requirements. |
| Sections 5-7 | Organizational Structure, Changes and Corrective Actions, Documentation | |
| Section 8 | Construction Inspection and Testing | Documents required test frequencies, etc. Frequencies given in Section 8.3.2 were modified by Umetco letter dated 2/13/98. |
| Section 9 | Quality Control Procedures | *Quality Control Procedure for Radiological Monitoring of Borrow Materials* added by Umetco letter dated 6/6/97. |

DRAWINGS – Note that Drawings and Scour and Riprap Size Calculations amended by Umetco letter dated 1-15-98; also see December 2000 modifications)

Appendix A - Radon Attenuation Calculations; Appendix B – Infiltration/Geotechnical Data; Appendix C – Slope Stability Calculations; and Appendix D – Erosion Protection Calculations

## Table 3.2. Design Plan Submittal History for the Heap Leach Disposal Cell



*Preface:* License Condition 61, the primary license condition pertaining to the Heap Leach reclamation, states the following: The final reclamation of the heap leach impoundment shall be in accordance with the reclamation plan submitted September 25, 1996, as supplemented or revised by submittals dated June 6, August 19, and October 15, 1997, and January 15, February 11 and 13, 1998, and December 20, 2000. [Applicable Amendments: 38, 44, 52] (*The latter language reflects the most recent revised license as of April 2007.*) To facilitate review, the following table summarizes the contents of each of these submittals and any associated license condition changes.

| Report or Submittal | Submittal Date(s) | Summary of Contents |
|---|---|---|
| Initial reclamation plan for the Heap Leach Pile (Grant Environmental) | 1991, 1994 | The 1991 plan as amended by 1994 submittals was never approved and was still undergoing NRC review in January 1996. |
| *Heap Leach Reclamation Plan Modifications and Reclamation Plan for GHP No. 2/Mill Area* | September 25, 1996 | Enhanced reclamation design consisting of three parts: Part I – Design Report; Part II – Construction Plans and Specifications; and Part III – Quality Plan (see Table 3.1). |
| *Submittals in Response to Subsequent NRC Written and Verbal Comments* | | |
| Umetco's responses to NRC comments and request for additional information dated May 9, 1997 | June 6, 1997 | Issues addressed included gully headcutting, strength parameters used for the slope stability analysis, radium activity of cover materials, and gamma exposure rates over the completed reclamation cover prior to erosion protection placement. |
| Additional Umetco responses to NRC's comments of May 9, 1997 | August 19, 1997 | Provides additional technical information and design revisions addressing erosion protection toe design and geotechnical slope stability. |
| Additional Umetco response to NRC's comments of May 9, 1997 | October 15, 1997 | Provides results of additional radon barrier testing. |
| Umetco's response to NRC comments and request for additional information dated December 15, 1997 | January 15, 1998 | As part of this submittal, Umetco submitted a complete set of design drawings incorporating all modification to date resulting from NRC review of the Heap Leach reclamation plan. |
| Umetco's formal written response to three verbal comments on the design plan as discussed during a phone conversation with Elaine Brummett and Banad Jagannath on February 2, 1998. | February 11, 1998 | The most notable modification in this submittal was the change in specifications for the Heap Leach radon barrier material, summarized as follows: CL or CH only , >75% <#200, LL >30%, PI >20% and more stringent testing frequency .Umetco also submitted revised calculations for channel scour depth and riprap sizing. |

## Table 3.2. Design Plan Submittal History for the Heap Leach Disposal Cell



| Report or Submittal | Submittal Date(s) | Summary of Contents |
|---|---|---|
| | February 11, 1998 | Finally, although not related to the Heap reclamation, this submittal also removed the aspect of the plan relating to GHP-2. Umetco committed to providing a final closure design for the pond when disposal activities were complete and the necessary data were available. |
| Umetco submitted revised page changes to be substituted for the attachments submitted in the February 11, 1998 letter. | February 13, 1998 | Corrected radon barrier testing frequency specifications. |
| *Note: All above approved by the NRC as License Amendment 38 dated May 28, 1998.* | | |
| *Proposal for Erosion Protection Modification for the Above-Grade Tailings Impoundment and Heap Leach* | December 20, 2000 | Umetco proposed a modification for the erosion protection design for the Channel 2 outlet. This was approved by the NRC as part of License Amendment 44 on April 5, 2001 (see Section 6 and Attachment 2). |

**Table 3.3 Radon Flux Model Input Parameters Used as the Basis for the Heap Leach Design Modifications: Top Cover and Side Slopes**

| Input Parameter | Tailings | Radon Barrier | Frost Protection | Comment (Basis) |
|---|---|---|---|---|
| Radium content – Side Slopes<br>(values are assumed or measured averages) | 109 pCi/g | 3.6 pCi/g | Existing Cover: filter layer = 32.8 pCi/g; frost = 20 pCi/g<br>Additional Cover: 10 pCi/g | Site-Specific |
| Layer Thickness | 16 ft | 1 ft | Top Cover: 5 ft<br>Sideslope: 4.5 ft | |
| Emanation Coefficient | 0.216 | 0.2005 | 0.262 | Measured value for the tailings, radon barrier and frost protection layers, respectively |
| Specific Gravity | 2.65 | 2.65 | 2.65 | Default value |
| Dry Density *<br>(average) | 1.59 g/cm$^3$<br>(99.3 pcf) | 1.7 g/cm$^3$ *<br>(106.1 pcf) | 1.8 g/cm$^3$ *<br>(112.4 pcf) | Site-specific measurements |
| Porosity | 0.40 | 0.36 | 0.32 | RADON-code calculated |
| Moisture Content (average long-term) | 6 % | 6% | 6% | To be conservative 6% moisture content used as input for all layers |
| Diffusion coefficient*<br>(all units = cm$^2$/s) | 3.13 x 10$^{-2}$<br>Calculated | 4.14 x 10$^{-3}$ | 5.21 x 10$^{-3}$ | Heap Tailings input values RADON-code calculated. Measured values utilized for radon and frost input parameters. |

All values and assumptions listed above were accepted by the NRC, as documented in the Technical Evaluation Report (TER) supporting their approval of the Heap Leach Reclamation Plan Modification design and corresponding license amendment (License Amendment 38, May 28, 1998, and associated TER). This modeling yielded radon flux values of 5.63 pCi/m$^2$s for the Heap Side Cover and 7.66 pCi/m$^2$s for the Top Cover of the Heap Leach Tailings Impoundment. Later NESHAPS sampling conducted in 1999 yielded an average radon flux of 1.1 pCi/m$^2$s. Both modeled and measured values are well below the 20 pCi/m$^2$s criterion required by 10 CFR Part 40, Appendix A, Criterion 6(2).

# 4.0 OVERVIEW OF HEAP LEACH RECLAMATION CONSTRUCTION ACTIVITIES

As a prelude to Section 5, this section provides an overview of the Heap Leach reclamation construction activities performed between 1997 and 2002. Although the Plan Modifications had not been accepted until May 28, 1998 (Attachment 1), all work conducted in 1997 was performed in accordance with the subsequently approved reclamation plan. Section 4.1 summarizes the findings of an NRC inspection of the 1997 construction work. Section 4.2 summarizes the quality control testing frequencies and methods implemented throughout the reclamation. Tables 4.1 and 4.2 summarize the Heap Leach reclamation construction activities and corresponding plan specifications.

## 4.1 NRC Inspection Findings

On July 30, 1997, the NRC completed an inspection of the reclamation construction activities (including embankment stability) at the Gas Hills site. At the time of this inspection, the primary reclamation construction activity at the site was placement of the radon barrier and frost protection covers on the heap leach impoundment area. Areas inspected included the radon cover stockpile, the radon cover and frost protection placement area, and the frost protection soil borrow site. [See Volume I, Section 4 for additional information about radon barrier and frost protection material borrow sources.] The focus of the tour was to determine if the reclamation construction activities performed at the Heap Leach were being performed in accordance with the specifications provided in the reclamation plan. In the inspection report (Report No. 40/0299/97-02, August 29, 1997; see Volume I, Table 3.3), the NRC concluded that the radon barrier and frost protection covers for the Heap Leach impoundment were being constructed in accordance with the September 25, 1996 reclamation plan and that the field and laboratory quality control program presented in the reclamation plan was being followed.

## 4.2 Quality Control Test Frequencies and Methods

Quality control testing frequencies, as specified in Part III of the enhanced reclamation plan (Quality Control Plan), are summarized below.

| **Quality Control Test** | **Required Frequency** | **Method** |
|---|---|---|
| Field Moisture and Density | Contaminated Fill: 1: 1000 CY<br>Radon Barrier: All other work: 1: 500 CY | ASTM D2922<br>ASTM D3017 |
| Sand Cone Correlation | 1:10 nuclear gauge test | ASTM D1556<br>ASTM D2216 |
| Laboratory Compaction (Standard Proctor) | 1: 5000 CY | ASTM D698 |
| Soil Classification<br>• Particle Size Analysis<br>• Atterberg Limits | Radon Barrier: 1:1000 CY<br>Frost Protection: 1:2000 CY | ASTM D2487<br>ASTM D4318<br>ASTM D1140<br>ASTM D422 |

CY cubic yards
NA Not Applicable

**Table 4.2 Summary of Specifications for the Heap Leach Cell Cover Construction**

| Layer | Specifications / Requirements |
|---|---|
| Contaminated Fill | • Lift thickness $\leq$ 12 inches (compacted depth)<br>• Percent compaction: $\geq$ 90 percent of Standard Proctor maximum density |
| Radon Barrier<br>(see note below) | Soil Characteristics<br>• Classification as CL or CH (lean clay or fat clay), based on ASTM D2487<br>• $\geq$ 75 % passing the No. 200 sieve<br>• Maximum particle size of 1 inch<br>• Liquid limit $\geq$ 30 percent<br>• Plasticity index $\geq$ 20 percent<br>• Hydraulic conductivity $\leq$ 1E-7 cm/sec (when compacted to 95 percent of Standard Proctor maximum density)<br>Placement<br>• Lift thickness $\leq$ 6 inches (compacted depth)<br>• Percent compaction: $\geq$ 95 percent of Standard Proctor maximum density<br>• Optimum $\leq$ Moisture Content $\leq$ Optimum + 4 |
| Frost Protection<br>(includes Toe protection) | Soil Characteristics *<br>• Classification as SC and/or SC-SM (clayey and/or silty-clayey sand)<br>*The allowable radium content for frost protection materials—10 pCi/g for all areas except GHP-2 (see Volumes I and V)—had not been established until the enhanced reclamation plan for the Above-Grade Tailings Impoundment was submitted in 1997. Although not formalized in the Heap Leach design specifications, this criterion was followed during placement of Heap frost protection materials (see Section 7, Final Radiological Conditions).<br>Placement<br>• Layer thickness: 4.5 feet<br>• Lift thickness $\leq$ 12 inches when compacted<br>• Percent compaction: $\geq$ 95 percent of Standard Proctor maximum density<br>• Moisture content: $\geq$ Optimum minus 2 |
| Erosion Protection | Placement of Type A, B, and C rock; see Section 6 for specifications and locations. |

Note that the specifications for the radon barrier were revised in a February 11, 1998 submittal – the final specifications are more conservative than those originally specified in the 1996 plan (see Table 3.2).

As demonstrated in the following section and supporting appendices, the required test frequencies were met and usually exceeded. Field density and moisture tests documented in the appendices and summarized in the following sections were taken using a nuclear density gauge. The gauge was field standardized at each test location and was correlated by a sand-cone test at a minimum frequency of one for every ten nuclear gauge tests. For non-clay material, field rock corrections were performed at each compaction test location. Material placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content were reworked to meet the density and moisture requirements or removed and replaced by acceptable fill compacted to meet these requirements.

For all soil placement, a sand-cone correlation test was performed for every 10 nuclear gauge tests or higher frequency. Correlations were deemed acceptable if the average of ten nuclear gauge test vs. sand cone test result comparisons met the following criteria: 1) wet density variation less than or equal to 3 percent, and moisture content variation less than or equal to 2 percent. As demonstrated in the appendices, the majority of results for discrete tests (vs. running average) were below the latter criteria.

## 5.0 CONSTRUCTION ACTIVITIES AND QUALITY CONTROL TEST RESULTS

This section describes the Heap Leach reclamation construction activities and summarizes the results of the corresponding field and laboratory quality control tests performed between 1997 and 2002. The completion of construction activities in accordance with the enhanced reclamation plan is demonstrated largely by the quality assurance/quality control records provided in the appendices and in the following as-built drawings and plates:

| Layer/Aspect | Drawing/Plate No.(s) |
|---|---|
| Final Heap Leach Site Plan | 1 |
| Existing Cover* and 1997-2002 Modifications | 2 |
| Contaminated Fill | 3 and 4 |
| Radon Barrier | 5 - 7 |
| Frost Protection | 8 and 9 |
| Toe Protection | 8 and 10 |
| Erosion Protection (addressed in Section 6) | 11 – 13 |

**The existing cover refers to that portion of the cover completed in 1992 (see Section 2).*

For each layer or construction aspect, these drawings show the final contours and survey verification points, representative cross-sections, and corresponding quality control test locations. As stated in the introduction, these drawings are provided in two formats: standard plate (provided in the following binder) and, for easier access and reference, 11 x 17 format. Geotechnical quality control tests conducted during placement of these materials and documented in detail in the appendices include field density tests, laboratory Standard Proctors, sand-cone correlation tests, gradations, and Atterberg Limits.

### 5.1 Contaminated Fill

Between 1997 and 1998, 130,392 cubic yards of contaminated fill material were placed as part of the Heap Leach reclamation modifications (Table 4.1). Placement (daily load counts) and quality control test records associated with contaminated fill placement are documented in detail in Appendix A. Table A.1 lists the daily quantities and corresponding daily testing frequencies. Field compaction tests are documented in Table A.2. Table A.3 documents the Standard Proctor Test results, and Table A.4 presents the sand-cone correlation tests. As-built Drawing 3 shows the final contours and survey verification points; Drawing 4 shows the compaction test locations. Quality control tests results associated with these activities are summarized in Tables 5.1 and 5.2 for field and laboratory tests, respectively.

#### 5.1.1 Placement

In the designated fill areas shown in Drawings 3 and 4 (north and west slopes), and in accordance with the enhanced reclamation plan, fill materials were placed in maximum lift thicknesses of 12 inches (compacted depth) and were compacted to a minimum of 90 percent of the maximum density (ASTM D698). Between 1997 and 1998, 130,392 cubic yards of material were placed as part of this effort (Table 4.1, 5.1, and Appendix A, Table A.1).

## Table 5.1 Summary of Field Quality Control Test Results for the 1997-2002 Heap Leach Reclamation

| **Layer** | **Total Yards Placed** | **Design (Plan) Requirements** | **Nuclear Density Gauge Test Results** | | | | **Sand-Cone Correlation** |
|---|---|---|---|---|---|---|---|
| | | | Frequency (No. of Tests) | Dry Density (pcf) | Percent Moisture | Percent Compaction | Frequency (No. of Tests) |
| Contaminated Fill: 1997-1998 | 130,392 CY | Frequency: 1:1000 CY<br>% Compaction: ≥ 90 *<br>% Moisture: NA | 1:767 CY<br>(n = 170) | *avg:* 110.5<br>*range:* 100.9 - 118.6 | *avg:* 13.2<br>*range:* 6.1 - 19.8 | *avg:* 96.2<br>*range:* 89.7 - 103.1 | 1:6<br>(n = 27) |
| Radon Barrier: 1997-1998, 2000 | 84,857 CY | Frequency: 1:500 CY<br>% Compaction: ≥ 95*<br>% Moisture (PM): Opt. ≤ PM ≤ Opt.+4 | 1:493 CY<br>(n = 172) | *avg:* 101.9<br>*range:* 97.2 - 106.6 | *avg:* 21.4<br>*range:* 18.7 - 25.3 | *avg:* 97.1<br>*range:* 94.9 - 101.5 | 1: 10<br>(n = 17) |
| Frost Protection: 1997-1998, 2000 | 475,737 CY | Frequency: 1:500 CY<br>% Compaction: ≥ 95*<br>% Moisture: ≥ Opt. -2 | 1:489 CY<br>(n = 973) | *avg:* 111.4<br>*range:* 96.0 – 121.6 | *avg:* 14.5<br>*range:* 9.1 - 25.2 | *avg:* 97.4<br>*range:* 94.9 - 108.7 | 1:9<br>(n = 105) |
| Toe 2001-2002 | 37,899 CY | Frequency: Not Specified<br>% Compaction: ≥ 95*<br>% Moisture: ≥ Opt. -2 | 1:332 CY<br>(n = 114) | *avg:* 112.2<br>*range:* 101.0- 123.4 | *avg:* 14.5<br>*range:* 10.5 - 23.3 | *avg:* 98.6<br>*range:* 95.0 - 103.9 | 1:10<br>(n = 11) |

*All compaction results summarized above reflect percentages of the Standard Proctor maximum density (ASTM D698).

This summary reflects passing tests only. Failed field tests resulted in re-compaction of the area and re-testing, as documented in detail in Appendix A, B, and C for contaminated fill, radon barrier, and frost protection material, respectively.

Abbreviations

| | |
|---|---|
| avg | average (arithmetic mean) |
| CY | cubic yards |
| n | number |
| NA | Not Applicable |
| Opt. | Optimum |
| pcf | pounds per cubic feet |
| % | percent |

**Table 5.2 Summary of Laboratory Quality Control Test Results for the Heap Leach Reclamation Cover Construction**

| Layer | Design (Plan) Requirements | Laboratory Standard Proctor [1] | | | Atterberg Limits | | | Soil Classification & Gradation |
|---|---|---|---|---|---|---|---|---|
| | | Frequency (Number of Tests) | Maximum Dry Density (pcf) | Optimum Moisture (%) | Frequency (Number of Tests) | Liquid Limit Results | Plastic Index Results | |
| Contaminated Fill<br>130,392 CY | NA for all except Proctor frequency | 1:3343 CY<br>(n = 39) | *avg:* 115.0<br>*range:* 109.3 – 124.0 | *avg:* 13.5<br>*range:* 8.4 – 16.9 | NA | NA | NA | NA |
| Radon Barrier<br>84,857 CY | Gradation-Atterberg Frequency: 1:1000 CY<br>Liquid limit: ≥ 30<br>Plasticity index: ≥ 20<br>Unified Soil Classification: CL or CH<br>≥ 75% passing #200 sieve<br>Max. particle size = 1"<br>Hydraulic conductivity: ≤ 1E-7 cm/sec | 1:4466 CY<br>(n = 19) | *avg:* 104.9<br>*range:* 102.3 – 108.6<br><br>Hydraulic conductivity was tested for 11 samples: results ranged from 3.9E-9 to 9.0E-8 cm/sec, with an average of 2.9E-8 cm/sec. | *avg:* 19.6<br>*range:* 18.2 – 21.1 | 1:884 CY<br>(n = 96) | *avg:* 50.5<br>*range:* 43 – 60 | *avg:* 32.4<br>*range:* 20 - 43 | Fat Clay (CH): 58%<br>Lean Clay (CL): 42%<br><br>Percent passing #200 sieve: avg = 94.1%<br>*range:* 86.4 – 98.4%<br><br>All gradation requirements were met. |
| Frost Protection<br>475,737 CY | Gradation-Atterberg Frequency: 1:2000 CY<br>Unified Soil Classification: SC and/or SC-SM | 1:3806 CY<br>(n = 125) | *avg:* 114.3<br>*range:* 100.1 - 122.6 | *avg:* 14.4<br>*range:* 10.1 - 21.8 | 1:1675 CY<br>(n = 284) | *avg:* 34.6<br>*range:* 25 – 47 | *avg:* 17.7<br>*range:* 5 - 31 | SC: 76%<br>CL: 14%<br>SM: 9%<br>SC-SM: 1% |

[1] Proctor frequency requirements for all layers are 1:5000 CY. Details are provided in Appendices A, B, and C for contaminated fill, radon barrier, and frost protection material, respectively.

Abbreviations

| | |
|---|---|
| avg | average (arithmetic mean) |
| cm/sec | centimeters per second |
| CY | cubic yards |
| n | number |
| NA | Not Applicable |
| Opt. | Optimum |
| pcf | pounds per cubic feet |

ASTM 2487 Term Definitions

| | |
|---|---|
| CH | Fat Clay |
| CL | Lean Clay |
| SC | Clayey Sand |
| SC-SM | Silty, Clayey Sand |
| SM | Silty Sand |

### 5.1.2 Quality Control Test Results

As summarized in Table 5.1 and in the inset below, based on 170 passing tests, contaminated fill soils were compacted to an average of 96.2 percent of the maximum Standard Proctor dry density, ranging from 89.7 to 103.1 percent. The maximum Standard Proctor dry density ranges from 109.3 to 124 pcf (average of 115 pcf), with optimum moisture content ranging from 8.4 to 16.9 percent (average of 13.5 percent).

Heap Leach Contaminated Fill Field and Laboratory Compaction Test Results

| | **Dry Density** (pcf) | **Percent Moisture** | **Percent Compaction** | **Maximum Dry Density** (pcf) | **Optimum Moisture** (%) |
|---|---|---|---|---|---|
| *average:* | 110.5 | 13.2 | 96.2 | 115.0 | 13.5 |
| *range:* | 100.9 – 118.6 | 6.1 – 19.8 | 89.7 - 103.1 | 109.3 – 124.0 | 8.4 – 16.9 |
| *std. deviation:* | 3.6 | 2.7 | 3.2 | 3.0 | 1.5 |

Nuclear Gauge N = 170; frequency = 1 test for every 767 cubic yards placed
Proctor N = 39; frequency = 1 test for every 3343 cubic yards placed

Correlation results documented in Appendix B, Table B.4 indicate good agreement between the nuclear gauge and sand-cone test, with averages of 1.1 and 1.0 percent variation (absolute value) for wet density and moisture, respectively.

Tables 5.1 and 5.2 demonstrate that the quality control tests for the contaminated fill were conducted at much higher frequencies than those called for in the reclamation plan. For example, the compaction test frequency was 1:767 cubic yards (CY), exceeding the required 1:1000 CY frequency. Similarly, Standard Proctors were performed at a frequency of 1 test for every 3,343 cubic yards placed, greatly exceeding the required frequency of 1:5000 CY. Correlation tests documented in Appendix A, Table A.4 indicate generally good agreement between the nuclear gauge and sand-cone tests, with averages of 2.2 and 1.0 percent variation (absolute value) for wet density and moisture, respectively.

## 5.2 Radon Barrier

Construction activities for extension of the radon barrier took place in 1997 and 1998. During this time, 84,857 cubic yards of Cody Shale clay material were placed as part of the radon barrier on the sideslopes of the Heap Leach. Placement (daily load counts) and quality control test records associated with radon barrier placement are documented in detail in Appendix B. Table B.1 lists the daily quantities and corresponding daily testing frequencies. Field compaction tests are documented in Table B.2. Tables B.3 and B.4 provide the laboratory Standard Proctor and sand-cone correlation test results, respectively. Radon barrier soil classification and gradation test results are listed in Table B.5. Quality control tests results obtained for the radon barrier extension are summarized in Table 5.1 and 5.2 for field and laboratory tests, respectively.

### 5.2.1 Placement

Clayey soils for construction of the radon barrier were excavated from the Clay Borrow area, discussed in detail in Section 4 of Volume I. In accordance with the enhanced reclamation plan, this material was placed in equal continuous layers not exceeding 6 inches compacted depth and compacted to a minimum of 95 percent of maximum Standard Proctor dry density (ASTM D698), at a moisture content between optimum and 4 percent above optimum (Table 5.2, Appendix B, Table B.2).

Drawing 5 shows the placement areas, thickness, final grades, and survey verification points for the radon barrier extension. This drawing also provides several cross-sections showing the tie-in to the existing radon barrier (i.e., the radon barrier constructed under the previously-approved plan). Drawing 6 shows the compaction test locations, demonstrating their high density and extensive spatial coverage. Although not specified in the enhanced reclamation plan, Umetco conducted regular checks of the in-place thickness of the radon barrier layer to ensure that depths met the 12-inch specification. Locations and corresponding test results are shown on Drawing 7.

### 5.2.2 Quality Control Test Results

**Field Compaction Test Results.** As summarized in Table 5.1 and detailed in Table B.2, based on 172 passing tests, radon barrier soils were compacted to a average of 97.1 percent of the maximum Standard Proctor dry density, ranging from 94.9 to 101.5 percent. The average dry density of this material ranges from 97.2 to 106.6 pcf (average of 101.9 pcf). Moisture content of the material ranges from 18.7 percent to 25.3 percent (average of 21.4%).

Heap Leach Radon Barrier Field Compaction Test Results

| | Dry Density (pcf) | % Moisture | % Compaction |
|---|---|---|---|
| *average:* | 101.9 | 21.4 | 97.1 |
| *range:* | 97.2 – 106.6 | 18.7 – 25.3 | 94.9 – 101.5 |
| *std. deviation:* | 1.9 | 1.3 | 1.7 |

N = 172; frequency = 1 test for every 493 cubic yards placed

Correlation results documented in Table B.4 indicate good agreement between the nuclear gauge and sand-cone test, with averages of 1.1 and 1.0 percent variation (absolute value) for wet density and moisture, respectively. Although not specified in the enhanced reclamation plan, Umetco conducted regular checks of the in-place thickness of the radon barrier layer to ensure that depths met the 18-inch specification. Based on 50 tests at the locations shown on Drawing 7, depths ranged from 1.5 to 2.2 ft, with an average depth of 1.7 feet and standard deviation of 0.19 ft (2.3 inches). Appendix B, Table B.6 documents the results of these depth verification samples.

**Standard Proctor Test Results.** As summarized in Table 5.2 and in the inset on the following page, the maximum Standard Proctor dry density of the radon barrier material ranges from 102.3 to 108.6 pcf (average of 104.9 pcf), with optimum moisture content ranging from 18.2 to 21.1 percent (average of 19.6 percent moisture).

Heap Leach Radon Barrier Standard Proctor Test Results

| | **Maximum Dry Density** (pcf) | **Optimum Moisture** (%) |
|---|---|---|
| *average:* | 104.9 | 19.6 |
| *range:* | 102.3 – 108.6 | 18.2 – 21.1 |
| *std. deviation:* | 1.9 | 0.9 |

Proctor N = 19; frequency = 1 test for every 4,466 cubic yards placed

**Hydraulic Conductivity.** As indicated in Table 4.2, the reclamation plan specified a maximum hydraulic conductivity of 1E-7 cm/s (when compacted to 95% of Standard Proctor maximum dry density). To demonstrate satisfaction of this requirement, hydraulic conductivity was measured by Inberg-Miller in early 1998 using a flexible wall permeameter (ASTM D 5084 Method C). Appendix B, Table B.3 documents the results, which ranged from 3.9E-9 to 9.0E-8 cm/s, with an average of 2.9E-8 cm/s (hydraulic conductivity was tested for 11 samples). All hydraulic conductivity results are below the 1.0E-7 maximum requirement. The specific gravity was 2.8 for each sample.

**Soil Classification, Atterberg Limits, and Gradations.** The Heap reclamation plan modifications included the following specifications for radon barrier material characteristics:

- classification as CL or CH (lean clay or fat clay)
- at least 75 percent passing the No. 200 sieve
- maximum particle size of 1 inch
- minimum liquid limit of 30 percent; and
- minimum plasticity index of 20

As documented in Table B.5 and summarized in Table 5.2, all Heap Leach soil classification tests met the design specifications. The maximum particle size was 1 inch (the majority of tests passed the No. 4 sieve); an average of 94.1% passed the #200 sieve. Liquid limits and plastic indices were all well above the plan requirements; averages were 50.5 and 32.4 percent, respectively. In accordance with plan requirements, all unified soil classifications were either CH (Fat Clay, 58%) or CL (Lean Clay, 42%).

## 5.3 Frost Protection Material

Construction activities for extension of the frost protection layer took place between 1997 and 2000; however, the majority of the work was completed in 1997. During this period, 475,737 cubic yards of frost protection material were placed on the Heap Leach. This aspect of the work is distinguished from that done for contaminated fill and radon barrier placement in that the entire Heap Leach was addressed (vs. sideslopes)—i.e., additional frost protection was placed over the entire existing cover.

This section will demonstrate the homogeneity of frost protection soils and that all plan requirements were met. Placement (daily load counts) and quality control test records associated with frost protection placement are documented in detail in Appendix C. Table C.1 lists the daily quantities and corresponding daily testing frequencies. Field compaction tests are documented in Table C.2. Tables C.3 and C.4 provide the laboratory Standard Proctor and sand-cone correlation test results, respectively. Results of soil classification and gradation tests are documented in Table C.5. These results are summarized in Tables 5.1 and 5.2 for field and laboratory tests, respectively. Primary findings are discussed below.

### 5.3.1 Placement

The augmented frost protection layer for the Heap Leach cover was constructed with soils obtained primarily from the B-Spoils borrow area located east of the Heap Leach repository. Sources and characteristics of this material are discussed in detail in Volume I, Section 4 and shown on Figure 4.5. As discussed in that section, borrow excavations were continuously monitored by Umetco in the field to ensure that the 10 pCi/g Ra-226 criterion was met. As indicated in Table 4.2, the allowable radium content for frost protection materials—10 pCi/g for all areas except GHP-2 (see Volumes I and V)—had not been established until 1997, in response to NRC comments and coinciding with the submittal of the enhanced reclamation plan for the Above-Grade Tailings Impoundment. Although not formalized in the 1996 Heap Leach design specifications, this criterion was followed during placement of all Heap frost protection materials.

Frost protection soils were placed in equal continuous layers not exceeding 12-inches compacted depth and compacted to a minimum of 95 percent of maximum Standard Proctor dry density (ASTM D698), and at a moisture content greater than or equal to optimum minus 2. The final contours and survey verification points are shown on Drawing 8; Drawing 9 shows the compaction test locations.

### 5.3.2 Quality Control Test Results

**Field Compaction Test Results.** As summarized in Table 5.1 and in the inset below, based on 973 passing tests, frost protection soils were compacted to an average of 97.4 percent of the maximum Standard Proctor density, ranging from 94.9 to 108.7 percent. The average dry density of the compacted material was 111.4 pcf, ranging from 96.0 pcf to 121.6 pcf. The average moisture content was 14.5 percent, ranging from 9.1 percent to 25.2 percent (Appendix C, Table C.2). Drawing 9 demonstrates the high density and extensive spatial coverage of the compaction test locations. Based on the total volume placed of 475,737 cubic yards, the testing frequency was 1 test for every 489 cubic yards placed, satisfying plan requirements.

Heap Leach Frost Protection Field Compaction Test Results

| | Dry Density (pcf) | % Moisture | % Compaction |
|---|---|---|---|
| *average:* | 111.4 | 14.5 | 97.4 |
| *range:* | 96.0 – 121.6 | 9.1 – 25.2 | 94.9 – 108.7 |
| *std. deviation:* | 3.2 | 2.2 | 1.7 |

N = 973; frequency = 1 test for every 489 cubic yards placed

**Standard Proctor Test Results.** Table 5.2 summarizes the Standard Proctor results, which yielded an average maximum dry density for frost protection materials of 114.3 pcf, ranging from 100.1 to 122.6 pcf. The optimum moisture was 14.4 percent, ranging from 10.1 to 21.8 percent.

Heap Leach Frost Protection Material Standard Proctor Test Results

| | **Maximum Dry Density** (pcf) | **Optimum Moisture** (%) |
|---|---|---|
| *average:* | 114.3 | 14.4 |
| *range:* | 100.1 - 122.6 | 10.1 - 21.8 |
| *std. deviation:* | 3.7 | 1.9 |

Proctor N = 125; frequency = 1 test for every 3,806 cubic yards placed

**Soil Classification.** The enhanced reclamation plan specified that frost protection materials shall consist of clayey and/or silty sand, classified as SC and/or S-SM. As documented in Appendix C, Table C.2 and summarized in Table 5.2, these requirements were generally met. Based on the 284 soil classification tests performed, frost protection soils consisted primarily (76%) of clayey sand (SC). Although 14 percent of the samples were classified as clay, this is not considered to have an adverse effect on the cover construction, especially in light of the fact that—ultimately—the main criterion for frost protection material characteristics was the demonstration that the soil radium content was less than or equal to the established background levels (10 pCi/g for all repositories except GHP-2; see Volumes I and V). Remaining frost protection materials were classified as silty sand (SM, 9%) and a very small percentage as silty, clayey sand (SC-SM, 1%).

## 5.4 Toe Protection

Placement (daily load counts) and quality control test records associated with construction of the Heap Leach toe are documented in Appendix D and summarized below. Drawing 8 shows the final contours and survey verification points for the toe protection excavation (along with those for frost protection materials). Corresponding compaction test locations are shown on Drawing 10. As demonstrated in Table 5.1, Appendix D, and in the corresponding as-builts, all construction activities for the Heap Leach toe were conducted in accordance with the approved reclamation plan.

## 6.0 EROSION PROTECTION

Erosion protection placement at the Heap Leach began in 2000 and continued until 2002. During this period, over 102,000 cubic yards of erosion protection material were placed on the Heap Leach. As-built Drawing 11 shows the Type A Bedding survey verification points and cross-sections. Drawing 12 shows the placement areas, final contours and survey verification points, and relevant cross-sections for the overlying erosion protection material. Drawing 13 shows the corresponding visual depth check and in-place gradation test locations.

For detailed information regarding rock quality and gradation test results, refer to Volume I, Section 5. This section demonstrates that the combination of the erosion protection source and the quality control program used during production and placement at the Gas Hills site repositories has resulted in a finished product which satisfies the erosion protection requirements of 10 CFR 40, Appendix A.

### 6.1 Scope of Work

The scope of work for the Heap Leach erosion protection placement is summarized in Table 6.1 and demonstrated in Drawings 11 through 13. Three sizes ($D_{50}$) of riprap were used as erosion protection for the Heap Leach cover. These three sizes are categorized as Type A, Type B, and Type C, having median grain sizes ($D_{50}$) of 0.5, 3.0, and 6.0 inches, respectively. Type A riprap was used on the top cover and was also placed as bedding material for the larger riprap shown on Drawings 12 and 13. Type B rock was used on the majority of the sideslopes, except for the area of concentrated flows on the 5:1 outslope and channel outlet, where a 12-inch layer of Type C rock was placed.

**Table 6.1 Summary of Heap Leach Erosion Protection Placement: 2000-2002**

| Rock Type | Area(s) Placed | Total Volume Placed (cubic yards) | $D_{50}$ and In-Place Thickness |
|---|---|---|---|
| Type A | Bedding Material (Drawing 11) and top of Heap | 46,313 | $D_{50}$ = 0.5 inches, minimum in-place thickness of 0.5 feet. |
| Type B | Sideslopes | 24,999 | $D_{50}$ = 3.0 inches, minimum in-place thickness of 0.5 feet |
| Type C | Area of concentrated flows on 5:1 outslope and channel outlet | 5,317 | $D_{50}$ = 6.0 inches; minimum in-place thickness of 1.0 foot |

Details regarding the design and underlying assumptions are documented in detail in the 1996 design report, the 2000 modification (see Section 6.2 below), and in the technical evaluations accompanying the NRC's approval of the plan and modifications (Attachments 1 and 2). Corresponding gradation curves are shown on Figure 6.1.

## 6.2 December 2000 Modifications

On December 20, 2000, Umetco submitted a request to modify the Channel 2 outlet configuration and erosion protection design for the Heap Leach (entitled *Proposal for Erosion Protection Modification for the Above-Grade Tailings Impoundment and Heap Leach* (December 18, 2000). [Modifications for the Above-Grade Tailings Impoundment are addressed in the Volume III.] The re-design for the Heap Leach was made to better conform the design of the outlet channel to existing topography and the adjacent designs of the Wyoming Department of Environmental Quality (WDEQ) reclamation plan for the B-Spoils Borrow Area, into which Channel 2 discharges. The modifications to the Channel 2 Outlet consisted of narrowing the channel width at the outlet to 250 feet and provision of a drop apron design and modified scour apron at the channel outlet to lower the discharge elevation of surface flows.

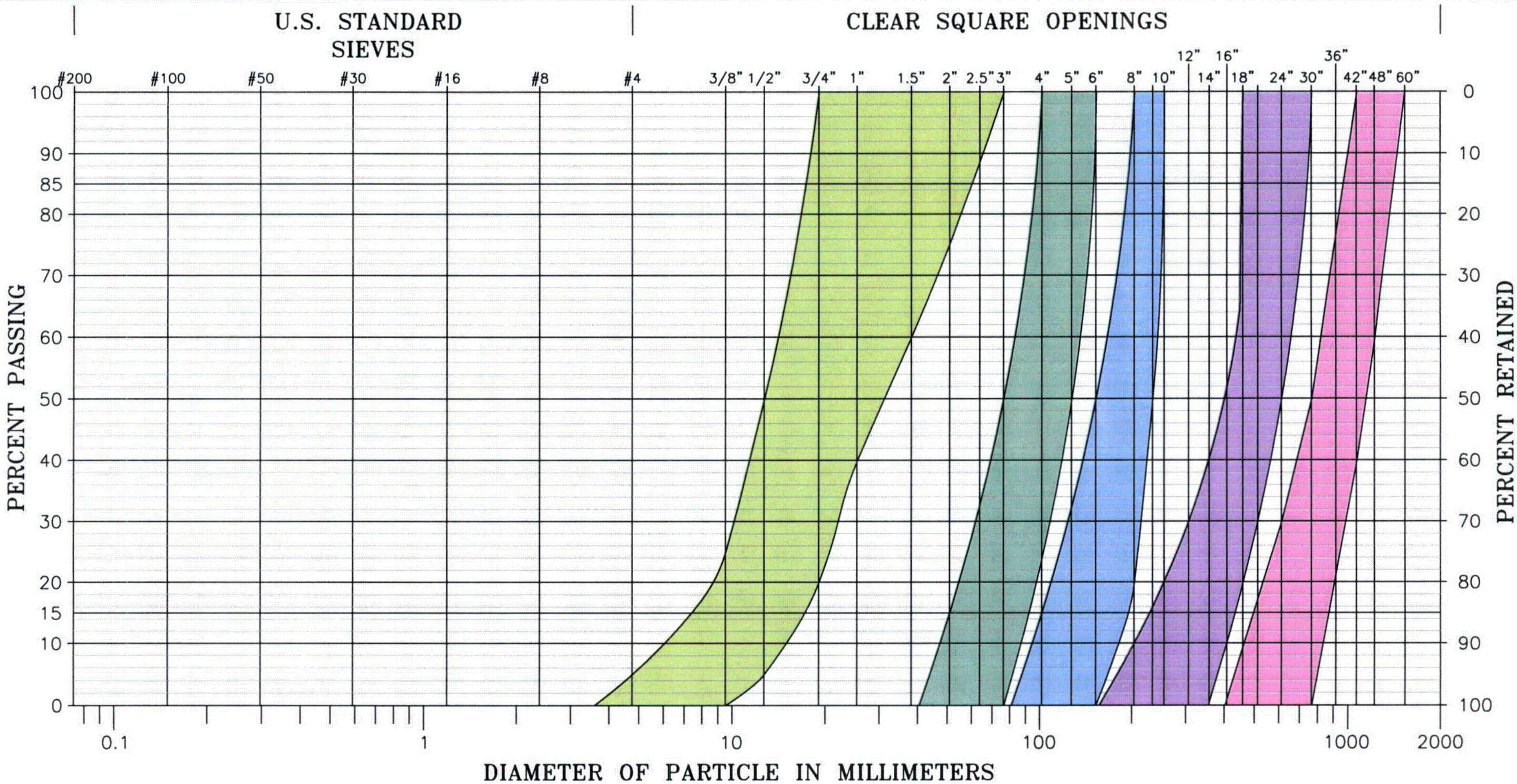
Details of the channel outlet design are documented of the December 2000 design modification submittal (see Section 3.1 and Drawing 2). As discussed in Volume I (Section 5), this submittal also included a request to modify gradation requirements for Type A rock, by increasing the maximum size from 1 to 3 inches. These modifications were approved by the NRC by License Amendment 44 in April 2001, provided in Attachment 2.

## 6.3 Rock Placement – General Procedures

In accordance with the approved Heap Leach reclamation plan, the following requirements were met:

- The riprap met or exceeded the size requirements presented in the Construction Drawings and design report.
- When necessary, riprap was oversized in accordance with the NRC STP, Appendix D.
- Riprap material was placed to the lines and grades shown in Drawings 10 and 11, consistent with the design plan.
- Placement of all riprap materials was accomplished in a manner providing well-keyed, densely placed layers of the specified thickness.
- For placement control purposes one test section (approximately 30 feet wide by 50 feet long) was constructed for each type of riprap material to be placed.

GHRIPRAP-REV2002.DWG




**Type A Specification**
**($D_{50}$ = 0.5")**

| SIEVE | PERCENT PASSING |
|---|---|
| 3" | 100 |
| 1.5" | 60 – 100 |
| 1" | 40 – 100 |
| 3/4" | 20 – 100 |
| 1/2" | 5 – 50 |
| 3/8" | 0 – 25 |
| #4 | 0 – 5 |

**Type B Specification**
**($D_{50}$ = 3")**

| SIEVE | PERCENT PASSING |
|---|---|
| 6" | 100 |
| 5" | 50 – 100 |
| 4" | 30 – 100 |
| 3" | 0 – 50 |
| 2" | 0 – 15 |

**Type C Specification**
**($D_{50}$ = 6")**

| SIEVE | PERCENT PASSING |
|---|---|
| 10" | 100 |
| 9" | 50 – 100 |
| 8" | 20 – 100 |
| 6" | 0 – 50 |
| 4" | 0 – 15 |

**Type D Specification**
**($D_{50}$ = 16")**

| SIEVE | PERCENT PASSING |
|---|---|
| 30" | 100 |
| 24" | 50 – 100 |
| 18" | 20 – 100 |
| 12" | 0 – 30 |
| 8" | 0 – 10 |

**Type E Specification**
**($D_{50\ MIN}$ = 30")**

| SIEVE | PERCENT PASSING |
|---|---|
| 60" | 100 |
| 48" | 60 – 100 |
| 42" | 40 – 100 |
| 30" | 0 – 50 |
| 24" | 0 – 30 |

**LEGEND:**

- TYPE A RIPRAP
- TYPE B RIPRAP
- TYPE C RIPRAP
- TYPE D RIPRAP
- TYPE E RIPRAP

**FIGURE 6.1**
**RIPRAP GRADATIONS**
**UMETCO GAS HILLS SITE**
JUNE, 2002

## 6.4 Quality Control Test Results

As indicated in the introduction to this section, the reader is referred to Section 5 of Volume 1 for detailed information regarding rock quality (Table 5.5), gradation test results (Tables 5.6 through 5.11), and in-place visual depth check documentation (Table 5.12). The subset of these results corresponding to placement at the Heap Leach is provided in Tables 6.2 through 6.4. Tables 6.2 and 6.3 document the in-place gradation test results for Type A and Type B rock, respectively. Table 6.4 lists the in-place depth check verification results.

As demonstrated in these tables and in Drawings 11 through 13, placement of erosion protection materials on the Heap Leach was conducted in accordance with plan requirements (including the December 2000 submittal) and satisfies the criteria set forth in 10 CFR Part 40, Appendix A for the following criteria:

> *Criterion 4(c)* – provides requirements for the long-term stability of the embankment and cover slopes for tailings;
>
> *Criterion 4(d)* – requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient.

## 7.0 FINAL RADIOLOGICAL STATUS

To verify that the completed Heap Leach repository cover meets the criteria set forth in 10 CFR 40, Appendix A, Criterion 6(1) and Criterion 6(2), this section summarizes: 1) verification data documenting the Ra-226 content of frost protection materials placed on the heap; 2) radon emission rate measurements; and 3) the results of the Heap Leach gamma exposure rate survey. The latter information is already documented in the *Final Status Survey Report* (Umetco 2003), which was approved by the NRC on September 27, 2004.

### 7.1 Cover Radium Content (Frost Protection)

During construction of the Heap Leach frost protection layer, frost protection materials were continuously gamma surveyed and the upper two feet sampled and analyzed for Ra-226. Although an allowable Ra-226 content had not been formally established at the time the 1996 Heap Leach plan was developed, a background value of 10 pCi/g was subsequently established for the site, and this was used as the criterion for frost protection placement for all repository areas except GHP-2 (see Volume I, Section 4.2). Tables 7.1 and 7.2 (following page) summarize the results of the frost protection verification sampling for the Heap Leach (top cover) and gap areas, respectively. For the newly constructed main top cover, these analyses yielded an average Ra-226 content of 3.3 pCi/g and 3.4 pCi/g for the 0-1 foot and 1-2 foot depth profiles, respectively. For the Heap Leach gap, results were slightly higher, but still well below the 10 pCi/g criterion: 3.9 pCi/g (0-1 ft depth) and 4.1 (1-2 ft).

### 7.2 Radon Emanation (NESHAPS)

Radon emission rates were measured from the Heap Leach in 1999 for comparison with the regulatory limit in 10 CFR 40, Appendix A, Criterion 6(2) of 20 pCi/m$^2$s (NESHAPs report submitted November 12, 1999). The radon emission rate measured for the Heap Leach cover was 1.1 pCi/m$^2$-s, well within the regulatory limit of 20 pCi/m$^2$-s established in 10 CFR 40 and consistent with the radon emission rate measurements from the adjacent Heap Leach repositories (1.1 pCi/m$^2$-s).

### 7.3 Direct Gamma Exposure Rates

10 CFR 40, Appendix A, Criterion 6(1) requires demonstrating that direct gamma exposure from tailings or wastes be reduced to background levels. To demonstrate compliance with this requirement, direct gamma exposure surveys of the Heap Leach were made over the completed earthen cover between April and July 2001, prior to placement of erosion protection material. One-meter high bare gamma exposure readings were collected and then averaged over the entire area. The results of this survey are documented in the Final Status Survey Report (Umetco 2004) and summarized below.

The average exposure rate measured over the Heap Leach was 27 μR/hr, satisfying the 30 μR/hr criterion. This was approved by the NRC in the September 27, 2004 TER, which states the following: "The average exposure rate measured on the earthen covers of the AGTI and the Heap Leach was 27 μR/hr, therefore, the gamma levels comply with the approved limit of 30 μR/hr, demonstrating compliance with Part 40, Appendix A, Criterion 6(1). The potential dose is very low and the radiation levels on the Umetco site are comparable to the surrounding area."

## Table 7.1 Heap Leach Frost Protection Verification Sampling Results

| Grid | 0-1 ft Ra-226 (pCi/g) | 1-2 ft Ra-226 (pCi/g) |
|---|---|---|
| 1 | 3.1 | 3.8 |
| 2 | 3.4 | 4.2 |
| 3 | 4.0 | 3.3 |
| 4 | 4.0 | 2.8 |
| 5 | 3.8 | 3.3 |
| 6 | 3.1 | 3.3 |
| 7 | 3.3 | 4.1 |
| 8 | 2.8 | 3.0 |
| 9 | 3.9 | 4.0 |
| 10 | 2.6 | 3.9 |
| 11 | -- | -- |
| 12 | 3.0 | 4.0 |
| 13 | 2.5 | 3.5 |
| 14 | 3.3 | 3.7 |
| 15 | 3.2 | 4.0 |
| 16 | 3.1 | 3.5 |
| 17 | 2.9 | 2.7 |
| 18 | 3.6 | 3.4 |
| 19 | No Data | 3.1 |
| 20 | 3.1 | 2.2 |
| 21 | 3.1 | 4.0 |
| 22 | 3.1 | 2.1 |
| 23 | 3.9 | 2.6 |
| **Average:** | **3.3** | **3.4** |

0-1 ft sampling was conducted on 10/9/97; 1-2 ft verification sampling was conducted on 9/3/97.
For frost protection verification sampling, Umetco established a grid system that yielded a conservative testing frequency: 1:3675 cubic yards vs. the 1:5000 CY requirement. Grid 11 was established but not sampled because the majority of the grid fell outside the Heap repository boundary.

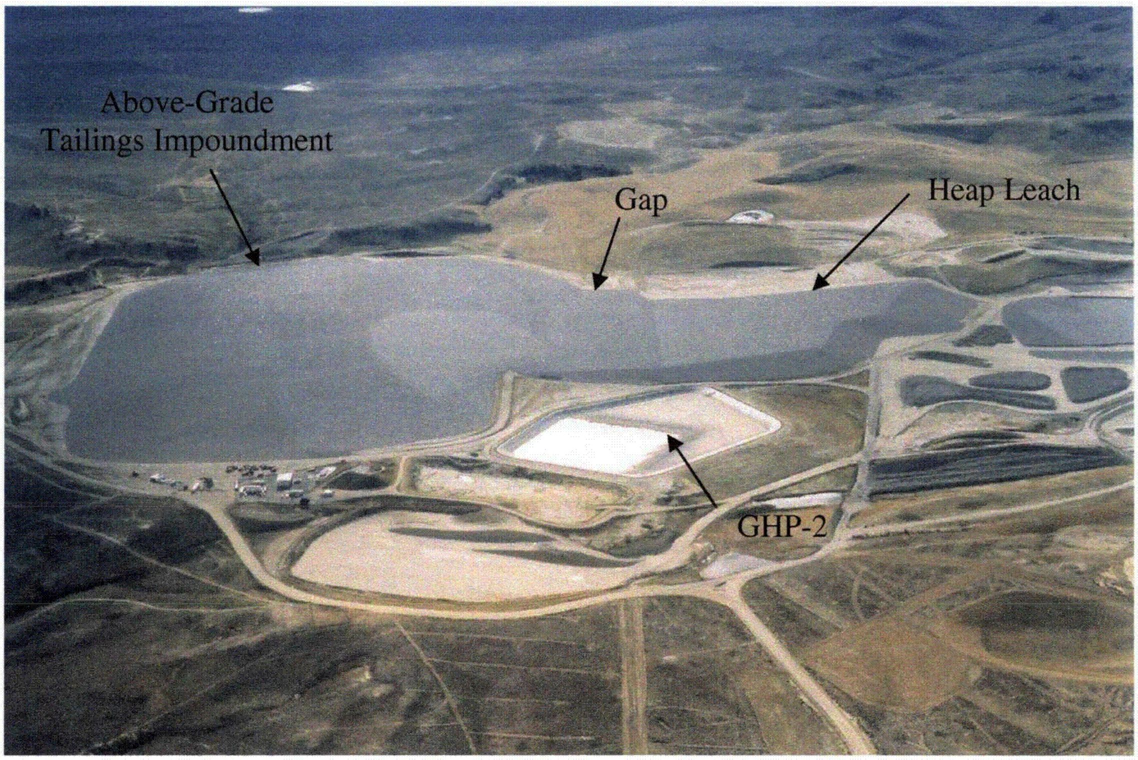
## Table 7.2 Heap Leach Gap Frost Protection Verification Sampling Results

| Grid | 0-1 ft Ra-226 (pCi/g) | 1-2 ft Ra-226 (pCi/g) |
|---|---|---|
| 1 | 3.4 | 3.7 |
| 2 | 2.7 | 3.6 |
| 3 | 2.7 | 4.9 |
| 4 | 4.0 | 4.0 |
| 5 | 3.3 | 4.9 |
| 6 | 3.2 | 4.7 |
| 7 | 7.3 | 3.2 |
| 8 | 4.8 | 3.8 |
| **Average:** | **3.9** | **4.1** |

0-1 ft sampling was conducted on 10/28/98;
1-2 ft verification sampling was conducted on 10/19/98.

## 8.0 SUMMARY AND CONCLUSIONS

In summary, this volume of the Construction Completion Report demonstrates that all work documented herein for the Heap Leach was performed in accordance with the design and procedures in the approved reclamation plan. Additionally, it verifies that the completed cover will the requirements established in 10 CFR 40, Appendix A, Criteria 4 (c), (d), (e), 6(1), and 6(2) with regard to reasonable assurance of stability and control of the contaminated material and limitation of the radon flux from the disposal area to the atmosphere to 20 pCi/m$^2$-s.




Heap Leach Repository viewed from the West to the East.

## 9.0 REFERENCES


D'Appolonia Consulting Engineers (D'Appolonia). 1980. Reclamation Plan – Inactive Tailings Areas and Heap Leach Site. Submitted by letter dated December 18, 1980.

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U.S. Nuclear Regulatory Commission (NRC). 2001. Technical Evaluation of the Revised Soil Decommissioning Plan and Surety for the Umetco Minerals Corporation Gas Hills Uranium Mill Site. March 28, 2001. Submitted by letter dated April 5, 1001 from D.M. Gillen (NRC) to C.O Sealy (Umetco) re: "Amendment 44, Revised Soil Decommissioning and Erosion Protection Plans and Surety Update for License SUA-648, Umetco Minerals Corporation, Gas Hills Uranium Mill Site."

U.S. Nuclear Regulatory Commission (NRC). 2002. *Design of Erosion Protection for Long-Term Stabilization*. NUREG-1623, Final Report. Prepared by T.L. Johnson, September 2002.

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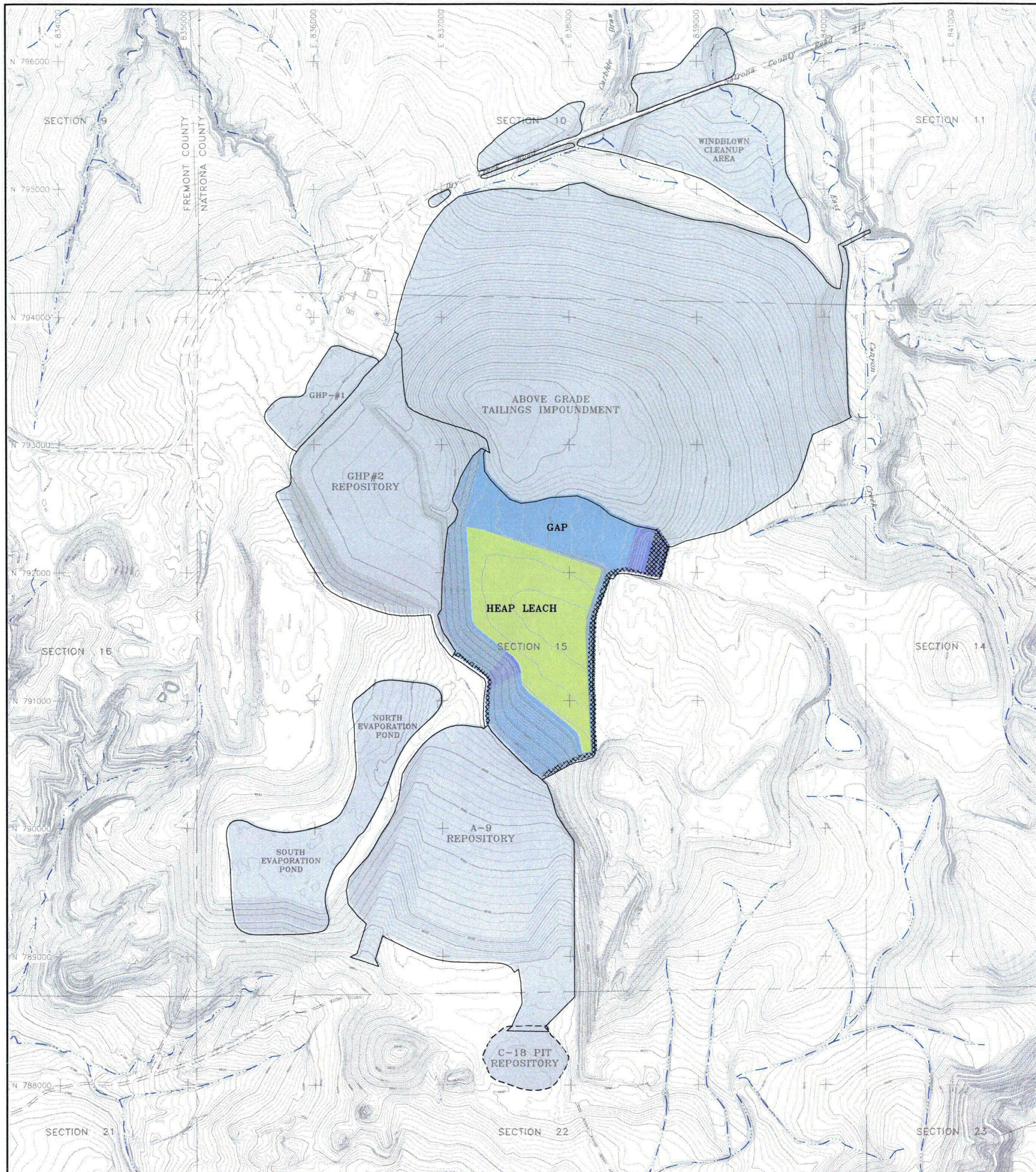
U.S. Nuclear Regulatory Commission (NRC). 2004. Technical Evaluation Report for Umetco Minerals Corporation's Status Survey Report for the Gas Hills Uranium Tailings Site. Submitted by letter from G.S. Janosko (NRC) to T. Gieck (Umetco) dated September 27, 2004. SUA-648 (TAC LU0040). September 2004 TER.

# DRAWINGS




N

400' 0 400'

SCALE IN FEET

CONTOUR INTERVAL : 2'

| SHEET NO. | TITLE |
|---|---|
| 1 OF 13 | FINAL HEAP LEACH/GAP SITE PLAN<br>REFLECTING POST-RECLAMATION CONSTRUCTION FINAL GRADES |
| 2 OF 13 | HEAP LEACH/GAP<br>EXISTING COVER AND<br>1997 – 2002 MODIFICATIONS |
| 3 OF 13 | HEAP LEACH/GAP<br>FINAL CONTOURS AND SURVEY VERIFICATION POINTS<br>CONTAMINATED FILL AREA |
| 4 OF 13 | HEAP LEACH/GAP<br>COMPACTION TEST LOCATIONS<br>CONTAMINATED FILL AREA |
| 5 OF 13 | HEAP LEACH/GAP<br>FINAL CONTOURS AND SURVEY VERIFICATION POINTS<br>RADON BARRIER FILL AREA |
| 6 OF 13 | HEAP LEACH/GAP<br>COMPACTION TEST LOCATIONS<br>RADON BARRIER FILL AREA |
| 7 OF 13 | HEAP LEACH/GAP<br>VISUAL DEPTH CHECK LOCATIONS<br>RADON BARRIER FILL AREA |
| 8 OF 13 | HEAP LEACH/GAP<br>FINAL CONTOURS AND SURVEY VERIFICATION POINTS<br>FROST PROTECTION FILL AREA<br>AND TOE PROTECTION SUBGRADE |
| 9 OF 13 | HEAP LEACH/GAP<br>COMPACTION TEST LOCATIONS<br>FROST PROTECTION FILL AREA |
| 10 OF 13 | HEAP LEACH/GAP<br>COMPACTION TEST LOCATIONS<br>TOE PROTECTION FILL AREAS |
| 11 OF 13 | HEAP LEACH/GAP<br>FINAL CONTOURS AND SURVEY VERIFICATION POINTS<br>TYPE "A" BEDDING MATERIAL<br>EROSION PROTECTION PLACEMENT |
| 12 OF 13 | HEAP LEACH/GAP<br>FINAL CONTOURS AND SURVEY VERIFICATION POINTS<br>EROSION PROTECTION PLACEMENT |
| 13 OF 13 | HEAP LEACH/GAP<br>IN-PLACE GRADATION TEST LOCATIONS<br>AND VISUAL DEPTH CHECK TEST LOCATIONS<br>EROSION PROTECTION PLACEMENT |

## LEGEND

- 7060 — 2006 FINISHED GRADE TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 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
- 12-INCHES OF RIPRAP TYPE "C" $D_{50}$ = 6.0 INCH WITH 6-INCHES OF FILTER TYPE "A" $D_{50}$ = 0.5 INCH
- BELOW-GRADE APRON

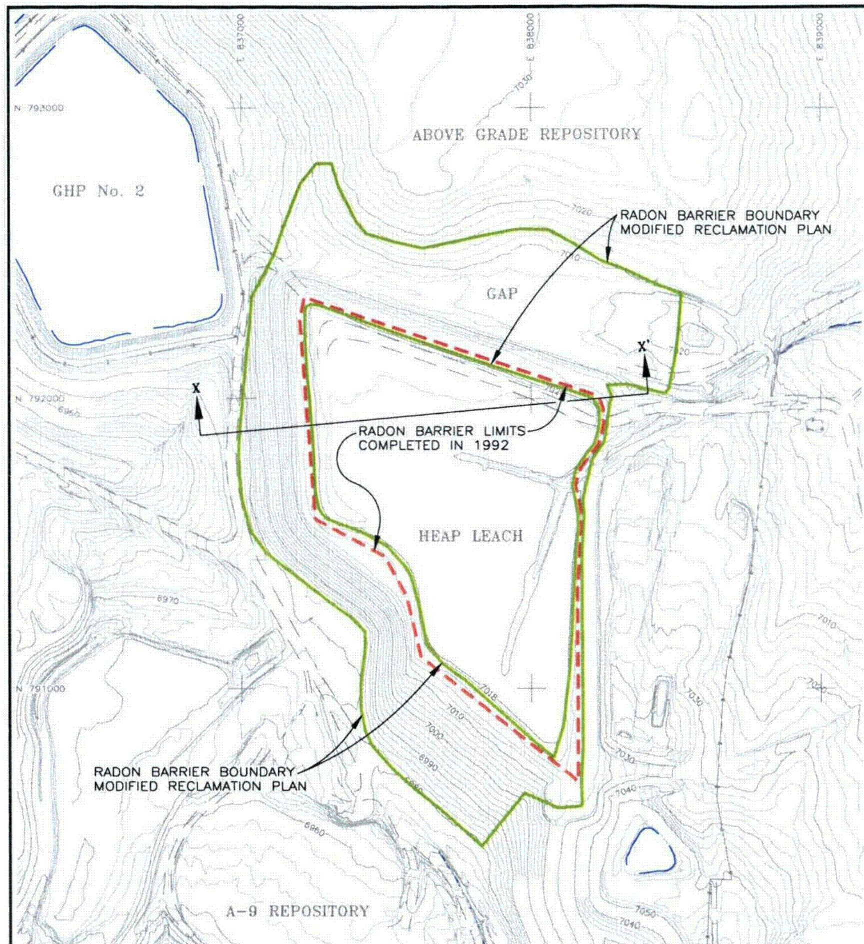
**Umetco Minerals Corporation**
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

FINAL HEAP LEACH/GAP SITE PLAN REFLECTING POST-RECLAMATION CONSTRUCTION FINAL GRADES

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-01-AB SHEET 1 OF 13




N

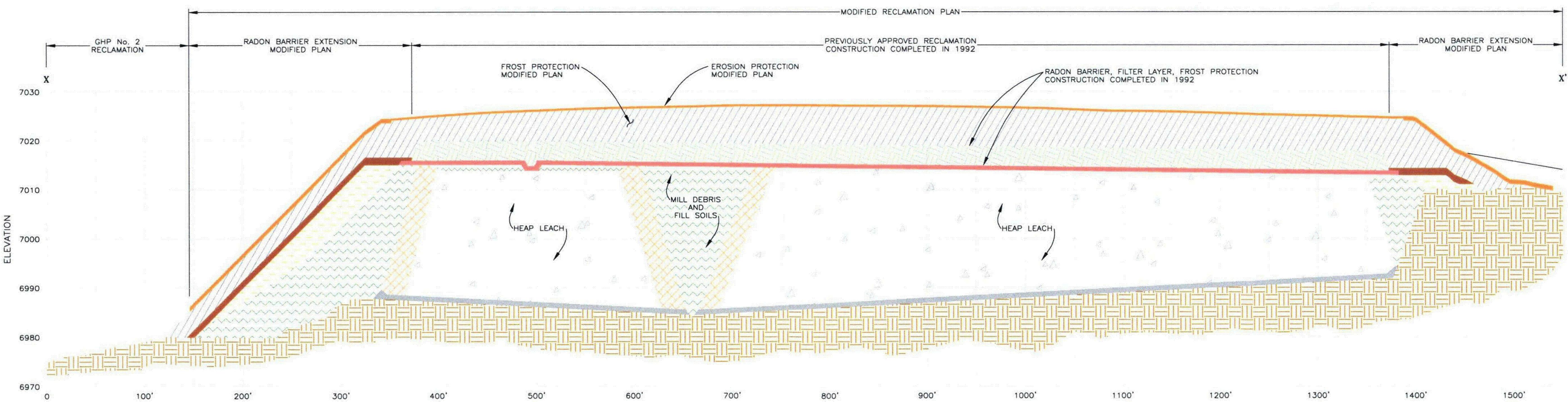
300' 0 300'

SCALE IN FEET
CONTOUR INTERVAL : 2'

**LEGEND:**

- 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- RADON BARRIER LIMITS 1992 CONTRUCTION
- RADON BARRIER BOUNDARY MODIFIED RECLAMATION PLAN

THE MODIFIED RECLAMATION DESIGN INCLUDED (WITH SUBSEQUENT NRC APPROVAL) EVALUATION OF THE EXISTING RECLAMATION COVER CONSTRUCTION COMPLETED IN 1992. ENDPOINTS EVALUATED INCLUDED SEISMIC DESIGN, SLOPE STABILITY, LIQUEFACTION POTENTIAL, SETTLEMENT, RADON BARRIER COVER CRACKING POTENTIAL, AND RADON ATTENUATION. REFER TO LICENSE AMENDMENT 38 AND CORRESPONDING TER DATED MAY 28, 1998 (SEE ATTACHMENT 1).




**SECTION X–X'**
SCALE: HORIZ. 1" = 50'
VERT. 1" = 10'

LEGEND 1992 RECLAMATION CONSTRUCTION

- EXISTING 1992 COVER
- EXISTING EMBANKMENT FILL
- EXISTING 1992 RECLAMATION FILL
- EXISTING CLAY LINER
- FOUNDATION SOIL
- HEAP LEACH MATERIAL
- EXISTING 1992 RADON BARRIER (12")

LEGEND MODIFIED RECLAMATION PLAN

- RECLAMATION FILL
- FROST PROTECTION LAYER
- TOE APRON FILL
- RADON BARRIER (18")
- RIPRAP

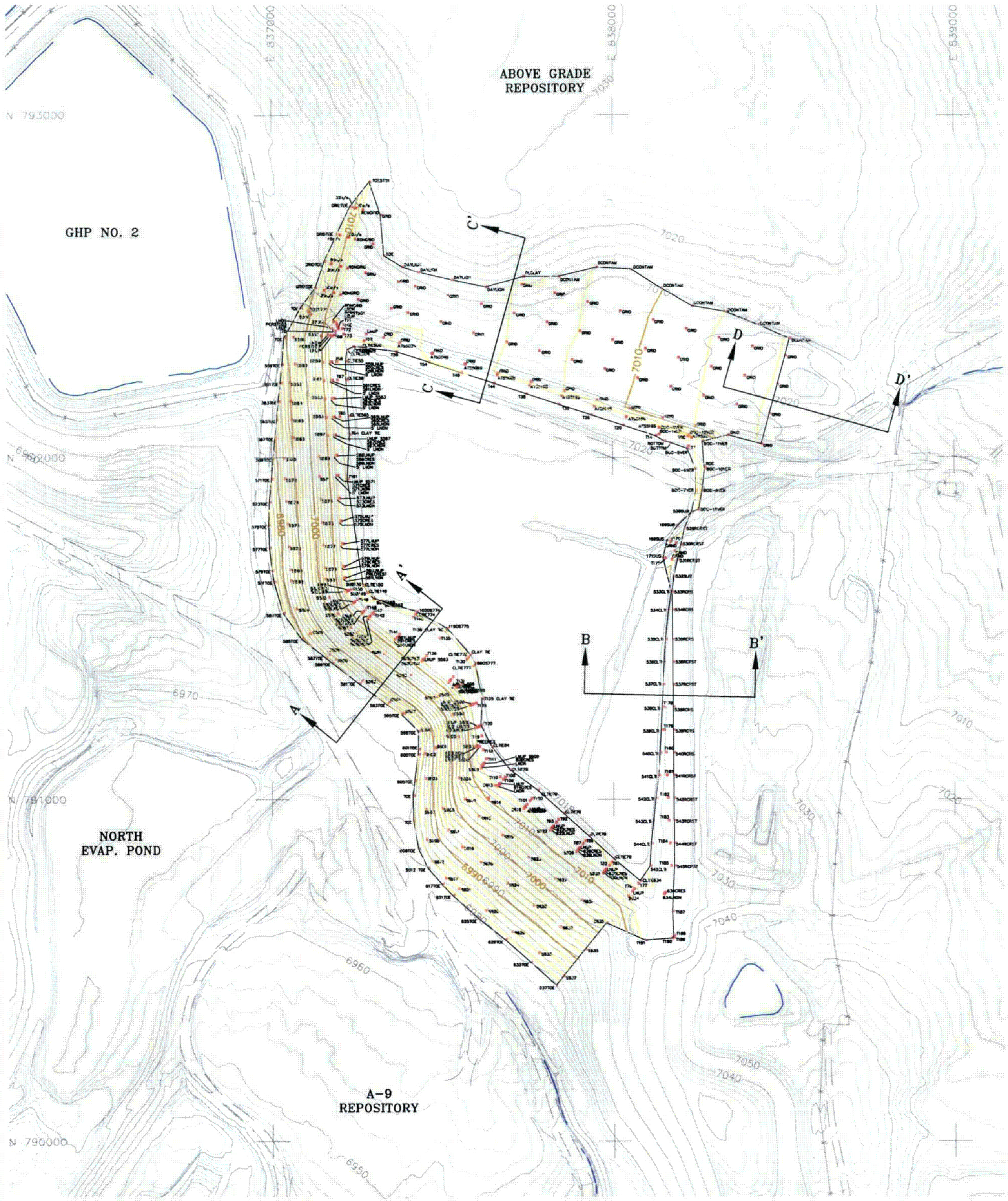
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
EXISTING COVER
AND
1997 – 2002 MODIFICATIONS

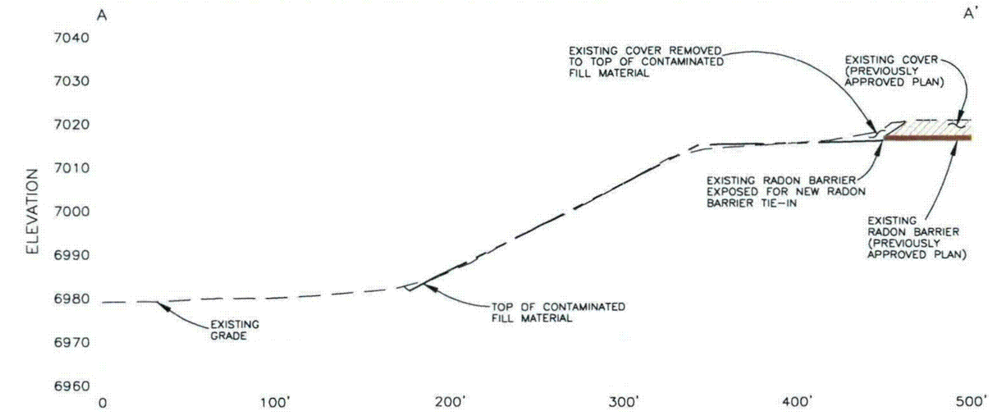
GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-02-AB SHEET 2 OF 13




**PROFILE LEGEND:**

EXISTING GRADE 1997 TOPOGRAPHY
EXISTING RADON BARRIER
TOP OF THE CONTAMINATED FILL




**SECTION A–A'**
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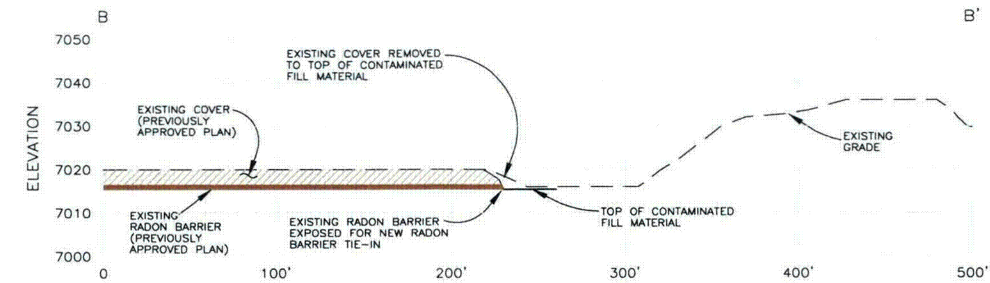
VERT. 1' = 20'

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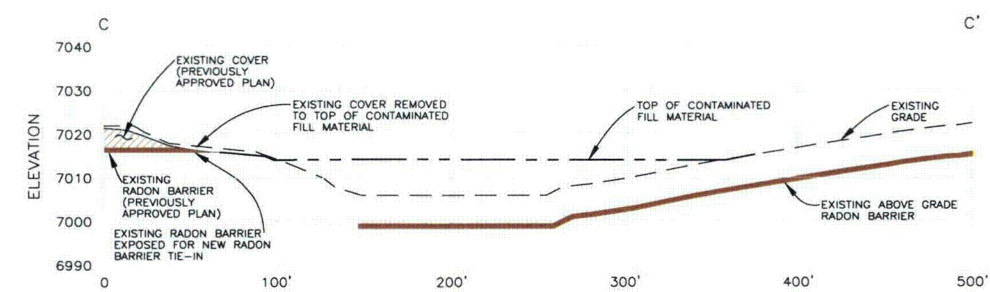


**SECTION C–C'**
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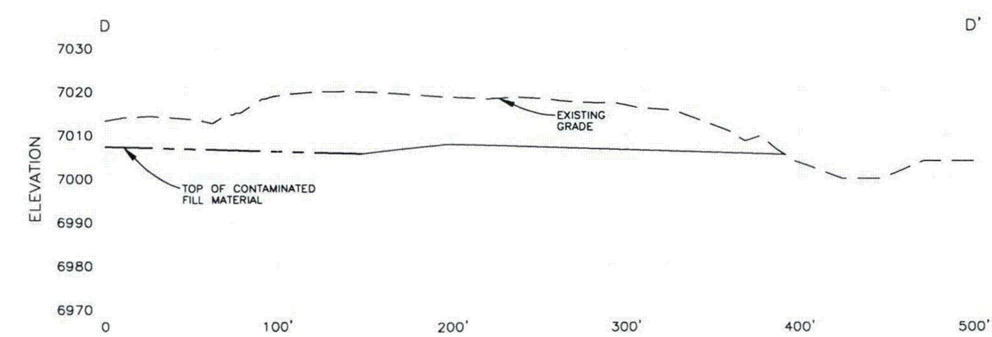


**SECTION D–D'**
SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

**LEGEND:**

EXISTING 1997 AERIAL TOPOGRAPHY
DRAINAGE PATH/PONDED WATER
UN-PAVED ROADS
UMETCO 1000' SITE GRID
FINISH GRADE TOPOGRAPHY CONTAMINATED FILL AREA
CONTAMINATED FILL SURVEY VERIFICATION POINT

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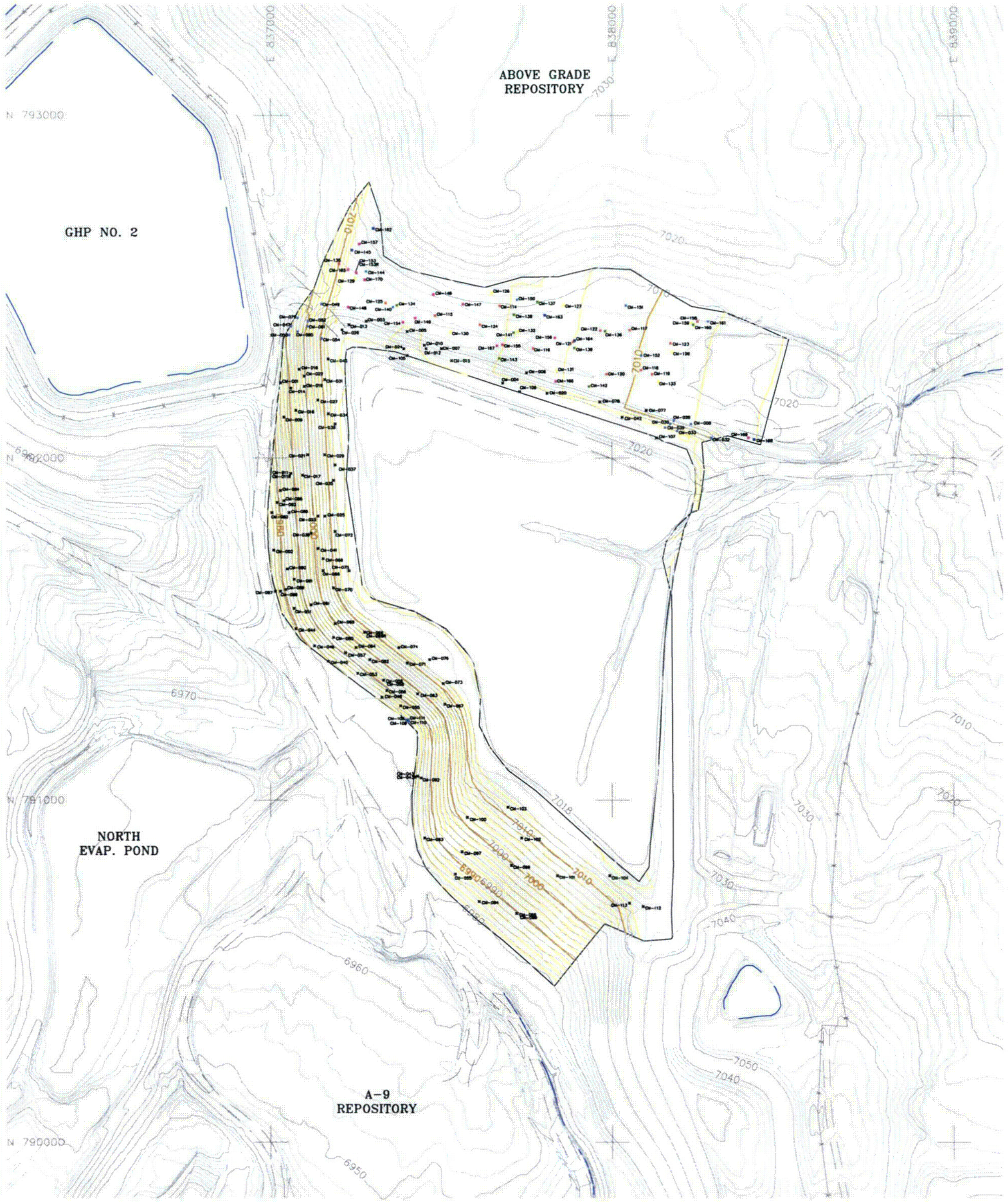
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
FINAL CONTOURS AND
SURVEY VERIFICATION POINTS
CONTAMINATED FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-03-AB SHEET 3 OF 13




N

200' 0 200'

SCALE IN FEET

CONTOUR INTERVAL : 2'

**LEGEND:**

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 UMETCO 1000' SITE GRID
- 6960 FINISH GRADE TOPOGRAPHY CONTAMINATED FILL AREA
- 1997 CONTAMINATED FILL COMPACTION TEST LOCATION – FINISHED GRADE
- 1997 CONTAMINATED FILL COMPACTION TEST LOCATION – FILL AREAS TESTED IN 1-FOOT LIFTS
- 1998 CONTAMINATED FILL COMPACTION TEST LOCATION – FIRST LIFT
- 1998 CONTAMINATED FILL COMPACTION TEST LOCATION – SECOND LIFT
- 1998 CONTAMINATED FILL COMPACTION TEST LOCATION – THIRD LIFT
- 1998 CONTAMINATED FILL COMPACTION TEST LOCATION – FOURTH LIFT
- 1998 CONTAMINATED FILL COMPACTION TEST LOCATION – FIFTH LIFT
- 1998 CONTAMINATED FILL COMPACTION TEST LOCATION – LIFTS 6 THRU 8 AND FINISHED GRADE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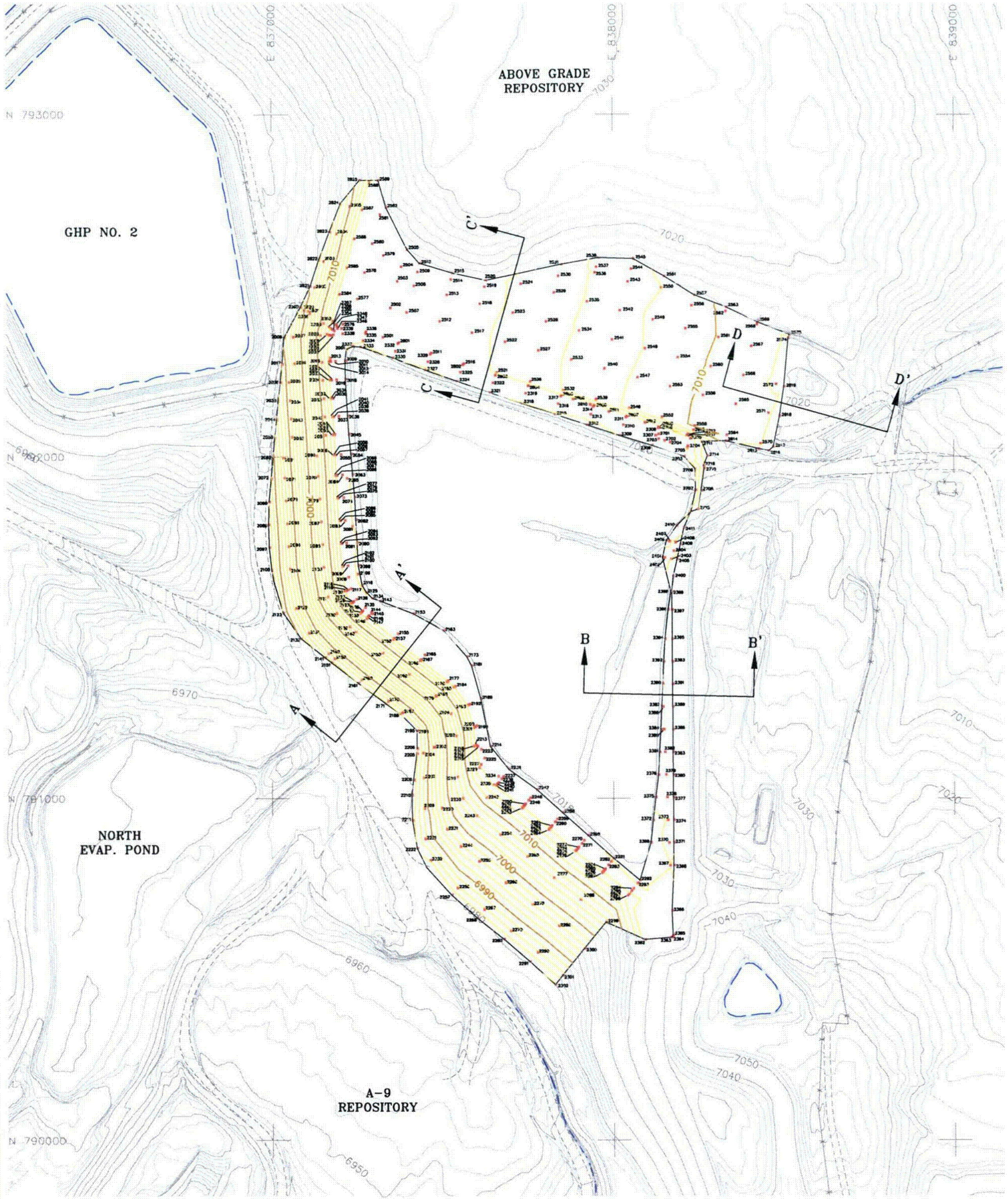
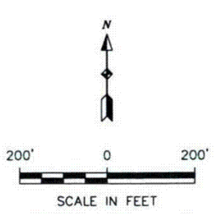
AS BUILT

HEAP LEACH/GAP RECLAMATION
COMPACTION TEST LOCATIONS
CONTAMINATED FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-04-AB SHEET 4 OF 13



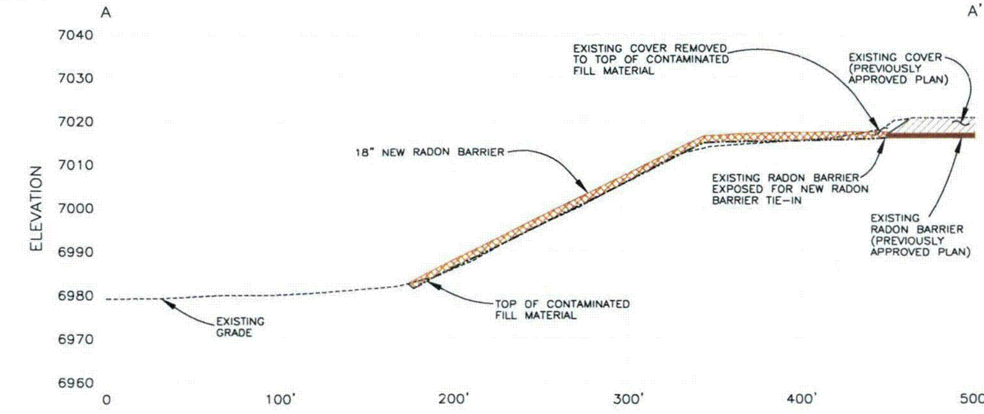




**LEGEND:**

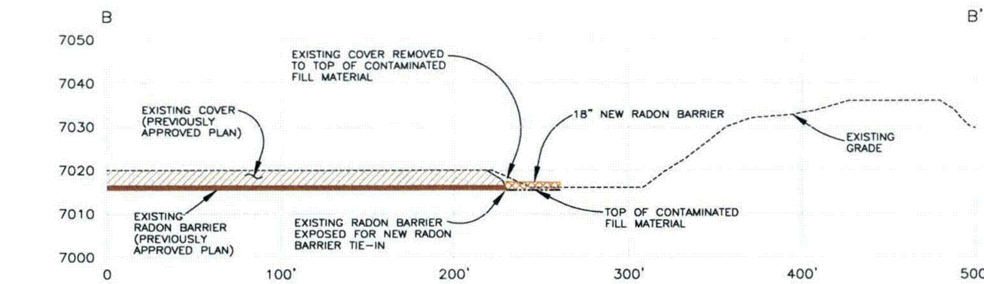
| | |
|---|---|
| 7000 | EXISTING 1997 AERIAL TOPOGRAPHY |
| | DRAINAGE PATH/PONDED WATER |
| | UN-PAVED ROADS |
| N 794,000 | UMETCO 1000' SITE GRID |
| 6980 | FINISH GRADE TOPOGRAPHY RADON BARRIER FILL AREA |
| | RADON BARRIER FILL SURVEY VERIFICATION POINT |

**PROFILE LEGEND:**

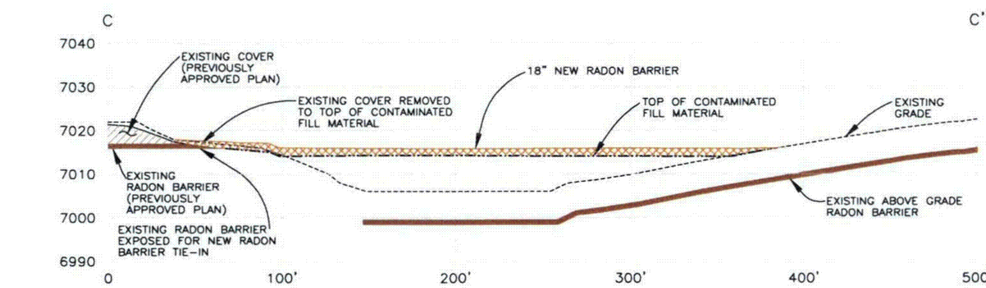
- EXISTING GRADE 1997 TOPOGRAPHY
- EXISTING RADON BARRIER
- TOP OF THE CONTAMINATED FILL
- 18" NEW RADON BARRIER



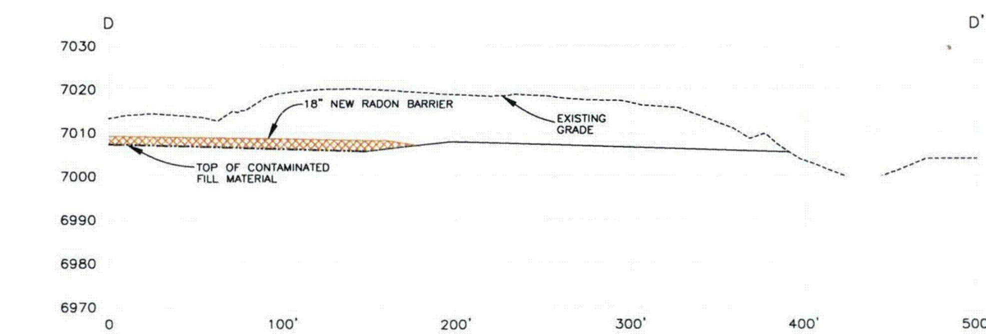

**SECTION A–A'**
SCALE: HORIZ. 1" = 50' VERT. 1' = 20'




**SECTION B–B'**
SCALE: HORIZ. 1" = 50' VERT. 1' = 20'




**SECTION C–C'**
SCALE: HORIZ. 1" = 50' VERT. 1' = 20'




**SECTION D–D'**
SCALE: HORIZ. 1" = 50' VERT. 1' = 20'

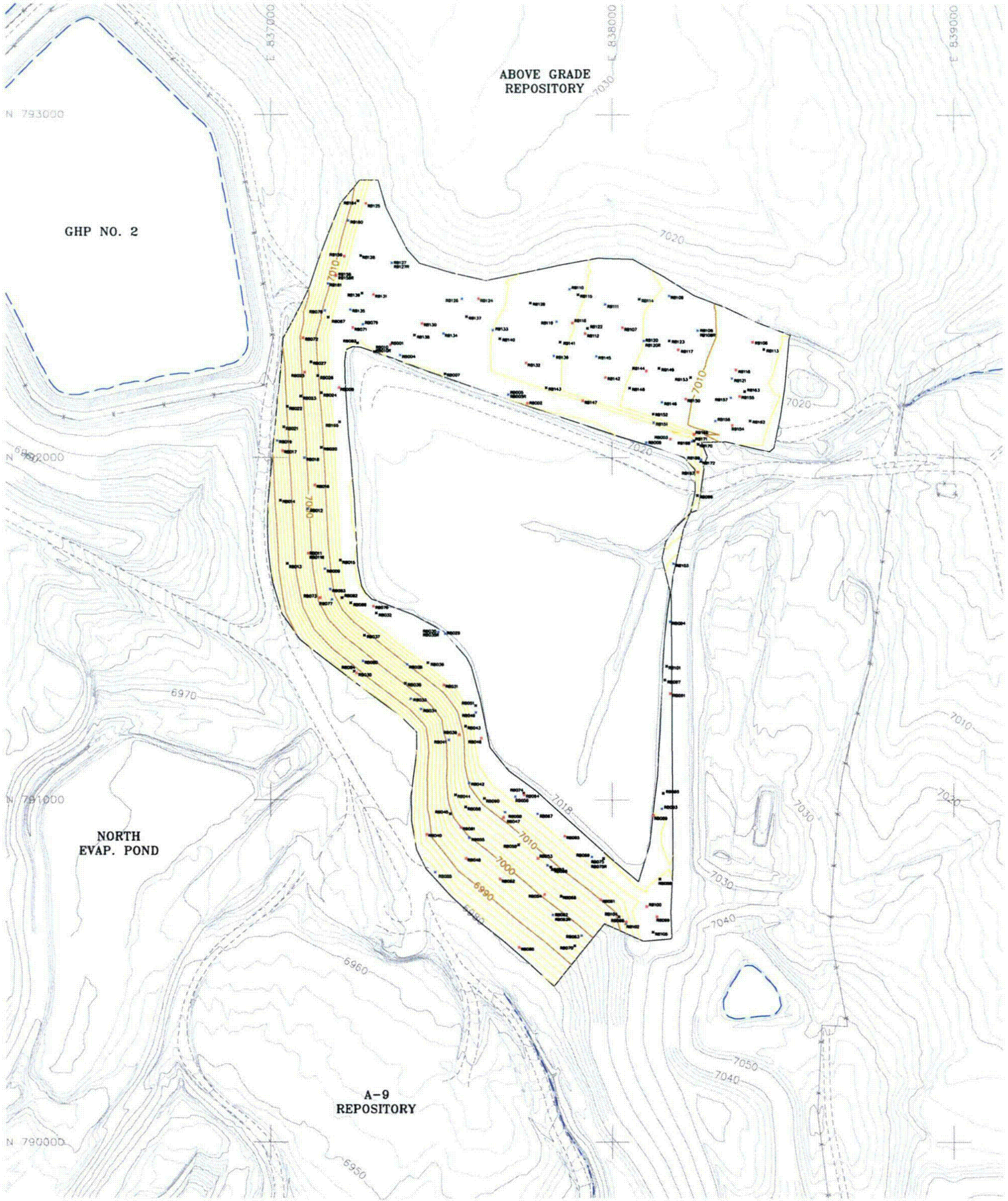
**Umetco Minerals Corporation**
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
FINAL CONTOURS AND
SURVEY VERIFICATION POINTS
RADON BARRIER FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-05-AB SHEET 5 OF 13




**LEGEND:**

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY RADON BARRIER FILL AREA
- RADON BARRIER FILL COMPACTION TEST LOCATION – FIRST LIFT
- RADON BARRIER FILL COMPACTION TEST LOCATION – SECOND LIFT
- RADON BARRIER FILL COMPACTION TEST LOCATION – THIRD LIFT

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

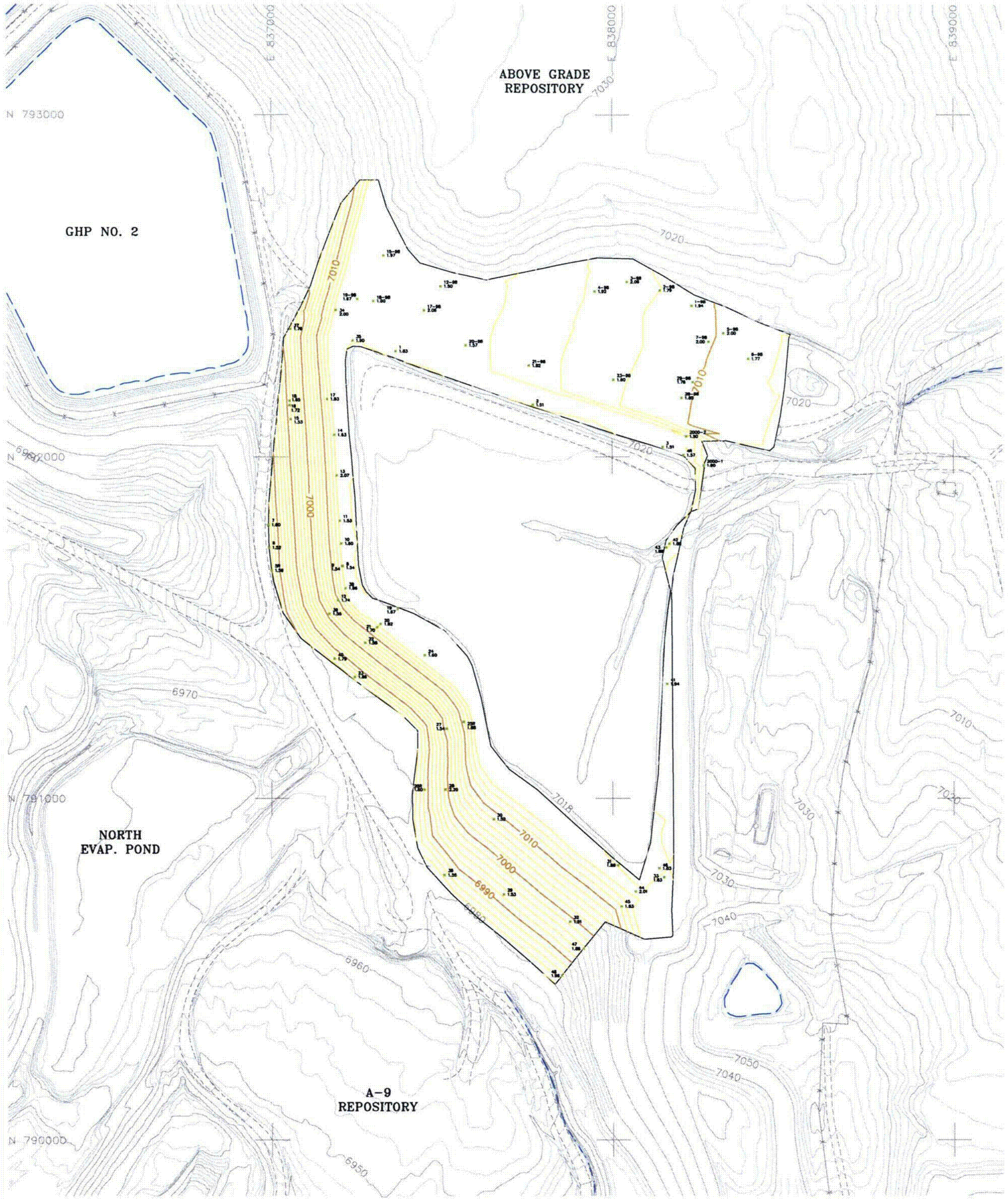
**Umetco Minerals Corporation**
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
COMPACTION TEST LOCATIONS
RADON BARRIER FILL AREA

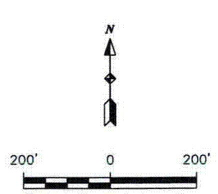
GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-06-AB SHEET 6 OF 13




**LEGEND:**

| | |
|---|---|
| 7000 | EXISTING 1997 AERIAL TOPOGRAPHY |
| | DRAINAGE PATH/PONDED WATER |
| | UN-PAVED ROADS |
| N 794,000 | UMETCO 1000' SITE GRID |
| 6960 | FINISH GRADE TOPOGRAPHY RADON BARRIER FILL AREA |
| | RADON BARRIER FILL COMPACTION VISUAL DEPTH CHECK<br>20 = TEST LOCATION NUMBER<br>1.62 = MEASURED THICKNESS |




SCALE IN FEET
CONTOUR INTERVAL : 2'

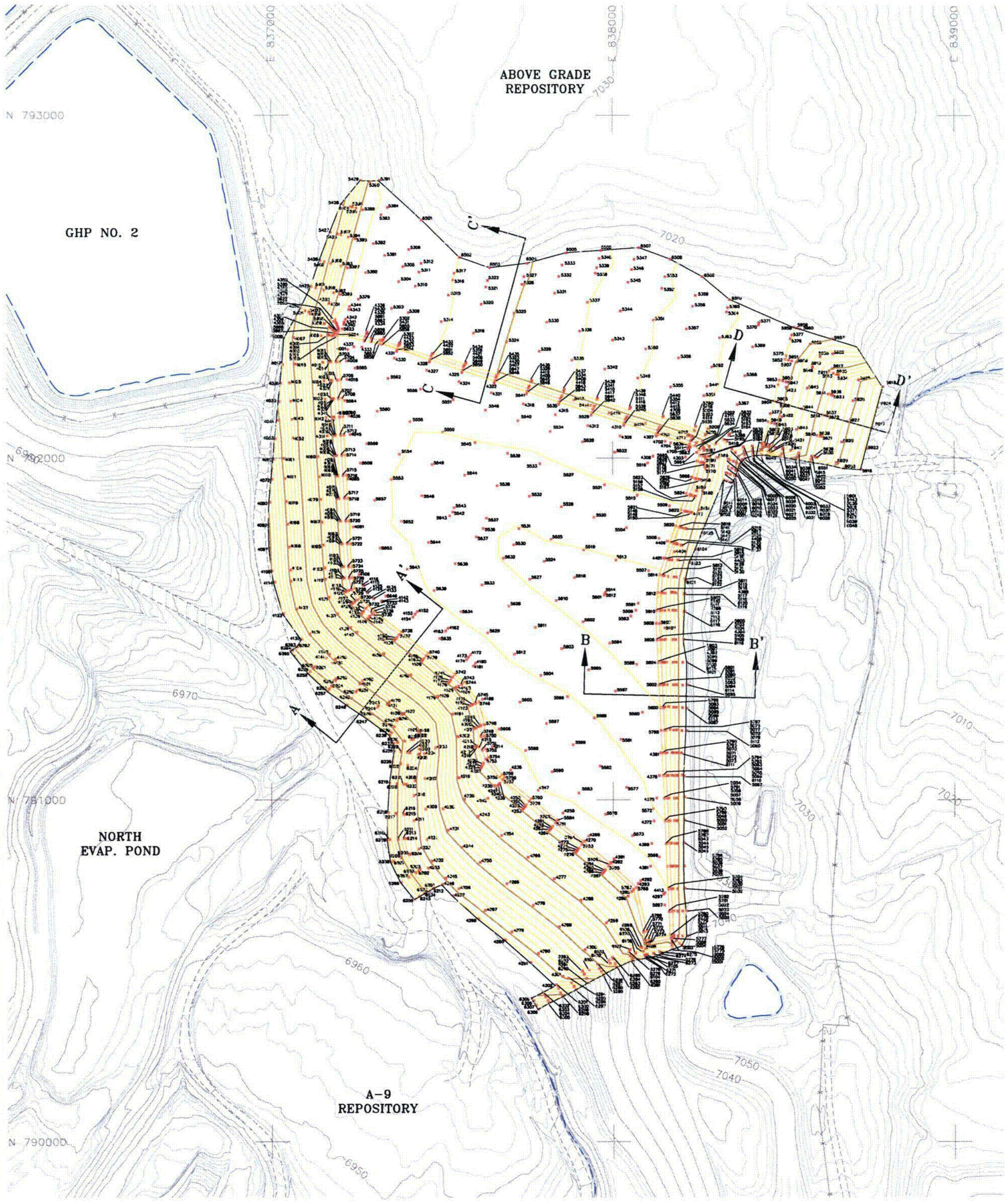
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

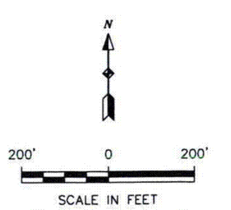
AS BUILT

HEAP LEACH/GAP RECLAMATION
VISUAL DEPTH CHECK LOCATIONS
RADON BARRIER FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-07-AB SHEET 7 OF 13



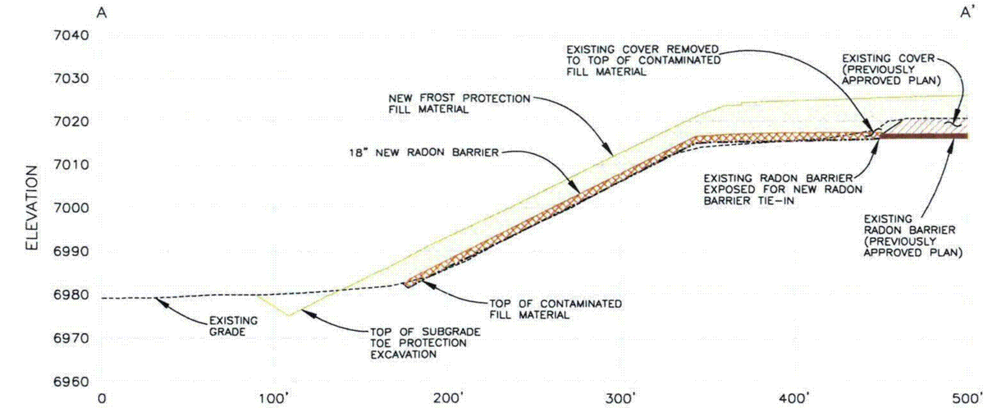




**LEGEND:**

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY FROST PROTECTION FILL AREA
- FROST PROTECTION FILL SURVEY VERIFICATION POINT

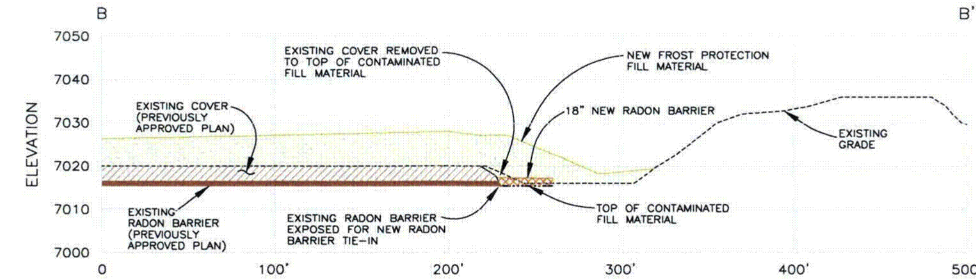
**PROFILE LEGEND:**

- EXISTING GRADE 1997 TOPOGRAPHY
- EXISTING RADON BARRIER
- TOP OF THE CONTAMINATED FILL
- 18" NEW RADON BARRIER
- NEW FROST PROTECTION MATERIAL



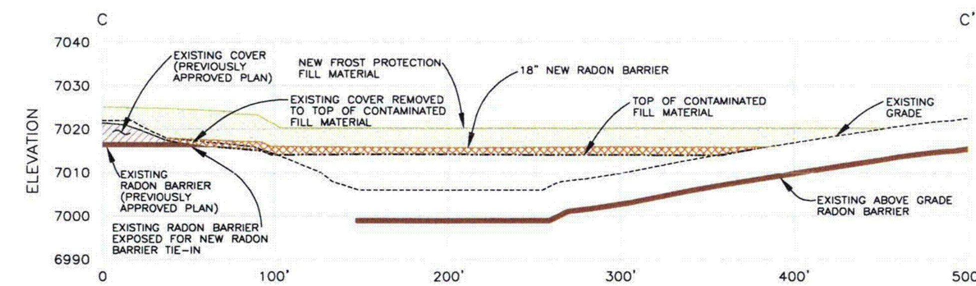

**SECTION A-A'**

SCALE: HORIZ. 1" = 50' VERT. 1' = 20'



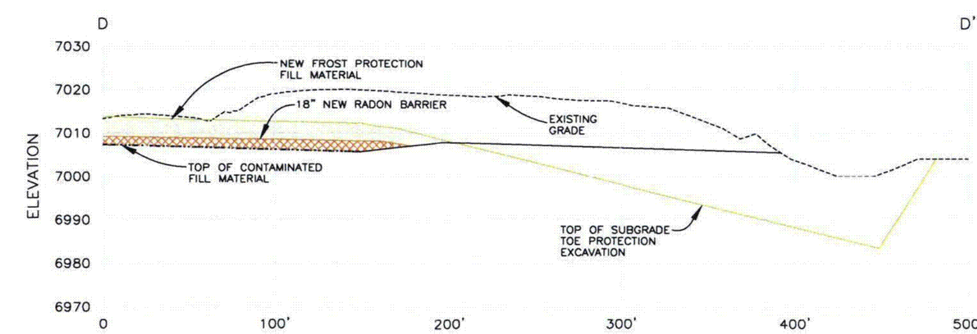

**SECTION B-B'**

SCALE: HORIZ. 1" = 50' VERT. 1' = 20'




**SECTION C-C'**

SCALE: HORIZ. 1" = 50' VERT. 1' = 20'




**SECTION D-D'**

SCALE: HORIZ. 1" = 50' VERT. 1' = 20'

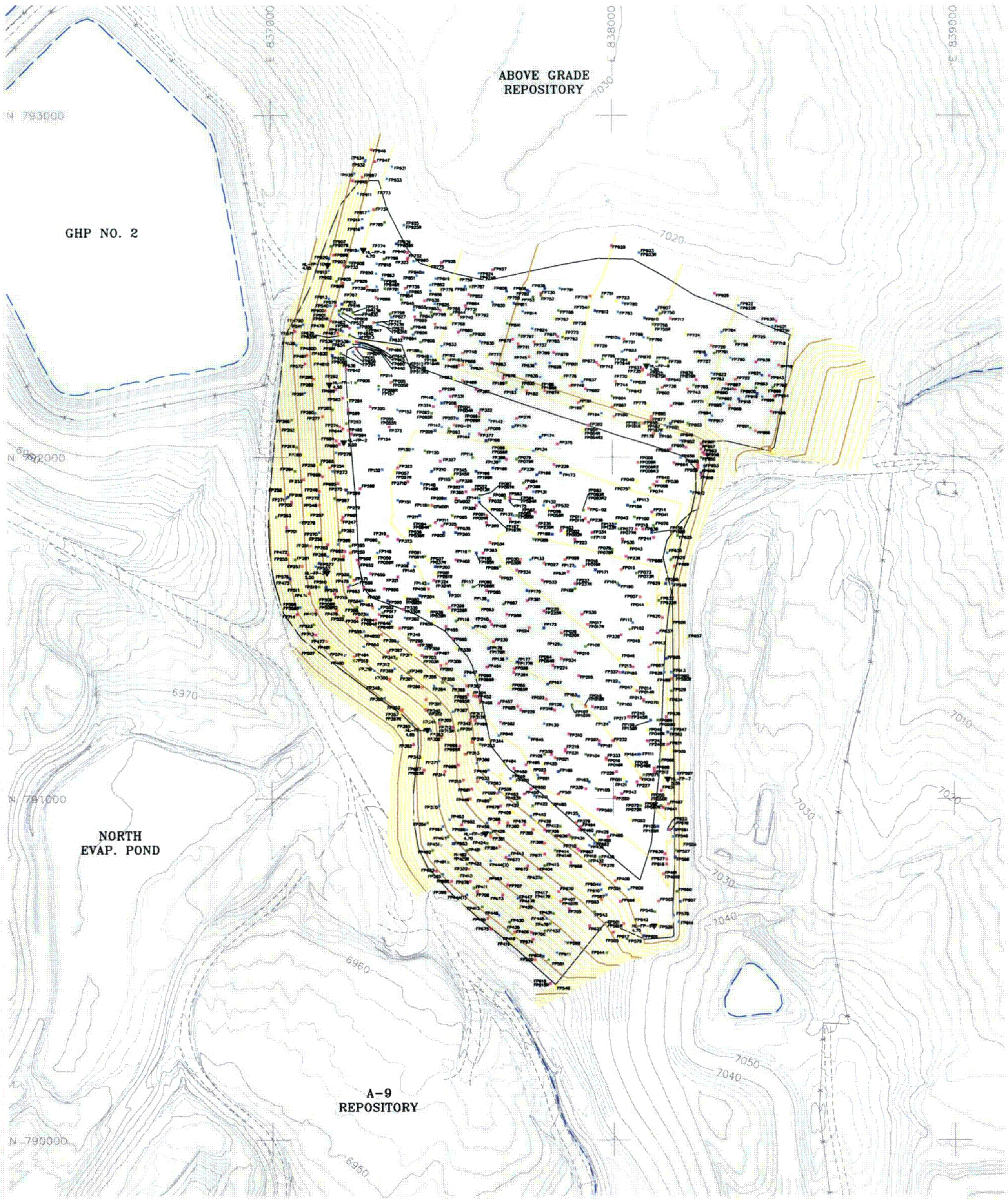
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
FINAL CONTOURS AND
SURVEY VERIFICATION POINTS
FROST PROTECTION FILL AREA
AND TOE PROTECTION SUBGRADE

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-08-AB SHEET 8 OF 13




N

200' 0 200'

SCALE IN FEET

CONTOUR INTERVAL : 2'

**LEGEND:**

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- FINISH GRADE TOPOGRAPHY FROST PROTECTION FILL AREA
- FROST PROTECTION FILL COMPACTION TEST LOCATION – FIRST LIFT
- FROST PROTECTION FILL COMPACTION TEST LOCATION – SECOND LIFT
- FROST PROTECTION FILL COMPACTION TEST LOCATION – THIRD LIFT
- FROST PROTECTION FILL COMPACTION TEST LOCATION – FOURTH LIFT
- FROST PROTECTION FILL COMPACTION TEST LOCATION – FIFTH LIFT
- FROST PROTECTION FILL COMPACTION TEST LOCATION – LIFTS 6 THRU 8 AND FINISHED GRADE
- HL-FP-1 4.50 — FROST PROTECTION VISUAL DEPTH LOCATION HL-FP-1 = FIELD IDENTIFICATION NUMBER 4.50 = DEPTH MEASURED IN FEET

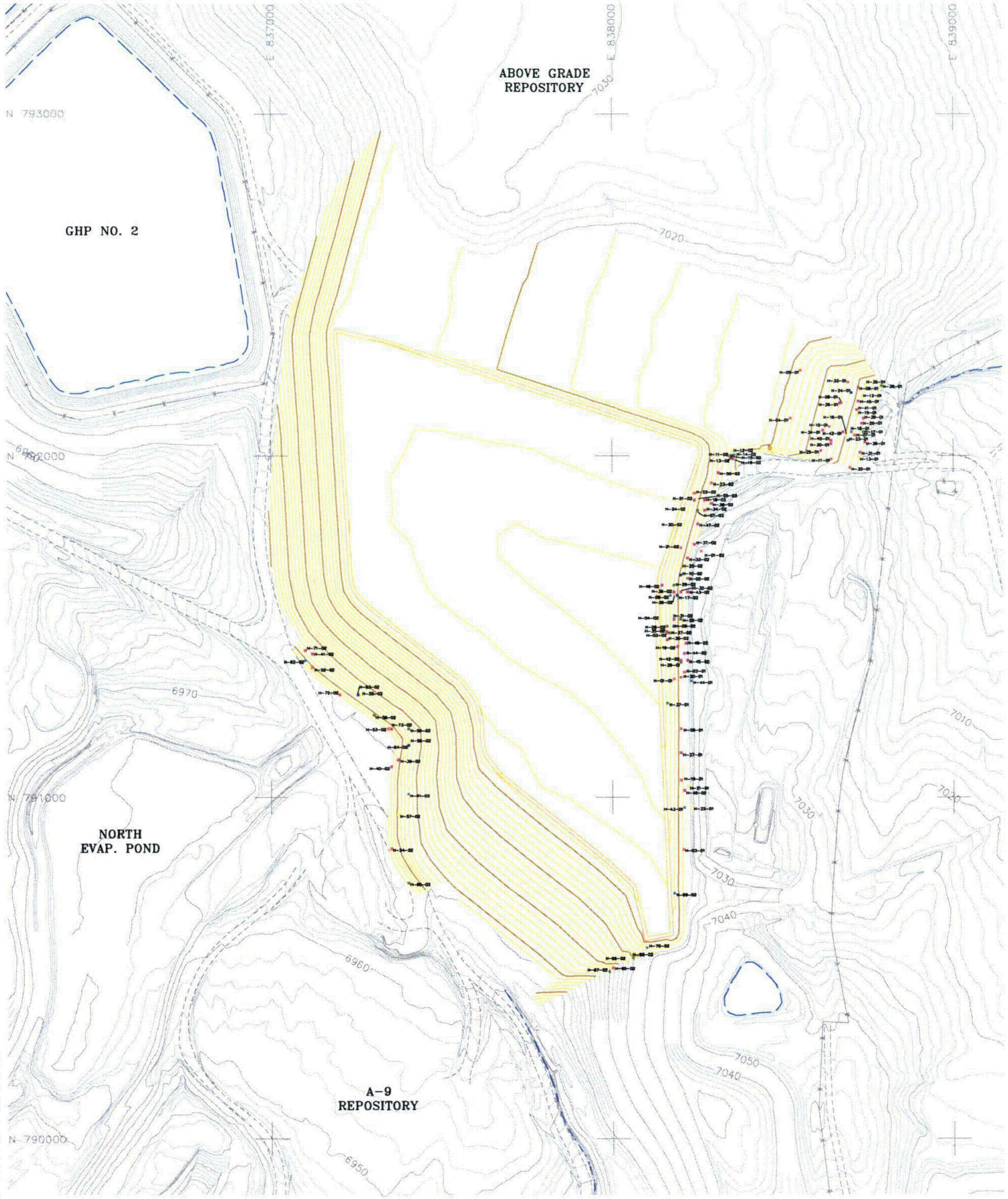
**Umetco Minerals Corporation**
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
COMPACTION TEST LOCATIONS
FROST PROTECTION FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-09-AB SHEET 9 OF 13




**LEGEND:**

| | |
|---|---|
| 7000 | EXISTING 1997 AERIAL TOPOGRAPHY |
| | DRAINAGE PATH/PONDED WATER |
| | UN-PAVED ROADS |
| N 794,000 | UMETCO 1000' SITE GRID |
| 6960 | FINISH GRADE TOPOGRAPHY FROST PROTECTION FILL AREA |
| | TOE PROTECTION FILL COMPACTION TEST LOCATION – FIRST LIFT |
| | TOE PROTECTION FILL COMPACTION TEST LOCATION – SECOND LIFT |
| | TOE PROTECTION FILL COMPACTION TEST LOCATION – THIRD LIFT |
| | TOE PROTECTION FILL COMPACTION TEST LOCATION – FOURTH LIFT |
| | TOE PROTECTION FILL COMPACTION TEST LOCATION – FIFTH LIFT |
| | TOE PROTECTION FILL COMPACTION TEST LOCATION – LIFTS 6 THRU 9 AND FINISHED GRADE |

N

200' 0 200'

SCALE IN FEET

CONTOUR INTERVAL : 2'

Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

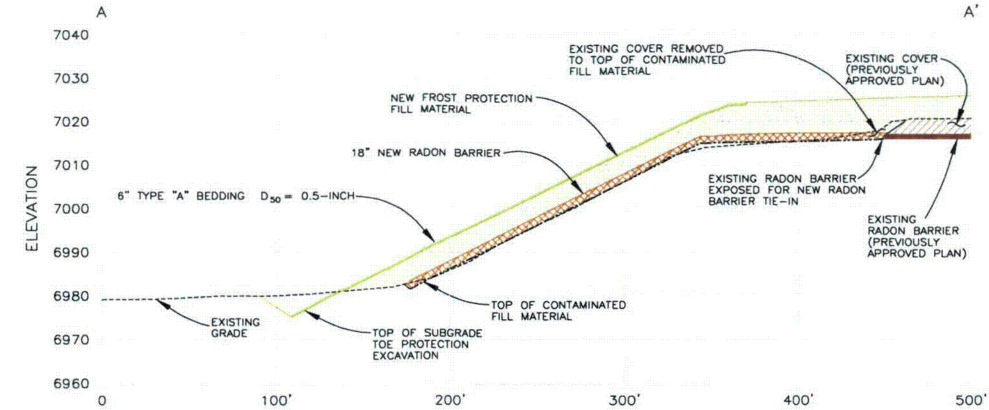
HEAP LEACH/GAP RECLAMATION
COMPACTION TEST LOCATIONS
TOE PROTECTION FILL AREAS

GAS HILLS, WYOMING

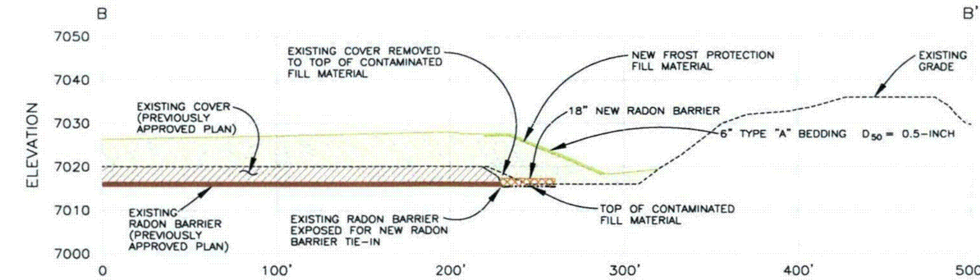
DATE: JUNE 2007 DWG: GH-HL-10-AB SHEET 10 OF 13


**PROFILE LEGEND:**

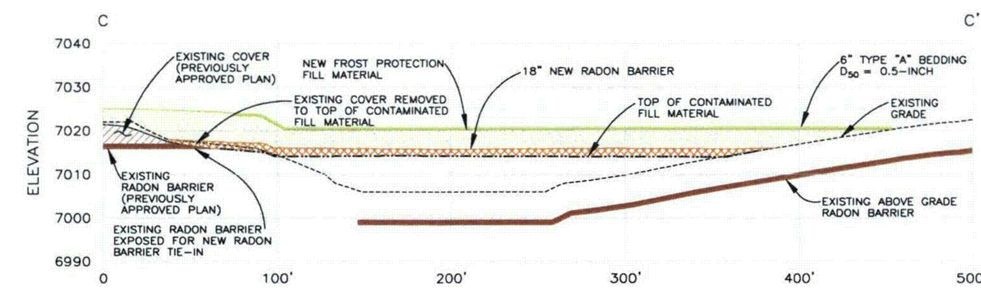
- EXISTING GRADE 1997 TOPOGRAPHY
- EXISTING RADON BARRIER
- TOP OF THE CONTAMINATED FILL
- 18" NEW RADON BARRIER
- NEW FROST PROTECTION MATERIAL
- TYPE "A" BEDDING $D_{50}$ = 0.5-INCH



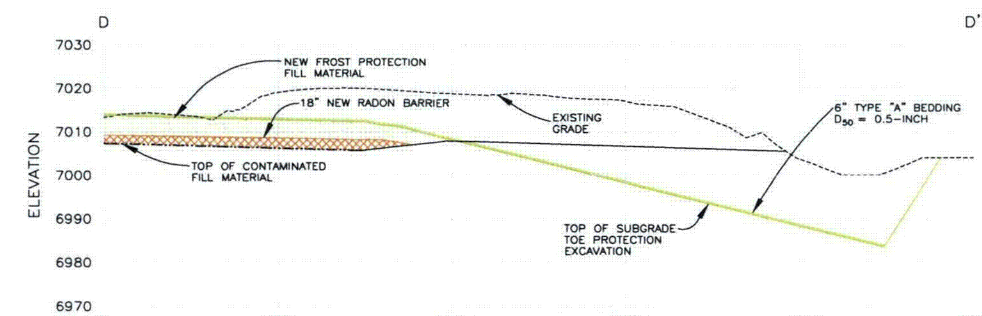

**SECTION A-A'**
SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'



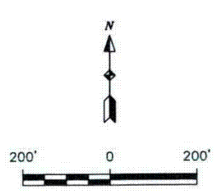

**SECTION B-B'**
SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'




**SECTION C-C'**
SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'




**SECTION D-D'**
SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'




SCALE IN FEET
CONTOUR INTERVAL : 2'

**LEGEND:**

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- FINISH GRADE TOPOGRAPHY FROST PROTECTION FILL AREA
- TYPE "A" BEDDING FILL SURVEY VERIFICATION POINT
- TYPE "A" BEDDING $D_{50}$ = 0.5-INCH

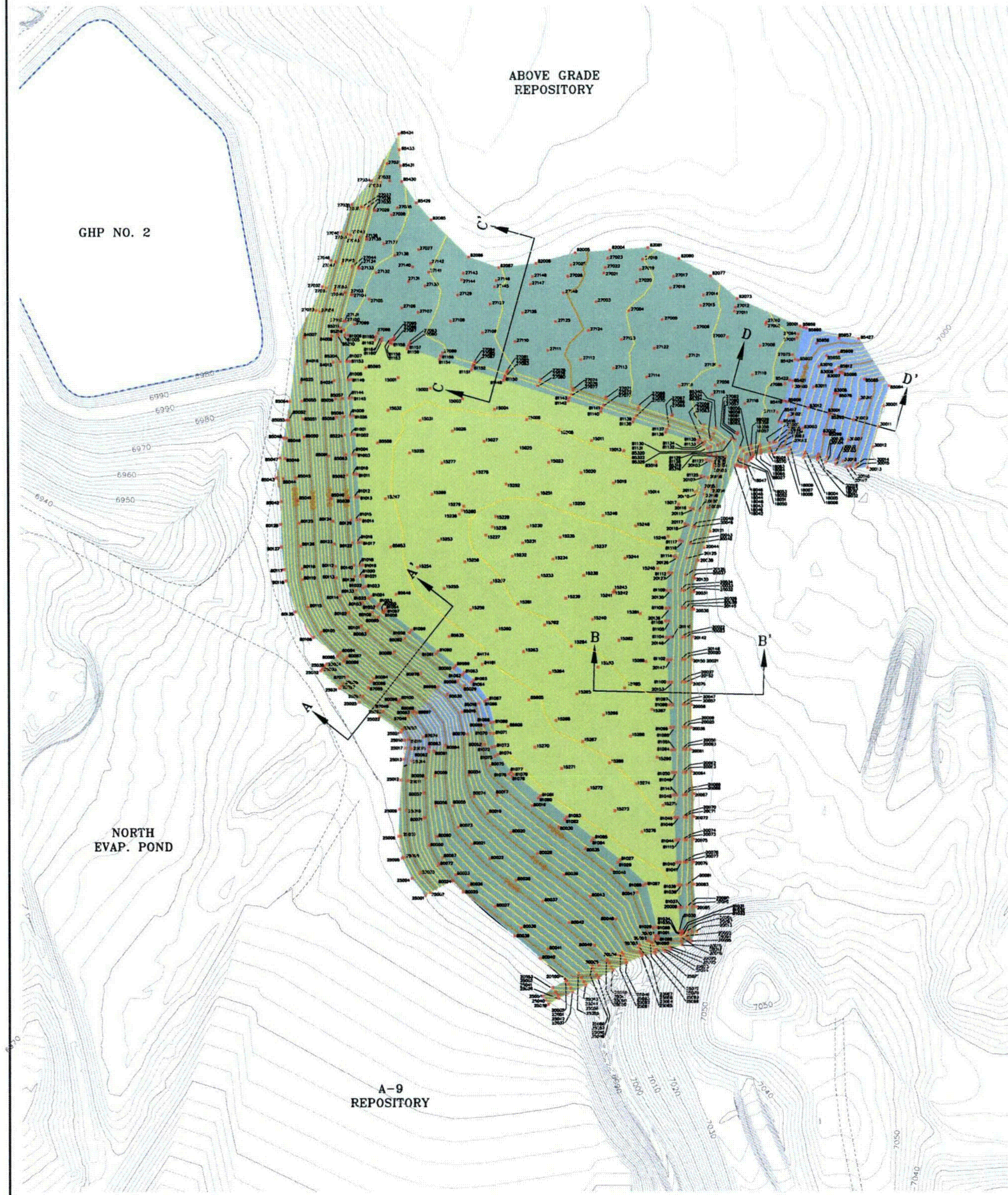
**Umetco Minerals Corporation**
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

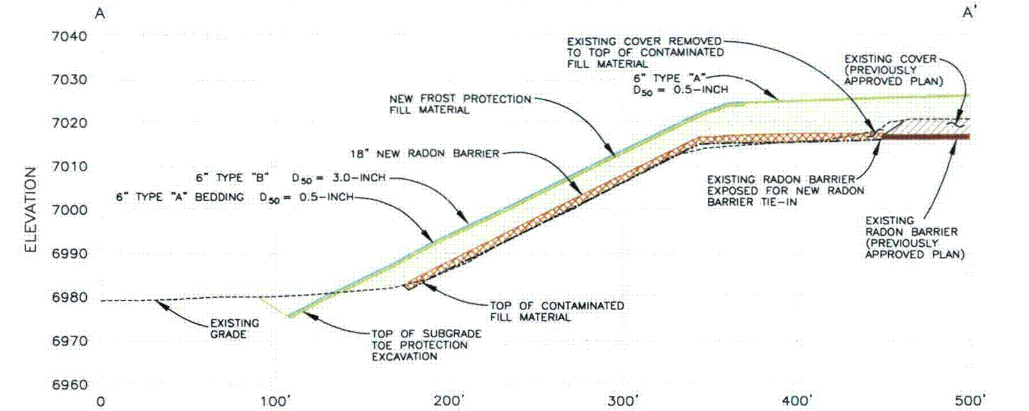
AS BUILT

HEAP LEACH/GAP RECLAMATION
SURVEY VERIFICATION POINTS
EROSION PROTECTION
TYPE "A" BEDDING MATERIAL

GAS HILLS, WYOMING

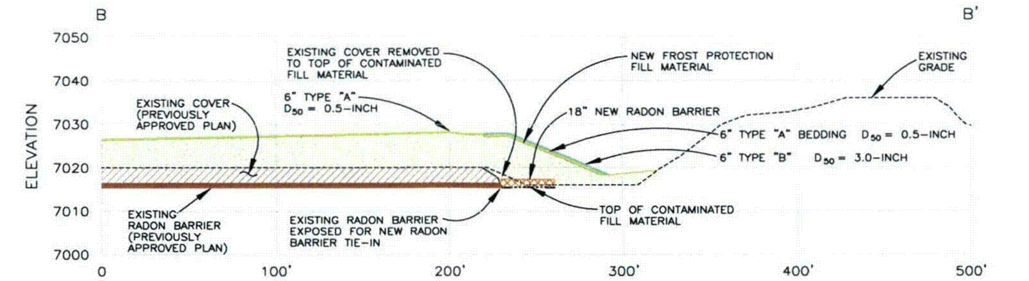
DATE: JUNE 2007 DWG: GH-HL-11-AB SHEET 11 OF 13



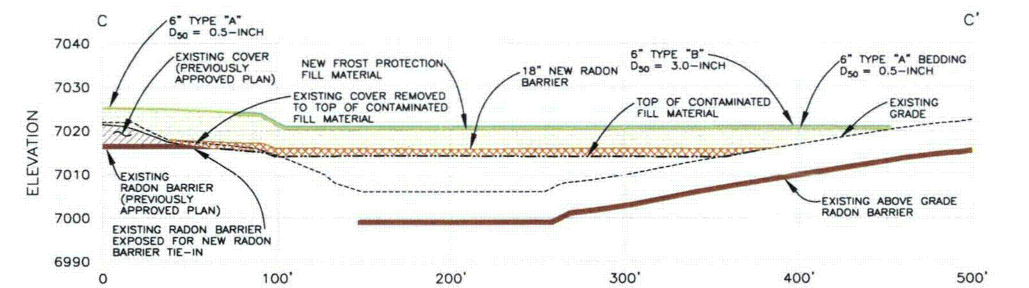

**SECTION A-A'**

SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'



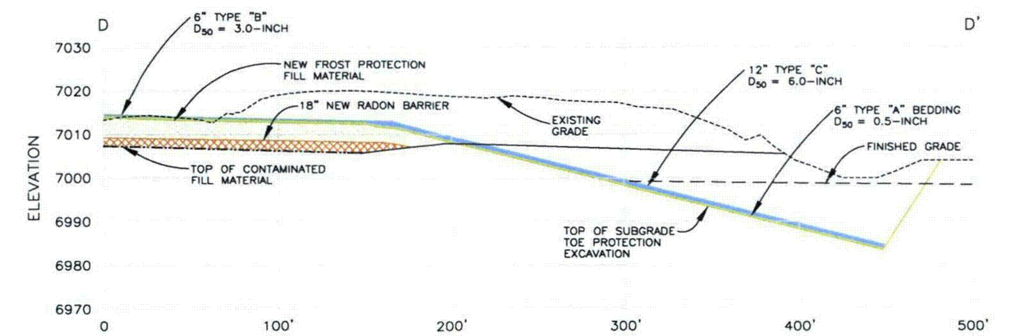

**SECTION B-B'**

SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'




**SECTION C-C'**

SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'




**SECTION D-D'**

SCALE: HORIZ. 1" = 50'
VERT. 1' = 20'

**PROFILE LEGEND:**

- EXISTING GRADE 1997 TOPOGRAPHY
- EXISTING RADON BARRIER
- TOP OF THE CONTAMINATED FILL
- 18" NEW RADON BARRIER
- NEW FROST PROTECTION MATERIAL
- TYPE "A" RIPRAP $D_{50}$ = 0.5-INCH
- TYPE "B" RIPRAP $D_{50}$ = 3.0-INCH
- TYPE "C" RIPRAP $D_{50}$ = 6.0-INCH

**LEGEND:**

- 2000 AERIAL TOPOGRAPHY UPDATED WITH 2002 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY EROSION PROTECTION FILL AREA
- EROSION PROTECTION FILL SURVEY VERIFICATION POINT
- TYPE "A" RIPRAP $D_{50}$ = 0.5-INCH
- TYPE "B" RIPRAP $D_{50}$ = 3.0-INCH
- TYPE "C" RIPRAP $D_{50}$ = 6.0-INCH

N

200' 0 200'

SCALE IN FEET

CONTOUR INTERVAL : 2'

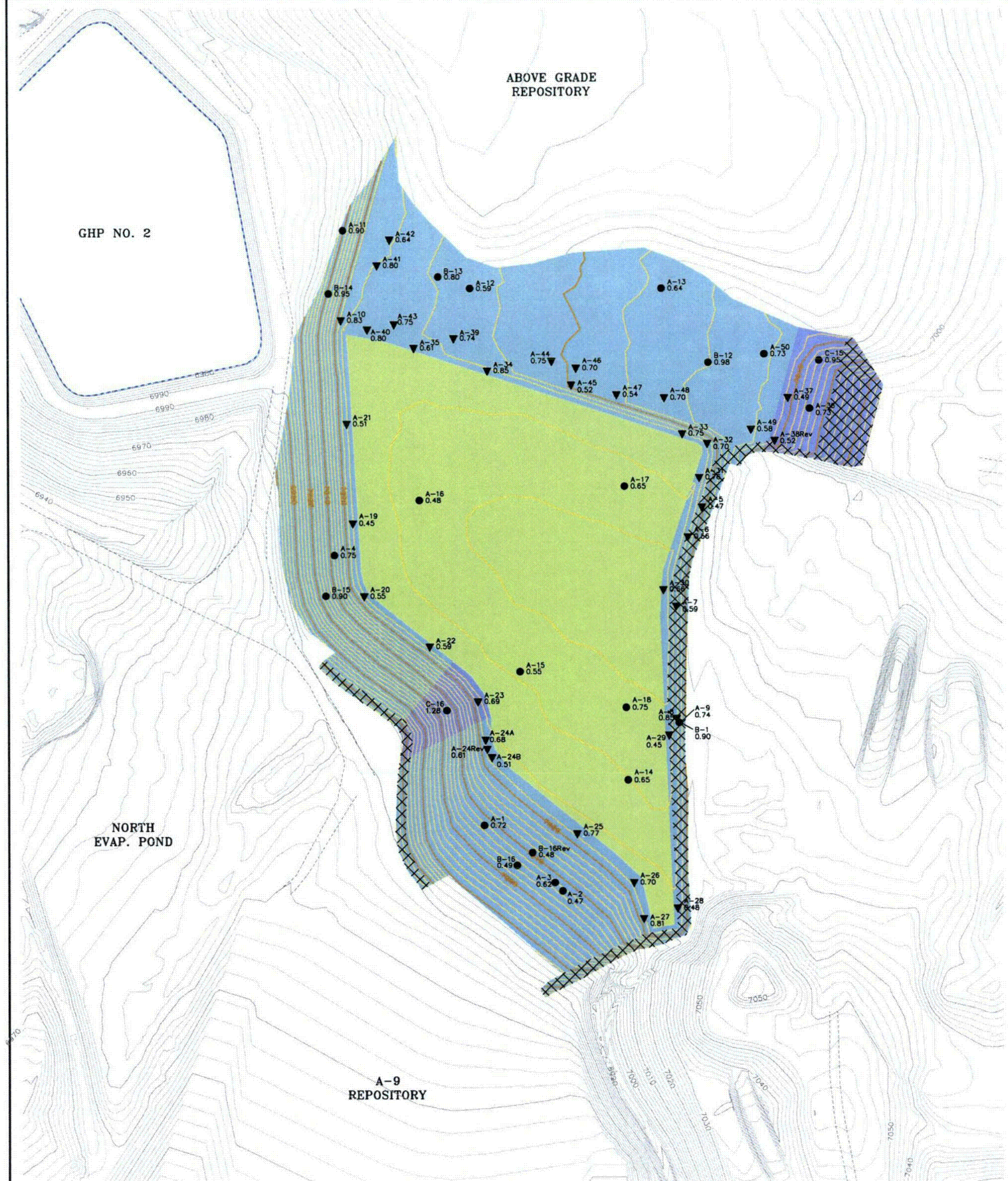
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
FINAL CONTOURS AND
SURVEY VERIFICATION POINTS
EROSION PROTECTION PLACEMENT

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-12-AB SHEET 12 OF 13




**LEGEND:**

- 2000 AERIAL TOPOGRAPHY UPDATED WITH 2002 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY HEAP LEACH/GAP RECLAMATION ERSOION PROTECTION PLACEMENT
- ● A-15 0.55 — IN-PLACE VISUAL DEPTH CHECK AND IN-PLACE GRADATION SAMPLE; C-6 = FIELD IDENTIFICATION NUMBER; 1.40 = DEPTH MEASURED IN FEET
- ▼ A-45 0.52 — IN-PLACE VISUAL DEPTH CHECK; A-64 = FIELD IDENTIFICATION NUMBER; 0.78 = DEPTH MEASURED IN FEET
- 6-INCHES OF TYPE "A" RIPRAP $D_{50}$ = 0.5 INCH
- 6-INCHES OF TYPE "B" RIPRAP $D_{50}$ = 3.0 INCH WITH 6-INCHES OF TYPE "A" BEDDING $D_{50}$ = 0.5 INCH
- 12-INCHES OF TYPE "C" RIPRAP $D_{50}$ = 6.0 INCH WITH 6-INCHES OF TYPE "A" BEDDING $D_{50}$ = 0.5 INCH
- BELOW GRADE APRON

N

200' 0 200'

SCALE IN FEET

CONTOUR INTERVAL : 2'

Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

HEAP LEACH/GAP RECLAMATION
IN-PLACE GRADATIONS
AND VISUAL DEPTH CHECK TEST LOCATIONS
EROSION PROTECTION PLACEMENT

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-HL-13-AB SHEET 13 OF 13

Attachment 1

# ATTACHMENT 1

## NRC Approval of the Heap Leach Design Plan Modifications: License Amendment 38

Submitted by letter dated May 28, 1998

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

May 28, 1998

RECEIVED JUN 04 1998

Mr. Curtis O. Sealy, General Manager
Umetco Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

SUBJECT: UMETCO MINERALS CORPORATION'S RECLAMATION PLAN FOR THE HEAP LEACH PILE AT THE GAS HILLS, WYOMING, URANIUM MILL SITE - AMENDMENT 38

Dear Mr. Sealy:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the Umetco Mineral Corporation's (Umetco's) Heap Leach Reclamation Plan submitted September 25, 1996, with a request to authorize implementation of the plan by amendment of the license. The plan was supplemented or revised by letters dated June 6, August 19, and October 15, 1997, and January 15, and February 11 and 13, 1998. The original submittal included the same cover design for Pond No. 2, but in response to staff questions, the licensee responded on February 11, 1998, that the data for the pond was limited because disposal there was not complete. The licensee committed to providing a final design for closure of Pond No. 2, when the required data is available.

The NRC staff determined, in accordance with 10 CFR 51.21, that preparation of an environmental assessment (EA) was necessary to document its review. A copy of the EA is provided in Enclosure 1. Based on its analysis, the NRC staff concluded that the environmental impacts associated with the proposed licensing action (i.e., amendment of SUA-648 to authorize implementation of the reclamation plan) were not significant and that the proposed action was acceptable. A final finding of no significant impact (FONSI) was prepared in accordance with 10 CFR 51.32, and, on May 6, 1998, published in the Federal Register (Enclosure 2), providing notice of: (1) the NRC's intent to issue the proposed license amendment; (2) the availability of the EA to the public; and (3) an opportunity for hearing for affected individuals.

The NRC staff also reviewed the reclamation plan for compliance with the requirements under 10 CFR Part 40, and prepared a Technical Evaluation Report (Enclosure 3), documenting the staff's assessment of the plan. Based on its review, the NRC staff has found the proposed amendment request to be acceptable. Approval of the request, which is reflected in License Condition 61, and revision of License Condition 54, to clarify that it refers to the small experimental heap leach, was discussed in the telephone conversation on April 30, 1998, between John Hamrick of your staff and Ms. Brummett, the NRC Project Manager for the

Umetco site. Therefore, pursuant to 10 CFR Part 40, Source Material License SUA-648 is hereby amended to authorize reclamation of the Heap Leach Area according to the reclamation plan, as revised. The license is being issued to incorporate the requested change and to revise License Condition 59 A (1) to indicate that windblown tailings retrieval and placement on the pile was complete as stated in inspection report 40-0299/94-01 dated October 28, 1994 (Enclosure 4).

If you have any questions, please contact the NRC Project Manager, Elaine Brummett, at (301) 415-6606.

Sincerely,

Joseph J. Holonich

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket No: 40-0299
License No. SUA-648
TAC No.: L51463 (closed)

Enclosures: As stated (4)

cc w/o enclosures:
D. Finley, DEQ, WY
J. Hough, RCPD, WY
WDEQ-LQD, WY
R. Edge, DOE, CO

TECHNICAL EVALUATION REPORT
UMETCO HEAP LEACH RECLAMATION PLAN

DATE:

DOCKET NO. 40-0299    LICENSE NO. SUA- 648

LICENSEE: Umetco Minerals Corporation

FACILITY: Heap Leach Disposal Area, East Gas Hills Uranium Mill Site, Natrona County, Wyoming,

PROJECT MANAGER: E. Brummett

TECHNICAL REVIEWERS: E. Brummett, B. Jagannath, T. L. Johnson

SUMMARY AND CONCLUSIONS:

The U.S. Nuclear Regulatory Commission (NRC) staff concludes that the heap leach site design, as proposed, will meet NRC regulations as stated in 10 CFR Part 40, Appendix A, Criteria 4(c)(d)(e) and 6(1), with regard to reasonable assurance of stability and control of the contaminated material, and limitation of the radon flux from the disposal area to the atmosphere to 20 picocuries per square meter per second ($pCi/m^2/s$) at the Heap Leach Area for a period of 1000 years, or in any case, at least 200 years. Compliance with Criterion 6(7), regarding disposal to minimize further maintenance, and Criterion 12, regarding active maintenance, were also acceptably demonstrated. Criterion 6(7) requires, in part, that licensees address the non-radiological hazards associated with wastes in planning and implementing closure. This aspect of reclamation is primarily addressed in the ground-water protection program. However, control of the heap leach wastes by the proposed cover design would also control the dispersion into air and surface water of the non-radiological wastes.

DESCRIPTION OF LICENSEE'S AMENDMENT REQUEST:

The licensee requested approval of a revised reclamation plan for the Heap Leach Area and the adjacent evaporation pond area built over the former mill area (Gas Hills Pond (GHP) No. 2), submitted September 25, 1996. The plan was supplemented by data in the licensee's responses to comments on June 6, August 19, and October 15, 1997, and January 15, and February 11 and 13, 1998. For the GHP No. 2, the licensee's submittal presented minimal site data, and in response to staff questions, the licensee responded on February 11, 1998, that the data for the pond was limited because disposal there was not complete and, therefore, was a preliminary design. The licensee committed to providing a final design for closure of GHP No. 2, when the required data is available.

Approval of the Heap Leach Reclamation Plan requires a license amendment and clarification of License Condition No. 54. That condition requires reclamation according to the 1980 reclamation plan, and the May 1982 letter, for the above grade tailings pile and the heap leach, with additional requirements stipulated by NRC staff. However, the 1980 plan addressed the small experimental heap leach at the toe of the above grade tailings pile. Several later reclamation plans were submitted to address the near-by operating heap leach (see Figure 1),

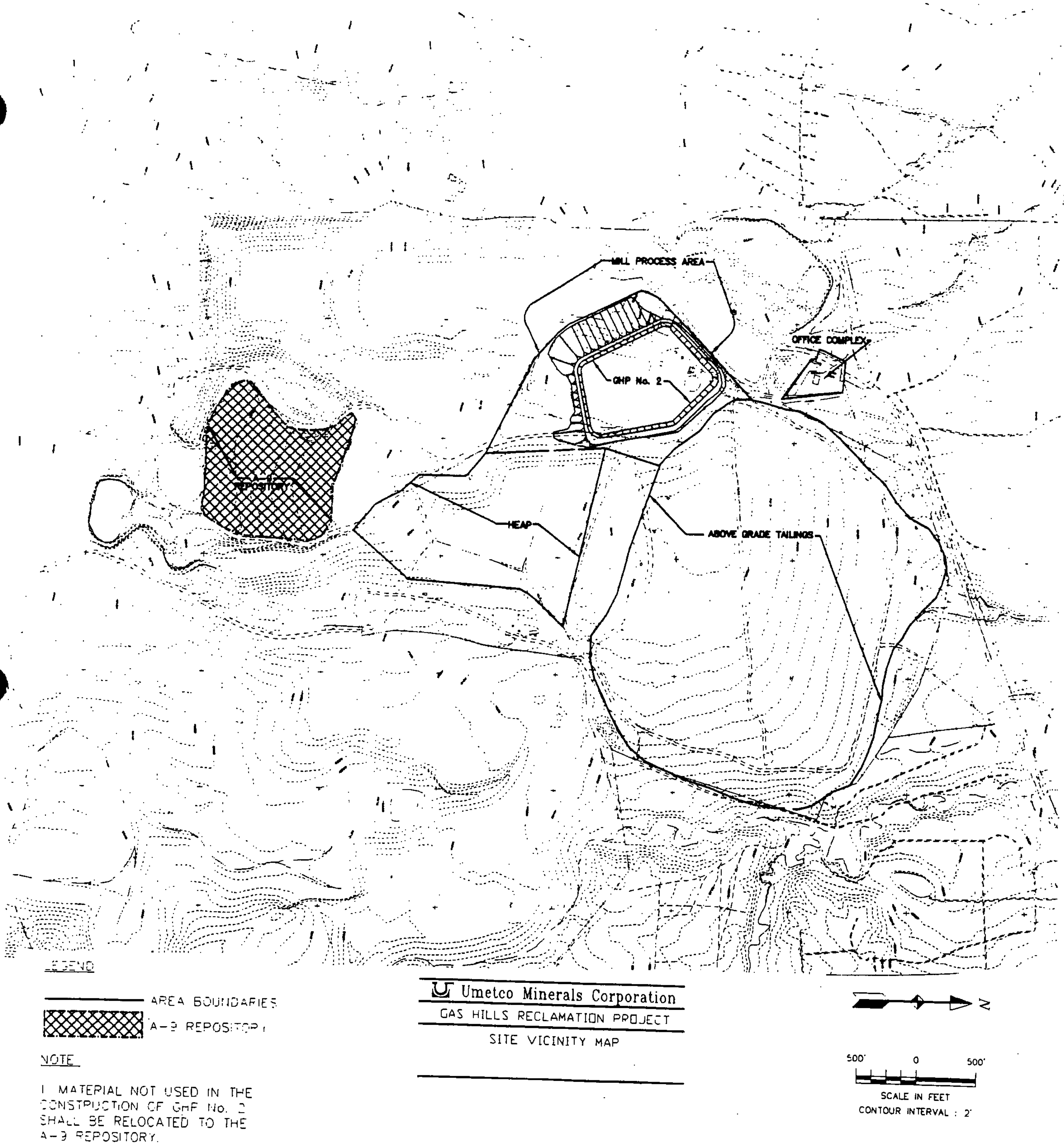

MILL PROCESS AREA
OFFICE COMPLEX
GHP No. 2
REPOSITORY
HEAP
ABOVE GRADE TAILINGS
LEGEND
AREA BOUNDARIES
A-9 REPOSITORY
NOTE
1. MATERIAL NOT USED IN THE CONSTRUCTION OF GHP No. 2 SHALL BE RELOCATED TO THE A-9 REPOSITORY.
Umetco Minerals Corporation
GAS HILLS RECLAMATION PROJECT
SITE VICINITY MAP
N
500' 0 500'
SCALE IN FEET
CONTOUR INTERVAL : 2'

FIGURE 1

but none were approved. The 1996 reclamation plan, although titled plan modification, represents the first design to be approved for this disposal area, and, therefore, an environmental assessment has been prepared.

BACKGROUND:

The Umetco mill site is located in the East Gas Hills area of central Wyoming, 50 miles (80 km) southeast of Riverton, and west of East Canyon Creek. The heap leach operations at the site began in March 1980 under NRC License No. SUA-648, Amendment No. 11. The operations were extended in November 1982 as permitted by Amendment No. 17 of the license and operated until December 1984. Operations were restarted in May 1987 and finally shut down on January 1, 1988. Umetco has previously submitted reclamation plans for the Heap Leach Area in 1988, 1990, 1991, and 1994. None of these were approved.

In the 1991 plan, the reclamation design consisted of a 12-inch (30.5 cm) radon barrier, 12-inch (30.5 cm) filter layer, 30-inch (76.2 cm) frost protection layer, and a 6-inch (15.2 cm) topsoil layer on top of the Heap Leach. Side slopes were to be reclaimed by constructing a multi-gradient sacrificial fill layer with a nominal slope of 5h:1v, a 6-inch (15.2 cm) topsoil layer, and vegetation to control erosion. While NRC review comments and Umetco's responses were ongoing, Umetco proceeded with the Heap Leach Area reclamation construction before NRC approval, and the work was completed in 1992, except for topsoil placement and seeding (Umetco 1994). Umetco made a series of responses to NRC comments in 1994 and 1995, discussing the reclamation plan and evaluation of reclamation construction activities. During this evaluation, it was discovered that some of the soils used in the top cover of the Heap Leach Area exhibited elevated radium concentrations which is in conflict with Criterion 6(5) of 10 CFR 40, Appendix A. The 1996 reclamation plan modifications and related documents propose design revisions to address the above concerns. The modified reclamation plan also includes a preliminary reclamation design for the GHP No. 2.

The 1996 plan proposed major modifications to the 1991 proposed plan that include:

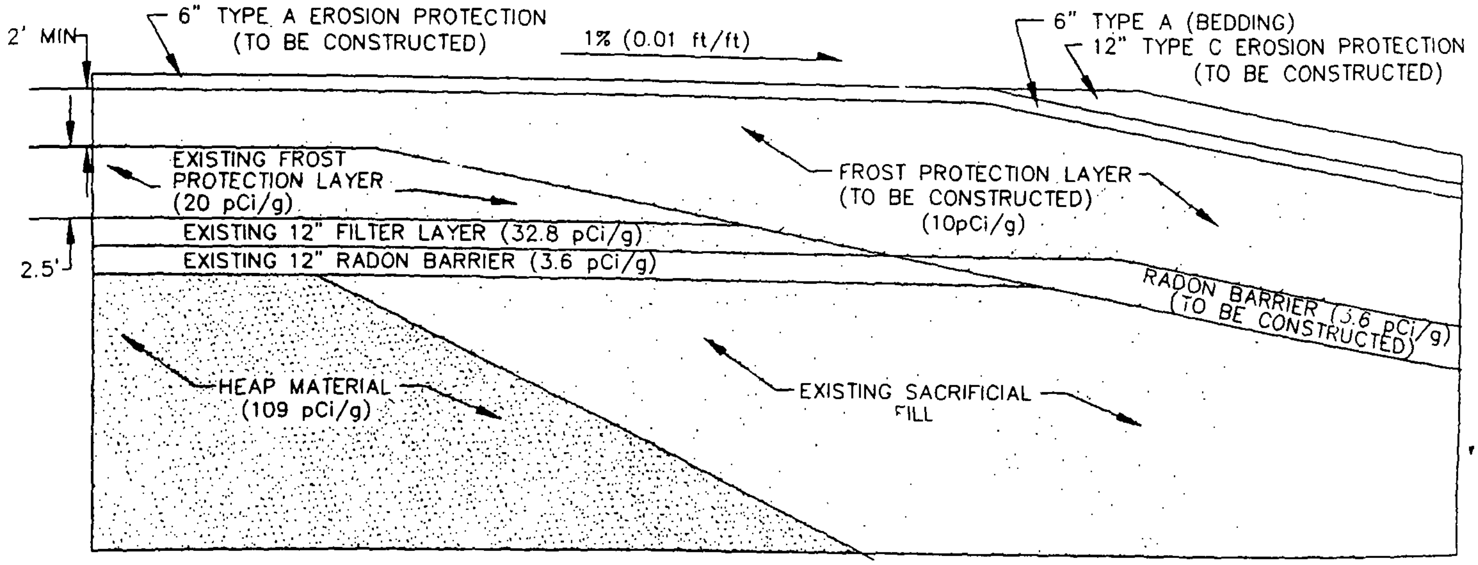
1. Place additional frost protection soil (24 inches) on top of the existing cover.

2. Extend the proposed reclamation cover, i.e., 18-inch (45.7 cm) radon barrier, 54-inch (137 cm) frost protection layer and the erosion protection layer, down the side slopes of the Heap Leach Area.

3. Extend the proposed reclamation cover over the gap between the Heap Leach and Above-Grade Tailings Impoundment and over GHP No. 2.

4. Replace the previously proposed vegetative covers surface with riprap erosion protection on both the top and side slopes of the Heap Leach Area.

It should be noted that with the existing cover, the proposed modifications will result in two different thicknesses of radon barrier layer (12 inches (30.5 cm) on top and 18 inches (45.7 cm) on side slopes). Figure 2 shows details of the two thicknesses of the radon barrier in the cover.




TYPICAL PLAN MODIFICATION

FIGURE 2

The Heap Leach Area will be approximately 50 feet (15.2 m) in height. The reclaimed GHP No. 2/Mill Area will be approximately 25 feet (7.6 m) above the existing grade. The 1996 cover design includes the 60 acre (24 ha) Heap Leach Area and the 17 acre (6.8 ha) GHP No. 2 that was constructed over the former mill site.

The heap leach reclamation plan required NRC staff evaluation in three technical areas: (1) surface water hydrology and erosion protection; (2) geotechnical design and testing; and (3) radon attenuation. Site surface (soil) and ground-water cleanup are addressed in other documents.

TECHNICAL EVALUATION:

## 1.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

### 1.1 Hydrologic Description and Site Conceptual Design

In order to comply with NRC regulations, which require stability of the contaminated material for 1000 years to the extent reasonably achievable and, in any case, for at least 200 years, Umetco proposes to stabilize the contaminated materials in an engineered embankment to protect them from flooding and erosion. The design basis events for design of the erosion protection included the Probable Maximum Precipitation (PMP) and the Probable Maximum Flood (PMF), both of which are considered to have low probabilities of occurrence during the 1000-year stabilization period.

As proposed by Umetco, the contaminated materials will be stabilized and protected by rock covers on the top and side slopes. The covers will have maximum slopes of 1 percent on the top and 20 percent on the sides. The side slopes will be surrounded by riprap aprons which will convey flood runoff away from the cell and prevent gully intrusion into the contaminated materials. In addition, riprap-protected drainage channels will be constructed to convey flood flows away from the site.

### 1.2 Flooding Determinations

The computation of peak flood discharges for various design features at the site was performed by Umetco in several steps. These steps included: (1) selection of a design rainfall event; (2) determination of infiltration losses; (3) determination of times of concentration; and (4) determination of appropriate rainfall distributions, corresponding to the computed times of concentration. Input parameters were derived from each of these steps, and were then used to determine the peak flood discharges to be used in water surface profile modeling and in the final determination of rock sizes for erosion protection.

#### 1.2.1 Selection of Design Rainfall Event

One of the most disruptive phenomena affecting long-term stability is surface water erosion. To account for extreme rainfall and flood events, Umetco utilized the PMP, which is computed by deterministic methods (rather than statistical methods), and is based on site-specific hydrometeorological characteristics. The PMP has been defined as the most severe, reasonably possible rainfall event that could occur as a result of a combination of the most severe meteorological conditions occurring over a watershed. Therefore, the PMP is considered by the NRC staff to provide an acceptable design basis.

A PMP rainfall depth of approximately 9.3 inches in one hour was used by Umetco to estimate the PMFs for the small drainage areas at the disposal site. This rainfall estimate was developed by Umetco, using Hydrometeorological Report (HMR) 55A (DOC, 1988). The staff performed an independent check of the PMP value, based on the procedures given in HMR 55A. Based on this check of the rainfall computations, the staff concludes that the PMP was acceptably derived for this site.

### 1.2.2 Infiltration Losses

Determination of the peak runoff rate is dependent on the amount of precipitation that infiltrates into the ground during the occurrence of the rainfall. If the ground is saturated from previous rains, very little of the rainfall will infiltrate and most of it will become surface runoff.
In computing the peak flow rate for the design of the rock riprap erosion protection at the proposed disposal site, Umetco used the Rational Formula. In this formula, the runoff coefficient was assumed by Umetco to be unity; that is, Umetco assumed that no infiltration would occur. Based on a review of the computations, the staff concludes that this is a conservative assumption and is, therefore, acceptable.

### 1.2.3 Times of Concentration

The time of concentration (tc) is the amount of time required for runoff to reach the outlet of a drainage basin from the most remote point in that basin. Various tcs for the riprap design were estimated by Umetco, using the Kirpich Method (USBR, 1977). This method is generally velocity-based and is considered by the staff to be appropriate for estimating times of concentration. Based on the precision and conservatism associated with the methods, the staff concludes that the tcs have been acceptably derived. The staff further concludes that the procedures used for computing tc are representative of the small steep drainage areas present at the site.

### 1.2.4 Rainfall Distributions

After the PMP is determined, it is necessary to calculate the rainfall intensities corresponding to shorter rainfall durations and times of concentration. A typical PMP value is derived for periods of about one hour. If the time of concentration is less than one hour, it is necessary to extrapolate the data presented in the various HMRs to shorter time periods. Umetco utilized procedures recommended in HMR 55A and by the NRC staff (NRC, 1990). These procedures are used to determine rainfall amounts as a percentage of the one-hour PMP and rainfall intensities for very short periods of time. The staff checked the rainfall intensities for the short durations associated with small drainage basins. Based on a review of this aspect of the flooding determination, the staff concludes that the computed peak rainfall intensities are conservative.

1.2.5 Computation of PMF

The PMF was estimated for the top and side slopes, using the Rational Formula, which provides a standard method for estimating flood discharges for small drainage areas. For the top slope and the side slope, Umetco estimated the peak flow rates based on various slope lengths and magnitudes. Based on staff review of the calculations, the estimates are considered to be conservative.

A PMF flow rates for the apron were computed similarly to the design flow rate for the top and side slopes. As discussed above, the flow rates are considered to be conservative.

Trapezoidal drainage channels are proposed to intercept and divert runoff away from the site. In the PMF analyses, the Rational Formula was used to compute peak flow rates in these channels. Based on a check of the calculations of drainage area, time of concentration, and rainfall intensity, the staff concludes that the PMF estimates have been acceptably derived.

1.3 Water Surface Profiles and Channel Velocities

Following the determination of the peak flood discharge, it is necessary to determine the resulting water levels, velocities, and shear stresses associated with that discharge. These parameters then provide the basis for the determination of the required riprap size and layer thickness needed to assure stability during the occurrence of the design event.

1.3.1 Top Slopes

To determine riprap requirements for the relatively flat top slopes, Umetco used the Safety Factors Method (Stevens, et al., 1976). This method is recommended by the staff for slopes of less than 10 percent. Based on a review of the calculations provided, the staff concludes that the calculations are acceptable.

1.3.2 Side Slope

Riprap requirements for the side slopes were determined using the Stephenson Method (Stephenson, 1979). This method is used for the design of riprap on slopes steeper than 10 percent. The validity and conservatism of this design approach has been verified by the NRC staff through the use of flume tests at Colorado State University. It was determined that the selection of an appropriate design procedure depends on the magnitude of the slope (Abt, et al., 1987). The staff, therefore, concludes that the procedures and design approaches used by Umetco are acceptable and reflect state-of-the-art methods for designing riprap erosion protection.

1.3.3 Apron/Toe

The design of the apron along the toe of the side slopes is based on: (1) provide riprap of adequate size to be stable against the design storm (PMP); (2) provide uniform and/or gentle grades along the apron and the adjacent ground surface such that runoff from the cell is distributed uniformly at a relatively low velocity, minimizing the potential for flow concentration and erosion; and (3) provide an adequate apron thickness to prevent undercutting of the disposal cell by local scour that could result from the PMP, or potential gully encroachment that could occur due to gradual head cutting over a long period of time.

Umetco used several analytical methods for designing the riprap for the apron/toe. Additional detailed discussion of the riprap design of various components of the apron/toe can be found below.

### 1.3.4 Drainage Channels

Normal depth, computed using Manning's Equation (Chow, 1959), was used to estimate depths and velocities for the estimated discharge conditions in the channels. The maximum flow depths and velocities in the various segments of the channels were estimated, based on PMF discharge and the applicable slopes. The design of erosion protection for the outlet of the channel is discussed below.

## 1.4 Erosion Protection

### 1.4.1 Sizing of Erosion Protection

Riprap layers of various sizes and thicknesses are proposed for use at the site. The design of each layer is dependent on its location and purpose.

The rock on the top and side slopes has been sized to withstand the erosive velocities resulting from a PMP, as discussed above. For the top and side slopes, Umetco proposes to use a 6-inch-thick layer of rock with a minimum $D_{50}$ of about 0.5 and 3.0 inches, respectively. The Safety Factors Method and the Stephenson Method were used to determine the required rock sizes. Conservative values were used for the specific gravity of the rock, the rock angle of internal friction, and porosity. Based on staff review of the Umetco's analyses and the acceptability of using design methods recommended by the NRC staff, as discussed in Section 1.3 of this report, the staff concludes that the proposed rock sizes are adequate.

Umetco evaluated the design of the apron/toe in several segments, using several methods to determine the extent and depth of the toe. The actual toe area will be an extension of the side slope where it meets natural ground and will extend to a depth of 6 feet below grade. A 12-inch layer of Type C riprap, with an average $D_{50}$ of about 4 inches will be provided. As part of the analysis of the toe area, Umetco conservatively assumed that the natural ground downstream of the toe would be eroded due to cumulative local scour and/or erosion at its base, resulting in the collapse of the rock into the eroded area. The required rock size was calculated using the Stephenson Method. Based on staff analysis of the calculations, the rock size is acceptable.

To determine the depth to which the toe must be placed, it is necessary to estimate the depth of scour which will occur to the graded natural ground slope just downstream of the toe. Umetco conducted an extensive geomorphic investigation of gullying in the site area to determine expected depths of gullying that would occur, based on drainage areas and other conditions. Umetco determined that the maximum depth of gullying in the site area was about 6 feet, for gullies with significant drainage areas. Umetco proposes to extend the toe to this depth of

6 feet, even though the drainage areas are significantly less. Staff review of the proposed gully depths indicates that they have been conservatively derived and are acceptable.

The riprap design of the drainage channels was analyzed by the staff in the following areas: (1) design of the channel side slopes for runoff directly down the side slopes from the embankment and from the upland drainage area; (2) design for runoff directly through the channel; (3) design of channel outlet; and (4) sediment considerations.

Because the channel side slopes are generally extensions of the side slopes of the pile, the riprap layers that are designed for longitudinal flows in the ditches are also adequate to prevent erosion from flows perpendicular to the ditch (down the slopes). No natural gullies exist that discharge flows directly onto the side slope riprap.

For flows directly in the drainage channels, the Safety Factors Method was used to determine the rock sizes in the various channels. Based on a review of the calculations, the proposed rock sizes for the channels are considered to be adequate.

The maximum scour depths for the channel outlets were calculated by Umetco using several procedures, including: (1) the U.S. Department of Transportation, Federal Highway Administration Method (DOT, 1975); (2) Lacey Regime Equation (Davis and Sorensen, 1969); and the Schoklitsch Method (Simons and Senturk, 1977). Umetco calculated the scour depth to be approximately 12 feet, using the two largest scour depths computed using the three methods. For additional conservatism to protect against scour, Umetco proposes that the riprap at the channel outlet will extend down to a depth of 15 feet. The riprap size was calculated using the Stephenson Method. Based on review of the calculations provided, the staff concludes that the scour depth and erosion protection are acceptable.

For this site, very small amounts of sediment from the upland drainage areas are expected to enter the diversion channels. Most of the drainage area to the channels will be protected by rock covers, and the velocities in the channels are sufficiently high (requiring riprap for erosion protection) to flush away the limited amount of sediment that is expected to enter the channels.

### 1.4.2 Rock Durability

NRC regulations require that control of residual radioactive materials be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The previous sections of this report examined the ability of the erosion protection to withstand flooding events reasonably expected to occur in 1000 years. In this section, rock durability is considered to determine if there is reasonable assurance that the rock itself will survive and remain effective for 1000 years.

Rock durability is defined as the ability of a material to withstand the forces of weathering. Factors that affect rock durability are: (1) chemical reactions with water; (2) saturation time; (3) temperature of the water; (4) scour by sediments; (5) windblown scour;(6) wetting and drying; and (7) freezing and thawing.

For rock selection and production, Umetco proposes to follow the procedures suggested in the NRC Staff Technical Position (NRC, 1990). When a rock source is definitely located, Umetco will conduct durability tests, and rock quality scores will be determined. Umetco indicates that a minimum score of 80 will be used and, if necessary, the rock will be oversized, using suggested NRC criteria (NRC, 1990). The staff concludes that the licensee's commitment to meet NRC-suggested criteria is acceptable.

1.4.3 Testing and Inspection of Erosion Protection

The staff has reviewed and evaluated the testing and inspection quality control requirements for the erosion protection materials. Umetco has proposed a program to test and inspect the rock at various times, and has proposed a plan to assure that adequate placement, gradation, and thicknesses are achieved. The program is similar to programs previously approved by the staff. Based on a review of the information provided by Umetco, the staff concludes that the proposed testing program is acceptable.

1.5 Upstream Dam Failures

There are no impoundments near the site whose failure could potentially affect the site.

1.6 Conclusions

The staff review of the preliminary design for the evaporation pond area, GHP No. 2, indicates that the design concept is acceptable, as Umetco used hydraulic design procedures similar to the procedures used for the heap leach area. Based on review of the information on the Heap Leach Area submitted by Umetco, the NRC staff concludes that the site design meets NRC regulations as stated in 10 CFR Part 40, Appendix A Criterion 4(c)(d), with regard to flood design measures and erosion protection. The staff concludes that an adequate hydraulic design has been provided to reasonably assure stability of the contaminated material at the disposal site for a period of 1000 years, or in any case, at least 200 years, as required by Criterion 6(1). Criteria 6(7) and 12 have been addressed in that the proposed closure plan for the Heap Leach Area is conservative to minimize further maintenance, and there is no reliance on active maintenance to preserve the isolation of the wastes.

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## GEOTECHNICAL DESIGN AND TESTING

## 2.0 GEOTECHNICAL STABILITY

### 2.1 Introduction

This section of the technical evaluation presents the NRC staff review of the geotechnical engineering aspects of the Heap Leach Reclamation Plan Modifications and Preliminary Reclamation Plan for GHP No. 2. The scope of the geotechnical review consisted primarily of evaluations of the site characterization and geotechnical stability aspects of the Heap Leach Area.

### 2.2 Site and Material Characterization

#### 2.2.1 Geotechnical Investigations

Umetco submitted, on December 2, 1991, results of geotechnical field investigations and test data in response to staff questions on the February 1991 reclamation plan for the Heap Leach Area (Umetco, 1991b). NRC staff questioned the seismic coefficient used in the stability evaluation, but not the strength parameters, although some of the parameters were assumed. The original design and the design in the modified reclamation plan were based on geotechnical parameters previously approved by NRC. However, in response to recent NRC questions on the number of samples and tests on which the parameters were established, Umetco performed additional field investigations and testing to establish the physical and strength parameters of various soils/materials at the site (Umetco, 1997a, 1997b, 1997c, and 1998a). The field investigations to collect test samples consisted of test pits to obtain bulk samples of the foundation material, radon barrier borrow material, frost protection/structural fill material, and borings through the Heap Leach Area cover down to about 30 feet into the foundation.

### 2.2.2 Geotechnical Testing

Standard Proctor, grain size analysis with hydrometer, Atterberg limits, unconfined compression, triaxial shear, and 15-bar capillary moisture measurement tests were performed on soil samples to determine their physical and strength parameters. Major materials in the proposed reclamation at the site consist of foundation material, heap leach material, radon barrier material, structural fill, and frost protection material. A brief description of these is presented below.

<u>Foundation Materials</u>

The heap leach site is underlain by mine spoil material placed during open-pit backfill operations. Prior to construction of the heap leach, five test pits were excavated to evaluate the geotechnical properties of the foundation material. The fill consists mainly of a 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 included moisture and density, grain size distribution, compaction, and direct shear strength tests. Unit weight of 112 pcf (1.8 $T/m^3$), friction angle of 20 degrees, and cohesion of 1,100 psf (52.7 KPa) were used for the foundation material in the stability analysis.

<u>Heap Material</u>

The heap leach material primarily consists of generally well graded, run-of-mine rock particles in a matrix of clayey sand; classified as SC-SM, silty, clayey sand or silty clayey sand with gravel when classified by the Unified Soil Classification System. Laboratory tests on this material were reported in the Heap Leach Reclamation Plan (Umetco, 1991a). NRC comments resulted in additional field and laboratory investigations (Umetco, 1991b, 1996, 1997b, and 1997c). Based on Proctor compaction tests, triaxial and direct shear tests on remolded heap material samples, an internal friction angle of 13 degrees, cohesive strength of 500 psf (23.9 KPa), and a unit weight of 112 pcf (1.8 $T/m^3$) were used in the stability analysis.

<u>Radon Barrier Material</u>

Clay material proposed for the radon barrier is from a borrow source, 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 No. 200 sieve. The maximum

Standard Proctor density ranges from 100 to 105 pcf (1.6 to 1.7 T/m3) with optimum moisture content ranging from 19 percent to 22 percent. Long-term moisture content was determined by 15-bar capillary water retention tests. Data based on consolidated, undrained triaxial shear tests, strength parameters of 15 degrees angle of internal friction, and 16 psf (0.8 KPa) cohesion were used in the stability analysis. These values are considered to be conservative for a fat clay soil compacted to a density of 95 percent of maximum dry density by Standard Proctor method. Field hydraulic conductivity tests on existing radon barrier cover on the Heap Leach Area, borrowed from the same source, resulted in coefficient of permeability ranging from 3x10 $E^{-9}$ to 7x10 $E^{-9}$ cm/sec.

Frost Protection Soil and Structural Fill

The geotechnical properties of the frost protection soil placed on top of the radon barrier layer of the cover and the structural fill (also called sacrificial fill) placed on top of the slopes to flatten the slopes are similar. 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 to 121 pcf (1.9 $T/m^3$) with optimum moisture content of 11 percent to 14 percent. The results of consolidated undrained triaxial shear tests, angle of internal friction of 22 degrees, and cohesion of 200 psf (9.6 KPa) were used in the stability analysis.

Filter Material

The filter material is very similar to the structural fill material; classified as SC and/or SC-SM. The geotechnical properties of the existing filter material are essentially same as that of the structural fill material.

## 2.3 Geotechnical Engineering Evaluation

### 2.3.1 Stability Evaluation

The staff has reviewed the exploration data, test results, critical slope characteristics, and method of analyses pertinent to the slope stability aspects of the reclamation plan. The staff finds that the most critical slope section has been considered for the stability analyses.

Soil parameters for the various materials in the stabilized embankment slope have been adequately established by appropriate testing of representative material. Some of the parameter values have been assigned on the basis of data obtained from geotechnical explorations at the site and data published in the literature. The rest of the soil parameters used in the analyses are reasonably conservative values assigned on the basis of test data. The staff also finds that appropriate methods of stability analysis (Spencer, Bishop's Simplified, Ordinary Fellenius, and Janub's Simplified methods of stability evaluation using the SLOPE/W computer code) were used, and the lowest factor of safety under static and seismic loading conditions were determined.

Factors of safety against failure of the slope for seismic and static loading conditions have been evaluated for the long-term state. The value of the seismic coefficients used in the pseudo-static analysis is based on the Peak Ground Acceleration (PGA) of 0.3 g, recommended in the

Lawrence Livermore National Laboratory report, and used 0.2 (67 percent of PGA ) as the seismic coefficient. This value was derived in accordance with the recommended methods in the NRC Standard Review Plan (1993) and is acceptable to the staff. The staff finds that the use of pseudo-static method of analysis for seismic stability of the slopes is acceptable, considering the flatness of the slopes and conservatism in the soil parameter values. The minimum factors of safety against failure of the Heap Leach Area slope were 2.8 for the static condition and 1.3 for the seismic loading analyzed by the pseudo-static method of analysis. The factor of safety values are higher than the minimum values acceptable to NRC, and, therefore, the slopes are expected to be stable.

### 2.3.2 Settlement and Cover Cracking

The heap leach material consists of sandy material and has been in place for more than seven years. The licensee has placed radon barrier, filter, and cover on top of the Heap Leach Area. Data monitored from settlement platforms showed minimal settlement and, also, very low or negligible rate of settlement. The heap leach and foundation material are mostly granular (SC-SM) and are not expected to exhibit long-term (time dependent) settlement. However, any additional load placed during the proposed reclamation activity will result in additional settlement. But this is expected to be mostly instantaneous that will take place during the construction 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. However, the GHP No. 2 preliminary design did not address area settlement, but the final design should include such an analysis.

### 2.3.3 Liquefaction

The staff has reviewed the information presented on the potential for liquefaction at the site. Based on geotechnical investigations, borings and test pits logs and test data, the heap leach material is in an unsaturated condition and the water table is very deep. For liquefaction to occur, a soil must be saturated, loose, and cohesionless. The heap leach is a compacted, granular material in an unsaturated condition, and is, therefore, not susceptible to liquefaction. The foundation materials, SC-SM, are in a dense state and are also not susceptible to liquefaction. The staff concludes that the stability of the reclaimed Heap Leach Area will not be adversely affected by seismically-induced liquefaction.

The GHP No. 2 is a lined pond which will be filled with contaminated material. The potential for liquefaction of the contents of the reclaimed pond and the resulting settlement of the cover during a seismic event has not been addressed. The licensee has committed to submit detailed information on the reclamation of the GHP No. 2 area, for approval, before placing the cover.

### 2.3.4 Cover Frost Barrier

There will be a total of 72 inches (1.8 m) of soil and rock material on top of the radon barrier. The staff calculated the depth of frost penetration for this area, and finds the 54-inch (1.4-m)-thick frost protection layer to be adequate to protect the radon barrier from frost damage. The cover design to protect the radon barrier from frost/freezing damage is conservative and acceptable.

### 2.4 Geotechnical Construction Details

#### 2.4.1 Constriction Methods and Features

The staff has reviewed and evaluated the geotechnical construction criteria provided (Umetco, 1996, 1997a). Based on its review, the staff concludes that the plans and drawings clearly convey the proposed remedial action design features. In addition, the placement methods and specifications represent accepted standard practice.

#### 2.4.2 Testing and Inspection

The staff reviewed the specifications, testing, and inspection proposed for the construction. The staff compared the proposed inspection testing frequency with the testing frequency in the staff position on testing and inspection for the Uranium Mill Tailings Remedial Action Project (NRC, 1989) and identified certain discrepancies. In response to staff comments on this, Umetco submitted revisions to the reclamation plan, complying with the testing provisions in the staff technical position (Umetco, 1998b and 1998c). The testing and inspection proposed in the reclamation plan are acceptable to the staff, and will result in the construction as specified in the reclamation plan.

### 2.5 Conclusions

The details of the GHP No. 2 area are not presented in the revised reclamation plan. The licensee has committed to provide these in a submittal before placing the cover on the GHP No.2 area. The licensee is only seeking staff evaluation of the proposed conceptual design of a common cover for the two facilities, Heap Leach and GHP No. 2 Areas. The staff finds the concept to be acceptable from a geotechnical engineering perspective.

Based on review of the geotechnical engineering aspects of the design of the Heap Leach Area reclamation, the staff concludes there is reasonable assurance that the site characterization and geotechnical engineering design pertinent to long-term stability and performance of the Heap Leach Area, as presented in the modified reclamation plan, will result in a reclamation-satisfying Criteria 4(c)(e), and 6(1) of Appendix A to 10 CFR Part 40.

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Umetco, 1997a, Umetco Minerals Corporation, "Heap Leach Reclamation Plan Modification and Reclamation Plan for GHP No.2/Mill Area," response to NRC Comments of May 9, 1997; June 6, 1997.

Umetco, 1997b, Umetco Minerals Corporation, "Heap Leach Reclamation Plan Modification and Reclamation Plan for GHP No.2/Mill Area," response to NRC Comments of May 9,1997; August 19, 1997.

Umetco, 1997c, Umetco Minerals Corporation, "Heap Leach Reclamation Plan, results of Geotechnical Tests on Clay Samples," October 15, 1997.

Umetco, 1998a, Umetco Minerals Corporation, "Heap Leach Reclamation Plan, Response to NRC Comments of December 15, 1997" January 15, 1998.

Umetco, 1998b, Umetco Minerals Corporation, Letter from T. Gieck of Umetco to J. Holonich of NRC: Gas Hills, License No. SUA-648; Response to staff comments on Reclamation Plan; Revision1 to Reclamation Plan, February 11, 1998.

Umetco, 1998c, Umetco Minerals Corporation, Letter from T. Gieck of Umetco to J. Holonich of NRC: Gas Hills, License number SUA-648; Response to staff comments, Revision 2 to Reclamation Plan, February 13, 1998.

U.S. Nuclear Regulatory Commission (NRC), 1989, NRC Staff Position Technical Position on Testing and Inspection Plans During Construction of DOE's Remedial Action at Inactive Uranium Mill Tailings Sites, January 1989.

U.S. Nuclear Regulatory Commission, Final Standard Review Plan for the Review of Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Tailings Radiation Control Act, June 1993.

## 3.0 RADON ATTENUATION DESIGN

### 3.1 Introduction

This section of the staff evaluation of the final reclamation plan addresses the demonstration of compliance with that portion of Criterion 6(1) of 10 CFR Part 40, Appendix A, requiring that a disposal cell design limit releases of radon (Rn-222) from uranium byproduct materials to not exceed an average (over at least a year) release rate of 20 $pCi/m^2/s$ from the surface of the cell for 1000 years, to the extent reasonably achievable, but at least 200 years.

Because radon is a gas with a short half-life (3.8 days), the amount of radon from uranium mill tailings reaching the atmosphere is reduced by restricting the gas movement long enough so that radon decays to a solid daughter which remains within the disposal cell. The physical and radiological parameters influencing the amount of radon available to the soil pore spaces and its movement, are incorporated into a computer code to calculate the radon flux from the cover, or the cover thickness required to limit the flux.

In the September 1996 plan modification, Umetco increased the cover thickness and replaced the vegetative cover with riprap. Also, the radon flux model (code input) used to estimate the long-term radon flux was revised to reflect these changes and to incorporate additional testing results. In the plan, Umetco proposed a 1.0-foot (30.5-cm)-thick clay radon barrier for the top of the disposal cell and a 1.5-foot (45.7-cm)-thick layer on the sideslopes, to reduce the expected long-term radon flux to meet the design standard of 20 pCi/m$^2$/s. The other layers of the cover (filter and fill soil) on top total 5 feet (1.5 m) thick and are primarily for frost and erosion protection. On the sideslopes, approximately 22 feet (6.7 m) of fill has been placed (under the radon barrier) and the soil above the radon barrier is 4.5 feet (1.4 m) thick (see Figure 2).

The NRC staff review of the cover design for radon attenuation included evaluation of the pertinent design criteria for the contaminated materials and radon barrier soil, and a review of the specifications for materials placement. The staff considered that the barrier layer is designed to satisfy criteria for construction, settlement, cracking, and infiltration of surface water, as well as reduction of radon gas release at the surface of the completed cell. Also, the parameters of the other layers of the cover were evaluated for their ability to protect the radon barrier layer from drying and disruption, and the stability of the cell as a whole was assessed because of the potential for cracking of the barrier layer due to settlement or heaving. Previous sections of this report provide discussion of the cell materials and cell design from the aspect of stability (subsidence, freeze-thaw damage, erosion, etc.).

### 3.2 Radon Flux Model Parameters

The staff evaluated the physical and radiological data for the contaminated materials and the radon barrier soils used for input into the RADON computer code (NRC Regulatory Guide 3.64) by the licensee. In some cases, conservative estimates instead of measured values were used for input, and in other cases measurements were made, although not always under design conditions. The staff evaluated the justification and assumptions made, to confirm that each input value was representative of the material, consistent with anticipated construction specifications, and conservative or based on long-term conditions. The sampling and testing methods for the materials were also reviewed to determine their appropriateness and to insure that the data was adequate.

Measured maximum dry density values were used to calculate the average dry density at placement (or in-situ) compaction. Twelve samples of in-situ heap leach material (six surface and six at a 3-foot (0.9 m) depth) were tested. The percentage of compaction varied from 71.6 to 95.3, and the density values varied from 1.36 to 1.80 g/cm$^3$. The average value used in the model is acceptable because the density of this material is expected to increase (i.e., become more conservative for radon flux) when the cover is placed. The average density measurement taken during placement of the clay was used for the radon barrier layer. The density value for the fill material was calculated as 95 percent of the average measured maximum dry density. The code-calculated porosity value, based on the density input value, was used for all materials.

Umetco has indicated that the fill soil is mine spoils (overburden soil) that is primarily silty and clayey sand, and is similar to the filter layer material and the structural fill (both derive from portions of the Heap Waste Area). The same density value and diffusion coefficient value was used for all three cover layers.

The radium (Ra-226) value used in the model for the heap leach material was the maximum value measured, 109 pCi/g (4.0 Bq/g), based on 20 samples. The sideslope fill material was estimated (based on gamma readings) to contain 20 pCi/g (0.7 Bq/g), but the 109 pCi/g (4.0 Bq/g) value was used in the model to be conservative. The Ra-226 value for the radon barrier, filter, and fill soil was the maximum value of test results (four, three, and ten samples, respectively). Additional test data on five samples of barrier material in July 1997, indicate that the model Ra-226 value was conservative. The top 1.5 feet (45.7 cm) of cover was modeled as containing 10 pCi/g (0.37 Bq/g) Ra-226, as Umetco states that the radium content of this layer will be monitored continuously and have a maximum value of 10 pCi/g (0.37 Bq/g). The radon emanation fraction values in the model are the average of three or four measured values.

The long-term moisture value of 6.0 percent used for the heap leach material is a conservative estimate based on the average (12 samples) measured in-situ value of 16.8 percent. The 6.0 percent value also was used for the other materials and is conservative based on -15 bar test and placement moisture results.

The diffusion coefficient value for the heap material was calculated by the code, based on the input values for porosity, moisture, and density. The diffusion coefficient for each cover layer was initially measured on only one sample, but additional test data on five samples (submitted October 1997) were obtained on radon barrier material at about the optimum moisture content of 20 percent. The -15 bar test results indicate that the long-term moisture for the barrier material would be 17.5 percent, but as staff noted in correspondence of May 9, 1997, the -15 bar test results are not always conservative. The staff determined that the radon barrier diffusion coefficient value used in the radon model is not substantiated by recent testing because the barrier material was not tested at a reasonable long-term moisture content. However, as discussed in Section 3.3, staff used conservative moisture and diffusion coefficient values for the cover and calculated a radon flux that still meets the standard.

Freeze-thaw effects on the clay material (decreased density and increased porosity) were not modeled because the soil cover thickness above the clay radon barrier is the estimated depth of frost penetration. Also, a damaged barrier was not modeled because the effects of biointrusion (by animals or deep-rooted plants) on the radon barrier layer have been minimized by the additional cover material and riprap.

### 3.3 Modeling Results

Umetco used a conservative moisture value of 6.0 percent for all layers of the cover in the radon flux model, however, this conservatism is not reflected in the flux estimate because Umetco used cover diffusion coefficient values of 0.004 and 0.005 $cm^2/s$, measured at 14.8 and 12.7 percent moisture, in the code. To be conservative, the staff used moisture values of 12 and 9 percent (lower than the -15 bar test results) in the topslope flux model for the clay and filter/fill material, respectively, with code-calculated diffusion coefficients. The resulting radon flux was 14.5 $pCi/m^2/s$ which is approximately twice the value reported by Umetco. Since the staff estimated long-term radon flux is below the required limit, staff can approve the cover design without accepting Umetco's modeling results.

### 3.4 Cover Radium Content

To demonstrate that the cover design will allow compliance with Criterion 6(5), "... soils used for near surface cover must be essentially the same, as far as radioactivity is concerned, as that of surrounding soils", the staff agreed that Umetco should provide a long-term radon flux estimate that included the radon contribution (based on measured Ra-226 values) from all the cover layers, with only the upper 1.5 feet (45.7 cm) of cover required to contain background levels of Ra-226. Umetco provided (July 1997) a report on soil background Ra-226 for the East Gas Hills site that recommended a value of 10 pCi/g (0.37 Bq/g). The staff has concluded that this value is not representative of the background soil around the facility and Umetco has gathered additional data for a revised background report.

Umetco's plan limits the upper 2 (top) to 4.5 (sides) feet (61 to 137 cm) of frost protection material to a maximum Ra-226 content of 10 pCi/g (0.37 Bq/g), but staff has advised that the average value must be lower. Umetco is aware that the final Ra-226 data for this material must be provided in the completion (final survey) report to document compliance with Criterion 6(5).

### 3.5 Cover Integrity

In 1994, the staff asked Umetco to indicate if significant effects on radon attenuation due to biointrusion (penetrations into the radon barrier) could occur during the design life of the cover. Umetco responded that some burrowing animals and deep-rooted plants were in the area but unlikely to penetrate the cover enough to affect the long-term radon attenuation ability of the cover. One of the reasons listed for modifying the 1991 plan by increasing the cover thickness and using rock on the surface, was to address concerns for biointrusion. The staff concludes that the 1996 plan provides a conservative cover design that will minimize biointrusion so that cover integrity will be preserved sufficiently to maintain its radon attenuation capability. In addition, active maintenance is not required to ensure cover integrity.

### 3.6 Conclusions

The staff has determined that the parameters values used in the estimation of long-term radon flux from the cover are reasonable test results or conservative estimates, except for the cover diffusion coefficient values. Only one diffusion coefficient test result, performed at the approximate long-term moisture value, was presented for the radon barrier material. However, staff use of reasonably conservative moisture values and the code-calculated diffusion coefficient produced an acceptable long-term radon flux estimate. Therefore, based on the evidence that the cover will remain stable for the design period, there is reasonable assurance that the proposed cover design for the Heap Leach Area will meet the long-term radon emission limit in 10 CFR Part 40, Appendix A Criterion 6(1).

The same cover design is proposed (preliminary design) for GHP No. 2 and should be adequate. However, data on the final depth and Ra-226 content of contamination in the pond must be provided in the final design plan to substantiate the radon attenuation design. Therefore, GHP No. 2 will be addressed in a separate license amendment.

Data on Ra-226 content of the additional frost protection material placed (at least upper 1.5 feet (45.7 cm)), will need to be provided in the completion report to substantiate that Criterion 6(5) has been met.

3.7 Reference

U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers," June 1989.

RECOMMENDED LICENSE CHANGE:

License condition 54 should be modified to clarify that the experiment heap leach area was addressed in the 1980 reclamation plan. A new license condition would require reclamation of the Heap Leach Area as proposed in the 1996 reclamation plan, as revised.

Attachment 2

# ATTACHMENT 2

## NRC Approval of the 2000 Heap Leach Erosion Protection Design Modifications (Channel 2 Outlet): License Amendment 44

Submitted by letter dated April 5, 2001

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

April 5, 2001



Mr. Curtis O. Sealy, General Manager
Umetco Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

SUBJECT: AMENDMENT 44, REVISED SOIL DECOMMISSIONING AND EROSION PROTECTION PLANS AND SURETY UPDATE FOR LICENSE SUA–648, UMETCO MINERALS CORPORATION, GAS HILLS URANIUM MILL SITE

Dear Mr. Sealy:

The U.S. Nuclear Regulatory Commission (NRC) has completed its review of the revised annual surety amount for the Umetco Minerals Corporation (Umetco) Gas Hills Site, submitted in your letter dated December 20, 2000. Umetco proposes a reduction to $21,232,408 for the NRC portion of the surety ($22,176,508 total with the Wyoming portion). The revised cost estimate includes a reduction of $3,648,750 for cell cover work completed, as documented by the NRC inspection of July 18, 2000, modification to erosion protection design, and adjustments for the lower cost of cover materials, as documented by the submittal of January 10, 2001. The staff has also reviewed the revised decommissioning plan, submitted September 15 and November 17, 2000, and the revised erosion protection design submitted December 20, 2000. The plans are acceptable and the estimated costs in the proposed surety amount are justified.

The NRC staff has documented its review of the proposed surety amount and the decommissioning plan in a Technical Evaluation Report provided as Enclosure 1. The review of the erosion protection design is documented in a Technical Evaluation Report provided as Enclosure 2. The Umetco license has been modified to incorporate the changes in conditions 30, 54, 55, and 61 as requested. The amended license is provided as Enclosure 3.

An Environmental Assessment (Enclosure 4) was prepared in accordance with 10 CFR 51.21 and 51.30 to document compliance with the National Environmental Policy Act for the soil decommissioning. Based on the EA, a notice was published in the Federal Register March 1, 2001, indicating a finding that no significant impact should result from implementation of the decommissioning plan. The design change for erosion protection was requested in order to improve protection of the environment so the previous EA and FONSI issued May 25, 1999, do not need to be revised. The revised surety portion of the amendment is categorically excluded under Part 51.22(c)(10) and, therefore, requires no environmental review.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room).

If you have any questions concerning this letter or the enclosures, please contact Ms. Elaine Brummett of my staff at (301) 415-6606 or by e-mail to esb@nrc.gov.

Sincerely,

Daniel M. Gillen, Acting Chief
Fuel Cycle Licensing Branch
Division of Fuel Cycle Safety
and Safeguards, NMSS

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

cc: Moxley, WDEQ

Enclosures:
1. Tech Evaluation of Decommissioning Plan & Surety
2. Tech Evaluation of Erosion Protection
3. License Amendment 44
4. Environmental Assessment

TECHNICAL EVALUATION
SURFACE WATER HYDROLOGY AND EROSION PROTECTION
UMETCO EROSION PROTECTION MODIFICATION

TECHNICAL REVIEWER: Ted Johnson, Surface Water Hydrologist

INTRODUCTION

By letter dated December 20,2000, Umetco Minerals Corporation (Umetco) submitted a request to modify the erosion protection design for the Above-Grade Tailings Impoundment (AGTI) and the Heap Leach Cell. The re-design for the AGTI includes riprap armoring of the East Canyon Creek (ECC) slope adjacent to the tailings embankment on the east side. These changes resulted from the discovery of historic artifacts in this area and the need to minimize the impacts to these resources. The Heap Leach design change was made to better conform the design of the outlet channel to existing topography and the adjacent designs of the Wyoming Department of Environmental Quality (WDEQ). Also, during production of the Type A rock, Umetco determined that a more economical gradation could be produced and proposed that the gradation of this rock type replace the rock size for Type A in the original design.

TECHNICAL EVALUATION

1. Above-Grade Impoundment

Umetco proposes to straighten the channel alignment of ECC to minimize disturbance to cultural resources. A launched stone design will be provided instead of a below-grade scour apron, the side slopes of the ECC channel will be flattened to 1 Vertical (V) on 5 Horizontal (H), and a 40-foot (12.2-m) wide low flow channel will be constructed along the eastern channel bed.

To determine the size of the launched stone, Umetco determined the depth of flow and energy grade line slope using the HEC-RAS model, and used the Safety Factors Method to compute the required rock size. Using a scour depth of 9.4 feet (2.9 m) (greater than the previously-approved scour depth of 7.4 feet), the D50 rock size was determined to be 30 inches (76 cm). Staff review of the analyses and the supporting assumptions indicates that the rock size is conservative.

To determine the volume and gradation of the launched stone, Umetco used design criteria developed by the Army Corps of Engineers (ACE) in "Hydraulic Design of Flood Control Channels" and recommendations developed by the NRC staff in NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization." Umetco will provide a rock apron that will be 28 feet (8.5 m) in length to collapse to a scour depth of 14 feet on a 1V on 2H side slope and that will have a thickness of 3.5 feet (1.1 m). Although the use of the ACE procedure would result in an apron length of 31.3 feet (9.5 m) instead of 28 feet (8.5 m), staff determined that because of the various conservative aspects of the design, this does not present a problem. Staff review of the analyses and supporting assumptions indicates that the proposed design is in accordance with the design procedures suggested in NUREG-1623 and is therefore acceptable.

Umetco also proposes to provide a downstream scour apron at Station 1+75 of the ECC channel to prevent upstream headcutting. The design parameters and resulting rock sizes and thicknesses were similar to the design of the launched rock structure. Based on the acceptability of the calculations for the launched rock, as discussed above, the staff concludes that the design of the downstream apron is acceptable.

2. Heap Leach Channel 2 Modification

Umetco also proposes design modifications for the outlet configuration and erosion protection of Channel 2, associated with the Heap Leach design. A channel outlet will be provided that is more conducive to the existing topography and WDEQ reclamation for the B-Spoils Area in which Channel 2 discharges. The bottom width of Segment 2 of the channel will be modified to 250 feet 76.3 m), and a drop apron will be provided to drop the discharge elevation of flows.

Water surface profiles, flow velocities, and scour depths were computed and used in the Safety Factors Method to determine a required rock size of 6 inches (15 cm) for the apron that will be extended to a depth of 15 feet (4.6 m) below grade. Staff review indicates that the design parameters selected are conservative and/or conform to the design criteria suggested in NUREG-1623, and are therefore acceptable.

3. Modification of Type A Rock Gradation

Umetco intends to modify the previously-approved gradation for the Type A rock by increasing the maximum size rock in the gradation from 1½ inches to 3 inches (3.8 to7.6 cm). Because the layer thickness of the Type A rock is 6 inches (15 cm), the proposed change should have little effect on the ability to properly place the rock and may actually be more stable. Accordingly, the staff concludes that the change is acceptable.

RECOMMENDATION:

Conditions 54 and 61 refer to the erosion protection design for the Above-Grade and Heap Leach Cells, respectively. Reference to the revised design submitted for approval should be added to these conditions, as indicated below.

54. (End of first paragraph, add) ...and December 20, 2000.

61. (End of paragraph, add) ...and December 20, 2000.

# Appendix A
# Contaminated Fill

# Appendix A

# Heap Leach Contaminated Fill
# Quality Control Test Results

**Table A.1. Daily Quantities and Quality Control Test Frequencies for the Heap Leach Contaminated Fill Placement: 1997-1998**

*Note:* This table lists only those days that fill was placed and/or testing performed. CY = Cubic Yards; NG = Nuclear Gauge (test), i.e., field compaction test.
Testing Frequency Requirements: *Field Compaction Tests:* 1: 1000 CY *Proctors:* 1: 5000 CY *Sand-Cones:* 1:10 NG tests

| Date | Total Quantities Placed | | Field Compaction Test Frequency | | | Proctor Test Frequency | | | Sand-Cone Test Frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Yardage | Cumulative Yardage | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (/NG tests) |
| 5/20/97 | 0 | 0 | 2 | 2 | 1: 0 | | 0 | -- | 1 | 1 | 1: 2 |
| 5/21/97 | 2,375 | 2,375 | 4 | 6 | 1: 396 | 1 | 1 | 1: 2375 | 1 | 2 | 1: 3 |
| 5/22/97 | 3,420 | 5,795 | 3 | 9 | 1: 644 | 3 | 4 | 1: 1449 | | 2 | 1: 5 |
| 5/23/97 | 8,075 | 13,870 | 6 | 15 | 1: 925 | 1 | 5 | 1: 2774 | 1 | 3 | 1: 5 |
| 5/24/97 | 0 | 13,870 | | 15 | 1: 925 | 1 | 6 | 1: 2312 | | 3 | 1: 5 |
| 5/28/97 | 3,724 | 17,594 | 6 | 21 | 1: 838 | 2 | 8 | 1: 2199 | | 3 | 1: 7 |
| 5/29/97 | 8,265 | 25,859 | 7 | 28 | 1: 924 | 2 | 10 | 1: 2586 | 1 | 4 | 1: 7 |
| 5/30/97 | 8,018 | 33,877 | 8 | 36 | 1: 941 | 1 | 11 | 1: 3080 | 1 | 5 | 1: 7 |
| 6/2/97 | 7,942 | 41,819 | 9 | 45 | 1: 929 | 2 | 13 | 1: 3217 | 1 | 6 | 1: 8 |
| 6/3/97 | 9,101 | 50,920 | 10 | 55 | 1: 926 | 2 | 15 | 1: 3395 | | 6 | 1: 9 |
| 6/4/97 | 8,493 | 59,413 | 11 | 66 | 1: 900 | 3 | 18 | 1: 3301 | 1 | 7 | 1: 9 |
| 6/5/97 | 8,132 | 67,545 | 25 | 91 | 1: 742 | 5 | 23 | 1: 2937 | 4 | 11 | 1: 8 |
| 6/6/97 | 1,634 | 69,179 | 4 | 95 | 1: 728 | 1 | 24 | 1: 2882 | 1 | 12 | 1: 8 |
| 6/9/97 | 1,881 | 71,060 | 3 | 98 | 1: 725 | 1 | 25 | 1: 2842 | | 12 | 1: 8 |
| 6/10/97 | 2,356 | 73,416 | 3 | 101 | 1: 727 | 1 | 26 | 1: 2824 | 1 | 13 | 1: 8 |
| 6/11/97 | 0 | 73,416 | 3 | 104 | 1: 706 | | 26 | 1: 2824 | | 13 | 1: 8 |
| 6/12/97 | 0 | 73,416 | 3 | 107 | 1: 686 | 1 | 27 | 1: 2719 | | 13 | 1: 8 |
| 8/7/97 | 0 | 73,416 | | 107 | 1: 686 | 1 | 28 | 1: 2622 | | 13 | 1: 8 |
| 8/8/97 | 0 | 73,416 | 4 | 111 | 1: 661 | | 28 | 1: 2622 | | 13 | 1: 9 |
| 8/15/97 | 0 | 73,416 | 1 | 112 | 1: 656 | | 28 | 1: 2622 | | 13 | 1: 9 |
| 8/18/97 | 0 | 73,416 | 1 | 113 | 1: 650 | | 28 | 1: 2622 | | 13 | 1: 9 |
| 7/13/98 | 0 | 73,416 | 5 | 118 | 1: 622 | 1 | 29 | 1: 2532 | 1 | 14 | 1: 8 |
| 7/14/98 | 2,889 | 76,305 | 0 | 118 | 1: 647 | 1 | 30 | 1: 2544 | | 14 | 1: 8 |
| 7/15/98 | 5,454 | 81,759 | 7 | 125 | 1: 654 | 1 | 31 | 1: 2637 | 2 | 16 | 1: 8 |
| 7/16/98 | 5,481 | 87,240 | 6 | 131 | 1: 666 | 1 | 32 | 1: 2726 | 1 | 17 | 1: 8 |
| 7/17/98 | 6,102 | 93,342 | 4 | 135 | 1: 691 | 1 | 33 | 1: 2829 | 1 | 18 | 1: 8 |
| 7/20/98 | 5,346 | 98,688 | 4 | 139 | 1: 710 | 1 | 34 | 1: 2903 | 1 | 19 | 1: 7 |
| 7/21/98 | 4,347 | 103,035 | 6 | 145 | 1: 711 | 1 | 35 | 1: 2944 | 1 | 20 | 1: 7 |

**Table A.1. Daily Quantities and Quality Control Test Frequencies for the Heap Leach Contaminated Fill Placement: 1997-1998**

*Note:* This table lists only those days that fill was placed and/or testing performed. CY = Cubic Yards; NG = Nuclear Gauge (test), i.e., field compaction test.
Testing Frequency Requirements: *Field Compaction Tests:* 1: 1000 CY *Proctors:* 1: 5000 CY *Sand-Cones:* 1:10 NG tests

| Date | Total Quantities Placed | | Field Compaction Test Frequency | | | Proctor Test Frequency | | | Sand-Cone Test Frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Yardage | Cumulative Yardage | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (/NG tests) |
| 7/22/98 | 4,050 | 107,085 | 2 | 147 | 1: 728 | 1 | 36 | 1: 2975 | 1 | 21 | 1: 7 |
| 7/23/98 | 4,806 | 111,891 | 5 | 152 | 1: 736 | | 36 | 1: 3108 | 1 | 22 | 1: 7 |
| 7/24/98 | 3,429 | 115,320 | 1 | 153 | 1: 754 | 1 | 37 | 1: 3117 | | 22 | 1: 7 |
| 7/27/98 | 3,996 | 119,316 | 3 | 156 | 1: 765 | 1 | 38 | 1: 3140 | 1 | 23 | 1: 7 |
| 7/28/98 | 3,915 | 123,231 | 5 | 161 | 1: 765 | | 38 | 1: 3243 | | 23 | 1: 7 |
| 7/29/98 | 4,710 | 127,941 | 4 | 165 | 1: 775 | 2 | 40 | 1: 3199 | 1 | 24 | 1: 7 |
| 7/30/98 | 540 | 128,481 | 3 | 168 | 1: 765 | | 40 | 1: 3212 | 1 | 25 | 1: 7 |
| 7/31/98 | 701 | 129,182 | 2 | 170 | 1: 760 | | 40 | 1: 3230 | 1 | 26 | 1: 7 |
| 8/3/98 | 702 | 129,884 | | 170 | 1: 764 | | 40 | 1: 3247 | | 26 | 1: 7 |
| 9/30/98 | 400 | 130,284 | | 170 | 1: 766 | | 40 | 1: 3257 | | 26 | 1: 7 |
| 10/13/98 | 108 | 130,392 | | 170 | 1: 767 | | 40 | 1: 3260 | | 26 | 1: 7 |

**Total Quantities of Fill Placed in the Heap Leach, Summary by Year**

| Year | Cu Yds Placed |
|---|---|
| 1997 | 73,416 |
| 1998 | 56,976 |
| **TOTAL:** | **130,392** |

## Table A.2. Field Compaction Test Results for the Heap Leach Contaminated Fill: 1997-1998

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed.
Max.= Maximum; P = Pass; F Comp = Fails Compaction. See summary statistics at the end of this table.

| Compaction Test ID | | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Northing | Easting | Elevation | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | | *Requirements:* | NA** | $\geq$ 90 | | |
| CM-001 | * | 5/20/97 | 792220 | 837030 | 6984 | HM-01 | 115.3 | 14.0 | 108.6 | 15.7 | 94.2 | P | |
| CM-002 | | 5/20/97 | 791730 | 837010 | 6974 | HM-01 | 115.3 | 14.0 | 114.2 | 14.7 | 99.0 | P | |
| CM-003 | | 5/21/97 | 792400 | 837280 | 7005 | HM-01 | 115.3 | 14.0 | 111.0 | 18.3 | 96.3 | P | |
| CM-004 | | 5/21/97 | 792200 | 837680 | 7018 | HM-02 | 115.4 | 13.5 | 116.6 | 13.5 | 101.0 | P | |
| CM-005 | | 5/21/97 | 792370 | 837400 | 7006 | HM-02 | 115.4 | 13.5 | 109.1 | 14.4 | 94.5 | P | |
| CM-006 | * | 5/21/97 | 792250 | 837750 | 7007 | HM-02 | 115.4 | 13.5 | 105.9 | 13.8 | 91.8 | P | |
| CM-007 | | 5/22/97 | 792320 | 837500 | 7008 | HM-02 | 115.4 | 13.5 | 112.5 | 15.9 | 97.5 | P | |
| CM-008 | | 5/22/97 | 792100 | 838230 | 7006 | HM-01 | 115.3 | 14.0 | 112.3 | 17.7 | 97.4 | P | |
| CM-009 | | 5/22/97 | 792120 | 837040 | 6984 | HM-05 | 116.7 | 14.3 | 106.2 | 13.8 | 91.0 | P | |
| CM-010 | | 5/23/97 | 792330 | 837450 | 7011 | HM-03 | 109.8 | 14.6 | 109.1 | 19.0 | 99.4 | P | |
| CM-011 | | 5/23/97 | 791955 | 837060 | 6986 | HM-05 | 116.7 | 14.3 | 100.6 | 17.3 | 86.2 | F Comp | Fails Compaction |
| CM-011-R | | 5/23/97 | 791955 | 837060 | 6986 | HM-05 | 116.7 | 14.3 | 105.1 | 16.2 | 90.1 | P | Retest |
| CM-012 | * | 5/23/97 | 792320 | 837455 | 7012 | HM-06 | 121.0 | 11.9 | 113.9 | 14.3 | 94.1 | P | |
| CM-013 | | 5/23/97 | 792390 | 837230 | 7013 | HM-06 | 121.0 | 11.9 | 113.3 | 15.1 | 93.6 | P | |
| CM-014 | | 5/23/97 | 792205 | 837060 | 6988 | HM-05 | 116.7 | 14.3 | 109.4 | 15.4 | 93.7 | P | |
| CM-015 | | 5/23/97 | 792285 | 837530 | 7014 | HM-06 | 121.0 | 11.9 | 114.6 | 13.1 | 94.7 | P | |
| CM-016 | | 5/28/97 | 792140 | 837075 | 6992 | HM-02 | 115.4 | 13.5 | 108.7 | 15.5 | 94.2 | P | |
| CM-017 | | 5/28/97 | 791950 | 837095 | 6994 | HM-07 | 115.1 | 12.8 | 108.7 | 17.6 | 94.4 | P | |
| CM-018 | | 5/28/97 | 792260 | 837085 | 6996 | HM-07 | 115.1 | 12.8 | 107.8 | 14.4 | 93.7 | P | |
| CM-019 | | 5/28/97 | 792210 | 837100 | 6998 | HM-07 | 115.1 | 12.8 | 110.8 | 13.4 | 96.3 | P | |
| CM-020 | | 5/28/97 | 792190 | 837810 | 7014 | HM-07 | 115.1 | 12.8 | 105.6 | 18.9 | 91.7 | P | |
| CM-021 | | 5/28/97 | 792010 | 837110 | 7001 | HM-07 | 115.1 | 12.8 | 108.3 | 16.2 | 94.1 | P | |
| CM-022 | * | 5/29/97 | 792240 | 837100 | 7003 | HM-08 | 109.3 | 16.9 | 108.9 | 13.2 | 99.6 | P | |
| CM-023 | | 5/29/97 | 791830 | 837140 | 7004 | HM-08 | 109.3 | 16.9 | 111.4 | 12.3 | 101.9 | P | |
| CM-024 | | 5/29/97 | 792320 | 837390 | 7015 | HM-10 | 113.8 | 14.1 | 114.2 | 15.3 | 100.4 | P | |
| CM-025 | | 5/29/97 | 791830 | 837160 | 7005 | HM-08 | 109.3 | 16.9 | 103.2 | 16.3 | 94.4 | P | |
| CM-026 | | 5/29/97 | 792375 | 837210 | 7016 | HM-10 | 113.8 | 14.1 | 106.9 | 17.1 | 93.9 | P | |
| CM-027 | | 5/29/97 | 792170 | 837140 | 7007 | HM-08 | 109.3 | 16.9 | 107.2 | 15.6 | 98.1 | P | |
| CM-028 | | 5/29/97 | 792110 | 838180 | 7007 | HM-10 | 113.8 | 14.1 | 112.6 | 15.7 | 98.9 | P | |
| CM-029 | | 5/30/97 | 792010 | 837160 | 7009 | HM-08 | 109.3 | 16.9 | 112.3 | 12.7 | 102.7 | P | |
| CM-030 | | 5/30/97 | 792100 | 838180 | 7010 | HM-09 | 111.0 | 15.0 | 109.1 | 14.4 | 98.3 | P | |
| CM-031 | | 5/30/97 | 792230 | 837160 | 7011 | HM-09 | 111.0 | 15.0 | 111.8 | 13.2 | 100.7 | P | |
| CM-032 | | 5/30/97 | 792060 | 838290 | 7011 | HM-09 | 111.0 | 15.0 | 113.2 | 11.7 | 102.0 | P | |
| CM-033 | * | 5/30/97 | 792080 | 838190 | 7012 | HM-09 | 111.0 | 15.0 | 112.2 | 11.8 | 101.1 | P | |
| CM-034 | | 5/30/97 | 792130 | 837170 | 7012 | HM-09 | 111.0 | 15.0 | 111.6 | 12.0 | 100.5 | P | |
| CM-035 | | 5/30/97 | 791935 | 837185 | 7013 | HM-11 | 113.2 | 15.0 | 112.1 | 10.0 | 99.0 | P | |
| CM-036 | | 5/30/97 | 791780 | 837120 | 6999 | HM-11 | 113.2 | 15.0 | 104.5 | 14.5 | 92.3 | P | |
| CM-037 | | 6/2/97 | 791980 | 837190 | 7014 | HM-11 | 113.2 | 15.0 | 102.7 | 19.8 | 90.7 | P | |

## Table A.2. Field Compaction Test Results for the Heap Leach Contaminated Fill: 1997-1998

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed.
Max.= Maximum; P = Pass; F Comp = Fails Compaction. See summary statistics at the end of this table.

| Compaction Test ID | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Northing | Easting | Elevation | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | *Requirements:* | NA** | ≥ 90 | | |
| CM-038 | 6/2/97 | 792100 | 837190 | 7015 | HM-11 | 113.2 | 15.0 | 113.7 | 14.8 | 100.4 | P | |
| CM-039 | 6/2/97 | 792090 | 838155 | 7013 | HM-11 | 113.2 | 15.0 | 108.4 | 14.8 | 95.8 | P | |
| CM-040 | 6/2/97 | 791405 | 837170 | 6974 | HM-14 | 124.0 | 8.4 | 112.9 | 16.8 | 91.0 | P | |
| CM-041 | 6/2/97 | 791735 | 837140 | 7001 | HM-12 | 113.5 | 14.3 | 109.4 | 18.6 | 96.4 | P | |
| CM-042 | 6/2/97 | 792120 | 838030 | 7014 | HM-12 | 113.5 | 14.3 | 110.0 | 16.6 | 96.9 | P | |
| CM-043 * | 6/2/97 | 791070 | 837430 | 6982 | HM-14 | 124.0 | 8.4 | 107.2 | 14.4 | 86.5 | F Comp | Fails Compaction |
| CM-043-R * | 6/3/97 | 791070 | 837430 | 6982 | HM-14 | 124.0 | 8.4 | 117.7 | 12.1 | 94.9 | P | Retest |
| CM-044 | 6/2/97 | 791500 | 837075 | 6979 | HM-12 | 113.5 | 14.3 | 111.4 | 14.4 | 98.2 | P | |
| CM-045 | 6/2/97 | 792290 | 837170 | 7015 | HM-12 | 113.5 | 14.3 | 107.9 | 16.3 | 95.1 | P | |
| CM-046 | 6/3/97 | 791450 | 837130 | 6982 | HM-12 | 113.5 | 14.3 | 114.7 | 12.4 | 101.1 | P | |
| CM-047 | 6/3/97 | 792385 | 837060 | 6991 | HM-13 | 113.5 | 14.4 | 107.2 | 16.8 | 94.4 | P | |
| CM-048 | 6/3/97 | 791300 | 837325 | 6983 | HM-13 | 113.5 | 14.4 | 108.8 | 14.1 | 95.9 | P | |
| CM-049 | 6/3/97 | 792450 | 837150 | 7001 | HM-13 | 113.5 | 14.4 | 110.1 | 13.7 | 97.0 | P | |
| CM-050 | 6/3/97 | 792360 | 837055 | 6993 | HM-13 | 113.5 | 14.4 | 110.3 | 15.4 | 97.2 | P | |
| CM-051 | 6/3/97 | 791560 | 837070 | 6984 | HM-13 | 113.5 | 14.4 | 107.7 | 15.7 | 94.9 | P | |
| CM-052 | 6/3/97 | 792400 | 837110 | *7003* | HM-15 | 115.8 | 14.3 | 110.4 | 13.5 | 95.3 | P | |
| CM-053 | 6/3/97 | 791370 | 837255 | *6986* | HM-15 | 115.8 | 14.3 | 109.6 | 13.9 | 94.6 | P | |
| CM-054 | 6/3/97 | 792350 | 837150 | *7005* | HM-15 | 115.8 | 14.3 | 115.9 | 14.3 | 100.1 | P | |
| CM-055 | 6/3/97 | 791275 | 837380 | *6987* | HM-15 | 115.8 | 14.3 | 112.8 | 14.9 | 97.4 | P | |
| CM-056 | 6/4/97 | 791320 | 837340 | *6989* | HM-15 | 115.8 | 14.3 | 114.0 | 12.7 | 98.4 | P | |
| CM-057 | 6/4/97 | 791430 | 837220 | *6991* | HM-16 | 113.7 | 15.0 | 103.6 | 14.8 | 91.1 | P | |
| CM-058 | 6/4/97 | 791350 | 837330 | 6993 | HM-17 | 115.2 | 14.3 | 107.3 | 9.1 | 93.1 | P | |
| CM-059 | 6/4/97 | 791350 | 837330 | 6993 | HM-17 | 115.2 | 14.3 | 112.0 | 11.9 | 97.2 | P | |
| CM-060 * | 6/4/97 | 791475 | 837185 | 6995 | HM-17 | 115.2 | 14.3 | 108.4 | 10.6 | 94.1 | P | |
| CM-061 | 6/4/97 | 791570 | 837120 | 6996 | HM-17 | 115.2 | 14.3 | 112.0 | 15.0 | 97.2 | P | |
| CM-062 | 6/4/97 | 791410 | 837290 | 6998 | HM-17 | 115.2 | 14.3 | 108.2 | 7.4 | 93.9 | P | |
| CM-063 | 6/4/97 | 791310 | 837430 | 6999 | HM-18 | 116.0 | 12.8 | 106.8 | 8.7 | 92.1 | P | |
| CM-064 | 6/4/97 | 791445 | 837250 | 7000 | HM-18 | 116.0 | 12.8 | 109.7 | 8.8 | 94.6 | P | |
| CM-065 | 6/4/97 | 791515 | 837190 | 7002 | HM-18 | 116.0 | 12.8 | 110.5 | 8.8 | 95.3 | P | |
| CM-066 | 6/4/97 | 791670 | 837155 | 7003 | HM-18 | 116.0 | 12.8 | 110.6 | 8.9 | 95.3 | P | |
| CM-067 | 6/5/97 | 791280 | 837510 | 7005 | HM-19 | 114.8 | 13.1 | 105.3 | 6.9 | 91.7 | P | |
| CM-068 | 6/5/97 | 791705 | 837155 | 7006 | HM-19 | 114.8 | 13.1 | 106.1 | 9.8 | 92.4 | P | |
| CM-069 | 6/5/97 | 791490 | 837275 | 7008 | HM-19 | 114.8 | 13.1 | 103.1 | 11.7 | 89.8 | F Comp | Fails Compaction |
| CM-069-R | 6/5/97 | 791490 | 837275 | 7008 | HM-19 | 114.8 | 13.1 | 107.1 | 16.4 | 93.3 | P | Retest |
| CM-070 | 6/5/97 | 791620 | 837185 | 7009 | HM-19 | 114.8 | 13.1 | 114.6 | 10.4 | 99.8 | P | |
| CM-071 | 6/5/97 | 791400 | 837400 | 7010 | HM-20 | 113.3 | 15.5 | 108.6 | 10.0 | 95.9 | P | |
| CM-072 | 6/5/97 | 791785 | 837190 | 7012 | HM-20 | 113.3 | 15.5 | 107.9 | 12.1 | 95.2 | P | |
| CM-073 | 6/5/97 | 791340 | 837505 | 7013 | HM-20 | 113.3 | 15.5 | 108.5 | 9.2 | 95.8 | P | |

## Table A.2. Field Compaction Test Results for the Heap Leach Contaminated Fill: 1997-1998

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed.
Max.= Maximum; P = Pass; F Comp = Fails Compaction. See summary statistics at the end of this table.

| Compaction Test ID | | Date | Location: Northing | Location: Easting | Elevation | Laboratory Standard Proctor: Proctor ID | Laboratory Standard Proctor: Max. Dry Density (lbs/cu ft) | Laboratory Standard Proctor: Optimum Moisture (%) | Field Compaction Tests: Dry Density (lbs/cu ft) | Field Compaction Tests: Percent Moisture | Field Compaction Tests: Percent Compaction | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | *Requirements:* | NA** | ≥ 90 | | |
| CM-074 | | 6/5/97 | 791445 | 837375 | 7014 | HM-20 | 113.3 | 15.5 | 109.7 | 16.0 | 96.8 | P | |
| CM-075 | * | 6/5/97 | 791670 | 837230 | 7016 | HM-20 | 113.3 | 15.5 | 105.6 | 8.2 | 93.2 | P | |
| CM-076 | | 6/5/97 | 791410 | 837465 | 7016 | HM-24 | 111.2 | 14.4 | 106.2 | 16.0 | 95.5 | P | |
| CM-077 | | 6/5/97 | 792140 | 838100 | 7008 | HM-21 | 118.2 | 11.8 | 111.5 | 15.1 | 94.3 | P | |
| CM-078 | | 6/5/97 | 792165 | 837965 | 7011 | HM-21 | 118.2 | 11.8 | 115.6 | 14.8 | 97.8 | P | |
| CM-079 | | 6/5/97 | 792410 | 837080 | 6995 | HM-21 | 118.2 | 11.8 | 112.7 | 9.4 | 95.4 | P | |
| CM-080 | | 6/5/97 | 792370 | 837080 | 6997 | HM-21 | 118.2 | 11.8 | 111.7 | 12.5 | 94.5 | P | |
| CM-081 | * | 6/5/97 | 792385 | 837110 | 7003 | HM-21 | 118.2 | 11.8 | 111.5 | 16.3 | 94.3 | P | |
| CM-082 | | 6/5/97 | 791840 | 837005 | 6976 | HM-22 | 117.0 | 13.0 | 107.9 | 12.7 | 92.2 | P | |
| CM-083 | | 6/5/97 | 791870 | 837020 | 6980 | HM-22 | 117.0 | 13.0 | 109.4 | 13.3 | 93.5 | P | |
| CM-084 | | 6/5/97 | 791905 | 837030 | 6982 | HM-22 | 117.0 | 13.0 | 106.6 | 14.8 | 91.1 | P | |
| CM-085 | | 6/5/97 | 791875 | 837040 | 6984 | HM-22 | 117.0 | 13.0 | 108.5 | 14.9 | 92.7 | P | |
| CM-086 | * | 6/5/97 | 791840 | 837055 | 6986 | HM-22 | 117.0 | 13.0 | 106.8 | 13.5 | 91.3 | P | |
| CM-087 | | 6/5/97 | 791610 | 837015 | 6975 | HM-23 | 116.5 | 12.5 | 110.4 | 14.0 | 94.8 | P | |
| CM-088 | | 6/5/97 | 791610 | 837030 | 6978 | HM-23 | 116.5 | 12.5 | 111.6 | 12.5 | 95.8 | P | |
| CM-089 | | 6/5/97 | 791615 | 837045 | 6981 | HM-23 | 116.5 | 12.5 | 107.9 | 13.8 | 92.6 | P | |
| CM-090 | | 6/5/97 | 791675 | 837050 | 6983 | HM-23 | 116.5 | 12.5 | 113.3 | 14.8 | 97.3 | P | |
| CM-091 | * | 6/5/97 | 791645 | 837070 | 6987 | HM-23 | 116.5 | 12.5 | 110.6 | 15.7 | 94.9 | P | |
| CM-092 | | 6/6/97 | 791065 | 837440 | 6984 | HM-24 | 111.2 | 14.4 | 108.6 | 7.6 | 97.7 | P | |
| CM-093 | | 6/6/97 | 790890 | 837450 | 6985 | HM-24 | 111.2 | 14.4 | 112.4 | 10.0 | 101.1 | P | |
| CM-094 | | 6/6/97 | 790705 | 837610 | 6987 | HM-24 | 111.2 | 14.4 | 111.2 | 11.6 | 100.0 | P | |
| CM-095 | * | 6/6/97 | 790785 | 837540 | 6989 | HM-24 | 111.2 | 14.4 | 110.4 | 10.0 | 99.3 | P | |
| CM-096 | | 6/9/97 | 790670 | 837720 | 6991 | HM-25 | 115.3 | 14.4 | 105.9 | 12.1 | 91.8 | P | |
| CM-097 | | 6/9/97 | 790850 | 837560 | 6994 | HM-25 | 115.3 | 14.4 | 112.7 | 11.8 | 97.7 | P | |
| CM-098 | | 6/9/97 | 790670 | 837720 | 6996 | HM-25 | 115.3 | 14.4 | 113.3 | 9.7 | 98.3 | P | |
| CM-099 | | 6/10/97 | 790810 | 837705 | 7000 | HM-25 | 115.3 | 14.4 | 105.4 | 13.6 | 91.4 | P | |
| CM-100 | * | 6/10/97 | 790950 | 837575 | 7002 | HM-25 | 115.3 | 14.4 | 117.5 | 13.0 | 101.9 | P | |
| CM-101 | | 6/10/97 | 790780 | 837840 | 7005 | HM-26 | 117.1 | 11.7 | 109.5 | 11.5 | 93.5 | P | |
| CM-102 | | 6/11/97 | 790890 | 837735 | 7009 | HM-26 | 117.1 | 11.7 | 117.8 | 9.6 | 100.6 | P | |
| CM-103 | | 6/11/97 | 790980 | 837695 | 7011 | HM-26 | 117.1 | 11.7 | 112.3 | 9.9 | 95.9 | P | |
| CM-104 | | 6/11/97 | 790780 | 837993 | 7014 | HM-26 | 117.1 | 11.7 | 110.2 | 10.9 | 94.1 | P | |
| CM-105 | | 6/12/97 | 792300 | 837400 | 7016 | HM-27 | 116.9 | 11.4 | 113.4 | 12.9 | 97.0 | P | |
| CM-106 | | 6/12/97 | 792195 | 837730 | 7016 | HM-27 | 116.9 | 11.4 | 115.0 | 14.9 | 98.4 | P | |
| CM-107 | | 6/12/97 | 792060 | 838130 | 7016 | HM-27 | 116.9 | 11.4 | 113.7 | 16.4 | 97.3 | P | |
| CM-108 | | 8/8/97 | 791230 | 837400 | 5' Below S.G. | HM-28 | 119.8 | 12.5 | 116.0 | 13.6 | 96.8 | P | |
| CM-109 | | 8/8/97 | 791230 | 837400 | 4' Below S.G. | HM-28 | 119.8 | 12.5 | 113.0 | 13.8 | 94.3 | P | |
| CM-110 | | 8/8/97 | 791230 | 837400 | 3' Below S.G. | HM-28 | 119.8 | 12.5 | 113.6 | 13.6 | 94.8 | P | |
| CM-111 | | 8/8/97 | 791230 | 837400 | 2' Below S.G. | HM-28 | 119.8 | 12.5 | 117.0 | 13.1 | 97.7 | P | |

## Table A.2. Field Compaction Test Results for the Heap Leach Contaminated Fill: 1997-1998

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed.
Max.= Maximum; P = Pass; F Comp = Fails Compaction. See summary statistics at the end of this table.

| Compaction Test ID | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Northing | Easting | Elevation | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | *Requirements:* | NA** | ≥ 90 | | |
| CM-112 | 8/15/97 | 790690 | 838090 | 7015.5 | HM-28 | 119.8 | 12.5 | 110.7 | 10.0 | 92.4 | P | |
| CM-113 | 8/18/97 | 790700 | 838050 | 7018 | HM-28 | 119.8 | 12.5 | 110.6 | 12.1 | 92.3 | P | |
| CM-114 | 7/13/98 | 792445 | 837670 | 7011 | HM-29 | 113.9 | 11.9 | 117.4 | 13.2 | 103.1 | P | |
| CM-115 | 7/13/98 | 792416 | 837480 | 7005 | HM-29 | 113.9 | 11.9 | 108.2 | 14.1 | 94.9 | P | |
| CM-116 * | 7/13/98 | 792321 | 837768 | 7005 | HM-29 | 113.9 | 11.9 | 116.4 | 13.5 | 102.2 | P | |
| CM-117 | 7/13/98 | 792374 | 838050 | 7007 | HM-29 | 113.9 | 11.9 | 114.4 | 12.5 | 100.4 | P | |
| CM-118 | 7/13/98 | 792258 | 838083 | 7008 | HM-29 | 113.9 | 11.9 | 115.4 | 12.6 | 101.3 | P | |
| CM-119 | 7/15/98 | 792246 | 838116 | 7009 | HM-30 | 118.7 | 12.1 | 108.0 | 13.2 | 91.0 | P | |
| CM-120 * | 7/15/98 | 792246 | 837983 | 7009 | HM-30 | 118.7 | 12.1 | 114.4 | 14.0 | 96.4 | P | |
| CM-121 | 7/15/98 | 792340 | 837886 | 7009 | HM-30 | 118.7 | 12.1 | 113.7 | 11.4 | 95.8 | P | |
| CM-122 | 7/15/98 | 792373 | 837965 | 7009 | HM-30 | 118.7 | 12.1 | 106.8 | 14.4 | 90.0 | P | |
| CM-123 | 7/15/98 | 792336 | 838170 | 7009 | HM-30 | 118.7 | 12.1 | 108.8 | 12.0 | 91.7 | P | |
| CM-124 | 7/15/98 | 792390 | 837612 | 7007 | HM-32 | 115.2 | 12.7 | 117.5 | 12.2 | 102.0 | P | |
| CM-125 * | 7/15/98 | 792453 | 837335 | 7004 | HM-32 | 115.2 | 12.7 | 116.3 | 13.8 | 101.0 | P | |
| CM-126 * | 7/16/98 | 792483 | 837647 | 7014 | HM-32 | 115.2 | 12.7 | 114.1 | 12.1 | 99.0 | P | |
| CM-127 | 7/16/98 | 792448 | 837857 | 7011 | HM-32 | 115.2 | 12.7 | 110.5 | 15.3 | 95.9 | P | |
| CM-128 | 7/16/98 | 792310 | 838174 | 7009 | HM-32 | 115.2 | 12.7 | 112.9 | 12.2 | 98.0 | P | |
| CM-129 | 7/16/98 | 792525 | 837246 | 7006 | HM-31 | 110.5 | 14.0 | 105.7 | 8.6 | 95.7 | P | |
| CM-130 | 7/16/98 | 792368 | 837526 | 7006 | HM-31 | 110.5 | 14.0 | 105.9 | 12.8 | 95.8 | P | |
| CM-131 | 7/16/98 | 792255 | 837837 | 7010 | HM-31 | 110.5 | 14.0 | 107.8 | 17.9 | 97.6 | P | |
| CM-132 * | 7/17/98 | 792370 | 837723 | 7009 | HM-31 | 110.5 | 14.0 | 109.4 | 16.4 | 99.0 | P | |
| CM-133 | 7/17/98 | 792224 | 838133 | 7009 | HM-33 | 116.0 | 12.3 | 111.5 | 12.9 | 96.1 | P | |
| CM-134 | 7/17/98 | 792446 | 837369 | 7007 | HM-33 | 116.0 | 12.3 | 113.3 | 10.1 | 97.7 | P | |
| CM-135 | 7/17/98 | 792567 | 837200 | 7005 | HM-33 | 116.0 | 12.3 | 109.4 | 14.0 | 94.3 | P | |
| CM-136 | 7/20/98 | 792371 | 837980 | 7010 | HM-33 | 116.0 | 12.3 | 115.1 | 9.6 | 99.2 | P | |
| CM-137 * | 7/20/98 | 792457 | 837782 | 7014 | HM-33 | 116.0 | 12.3 | 109.5 | 10.3 | 94.4 | P | |
| CM-138 | 7/20/98 | 792419 | 837713 | 7012 | HM-34 | 117.0 | 12.2 | 110.2 | 7.6 | 94.2 | P | |
| CM-139 | 7/20/98 | 792322 | 837890 | 7010 | HM-34 | 117.0 | 12.2 | 112.3 | 8.3 | 96.0 | P | |
| CM-140 | 7/21/98 | 792441 | 837358 | 7009 | HM-34 | 117.0 | 12.2 | 118.6 | 10.9 | 101.4 | P | |
| CM-141 | 7/21/98 | 792367 | 837712 | 7011 | HM-34 | 117.0 | 12.2 | 115.6 | 9.3 | 98.8 | P | |
| CM-142 * | 7/21/98 | 792210 | 837933 | 7009 | HM-34 | 117.0 | 12.2 | 117.6 | 11.3 | 100.5 | P | |
| CM-143 | 7/21/98 | 792292 | 837670 | 7008 | HM-35 | 114.8 | 14.5 | 107.4 | 13.3 | 93.6 | P | |
| CM-144 | 7/21/98 | 792545 | 837279 | 7010 | HM-35 | 114.8 | 14.5 | 113.1 | 11.0 | 98.5 | P | |
| CM-145 | 7/21/98 | 792607 | 837238 | 7010 | HM-35 | 114.8 | 14.5 | 113.4 | 12.2 | 98.8 | P | |
| CM-146 | 7/22/98 | 792478 | 837475 | 7010 | HM-35 | 114.8 | 14.5 | 109.3 | 12.4 | 95.2 | P | |
| CM-147 * | 7/22/98 | 792450 | 837562 | 7016 | HM-35 | 114.8 | 14.5 | 110.9 | 12.1 | 96.6 | P | |
| CM-148 | 7/23/98 | 792441 | 837227 | 7011 | HM-36 | 113.6 | 14.2 | 111.5 | 13.3 | 98.2 | P | |
| CM-149 | 7/23/98 | 792409 | 837422 | 7011 | HM-36 | 113.6 | 14.2 | 112.9 | 8.9 | 99.4 | P | |

## Table A.2. Field Compaction Test Results for the Heap Leach Contaminated Fill: 1997-1998

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed.
Max.= Maximum; P = Pass; F Comp = Fails Compaction. See summary statistics at the end of this table.

| Compaction Test ID | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Northing | Easting | Elevation | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | Requirements: | NA** | ≥ 90 | | |
| CM-150 | 7/23/98 | 792463 | 837722 | 7015 | HM-36 | 113.6 | 14.2 | 108.1 | 6.1 | 95.2 | P | |
| CM-151 | 7/23/98 | 792446 | 838040 | 7014 | HM-36 | 113.6 | 14.2 | 109.0 | 9.5 | 96.0 | P | |
| CM-152 * | 7/23/98 | 792300 | 838085 | 7010 | HM-36 | 113.6 | 14.2 | 111.6 | 12.4 | 98.2 | P | |
| CM-153 | 7/24/98 | 792541 | 837250 | 7013 | HM-37 | 113.0 | 13.6 | 97.5 | 13.5 | 86.3 | F Comp | Fails Compaction |
| CM-153R | 7/27/98 | 792541 | 837250 | 7013 | HM-37 | 113.0 | 13.6 | 104.4 | 18.4 | 92.4 | P | Retest |
| CM-154 | 7/27/98 | 792397 | 837386 | 7012 | HM-37 | 113.0 | 13.6 | 104.0 | 16.6 | 92.0 | P | |
| CM-155 | 7/27/98 | 792332 | 837678 | 7012 | HM-37 | 113.0 | 13.6 | 109.9 | 17.0 | 97.3 | P | |
| CM-156 * | 7/27/98 | 792352 | 837832 | 7012 | HM-37 | 113.0 | 13.6 | 101.3 | 17.1 | 89.7 | P | Test passed at discretion of QC officer. |
| CM-157 | 7/28/98 | 792625 | 837259 | 7015 | HM-38 | 112.1 | 13.4 | 114.6 | 10.5 | 102.2 | P | |
| CM-158 | 7/28/98 | 792400 | 838248 | 7004 | HM-38 | 112.1 | 13.4 | 100.9 | 15.9 | 90.0 | P | |
| CM-159 | 7/28/98 | 792395 | 838230 | 7005 | HM-38 | 112.1 | 13.4 | 103.6 | 16.2 | 92.4 | P | |
| CM-160 | 7/28/98 | 792390 | 838237 | 7006 | HM-38 | 112.1 | 13.4 | 112.9 | 14.0 | 100.7 | P | |
| CM-161 | 7/28/98 | 792400 | 838280 | 7007 | HM-38 | 112.1 | 13.4 | 107.3 | 14.0 | 95.7 | P | |
| CM-162 | 7/29/98 | 792670 | 837300 | 7011 | HM-39 | 111.9 | 15.0 | 108.6 | 13.7 | 97.1 | P | |
| CM-163 | 7/29/98 | 792418 | 837803 | 7011 | HM-39 | 111.9 | 15.0 | 111.0 | 11.4 | 99.2 | P | |
| CM-164 | 7/29/98 | 792344 | 837891 | 7011 | HM-39 | 111.9 | 15.0 | 114.3 | 10.4 | 102.1 | P | |
| CM-165 | 7/29/98 | 792550 | 837226 | 7014 | HM-39 | 111.9 | 15.0 | 105.0 | 9.6 | 93.8 | P | |
| CM-166 * | 7/30/98 | 792225 | 837834 | 7012 | HM-40 | 117.3 | 13.5 | 113.7 | 13.1 | 96.9 | P | |
| CM-167 | 7/30/98 | 792329 | 837662 | 7014 | HM-40 | 117.3 | 13.5 | 113.1 | 14.4 | 96.4 | P | |
| CM-168 | 7/30/98 | 792055 | 838415 | 7004 | HM-40 | 117.3 | 13.5 | 108.5 | 13.7 | 92.5 | P | |
| CM-169 | 7/31/98 | 792060 | 838397 | 7006 | HM-40 | 117.3 | 13.5 | 111.6 | 17.2 | 95.1 | P | |
| CM-170 * | 7/31/98 | 792521 | 837274 | 7015 | HM-40 | 117.3 | 13.5 | 110.9 | 15.1 | 94.5 | P | |

Field density and moisture tests were taken using a nuclear density gauge. The gauge was field standardized at each test location and was correlated by a Sand Cone Test at a frequency of one for every five nuclear gauge tests. Field rock corrections were performed at each compaction test location.

| | | |
|---|---|---|
| *Total Number of Tests (N):* | 170 | (N reflects passing tests only) |
| *Total Quantities placed:* | 130,392 | cubic yards (CY) |
| *Frequency:* | 1: 767 CY | Exceeds the required frequency of 1:1000 CY. |

| | Dry Density | Percent Moisture | Percent Compaction |
|---|---|---|---|
| *average:* | **110.5** | **13.2** | **96.2** |
| *minimum:* | 100.9 | 6.1 | 89.7 |
| *maximum:* | 118.6 | 19.8 | 103.1 |
| *standard deviation:* | 3.6 | 2.7 | 3.2 |
| *# Failed:* | NA | NA | 4 |
| *# Retested:* | NA | NA | 4 |

## Table A.3. Standard Proctor Test Results for the Heap Leach Contaminated Fill Layer

| Date | Laboratory Standard Proctor | | |
|---|---|---|---|
| | Proctor ID | Maximum Dry Density (pcf) | Optimum Moisture (%) |
| 5/20/97 | HM-01 | 115.3 | 14.0 |
| 5/21/97 | HM-02 | 115.4 | 13.5 |
| 5/23/97 | HM-03 | 109.8 | 14.6 |
| 5/22/97 | HM-05 | 116.7 | 14.3 |
| 5/23/97 | HM-06 | 121.0 | 11.9 |
| 5/28/97 | HM-07 | 115.1 | 12.8 |
| 5/29/97 | HM-08 | 109.3 | 16.9 |
| 5/30/97 | HM-09 | 111.0 | 15.0 |
| 5/29/97 | HM-10 | 113.8 | 14.1 |
| 5/30/97 | HM-11 | 113.2 | 15.0 |
| 6/2/97 | HM-12 | 113.5 | 14.3 |
| 6/3/97 | HM-13 | 113.5 | 14.4 |
| 6/2/97 | HM-14 | 124.0 | 8.4 |
| 6/3/97 | HM-15 | 115.8 | 14.3 |
| 6/4/97 | HM-16 | 113.7 | 15.0 |
| 6/4/97 | HM-17 | 115.2 | 14.3 |
| 6/4/97 | HM-18 | 116.0 | 12.8 |
| 6/5/97 | HM-19 | 114.8 | 13.1 |
| 6/5/97 | HM-20 | 113.3 | 15.5 |
| 6/5/97 | HM-21 | 118.2 | 11.8 |
| 6/5/97 | HM-22 | 117.0 | 13.0 |
| 6/5/97 | HM-23 | 116.5 | 12.5 |
| 6/5/97 | HM-24 | 111.2 | 14.4 |
| 6/9/97 | HM-25 | 115.3 | 14.4 |
| 6/10/97 | HM-26 | 117.1 | 11.7 |
| 6/12/97 | HM-27 | 116.9 | 11.4 |
| 8/8/97 | HM-28 | 119.8 | 12.5 |
| 7/13/98 | HM-29 | 113.9 | 11.9 |
| 7/15/98 | HM-30 | 118.7 | 12.1 |
| 7/16/98 | HM-31 | 110.5 | 14.0 |
| 7/15/98 | HM-32 | 115.2 | 12.7 |
| 7/17/98 | HM-33 | 116.0 | 12.3 |
| 7/20/98 | HM-34 | 117.0 | 12.2 |
| 7/21/98 | HM-35 | 114.8 | 14.5 |
| 7/23/98 | HM-36 | 113.6 | 14.2 |
| 7/24/98 | HM-37 | 113.0 | 13.6 |
| 7/28/98 | HM-38 | 112.1 | 13.4 |
| 7/29/98 | HM-39 | 111.9 | 15.0 |
| 7/30/98 | HM-40 | 117.3 | 13.5 |
| | *count:* | 39 | 39 |
| | *average:* | **115.0** | **13.5** |
| | *minimum:* | 109.3 | 8.4 |
| | *maximum:* | 124.0 | 16.9 |
| | *standard deviation:* | 3.0 | 1.5 |

*Total cubic yards placed:* 130,392 (1997-1998)
*Proctor Frequency:* 1: 3343 CY This is well above the required frequency of 1:5000 CY placed.

## Table A.4. Heap Leach Contaminated Fill Sand-Cone Correlation Documentation

| Date | Compaction Test ID | Nuclear Gauge Test In-Place Wet Unit Weight (lbs/cu ft) | Nuclear Gauge Test Moisture Content (%) | Sand-Cone Compaction Tests In-Place Wet Unit Weight (lbs/cu ft) | Sand-Cone Compaction Tests Moisture Content (%) | Sand-Cone Correlation Results Wet Unit Weight Variation (%) | Sand-Cone Correlation Results Moisture Content Variation (%) |
|---|---|---|---|---|---|---|---|
| 5/20/97 | CMS-001 | 129.9 | 13.8 | 131.7 | 11.9 | 1.4 | -1.9 |
| 5/21/97 | CMS-006 | 122.0 | 13.2 | 124.7 | 11.9 | 2.2 | -1.3 |
| 5/23/97 | CMS-012 | 130.2 | 14.3 | 130.5 | 13.5 | 0.2 | -0.8 |
| 5/29/97 | CMS-022 | 123.2 | 13.2 | 127.2 | 11.5 | 3.2 | -1.7 |
| 5/30/97 | CMS-033 | 125.5 | 11.8 | 126.8 | 11.7 | 1.0 | -0.1 |
| 6/2/97 | CMS-043 | 122.6 | 14.4 | 124.0 | 13.4 | 1.1 | -1.0 |
| 6/3/97 | CMS-043R | 132.0 | 12.1 | 136.8 | 13.0 | 3.6 | 0.9 |
| 6/4/97 | CMS-060 | 125.2 | 9.3 | 127.9 | 9.2 | 2.2 | -0.1 |
| 6/5/97 | CMS-075 | 116.7 | 7.8 | 119.6 | 7.2 | 2.5 | -0.6 |
| 6/5/97 | CMS-081 | 129.6 | 16.3 | 131.9 | 14.9 | 1.8 | -1.4 |
| 6/5/97 | CMS-086 | 121.3 | 13.5 | 122.6 | 12.9 | 1.1 | -0.6 |
| 6/5/97 | CMS-091 | 129.9 | 14.7 | 132.4 | 13.1 | 1.9 | -1.6 |
| 6/6/97 | CMS-095 | 123.4 | 9.5 | 118.5 | 9.0 | -4.0 | -0.5 |
| 6/10/97 | CMS-100 | 132.8 | 13.0 | 132.8 | 11.1 | 0.0 | -1.9 |
| 7/13/98 | CMS-116 | 132.2 | 13.5 | 136.9 | 12.8 | 3.6 | -0.7 |
| 7/15/98 | CMS-120 | 132.7 | 13.0 | 134.2 | 13.2 | 1.1 | 0.2 |
| 7/15/98 | CMS-125 | 132.4 | 13.8 | 134.7 | 12.8 | 1.7 | -1.0 |
| 7/16/98 | CMS-126 | 127.9 | 12.1 | 133.1 | 12.2 | 4.1 | 0.1 |
| 7/17/98 | CMS-132 | 127.7 | 16.4 | 129.4 | 15.1 | 1.3 | -1.3 |
| 7/20/98 | CMS-137 | 120.7 | 10.3 | 118.8 | 9.3 | -1.6 | -1.0 |
| 7/21/98 | CMS-142 | 130.9 | 11.3 | 129.6 | 9.7 | -1.0 | -1.6 |
| 7/22/98 | CMS-147 | 124.3 | 12.1 | 125.2 | 12.2 | 0.7 | 0.1 |
| 7/23/98 | CMS-152 | 125.4 | 12.4 | 119.2 | 10.4 | -4.9 | -2.0 |
| 7/27/98 | CMS-156 | 118.6 | 17.1 | 123.8 | 14.7 | 4.4 | -2.4 |
| 7/29/98 | CMS-164 | 126.2 | 10.4 | 123.4 | 10.1 | -2.2 | -0.3 |
| 7/30/98 | CMS-166 | 128.6 | 13.1 | 132.5 | 11.5 | 3.0 | -1.6 |
| 7/31/98 | CMS-170 | 127.6 | 15.1 | 133.8 | 14.4 | 4.9 | -0.7 |
| | | | | | *Number of sand-cone tests:* | 27 | |
| | | | | | *average percent variation (on absolute value):* | **2.2** | **1.0** |
| | | | | | *standard deviation:* | 1.4 | 0.7 |

**Note:**
For Heap Leach contaminated materials, a sand-cone correlation test was performed for every seven nuclear gauge tests, exceeding the required frequency of 1 for every 10 tests. Correlations were deemed acceptable if the average of ten nuclear test results vs. sand cone test results comparisons met the following criteria:

sand-cone method wet density: +/- 3%
sand-cone method moisture content: +/- 2%

As shown above, most results closely correlated and variations were generally well below the above criteria. In cases where discrete variations exceeded these criteria (see highlighted cells above), the running averages were still well below 2% for both endpoints.

**Appendix B**
Radon Barrier

# Appendix B

## Heap Leach Radon Barrier Quality Control Test Results

## Table B.1. Daily Quantities and Quality Control Test Frequencies for the Heap Leach Radon Barrier Placement: 1997-1998, 2000

*Note:* This table lists only those days that fill was placed and/or testing performed. CY = Cubic Yards; NG = Nuclear Gauge (test), i.e., field compaction test.
Testing Frequency Requirements: *Field Compaction Tests:* 1: 500 CY *Proctors:* 1: 5000 CY *Sand-Cones:* 1:10 NG tests

| Date | Total Quantities Placed | | Field Compaction Test Frequency | | | Proctor Test Frequency | | | Sand-Cone Test Frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Yardage | Cumulative Yardage | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (/NG tests) |
| 6/9/97 | 0 | 0 | | 0 | -- | 1 | 1 | 1: 0 | | 0 | -- |
| 6/13/97 | 969 | 969 | 1 | 1 | 1: 969 | | 1 | 1: 969 | 1 | 1 | 1: 1 |
| 6/17/97 | 1,360 | 2,329 | 5 | 6 | 1: 388 | 1 | 2 | 1: 1165 | 1 | 2 | 1: 3 |
| 6/18/97 | 1,479 | 3,808 | 2 | 8 | 1: 476 | | 2 | 1: 1904 | | 2 | 1: 4 |
| 6/19/97 | 833 | 4,641 | 1 | 9 | 1: 516 | | 2 | 1: 2321 | | 2 | 1: 5 |
| 6/20/97 | 833 | 5,474 | | 9 | 1: 608 | | 2 | 1: 2737 | | 2 | 1: 5 |
| 6/25/97 | 0 | 5,474 | 1 | 10 | 1: 547 | | 2 | 1: 2737 | | 2 | 1: 5 |
| 6/26/97 | 578 | 6,052 | | 10 | 1: 605 | | 2 | 1: 3026 | | 2 | 1: 5 |
| 6/30/97 | 1,632 | 7,684 | 1 | 11 | 1: 699 | 1 | 3 | 1: 2561 | | 2 | 1: 6 |
| 7/1/97 | 1,309 | 8,993 | 3 | 14 | 1: 642 | | 3 | 1: 2998 | | 2 | 1: 7 |
| 7/2/97 | 1,581 | 10,574 | 1 | 15 | 1: 705 | | 3 | 1: 3525 | 1 | 3 | 1: 5 |
| 7/7/97 | 612 | 11,186 | 4 | 19 | 1: 589 | | 3 | 1: 3729 | | 3 | 1: 6 |
| 7/8/97 | 1,343 | 12,529 | 2 | 21 | 1: 597 | | 3 | 1: 4176 | | 3 | 1: 7 |
| 7/9/97 | 1,020 | 13,549 | 4 | 25 | 1: 542 | | 3 | 1: 4516 | | 3 | 1: 8 |
| 7/10/97 | 1,445 | 14,994 | 1 | 26 | 1: 577 | | 3 | 1: 4998 | | 3 | 1: 9 |
| 7/11/97 | 1,513 | 16,507 | 3 | 29 | 1: 569 | | 3 | 1: 5502 | | 3 | 1: 10 |
| 7/14/97 | 1,836 | 18,343 | 4 | 33 | 1: 556 | | 3 | 1: 6114 | | 3 | 1: 11 |
| 7/15/97 | 1,071 | 19,414 | 1 | 34 | 1: 571 | 1 | 4 | 1: 4854 | | 3 | 1: 11 |
| 7/16/97 | 1,530 | 20,944 | 3 | 37 | 1: 566 | | 4 | 1: 5236 | | 3 | 1: 12 |
| 7/17/97 | 1,615 | 22,559 | 3 | 40 | 1: 564 | 1 | 5 | 1: 4512 | 1 | 4 | 1: 10 |
| 7/18/97 | 1,972 | 24,531 | 2 | 42 | 1: 584 | 1 | 6 | 1: 4089 | | 4 | 1: 11 |
| 7/21/97 | 578 | 25,109 | 2 | 44 | 1: 571 | | 6 | 1: 4185 | | 4 | 1: 11 |
| 7/22/97 | 1,445 | 26,554 | 1 | 45 | 1: 590 | | 6 | 1: 4426 | | 4 | 1: 11 |
| 7/23/97 | 2,006 | 28,560 | 5 | 50 | 1: 571 | | 6 | 1: 4760 | | 4 | 1: 13 |
| 7/24/97 | 1,955 | 30,515 | 4 | 54 | 1: 565 | | 6 | 1: 5086 | 1 | 5 | 1: 11 |
| 7/25/97 | 1,853 | 32,368 | 4 | 58 | 1: 558 | | 6 | 1: 5395 | | 5 | 1: 12 |
| 7/28/97 | 1,802 | 34,170 | 2 | 60 | 1: 570 | 1 | 7 | 1: 4881 | | 5 | 1: 12 |
| 7/30/97 | 1,819 | 35,989 | 1 | 61 | 1: 590 | | 7 | 1: 5141 | | 5 | 1: 12 |
| 7/31/97 | 1,972 | 37,961 | 4 | 65 | 1: 584 | | 7 | 1: 5423 | 1 | 6 | 1: 11 |
| 8/1/97 | 1,717 | 39,678 | 5 | 70 | 1: 567 | | 7 | 1: 5668 | | 6 | 1: 12 |
| 8/4/97 | 1,632 | 41,310 | 2 | 72 | 1: 574 | 2 | 9 | 1: 4590 | | 6 | 1: 12 |

## Table B.1. Daily Quantities and Quality Control Test Frequencies for the Heap Leach Radon Barrier Placement: 1997-1998, 2000

*Note:* This table lists only those days that fill was placed and/or testing performed. CY = Cubic Yards; NG = Nuclear Gauge (test), i.e., field compaction test.

Testing Frequency Requirements: *Field Compaction Tests:* 1: 500 CY *Proctors:* 1: 5000 CY *Sand-Cones:* 1:10 NG tests

| Date | Total Quantities Placed | | Field Compaction Test Frequency | | | Proctor Test Frequency | | | Sand-Cone Test Frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Yardage | Cumulative Yardage | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (/NG tests) |
| 8/5/97 | 901 | 42,211 | 4 | 76 | 1: 555 | | 9 | 1: 4690 | | 6 | 1: 13 |
| 8/7/97 | 646 | 42,857 | 2 | 78 | 1: 549 | | 9 | 1: 4762 | | 6 | 1: 13 |
| 8/8/97 | 1,700 | 44,557 | 4 | 82 | 1: 543 | | 9 | 1: 4951 | | 6 | 1: 14 |
| 8/11/97 | 1,632 | 46,189 | 3 | 85 | 1: 543 | 1 | 10 | 1: 4619 | | 6 | 1: 14 |
| 8/12/97 | 884 | 47,073 | | 85 | 1: 554 | | 10 | 1: 4707 | | 6 | 1: 14 |
| 8/14/97 | 391 | 47,464 | 1 | 86 | 1: 552 | | 10 | 1: 4746 | | 6 | 1: 14 |
| 8/15/97 | 986 | 48,450 | 6 | 92 | 1: 527 | | 10 | 1: 4845 | 1 | 7 | 1: 13 |
| 8/18/97 | 1,071 | 49,521 | 2 | 94 | 1: 527 | | 10 | 1: 4952 | | 7 | 1: 13 |
| 8/19/97 | 1,479 | 51,000 | 5 | 99 | 1: 515 | | 10 | 1: 5100 | | 7 | 1: 14 |
| 8/20/97 | 1,156 | 52,156 | 4 | 103 | 1: 506 | | 10 | 1: 5216 | | 7 | 1: 15 |
| 8/21/97 | 0 | 52,156 | 2 | 105 | 1: 497 | | 10 | 1: 5216 | 1 | 8 | 1: 13 |
| 8/4/98 | 650 | 52,806 | | 105 | 1: 503 | 1 | 11 | 1: 4801 | | 8 | 1: 13 |
| 8/5/98 | 2,125 | 54,931 | 2 | 107 | 1: 513 | 1 | 12 | 1: 4578 | 1 | 9 | 1: 12 |
| 8/6/98 | 1,325 | 56,256 | 2 | 109 | 1: 516 | | 12 | 1: 4688 | 1 | 10 | 1: 11 |
| 8/7/98 | 1,050 | 57,306 | 3 | 112 | 1: 512 | | 12 | 1: 4776 | | 10 | 1: 11 |
| 8/10/98 | 1,475 | 58,781 | 3 | 115 | 1: 511 | | 12 | 1: 4898 | | 10 | 1: 12 |
| 8/11/98 | 1,700 | 60,481 | 4 | 119 | 1: 508 | 1 | 13 | 1: 4652 | 1 | 11 | 1: 11 |
| 8/12/98 | 1,350 | 61,831 | 2 | 121 | 1: 511 | | 13 | 1: 4756 | | 11 | 1: 11 |
| 8/13/98 | 1,150 | 62,981 | 2 | 123 | 1: 512 | | 13 | 1: 4845 | 1 | 12 | 1: 10 |
| 8/14/98 | 1,475 | 64,456 | 4 | 127 | 1: 508 | | 13 | 1: 4958 | | 12 | 1: 11 |
| 8/17/98 | 1,600 | 66,056 | 1 | 128 | 1: 516 | 1 | 14 | 1: 4718 | | 12 | 1: 11 |
| 8/18/98 | 300 | 66,356 | 1 | 129 | 1: 514 | | 14 | 1: 4740 | 1 | 13 | 1: 10 |
| 8/19/98 | 550 | 66,906 | 0 | 129 | 1: 519 | | 14 | 1: 4779 | | 13 | 1: 10 |
| 8/20/98 | 2,075 | 68,981 | 2 | 131 | 1: 527 | | 14 | 1: 4927 | | 13 | 1: 10 |
| 8/21/98 | 1,525 | 70,506 | 0 | 131 | 1: 538 | | 14 | 1: 5036 | | 13 | 1: 10 |
| 8/24/98 | 1,025 | 71,531 | 1 | 132 | 1: 542 | 1 | 15 | 1: 4769 | | 13 | 1: 10 |
| 8/25/98 | 1,550 | 73,081 | 4 | 136 | 1: 537 | | 15 | 1: 4872 | 1 | 14 | 1: 10 |
| 8/26/98 | 1,325 | 74,406 | 4 | 140 | 1: 531 | | 15 | 1: 4960 | | 14 | 1: 10 |
| 8/27/98 | 1,325 | 75,731 | 4 | 144 | 1: 526 | | 15 | 1: 5049 | | 14 | 1: 10 |
| 8/28/98 | 1,600 | 77,331 | 2 | 146 | 1: 530 | | 15 | 1: 5155 | | 14 | 1: 10 |
| 8/29/98 | 0 | 77,331 | | 146 | 1: 530 | 1 | 16 | 1: 4833 | | 14 | 1: 10 |

## Table B.1. Daily Quantities and Quality Control Test Frequencies for the Heap Leach Radon Barrier Placement: 1997-1998, 2000

*Note:* This table lists only those days that fill was placed and/or testing performed. CY = Cubic Yards; NG = Nuclear Gauge (test), i.e., field compaction test.
Testing Frequency Requirements: *Field Compaction Tests:* 1: 500 CY *Proctors:* 1: 5000 CY *Sand-Cones:* 1:10 NG tests

| Date | Total Quantities Placed | | Field Compaction Test Frequency | | | Proctor Test Frequency | | | Sand-Cone Test Frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Yardage | Cumulative Yardage | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (per CY) | Daily Tests Performed | Cumulative No. of Tests | Ratio (/NG tests) |
| 8/31/98 | 975 | 78,306 | 5 | 151 | 1: 519 | 1 | 17 | 1: 4606 | 1 | 15 | 1: 10 |
| 9/1/98 | 400 | 78,706 | 1 | 152 | 1: 518 | | 17 | 1: 4630 | | 15 | 1: 10 |
| 9/2/98 | 0 | 78,706 | 1 | 153 | 1: 514 | | 17 | 1: 4630 | | 15 | 1: 10 |
| 9/25/98 | 350 | 79,056 | 2 | 155 | 1: 510 | | 17 | 1: 4650 | | 15 | 1: 10 |
| 9/28/98 | 1,175 | 80,231 | 4 | 159 | 1: 505 | | 17 | 1: 4719 | | 15 | 1: 11 |
| 9/29/98 | 1,900 | 82,131 | 4 | 163 | 1: 504 | | 17 | 1: 4831 | 1 | 16 | 1: 10 |
| 9/30/98 | 1,050 | 83,181 | 0 | 163 | 1: 510 | | 17 | 1: 4893 | | 16 | 1: 10 |
| 10/1/98 | 0 | 83,181 | 2 | 165 | 1: 504 | | 17 | 1: 4893 | 1 | 17 | 1: 10 |
| 10/15/98 | 1,100 | 84,281 | 5 | 170 | 1: 496 | | 17 | 1: 4958 | | 17 | 1: 10 |
| No work in 1999; the final work in 2000 was conducted at the northwest corner of the Heap Leach at the Gap (see below). | | | | | | | | | | | |
| 6/27/00 | 0 | 84,281 | | 170 | 1: 496 | 1 | 18 | 1: 4682 | | 17 | 1: 10 |
| 6/29/00 | 288 | 84,569 | | 170 | 1: 497 | | 18 | 1: 4698 | | 17 | 1: 10 |
| 6/30/00 | 288 | **84,857** | 2 | **172** | **1: 493** | | **18** | **1: 4714** | | **17** | **1: 10** |

**Total Quantities Placed, Summary by Year:**

| Year | Cu Yds Placed |
|---|---|
| 1997 | 52,156 |
| 1998 | 32,125 |
| 1999 | no work |
| 2000 | 576 |
| **Total:** | **84,857** |

## Table B.2. Field Compaction Test Results for the Heap Leach Cell Radon Barrier: 1997-1998, 2000

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed.
Max.= Maximum; P = Pass; F Comp = Fails Compaction; F Moist = Fails Moisture; CY = Cubic Yards. See NOTES and summary statistics at the end of this table.

| Compaction Test ID | | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Northing | Easting | Lift | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | | *Requirements:* | ≥ Optimum | ≥ 95 | | |
| RB-001 | * | 6/13/97 | 792330 | 837350 | 1 | R-01 | 104.2 | 18.2 | 100.5 | 22.7 | 96.4 | P | |
| RB-002 | | 6/17/97 | 792160 | 837750 | 1 | R-01 | 104.2 | 18.2 | 100.4 | 22.3 | 96.4 | P | |
| RB-003 | * | 6/17/97 | 792055 | 838170 | 1 | R-01 | 104.2 | 18.2 | 101.8 | 22.0 | 97.7 | P | |
| RB-004 | | 6/17/97 | 792300 | 837380 | 2 | R-01 | 104.2 | 18.2 | 103.0 | 21.3 | 98.8 | P | |
| RB-005 | | 9/17/97 | 792185 | 837695 | 2 | R-01 | 104.2 | 18.2 | 98.2 | 23.8 | 94.2 | F Comp | Fails Compaction |
| RB-005-R | | 6/17/97 | 792185 | 837695 | 2 | R-01 | 104.2 | 18.2 | 104.1 | 21.3 | 99.9 | P | Retest |
| RB-006 | | 6/17/97 | 792045 | 838100 | 2 | R-01 | 104.2 | 18.2 | 101.1 | 23.2 | 97.0 | P | |
| RB-007 | | 6/18/97 | 792245 | 837510 | 3 | R-01 | 104.2 | 18.2 | 104.5 | 21.0 | 100.3 | P | |
| RB-008 | | 6/18/97 | 792205 | 837200 | 1 | R-01 | 104.2 | 18.2 | 100.9 | 21.7 | 96.8 | P | |
| RB-009 | | 6/19/97 | 791675 | 837160 | 2 | R-01 | 104.2 | 18.2 | 102.2 | 20.8 | 98.1 | P | |
| RB-010 | | 6/25/97 | 792310 | 837305 | 3 | R-01 | 104.2 | 18.2 | 99.3 | 18.0 | 95.3 | F Moist | Fails Moisture |
| RB-010-R | | 6/26/97 | 792310 | 837305 | 3 | R-01 | 104.2 | 18.2 | 99.8 | 21.8 | 95.8 | P | Retest by Sandcone |
| RB-011 | | 6/30/97 | 791720 | 837110 | 1 | R-02 | 102.3 | 21.0 | 102.7 | 20.8 | 100.4 | F Moist | Fails Moisture |
| RB-011-R | | 6/30/97 | 791720 | 837110 | 1 | R-02 | 102.3 | 21.0 | 97.2 | 25.3 | 95.0 | P | Retest |
| RB-012 | | 7/1/97 | 791850 | 837110 | 2 | R-02 | 102.3 | 21.0 | 98.9 | 23.3 | 96.7 | P | |
| RB-013 | | 7/1/97 | 791690 | 837050 | 3 | R-02 | 102.3 | 21.0 | 102.1 | 21.6 | 99.8 | P | |
| RB-014 | | 7/1/97 | 791875 | 837030 | 3 | R-02 | 102.3 | 21.0 | 102.4 | 21.6 | 100.1 | P | |
| RB-015 | * | 7/2/97 | 791700 | 837205 | 3 | R-02 | 102.3 | 21.0 | 97.2 | 23.8 | 95.0 | P | |
| RB-016 | | 7/7/97 | 791920 | 837130 | 1 | R-02 | 102.3 | 21.0 | 101.3 | 21.7 | 99.0 | P | |
| RB-017 | | 7/7/97 | 792020 | 837035 | 1 | R-02 | 102.3 | 21.0 | 97.4 | 24.0 | 95.2 | P | |
| RB-018 | | 7/7/97 | 792000 | 837100 | 2 | R-02 | 102.3 | 21.0 | 97.6 | 21.0 | 95.4 | P | |
| RB-019 | | 7/7/97 | 792050 | 837020 | 2 | R-02 | 102.3 | 21.0 | 98.3 | 23.8 | 96.1 | P | |
| RB-020 | | 7/8/97 | 792030 | 837150 | 3 | R-02 | 102.3 | 21.0 | 98.4 | 23.9 | 96.2 | P | |
| RB-021 | | 7/8/97 | 792090 | 837040 | 3 | R-03 | 102.6 | 20.9 | 97.9 | 25.0 | 95.4 | P | |
| RB-022 | | 7/9/97 | 792150 | 837050 | 3 | R-03 | 102.6 | 20.9 | 103.0 | 20.9 | 100.4 | P | |
| RB-023 | | 7/9/97 | 792180 | 837090 | 3 | R-03 | 102.6 | 20.9 | 101.9 | 21.4 | 99.3 | P | |
| RB-024 | | 7/9/97 | 792190 | 837150 | 3 | R-03 | 102.6 | 20.9 | 103.3 | 21.8 | 100.7 | P | |
| RB-025 | | 7/9/97 | 792250 | 837100 | 1 | R-03 | 102.6 | 20.9 | 100.0 | 23.5 | 97.5 | P | |
| RB-026 | | 7/10/97 | 792240 | 837140 | 3 | R-03 | 102.6 | 20.9 | 100.7 | 22.1 | 98.1 | P | |
| RB-027 | | 7/11/97 | 792280 | 837120 | 3 | R-03 | 102.6 | 20.9 | 102.3 | 21.0 | 99.7 | P | |
| RB-028 | | 7/11/97 | 791395 | 837400 | 2 | R-03 | 102.6 | 20.9 | 100.1 | 22.8 | 97.6 | P | |
| RB-029 | | 7/11/97 | 791485 | 837510 | 2 | R-03 | 102.6 | 20.9 | 100.9 | 22.5 | 98.3 | P | |
| RB-030 | | 7/14/97 | 791370 | 837250 | 1 | R-03 | 102.6 | 20.9 | 102.7 | 20.8 | 100.1 | P | Test passed at discretion of QC officer |
| RB-031 | | 7/14/97 | 791335 | 837505 | 1 | R-04 | 102.5 | 20.2 | 99.2 | 21.2 | 96.8 | P | |
| RB-032 | | 7/14/97 | 791545 | 837310 | 3 | R-04 | 102.5 | 20.2 | 102.5 | 21.7 | 100.0 | P | |

## Table B.2. Field Compaction Test Results for the Heap Leach Cell Radon Barrier: 1997-1998, 2000

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed. Max.= Maximum; P = Pass; F Comp = Fails Compaction; F Moist = Fails Moisture; CY = Cubic Yards. See NOTES and summary statistics at the end of this table.

| Compaction Test ID | Date | Location Northing | Location Easting | Lift | Laboratory Standard Proctor: Proctor ID | Laboratory Standard Proctor: Max. Dry Density (lbs/cu ft) | Laboratory Standard Proctor: Optimum Moisture (%) | Field Compaction Tests: Dry Density (lbs/cu ft) | Field Compaction Tests: Percent Moisture | Field Compaction Tests: Percent Compaction | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | *Requirements:* | ≥ Optimum | **≥ 95** | | |
| RB-033 | 7/14/97 | 791295 | 837410 | 2 | R-04 | 102.5 | 20.2 | 102.4 | 21.7 | 99.9 | P | |
| RB-034 | 7/15/97 | 791265 | 837440 | 2 | R-04 | 102.5 | 20.2 | 100.1 | 23.1 | 97.7 | P | |
| RB-035 | 7/16/97 | 791490 | 837490 | 2 | R-04 | 102.5 | 20.2 | 97.1 | 24.0 | **94.7** | F Comp | Fails Compaction |
| RB-035-R | 7/16/97 | 791490 | 837490 | 2 | R-04 | 102.5 | 20.2 | 102.3 | 21.6 | 99.8 | P | Retest |
| RB-036 | 7/16/97 | 791340 | 837395 | 3 | R-04 | 102.5 | 20.2 | 101.6 | 21.4 | 99.1 | P | |
| RB-037 | 7/16/97 | 791480 | 837275 | 3 | R-04 | 102.5 | 20.2 | 99.2 | 20.7 | 96.8 | P | |
| RB-038 * | 7/17/97 | 791400 | 837460 | 3 | R-04 | 102.5 | 20.2 | 97.7 | 24.7 | 95.3 | P | |
| RB-039 | 7/17/97 | 791190 | 837550 | 1 | R-04 | 102.5 | 20.2 | 99.2 | 23.7 | 96.8 | P | |
| RB-040 | 7/17/97 | 790900 | 837455 | 1 | R-04 | 102.5 | 20.2 | 102.2 | 21.3 | 99.7 | P | |
| RB-041 | 7/18/97 | 791175 | 837520 | 2 | R-05 | 103.3 | 21.1 | 100.3 | 21.4 | 97.1 | P | |
| RB-042 | 7/18/97 | 791050 | 837580 | 2 | R-05 | 103.3 | 21.1 | 99.9 | 23.1 | 96.7 | P | |
| RB-043 | 7/21/97 | 791215 | 837570 | 3 | R-05 | 103.3 | 21.1 | 99.3 | 24.3 | 96.1 | P | |
| RB-044 | 7/21/97 | 791015 | 837540 | 3 | R-05 | 103.3 | 21.1 | 101.4 | 21.5 | 98.2 | P | |
| RB-045 | 7/22/97 | 790960 | 837525 | 3 | R-05 | 103.3 | 21.1 | 102.2 | 21.6 | 98.9 | P | |
| RB-046 | 7/23/97 | 791180 | 837615 | 1 | R-05 | 103.3 | 21.1 | 102.6 | 21.5 | 99.3 | P | |
| RB-047 | 7/23/97 | 790950 | 837680 | 1 | R-05 | 103.3 | 21.1 | 100.8 | 21.4 | 97.6 | P | |
| RB-048 | 7/23/97 | 790830 | 837570 | 1 | R-05 | 103.3 | 21.1 | 99.6 | 22.6 | 96.4 | P | |
| RB-049 | 7/23/97 | 791255 | 837600 | 2 | R-05 | 103.3 | 21.1 | 104.9 | 21.6 | 101.5 | P | |
| RB-050 | 7/23/97 | 790965 | 837685 | 2 | R-05 | 103.3 | 21.1 | 101.1 | 22.0 | 97.9 | P | |
| RB-051 * | 7/24/97 | 791275 | 837600 | 3 | R-06 | 104.3 | 21.0 | 102.4 | 21.6 | 98.2 | P | |
| RB-052 | 7/24/97 | 790770 | 837670 | 1 | R-06 | 104.3 | 21.0 | 99.5 | 21.7 | 95.4 | P | |
| RB-053 | 7/24/97 | 790830 | 837780 | 1 | R-06 | 104.3 | 21.0 | 100.5 | 22.7 | 96.4 | P | |
| RB-054 | 7/24/97 | 790725 | 837800 | 1 | R-06 | 104.3 | 21.0 | 104.4 | 21.1 | 100.1 | P | |
| RB-055 | 7/25/97 | 790890 | 837580 | 2 | R-06 | 104.3 | 21.0 | 100.0 | 21.5 | 95.9 | P | |
| RB-056 | 7/25/97 | 791010 | 837715 | 2 | R-06 | 104.3 | 21.0 | 99.3 | 24.7 | 95.2 | P | |
| RB-057 | 7/25/97 | 790810 | 837810 | 2 | R-06 | 104.3 | 21.0 | 101.4 | 21.2 | 97.2 | P | |
| RB-058 | 7/25/97 | 790980 | 837570 | 3 | R-06 | 104.3 | 21.0 | 102.0 | 21.3 | 97.8 | P | |
| RB-059 | 7/28/97 | 790870 | 837725 | 3 | R-06 | 104.3 | 21.0 | 99.2 | 23.2 | 95.1 | P | |
| RB-060 | 7/28/97 | 790570 | 837725 | 1 | R-06 | 104.3 | 21.0 | 101.8 | 21.5 | 97.6 | P | |
| RB-061 | 7/30/97 | 790710 | 837965 | 1 | R-07 | 105.5 | 20.0 | 101.6 | 21.1 | 96.3 | P | |
| RB-062 | 7/31/97 | 790665 | 837825 | 2 | R-07 | 105.5 | 20.0 | 99.7 | 23.2 | **94.5** | F Comp | Fails Compaction |
| RB-062-R | 8/1/97 | 790665 | 837825 | 2 | R-07 | 105.5 | 20.0 | 102.6 | 21.5 | 97.3 | P | Retest |
| RB-063 * | 7/31/97 | 790605 | 837910 | 2 | R-07 | 105.5 | 20.0 | 103.5 | 21.2 | 98.1 | P | |
| RB-064 | 7/31/97 | 791015 | 837740 | 1 | R-07 | 105.5 | 20.0 | 101.0 | 21.8 | 95.7 | P | |
| RB-065 | 7/31/97 | 790895 | 837860 | 1 | R-07 | 105.5 | 20.0 | 102.2 | 22.5 | 96.9 | P | |

## Table B.2. Field Compaction Test Results for the Heap Leach Cell Radon Barrier: 1997-1998, 2000

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed. Max.= Maximum; P = Pass; F Comp = Fails Compaction; F Moist = Fails Moisture; CY = Cubic Yards. See NOTES and summary statistics at the end of this table.

| Compaction Test ID | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Northing | Easting | Lift | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | *Requirements:* | ≥ Optimum | **≥ 95** | | |
| RB-066 | 8/1/97 | 790805 | 837820 | 3 | R-07 | 105.5 | 20.0 | 102.5 | 22.7 | 97.2 | P | |
| RB-067 | 8/1/97 | 790960 | 837780 | 2 | R-07 | 105.5 | 20.0 | 102.4 | 21.9 | 97.1 | P | |
| RB-068 | 8/1/97 | 790720 | 837850 | 3 | R-07 | 105.5 | 20.0 | 101.2 | 21.0 | 95.9 | P | |
| RB-069 | 8/1/97 | 790835 | 837940 | 2 | R-07 | 105.5 | 20.0 | 101.4 | 22.5 | 96.1 | P | |
| RB-070 | 8/1/97 | 790575 | 837890 | 3 | R-07 | 105.5 | 20.0 | 101.0 | 21.7 | 95.7 | P | |
| RB-071 | 8/4/97 | 792380 | 837240 | 1 | R-08 | 107.0 | 19.0 | 104.0 | 21.1 | 97.2 | P | |
| RB-072 | 8/4/97 | 792350 | 837095 | 1 | R-08 | 107.0 | 19.0 | 102.7 | 21.0 | 96.0 | P | |
| RB-073 | 8/5/97 | 791590 | 837145 | 1 | R-08 | 107.0 | 19.0 | 102.2 | 22.7 | 95.5 | P | |
| RB-074 | 8/5/97 | 791020 | 837740 | 3 | R-08 | 107.0 | 19.0 | 105.9 | 20.1 | 99.0 | P | |
| RB-075 | 8/5/97 | 790830 | 837975 | 3 | R-08 | 107.0 | 19.0 | 100.8 | 22.4 | **94.2** | F Comp | Fails Compaction |
| RB-075-R | 8/11/97 | 790830 | 837975 | 3 | R-08 | 107.0 | 19.0 | 102.7 | 21.0 | 96.0 | P | Retest |
| RB-076 | 8/5/97 | 791565 | 837300 | 1 | R-08 | 107.0 | 19.0 | 103.1 | 21.5 | 96.4 | P | |
| RB-077 | 8/7/97 | 791585 | 837180 | 2 | R-08 | 107.0 | 19.0 | 102.3 | 20.4 | 95.6 | P | |
| RB-078 | 8/7/97 | 792430 | 837160 | 2 | R-08 | 107.0 | 19.0 | 101.8 | 20.4 | 95.1 | P | |
| RB-079 | 8/8/97 | 792390 | 837270 | 2 | R-08 | 107.0 | 19.0 | 102.3 | 22.0 | 95.6 | P | |
| RB-080 | 8/8/97 | 791405 | 837270 | 2 | R-09 | 103.8 | 19.3 | 98.7 | 21.8 | 95.1 | P | |
| RB-081 | 8/8/97 | 790920 | 837555 | 1 | R-09 | 103.8 | 19.3 | 100.2 | 21.2 | 96.5 | P | |
| RB-082 | 8/8/97 | 791590 | 837210 | 3 | R-09 | 103.8 | 19.3 | 102.4 | 21.0 | 98.7 | P | |
| RB-083 | 8/11/97 | 791615 | 837175 | 2 | R-09 | 103.8 | 19.3 | 101.5 | 24.0 | 97.8 | P | |
| RB-084 | 8/11/97 | 791375 | 837245 | 3 | R-09 | 103.8 | 19.3 | 102.2 | 20.7 | 98.5 | P | |
| RB-085 | 8/11/97 | 790790 | 837480 | 2 | R-09 | 103.8 | 19.3 | 101.2 | 23.1 | 97.5 | P | |
| RB-086 | 8/14/97 | 790770 | 838140 | 3 | R-09 | 103.8 | 19.3 | 104.0 | 19.4 | 100.2 | P | |
| RB-087 | 8/15/97 | 792410 | 837170 | 3 | R-09 | 103.8 | 19.3 | 101.0 | 22.4 | 97.3 | P | |
| RB-088 | 8/15/97 | 791575 | 837235 | 3 | R-09 | 103.8 | 19.3 | 103.2 | 21.9 | 99.4 | P | |
| RB-089 | 8/15/97 | 790955 | 838120 | 1 | R-09 | 103.8 | 19.3 | 99.8 | 24.4 | 96.1 | P | |
| RB-090 * | 8/15/97 | 791005 | 837625 | 3 | R-09 | 103.8 | 19.3 | 105.2 | 19.7 | 101.3 | P | |
| RB-091 | 8/15/97 | 791310 | 838170 | 1 | R-10 | 103.9 | 18.8 | 99.6 | 23.3 | 95.9 | P | |
| RB-092 | 8/15/97 | 792335 | 837255 | 3 | R-10 | 103.9 | 18.8 | 102.5 | 19.1 | 98.7 | P | |
| RB-093 | 8/18/97 | 790975 | 838145 | 2 | R-10 | 103.9 | 18.8 | 103.2 | 20.4 | 99.3 | P | |
| RB-094 | 8/18/97 | 791520 | 838170 | 2 | R-10 | 103.9 | 18.8 | 101.3 | 21.3 | 97.5 | P | |
| RB-095 | 8/19/97 | 791020 | 838150 | 3 | R-10 | 103.9 | 18.8 | 105.0 | 21.1 | 101.1 | P | |
| RB-096 | 8/19/97 | 791890 | 838250 | 3 | R-10 | 103.9 | 18.8 | 103.4 | 22.5 | 99.5 | P | |
| RB-097 | 8/19/97 | 791350 | 838155 | 3 | R-10 | 103.9 | 18.8 | 101.1 | 21.1 | 97.3 | P | |
| RB-098 | 8/19/97 | 790645 | 838040 | 1 | R-10 | 103.9 | 18.8 | 100.4 | 23.0 | 96.6 | P | |
| RB-099 | 8/19/97 | 790660 | 838130 | 1 | R-10 | 103.9 | 18.8 | 102.8 | 19.7 | 98.9 | P | |

## Table B.2. Field Compaction Test Results for the Heap Leach Cell Radon Barrier: 1997-1998, 2000

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed. Max.= Maximum; P = Pass; F Comp = Fails Compaction; F Moist = Fails Moisture; CY = Cubic Yards. See NOTES and summary statistics at the end of this table.

| Compaction Test ID | | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Northing | Easting | Lift | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | | *Requirements:* | ≥ Optimum | ≥ 95 | | |
| RB-100 | | 8/20/97 | 790690 | 838100 | 1 | R-10 | 103.9 | 18.8 | 99.0 | 23.5 | 95.3 | P | |
| RB-101 | | 8/20/97 | 791390 | 838160 | 3 | R-11 | 103.2 | 19.6 | 102.0 | 21.4 | 98.8 | P | |
| RB-102 | | 8/20/97 | 790640 | 838040 | 2 | R-11 | 103.2 | 19.6 | 102.2 | 22.0 | 99.0 | P | |
| RB-103 | | 8/20/97 | 791690 | 838180 | 2 | R-11 | 103.2 | 19.6 | 101.5 | 21.3 | 98.4 | P | |
| RB-104 | | 8/21/97 | 790660 | 838020 | 3 | R-11 | 103.2 | 19.6 | 99.4 | 23.7 | 96.3 | P | |
| RB-105 | * | 8/21/97 | 790615 | 838120 | 3 | R-11 | 103.2 | 19.6 | 103.8 | 20.2 | 100.6 | P | |
| RB-106 | | 8/5/98 | 792338 | 838410 | 1 | R-12 | 106.7 | 19.0 | 103.2 | 19.7 | 96.7 | P | |
| RB-107 | * | 8/5/98 | 792380 | 838030 | 1 | R-12 | 106.7 | 19.0 | 101.3 | 21.4 | 94.9 | P | Test passed at discretion of QC officer |
| RB-108 | | 8/6/98 | 792372 | 838250 | 2 | R-12 | 106.7 | 19.0 | 99.8 | 23.0 | **93.5** | F Comp | Fails Compaction |
| RB-108-R | | 8/6/98 | 792372 | 838250 | 2 | R-12 | 106.7 | 19.0 | 102.7 | 21.4 | 96.3 | P | Retest |
| RB-109 | * | 8/6/98 | 792473 | 838167 | 2 | R-12 | 106.7 | 19.0 | 102.6 | 21.1 | 96.2 | P | |
| RB-110 | | 8/7/98 | 792492 | 837875 | 2 | R-13 | 105.2 | 20.0 | 100.2 | 21.4 | 95.2 | P | |
| RB-111 | | 8/7/98 | 792448 | 837980 | 2 | R-13 | 105.2 | 20.0 | 104.6 | 21.0 | 99.4 | P | |
| RB-112 | | 8/7/98 | 792363 | 837920 | 1 | R-13 | 105.2 | 20.0 | 102.5 | 21.0 | 97.4 | P | |
| RB-113 | | 8/10/98 | 792317 | 838444 | 3 | R-13 | 105.2 | 20.0 | 103.0 | 20.6 | 97.9 | P | |
| RB-114 | | 8/10/98 | 792463 | 838080 | 3 | R-13 | 105.2 | 20.0 | 101.7 | 20.0 | 96.7 | P | |
| RB-115 | | 8/10/98 | 792476 | 837900 | 3 | R-13 | 105.2 | 20.0 | 102.6 | 20.0 | 97.5 | P | |
| RB-116 | | 8/11/98 | 792394 | 837882 | 1 | R-13 | 105.2 | 20.0 | 101.3 | 21.7 | 96.3 | P | |
| RB-117 | * | 8/11/98 | 792316 | 838193 | 1 | R-13 | 105.2 | 20.0 | 100.3 | 22.9 | 95.3 | P | |
| RB-118 | | 8/11/98 | 792257 | 838361 | 1 | R-13 | 105.2 | 20.0 | 103.5 | 19.9 | 98.4 | P | Test passed at discretion of QC officer |
| RB-119 | | 8/11/98 | 792398 | 837837 | 2 | R-13 | 105.2 | 20.0 | 103.9 | 20.4 | 98.8 | P | |
| RB-120 | | 8/12/98 | 792342 | 838093 | 2 | R-14 | 105.9 | 19.6 | 98.8 | 22.2 | **93.3** | F Comp | Fails Compaction |
| RB-120R | | 8/12/98 | 792342 | 838093 | 2 | R-14 | 105.9 | 19.6 | 100.6 | 20.9 | 95.0 | P | Retest |
| RB-121 | | 8/12/98 | 792232 | 838350 | 2 | R-14 | 105.9 | 19.6 | 104.2 | 20.2 | 98.4 | P | |
| RB-122 | * | 8/13/98 | 792378 | 837928 | 3 | R-14 | 105.9 | 19.6 | 102.4 | 20.9 | 96.7 | P | |
| RB-123 | | 8/13/98 | 792342 | 838168 | 3 | R-14 | 105.9 | 19.6 | 104.7 | 19.7 | 98.9 | P | |
| RB-124 | | 8/14/98 | 792464 | 837607 | 1 | R-14 | 105.9 | 19.6 | 104.0 | 20.7 | 98.2 | P | |
| RB-125 | | 8/14/98 | 792741 | 837278 | 1 | R-14 | 105.9 | 19.6 | 102.2 | 20.2 | 96.5 | P | |
| RB-126 | | 8/14/98 | 792464 | 837559 | 2 | R-14 | 105.9 | 19.6 | 100.9 | 20.4 | 95.3 | P | |
| RB-127 | | 8/14/98 | 792568 | 837355 | 2 | R-14 | 105.9 | 19.6 | 99.1 | 21.5 | **93.6** | F Comp | Fails Compaction |
| RB-127R | | 8/17/98 | 792568 | 837355 | 2 | R-14 | 105.9 | 19.6 | 103.6 | 20.6 | 97.8 | P | Retest |
| RB-128 | | 8/17/98 | 792589 | 837264 | 3 | R-14 | 105.9 | 19.6 | 102.0 | 21.6 | 96.3 | P | |
| RB-129 | * | 8/18/98 | 792452 | 837760 | 3 | R-14 | 105.9 | 19.6 | 101.0 | 21.0 | 95.4 | P | |
| RB-130 | | 8/20/98 | 792392 | 837442 | 1 | R-15 | 107.0 | 19.2 | 104.1 | 20.2 | 97.3 | P | |
| RB-131 | | 8/20/98 | 792476 | 837300 | 1 | R-15 | 107.0 | 19.2 | 102.5 | 20.3 | 95.8 | P | |

## Table B.2. Field Compaction Test Results for the Heap Leach Cell Radon Barrier: 1997-1998, 2000

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed. Max.= Maximum; P = Pass; F Comp = Fails Compaction; F Moist = Fails Moisture; CY = Cubic Yards. See NOTES and summary statistics at the end of this table.

| Compaction Test ID | Date | Location | | | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Northing | Easting | Lift | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | *Requirements:* | ≥ Optimum | ≥ 95 | | |
| RB-132 | 8/24/98 | 792277 | 837746 | 1 | R-15 | 107.0 | 19.2 | 104.1 | 20.0 | 97.3 | P | |
| RB-133 * | 8/25/98 | 792373 | 837650 | 2 | R-15 | 107.0 | 19.2 | 101.8 | 22.3 | 95.1 | P | |
| RB-134 | 8/25/98 | 792363 | 837505 | 2 | R-15 | 107.0 | 19.2 | 105.9 | 20.1 | 99.0 | P | |
| RB-135 | 8/25/98 | 792432 | 837233 | 2 | R-15 | 107.0 | 19.2 | 104.5 | 20.3 | 97.7 | P | |
| RB-136 | 8/25/98 | 792298 | 837829 | 2 | R-15 | 107.0 | 19.2 | 101.6 | 21.4 | 95.0 | P | |
| RB-137 | 8/26/98 | 792412 | 837573 | 3 | R-15 | 107.0 | 19.2 | 101.8 | 21.2 | 95.1 | P | |
| RB-138 | 8/26/98 | 792358 | 837422 | 3 | R-15 | 107.0 | 19.2 | 101.9 | 21.1 | 95.2 | P | |
| RB-139 | 8/26/98 | 792480 | 837268 | 3 | R-15 | 107.0 | 19.2 | 102.2 | 22.1 | 95.5 | P | |
| RB-140 | 8/26/98 | 792348 | 837671 | 3 | R-16 | 106.9 | 19.2 | 104.3 | 20.5 | 97.6 | P | |
| RB-141 | 8/27/98 | 792338 | 837848 | 3 | R-16 | 106.9 | 19.2 | 103.3 | 20.2 | 96.6 | P | |
| RB-142 | 8/27/98 | 792235 | 837980 | 1 | R-16 | 106.9 | 19.2 | 103.6 | 20.3 | 96.9 | P | |
| RB-143 | 8/27/98 | 792205 | 837807 | 3 | R-16 | 106.9 | 19.2 | 101.6 | 21.1 | 95.0 | P | |
| RB-144 | 8/27/98 | 792254 | 838100 | 1 | R-16 | 106.9 | 19.2 | 101.7 | 20.2 | 95.1 | P | |
| RB-145 | 8/28/98 | 792297 | 837954 | 2 | R-16 | 106.9 | 19.2 | 102.5 | 22.7 | 95.9 | P | |
| RB-146 | 8/28/98 | 792163 | 838146 | 2 | R-16 | 106.9 | 19.2 | 102.2 | 19.8 | 95.6 | P | |
| RB-147 | 8/31/98 | 792167 | 837913 | 1 | R-16 | 106.9 | 19.2 | 101.7 | 19.6 | 95.1 | P | |
| RB-148 | 8/31/98 | 792204 | 838052 | 3 | R-16 | 106.9 | 19.2 | 102.1 | 19.6 | 95.5 | P | |
| RB-149 * | 8/31/98 | 792262 | 838138 | 3 | R-16 | 106.9 | 19.2 | 102.9 | 20.5 | 96.3 | P | |
| RB-150 | 8/31/98 | 792172 | 838215 | 1 | R-17 | 107.2 | 18.4 | 102.1 | 19.4 | 95.2 | P | |
| RB-151 | 8/31/98 | 792103 | 838122 | 2 | R-17 | 107.2 | 18.4 | 102.1 | 19.4 | 95.2 | P | |
| RB-152 | 9/1/98 | 792128 | 838121 | 3 | R-17 | 107.2 | 18.4 | 102.0 | 19.6 | 95.1 | P | |
| RB-153 | 9/2/98 | 792235 | 838230 | 3 | R-17 | 107.2 | 18.4 | 101.8 | 20.7 | 95.0 | P | |
| RB-154 | 9/25/98 | 792095 | 838350 | 1 | R-17 | 107.2 | 18.4 | 106.6 | 18.9 | 99.4 | P | |
| RB-155 | 9/25/98 | 792180 | 838372 | 1 | R-17 | 107.2 | 18.4 | 105.9 | 21.3 | 98.8 | P | |
| RB-156 | 9/28/98 | 792108 | 838302 | 2 | R-17 | 107.2 | 18.4 | 104.5 | 20.3 | 97.5 | P | |
| RB-157 | 9/28/98 | 792176 | 838347 | 2 | R-17 | 107.2 | 18.4 | 102.5 | 19.3 | 95.6 | P | |
| RB-158 | 9/28/98 | 792531 | 837191 | 1 | R-17 | 107.2 | 18.4 | 96.4 | 23.2 | 89.9 | F Comp | Fails Compaction |
| RB-158R | 9/28/98 | 792531 | 837191 | 1 | R-17 | 107.2 | 18.4 | 102.2 | 22.4 | 95.3 | P | Retest |
| RB-159 | 9/28/98 | 792587 | 837215 | 1 | R-17 | 107.2 | 18.4 | 101.9 | 18.9 | 95.1 | P | |
| RB-160 | 9/29/98 | 792691 | 837227 | 2 | R-17 | 107.2 | 18.4 | 102.8 | 20.9 | 95.9 | P | |
| RB-161 | 9/29/98 | 792508 | 837169 | 2 | R-17 | 107.2 | 18.4 | 103.0 | 18.7 | 96.1 | P | |
| RB-162 * | 9/29/98 | 792108 | 838404 | 3 | R-17 | 107.2 | 18.4 | 102.8 | 21.7 | 95.9 | P | |
| RB-163 | 9/29/98 | 792194 | 838388 | 3 | R-17 | 107.2 | 18.4 | 102.2 | 20.5 | 95.4 | P | |
| RB-164 * | 10/1/98 | 792748 | 837256 | 3 | R-17 | 107.2 | 18.4 | 103.2 | 20.2 | 96.2 | P | |
| RB-165 | 10/1/98 | 792105 | 837203 | 3 | R-18 | 108.6 | 18.2 | 105.1 | 19.1 | 96.8 | P | |

## Table B.2. Field Compaction Test Results for the Heap Leach Cell Radon Barrier: 1997-1998, 2000

Note: R denotes Re-Test sample. To facilitate review, re-tests are shown directly under the corresponding failed test result (note dates). * Indicates that Sand-Cone Correlation performed. Max.= Maximum; P = Pass; F Comp = Fails Compaction; F Moist = Fails Moisture; CY = Cubic Yards. See NOTES and summary statistics at the end of this table.

| Compaction Test ID | Date | Location | | Lift | Laboratory Standard Proctor | | | Field Compaction Tests | | | Pass/Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Northing | Easting | | Proctor ID | Max. Dry Density (lbs/cu ft) | Optimum Moisture (%) | Dry Density (lbs/cu ft) | Percent Moisture | Percent Compaction | | |
| | | | | | | | | *Requirements:* | ≥ Optimum | ≥ 95 | | |
| RB-166 | 10/15/98 | 792069 | 838239 | 1 | R-18 | 108.6 | 18.2 | 105.4 | 20.4 | 97.1 | P | |
| RB-167 | 10/15/98 | 791958 | 838250 | 1 | R-18 | 108.6 | 18.2 | 103.4 | 19.3 | 95.2 | P | |
| RB-168 | 10/15/98 | 792048 | 838234 | 2 | R-18 | 108.6 | 18.2 | 103.9 | 20.4 | 95.7 | P | |
| RB-169 | 10/15/98 | 791995 | 838260 | 2 | R-18 | 108.6 | 18.2 | 105.5 | 19.4 | 97.1 | P | |
| RB-170 | 10/15/98 | 792040 | 838252 | 3 | R-18 | 108.6 | 18.2 | 103.9 | 19.2 | 95.7 | P | |
| RB-171 | 6/30/00 | 792050 | 838240 | 3 | R-19 | 103.9 | 19.3 | 99.8 | 22.8 | 96.1 | P | |
| RB-172 | 6/30/00 | 791990 | 838260 | 3 | R-19 | 103.9 | 19.3 | 98.7 | 24.9 | 95.0 | P | |

**Note:**
Field density and moisture tests were taken using a nuclear density gauge. The gauge was field standardized at each test location and was correlated by a Sand Cone Test at a frequency of one for every five nuclear gauge tests.

| | | | |
|---|---|---|---|
| *Total Number of Tests (N):* | 172 | (N reflects passing tests only) | |
| *Total Quantities placed:* | 84,857 | cubic yards (CY) | |
| *Frequency:* | 1: 493 CY | Meets the required frequency of 1:500 CY. | |
| *average:* | **101.9** | **21.4** | **97.1** |
| *minimum:* | 97.2 | 18.7 | 94.9 |
| *maximum:* | 106.6 | 25.3 | 101.5 |
| *standard deviation:* | 1.9 | 1.3 | 1.7 |
| *# Failed:* | NA | 2 | 8 |
| *# Retested:* | NA | 2 | 8 |

## Table B.3. Standard Proctor and Hydraulic Conductivity Test Results for the Heap Leach Radon Barrier

| Date | Laboratory Standard Proctor | | | Hydraulic Conductivity | |
|---|---|---|---|---|---|
| | Proctor ID | Maximum Dry Density (lbs/cu ft) | Optimum Moisture (%) | Sample ID | Result (cm/sec) |
| 6/2/97 | R-01 | 104.2 | 18.2 | R-01 | 8.4E-09 |
| 6/9/97 | R-02 | 102.3 | 21.0 | R-02 | 3.9E-09 |
| 6/30/97 | R-03 | 102.6 | 20.9 | R-03 | 6.8E-09 |
| 7/10/97 | R-04 | 102.5 | 20.2 | R-04 | 8.9E-09 |
| 7/15/97 | R-05 | 103.3 | 21.1 | R-05 | 9.0E-08 |
| 7/18/97 | R-06 | 104.3 | 21.0 | R-06 | 1.3E-08 |
| 7/28/97 | R-07 | 105.5 | 20.0 | R-07 | 1.1E-08 |
| 8/4/97 | R-08 | 107.0 | 19.0 | R-08 | 4.0E-08 |
| 8/4/97 | R-09 | 103.8 | 19.3 | R-09 | 3.0E-08 |
| 8/7/97 | R-10 | 103.9 | 18.8 | R-10 | 3.2E-08 |
| 8/11/97 | R-11 | 103.2 | 19.6 | R-11 | 7.2E-08 |
| 7/31/98 | R-12 | 106.7 | 19.0 | | |
| 8/4/98 | R-13 | 105.2 | 20.0 | Hydraulic conductivity tests conducted in 1997 only. | |
| 8/11/98 | R-14 | 105.9 | 19.6 | | |
| 8/17/98 | R-15 | 107.0 | 19.2 | | |
| 8/24/98 | R-16 | 106.9 | 19.2 | | |
| 8/31/98 | R-17 | 107.2 | 18.4 | | |
| 9/29/98 | R-18 | 108.6 | 18.2 | | |
| 6/27/00 | R-19 | 103.9 | 19.3 | | |
| | *count:* | 19 | 19 | | 11 |
| | ***average:*** | **104.9** | **19.6** | | **2.9E-08** |
| | *min:* | 102.3 | 18.2 | | 3.9E-09 |
| | *max:* | 108.6 | 21.1 | | 9.0E-08 |
| | *standard deviation:* | 1.9 | 0.9 | | 2.9E-08 |

*Total cubic yards placed:* 84,857

*Proctor Frequency:* 1: 4466 cubic yards placed, exceeding the required frequency of 1:5000 CY.

Hydraulic conductivity was measured by Inberg-Miller in early 1998 using a flexible wall permeameter (ASTM D 5084 Method C). All hydraulic conductivity results are below the 1.0E-7 maximum requirement. The specific gravity was 2.8 for each sample.

## Table B.4. Sand-Cone Correlation Documentation for the Heap Leach Radon Barrier

| Date | Compaction Test ID | Nuclear Gauge Test: In-Place Wet Unit Weight (pcf) | Nuclear Gauge Test: Moisture Content (%) | Sand-Cone Compaction Tests: In-Place Wet Unit Weight (pcf) | Sand-Cone Compaction Tests: Moisture Content (%) | Sand-Cone Correlation Results: Wet Unit Weight Variation (%) | Sand-Cone Correlation Results: Moisture Content Variation (%) |
|---|---|---|---|---|---|---|---|
| 6/13/97 | RBS-001 | 123.3 | 22.7 | 123.9 | 22.8 | 0.5 | 0.1 |
| 6/17/97 | RBS-003 | 124.2 | 22.0 | 125.3 | 22.4 | 0.9 | 0.4 |
| 7/2/97 | RBS-015 | 120.4 | 23.8 | 122.2 | 24.8 | 1.5 | 1.0 |
| 7/17/97 | RBS-038 | 121.9 | 24.7 | 122.0 | 25.0 | 0.1 | 0.3 |
| 7/24/97 | RBS-051 | 124.5 | 21.6 | 124.8 | 23.8 | 0.2 | 2.2 |
| 7/31/97 | RBS-063 | 125.4 | 21.2 | 126.4 | 21.4 | 0.8 | 0.2 |
| 8/15/97 | RBS-090 | 125.9 | 19.7 | 125.9 | 22.1 | 0.0 | 2.4 |
| 8/21/97 | RBS-105 | 124.7 | 20.2 | 124.1 | 22.5 | -0.5 | 2.3 |
| 8/5/98 | RBS-107 | 123.0 | 21.4 | 124.3 | 22.4 | 1.1 | 1.0 |
| 8/6/98 | RBS-109 | 124.2 | 21.1 | 125.1 | 22.5 | 0.7 | 1.4 |
| 8/11/98 | RBS-117 | 123.3 | 22.9 | 125.2 | 23.9 | 1.5 | 1.0 |
| 8/13/98 | RBS-122 | 123.8 | 20.9 | 125.7 | 21.7 | 1.5 | 0.8 |
| 8/18/98 | RBS-129 | 122.2 | 21.0 | 125.3 | 22.1 | 2.5 | 1.1 |
| 8/25/98 | RBS-133 | 124.6 | 22.3 | 126.0 | 23.6 | 1.1 | 1.3 |
| 8/31/98 | RBS-149 | 124.0 | 20.5 | 128.2 | 21.2 | 3.4 | 0.7 |
| 9/29/98 | RBS-162 | 125.2 | 21.7 | 127.3 | 21.5 | 1.7 | -0.2 |
| 10/1/98 | RBS-164 | 124.1 | 20.2 | 125.9 | 20.7 | 1.5 | 0.5 |

pcf - pounds per cubic foot

| | Wet Unit Weight | Moisture Content |
|---|---|---|
| *Number of sand-cone tests:* | 17 | |
| *average percent variation (on absolute value):* | **1.1** | **1.0** |
| *standard deviation:* | 0.9 | 0.7 |

**Note:**
For the Heap Leach radon barrier, a sand-cone correlation test was performed for every ten nuclear gauge tests. Correlations were deemed acceptable if the average of ten nuclear test results vs. sand cone test results comparisons met the following criteria:

sand-cone method wet density: +/- 3%
sand-cone method moisture content: +/- 2%

As indicated above, these criteria were met even for discrete results (vs. running average).

## Table B.5. Soil Classification Test Results for the Heap Leach Radon Barrier: 1997-1998, 2000

| Date Sampled | Gradation Sample ID | PARTICLE SIZE ANALYSIS Seive Size (% Passing) | | | | | | | | | | Atterberg Sample ID | Atterberg Limits | | Unified Soil Classification |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1" | 3/4" | 3/8" | #4 | #8 | #16 | #30 | #50 | #100 | #200 | | Liquid Limit | Plastic Index | |
| *Plan Requirements:* | | maximum particle size = 1" | | | | | | | | | ≥ 75 | | ≥ 30 | ≥ 20 | CL or CH |
| 6/2/97 | R-01 | - | - | - | 100 | 98.9 | 96.8 | 93.0 | 90.8 | 88.9 | 86.5 | R-01 | 49 | 40 | CL |
| 6/9/97 | R-02 | - | - | 100 | 99.6 | 98.8 | 97.9 | 96.8 | 95.9 | 95.1 | 94.2 | R-02 | 52 | 34 | CH |
| 6/13/97 | RG-01 | - | - | 100 | 97.2 | 96.8 | 96.0 | 94.9 | 93.8 | 92.9 | 91.7 | RA-01 | 47 | 28 | CL |
| 6/17/97 | RG-02 | - | - | 100 | 95.3 | 94.3 | 93.4 | 92.6 | 92.1 | 91.7 | 91.3 | RA-02 | 54 | 34 | CH |
| 6/17/97 | RG-03 | - | - | - | 100 | 98.1 | 97.0 | 95.4 | 94.2 | 93.1 | 91.7 | RA-03 | 49 | 31 | CL |
| 6/18/97 | RG-04 | - | - | - | 100 | 99.4 | 98.6 | 97.4 | 96.3 | 95.5 | 94.4 | RA-04 | 48 | 29 | CL |
| 6/19/97 | RG-05 | - | - | - | 100 | 98.0 | 96.9 | 95.7 | 94.8 | 93.8 | 92.6 | RA-05 | 45 | 25 | CL |
| 6/20/97 | RG-06 | - | - | - | 100 | 98.9 | 97.7 | 96.1 | 94.8 | 93.6 | 91.9 | RA-06 | 47 | 28 | CL |
| 6/26/97 | RG-07 | - | - | - | 100 | 99.1 | 98.1 | 96.7 | 95.4 | 93.8 | 91.5 | RA-07 | 46 | 29 | CL |
| 6/30/97 | R-03 | - | - | 100 | 98.5 | 97.1 | 96.2 | 95.0 | 93.8 | 92.6 | 90.7 | R-03 | 47 | 28 | CL |
| 7/1/97 | RG-08 | - | - | - | 100 | 98.5 | 97.6 | 96.1 | 94.9 | 93.7 | 91.8 | RA-08 | 51 | 33 | CH |
| 7/2/97 | RG-09 | - | - | - | 100 | 99.1 | 98.2 | 97.3 | 96.6 | 96.0 | 94.8 | RA-09 | 45 | 27 | CL |
| 7/8/97 | RG-10 | - | - | - | 100 | 99.6 | 98.8 | 97.9 | 97.1 | 96.5 | 95.4 | RA-10 | 46 | 29 | CL |
| 7/9/97 | RG-11 | - | - | - | 100 | 99.0 | 97.9 | 96.7 | 95.8 | 94.9 | 93.6 | RA-11 | 46 | 28 | CL |
| 7/10/97 | R-04 | - | - | - | 100 | 98.8 | 97.8 | 96.8 | 96.0 | 95.3 | 94.1 | R-04 | 43 | 25 | CL |
| 7/11/97 | RG-12 | - | - | - | 100 | 99.3 | 98.6 | 94.6 | 96.8 | 96.1 | 94.9 | RA-12 | 53 | 34 | CH |
| 7/14/97 | RG-13 | - | - | - | 100 | 98.6 | 97.4 | 96.1 | 95.2 | 94.5 | 93.6 | RA-13 | 47 | 30 | CL |
| 7/14/97 | RG-14 | - | - | - | 100 | 99.4 | 98.7 | 97.7 | 96.9 | 96.1 | 95.0 | RA-14 | 49 | 32 | CL |
| 7/15/97 | RG-15 | - | - | - | 100 | 99.4 | 98.6 | 97.7 | 97.0 | 96.3 | 95.1 | RA-15 | 48 | 29 | CL |
| 7/15/97 | R-05 | - | - | - | 100 | 99.1 | 98.1 | 96.8 | 95.8 | 94.9 | 93.2 | R-05 | 44 | 24 | CL |
| 7/16/97 | RG-16 | - | - | - | 100 | 99.4 | 98.7 | 97.8 | 97.1 | 96.5 | 95.5 | RA-16 | 48 | 30 | CL |
| 7/17/97 | RG-17 | - | - | - | 100 | 98.7 | 98.0 | 97.3 | 96.7 | 96.2 | 95.3 | RA-17 | 52 | 33 | CH |
| 7/18/97 | RG-18 | - | - | - | 100 | 98.5 | 97.5 | 96.4 | 95.5 | 94.8 | 93.5 | RA-18 | 48 | 32 | CL |
| 7/18/97 | RG-19 | - | - | - | 100 | 98.3 | 97.7 | 96.9 | 96.3 | 95.6 | 94.2 | RA-19 | 43 | 26 | CL |
| 7/18/97 | R-06 | - | - | - | 100 | 99.7 | 99.4 | 98.9 | 98.5 | 98.1 | 97.4 | R-06 | 47 | 29 | CL |
| 7/21/97 | RG-20 | - | - | - | 100 | 98.0 | 97.3 | 96.4 | 95.6 | 95.0 | 94.0 | RA-20 | 49 | 20 | CL |
| 7/22/97 | RG-21 | - | - | - | 100 | 99.3 | 98.4 | 97.4 | 96.5 | 95.7 | 94.4 | RA-21 | 46 | 29 | CL |
| 7/23/97 | RG-22 | - | - | - | 100 | 98.9 | 97.9 | 97.0 | 96.2 | 95.5 | 94.4 | RA-22 | 47 | 31 | CL |
| 7/23/97 | RG-23 | - | - | - | 100 | 98.9 | 97.8 | 96.3 | 95.1 | 94.1 | 92.7 | RA-23 | 44 | 26 | CL |
| 7/24/97 | RG-24 | - | - | - | 100 | 98.9 | 97.8 | 96.7 | 95.7 | 94.9 | 93.6 | RA-24 | 46 | 28 | CL |
| 7/24/97 | RG-25 | - | - | - | 100 | 99.0 | 98.2 | 97.2 | 96.4 | 95.7 | 94.5 | RA-25 | 51 | 33 | CH |
| 7/25/97 | RG-26 | - | - | - | 100 | 99.1 | 98.0 | 96.6 | 95.4 | 94.3 | 92.7 | RA-26 | 45 | 28 | CL |
| 7/28/97 | RG-27 | - | - | - | 100 | 99.3 | 98.5 | 97.6 | 96.9 | 96.4 | 95.6 | RA-27 | 51 | 32 | CH |
| 7/28/97 | R-07 | - | - | - | 100 | 98.9 | 98.1 | 96.8 | 95.8 | 94.9 | 93.5 | R-07 | 48 | 31 | CL |
| 7/30/97 | RG-28 | - | - | - | 100 | 99.5 | 98.7 | 98.2 | 97.6 | 97.2 | 96.6 | RA-28 | 48 | 32 | CL |
| 7/31/97 | RG-29 | - | - | - | 100 | 98.6 | 97.7 | 96.6 | 95.7 | 95.0 | 93.8 | RA-29 | 45 | 30 | CL |
| 7/31/97 | RG-30 | - | - | - | 100 | 99.1 | 98.3 | 97.6 | 97.0 | 96.5 | 95.9 | RA-30 | 51 | 35 | CH |
| 8/1/97 | RG-31 | - | - | - | 100 | 99.6 | 99.2 | 98.5 | 97.9 | 97.4 | 96.6 | RA-31 | 50 | 31 | CH |
| 8/1/97 | RG-32 | - | - | - | 100 | 98.6 | 97.5 | 95.9 | 94.5 | 93.6 | 91.4 | RA-32 | 44 | 28 | CL |
| 8/1/97 | RG-33 | - | - | - | 100 | 99.1 | 98.3 | 97.0 | 95.9 | 95.0 | 93.7 | RA-33 | 50 | 32 | CH |

## Table B.5. Soil Classification Test Results for the Heap Leach Radon Barrier: 1997-1998, 2000

| Date Sampled | Gradation Sample ID | PARTICLE SIZE ANALYSIS Seive Size (% Passing) | | | | | | | | | | Atterberg Sample ID | Atterberg Limits | | Unified Soil Classification |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1" | 3/4" | 3/8" | #4 | #8 | #16 | #30 | #50 | #100 | #200 | | Liquid Limit | Plastic Index | |
| *Plan Requirements:* | | maximum particle size = 1" | | | | | | | | | ≥ 75 | | ≥ 30 | ≥ 20 | CL or CH |
| 8/4/97 | R-08 | - | - | - | 100 | 98.5 | 97.5 | 96.3 | 95.3 | 94.5 | 93.3 | R-08 | 44 | 27 | CL |
| 8/4/97 | R-09 | - | - | - | 100 | 99.4 | 98.7 | 97.7 | 96.9 | 96.4 | 95.6 | R-09 | 48 | 28 | CL |
| 8/4/97 | RG-34 | - | - | - | 100 | 99.0 | 97.6 | 95.9 | 94.8 | 93.8 | 92.4 | RA-34 | 46 | 27 | CL |
| 8/5/97 | RG-35 | - | - | - | 100 | 98.1 | 97.1 | 95.7 | 94.4 | 93.4 | 91.8 | RA-35 | 46 | 30 | CL |
| 8/5/97 | RG-36 | - | - | - | 100 | 99.2 | 98.3 | 97.4 | 96.7 | 96.1 | 95.1 | RA-36 | 47 | 28 | CL |
| 8/7/97 | RG-37 | - | - | - | 100 | 98.5 | 97.6 | 96.5 | 95.6 | 94.9 | 93.7 | RA-37 | 50 | 34 | CH |
| 8/7/97 | R-10 | - | - | - | 100 | 99.5 | 98.8 | 97.7 | 96.9 | 96.3 | 95.5 | R-10 | 50 | 33 | CH |
| 8/8/97 | RG-38 | - | - | - | 100 | 98.5 | 97.5 | 96.1 | 94.9 | 94.0 | 92.7 | RA-38 | 51 | 35 | CH |
| 8/11/97 | R-11 | - | - | - | 100 | 99.2 | 97.6 | 95.5 | 93.7 | 92.7 | 91.8 | R-11 | 60 | 41 | CH |
| 8/11/97 | RG-39 | - | - | - | 100 | 98.0 | 96.4 | 93.8 | 91.4 | 89.2 | 96.2 | RA-39 | 50 | 32 | CH |
| 8/11/97 | RG-40 | - | - | - | 100 | 98.2 | 97.1 | 95.6 | 94.2 | 92.9 | 91.1 | RA-40 | 49 | 33 | CL |
| 8/14/97 | RG-41 | - | - | - | 100 | 99.3 | 98.4 | 97.3 | 96.5 | 95.9 | 95.0 | RA-41 | 52 | 35 | CH |
| 8/15/97 | RG-42 | - | - | - | 100 | 98.2 | 97.0 | 95.4 | 94.3 | 93.3 | 92.0 | RA-42 | 51 | 34 | CH |
| 8/15/97 | RG-43 | - | - | - | 100 | 99.0 | 98.2 | 97.3 | 96.6 | 96.0 | 94.8 | RA-43 | 50 | 32 | CH |
| 8/18/97 | RG-44 | - | - | - | 100 | 98.8 | 97.6 | 96.1 | 94.9 | 93.8 | 92.3 | RA-44 | 50 | 32 | CH |
| 8/19/97 | RG-45 | - | - | - | 100 | 98.0 | 97.0 | 95.5 | 94.2 | 93.1 | 91.9 | RA-45 | 52 | 36 | CH |
| 8/20/97 | RG-46 | - | - | - | 100 | 98.7 | 97.5 | 95.7 | 94.1 | 92.9 | 91.4 | RA-46 | 57 | 37 | CH |
| 7/31/98 | R-12 | 100 | 99.7 | 99.7 | 99.6 | 99.3 | 99.0 | 98.7 | 98.3 | 98.0 | 97.5 | R-12 | 50 | 31 | CH |
| 8/4/98 | R-13 | | 100 | 99.8 | 99.7 | 99.2 | 97.8 | 96.6 | 95.5 | 94.8 | 93.8 | R-13 | 57 | 36 | CH |
| 8/7/98 | RG-50 | | | | 100 | 99.7 | 99.3 | 98.9 | 98.5 | 98.1 | 97.0 | RG-50 | 52 | 33 | CH |
| 8/10/98 | RG-47 | | | | 100 | 99.4 | 98.5 | 97.4 | 96.5 | 95.8 | 95.1 | RG-47 | 54 | 34 | CH |
| 8/10/98 | RG-48 | | | | 100 | 99.8 | 99.5 | 99.0 | 98.6 | 98.3 | 97.7 | RG-48 | 54 | 37 | CH |
| 8/10/98 | RG-49 | | | | 100 | 99.6 | 98.6 | 97.3 | 96.4 | 95.7 | 94.5 | RG-49 | 53 | 34 | CH |
| 8/10/98 | RG-51 | | | | 100 | 99.8 | 99.4 | 99.0 | 98.6 | 98.1 | 97.3 | RG-51 | 53 | 36 | CH |
| 8/11/98 | R-14 | 100 | 99.7 | 99.4 | 99.2 | 98.6 | 97.8 | 96.7 | 95.8 | 95.1 | 94.1 | R-14 | 57 | 39 | CH |
| 8/11/98 | RG-52 | | | | 100 | 99.7 | 99.5 | 99.2 | 99.0 | 98.7 | 97.9 | RG-52 | 53 | 33 | CH |
| 8/12/98 | RG-54 | | | | 100 | 99.6 | 99.3 | 98.9 | 98.6 | 98.4 | 97.7 | RG-54 | 53 | 33 | CH |
| 8/13/98 | RG-55 | | | | 100 | 99.7 | 99.2 | 98.7 | 98.3 | 97.9 | 97.1 | RG-55 | 54 | 36 | CH |
| 8/14/98 | RG-56 | | | | 100 | 99.6 | 98.9 | 98.2 | 97.5 | 96.9 | 95.7 | RG-56 | 56 | 37 | CH |
| 8/17/98 | R-15 | | | | 100 | 99.8 | 99.6 | 99.4 | 99.3 | 99.1 | 98.4 | R-15 | 47 | 27 | CL |
| 8/17/98 | RG-53 | | | | 100 | 99.7 | 99.4 | 99.2 | 99.0 | 98.8 | 98.0 | RG-53 | 53 | 34 | CH |
| 8/18/98 | RG-57 | | | | 100 | 99.4 | 98.5 | 97.6 | 96.7 | 96.4 | 95.2 | RG-57 | 56 | 36 | CH |
| 8/20/98 | RG-58 | | | | 100 | 99.5 | 98.7 | 97.8 | 97.1 | 96.5 | 95.4 | RG-58 | 55 | 35 | CH |
| 8/24/98 | R-16 | | | 100 | 99.9 | 99.7 | 99.2 | 98.9 | 98.7 | 98.6 | 98.0 | R-16 | 53 | 33 | CH |
| 8/25/98 | RG-59 | | | 100 | 99.7 | 99.1 | 98.3 | 97.2 | 96.3 | 95.8 | 94.8 | RG-59 | 56 | 36 | CH |
| 8/25/98 | RG-60 | | | 100 | 99.7 | 99.4 | 98.9 | 98.4 | 98.0 | 97.6 | 96.6 | RG-60 | 54 | 35 | CH |
| 8/26/98 | RG-61 | | | | 100 | 99.5 | 99.1 | 98.7 | 98.3 | 97.9 | 96.9 | RG-61 | 54 | 36 | CH |
| 8/26/98 | RG-62 | | | | 100 | 99.3 | 98.6 | 97.7 | 97.0 | 96.4 | 95.4 | RG-62 | 56 | 37 | CH |
| 8/27/98 | RG-63 | | | 100 | 99.6 | 99.2 | 98.9 | 98.5 | 98.3 | 98.1 | 97.4 | RG-63 | 51 | 33 | CH |
| 8/27/98 | RG-64 | | | | 100 | 99.6 | 99.0 | 98.4 | 97.8 | 97.4 | 96.2 | RG-64 | 54 | 35 | CH |

## Table B.5. Soil Classification Test Results for the Heap Leach Radon Barrier: 1997-1998, 2000

| Date Sampled | Gradation Sample ID | PARTICLE SIZE ANALYSIS Seive Size (% Passing) | | | | | | | | | | Atterberg Sample ID | Atterberg Limits | | Unified Soil Classification |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1" | 3/4" | 3/8" | #4 | #8 | #16 | #30 | #50 | #100 | #200 | | Liquid Limit | Plastic Index | |
| *Plan Requirements:* | | maximum particle size = 1" | | | | | | | | | ≥ 75 | | ≥ 30 | ≥ 20 | CL or CH |
| 8/31/98 | R-17 | 100 | 99.6 | 99.6 | 99.5 | 98.6 | 97.4 | 95.7 | 94.3 | 93.4 | 91.7 | R-17 | 49 | 30 | CL |
| 8/31/98 | RG-65 | | | | 100 | 99.5 | 98.7 | 97.6 | 96.7 | 96.0 | 94.7 | RG-65 | 54 | 36 | CH |
| 8/31/98 | RG-66 | | | | 100 | 99.4 | 98.7 | 97.8 | 97.2 | 96.6 | 95.7 | RG-66 | 53 | 35 | CH |
| 9/2/98 | RG-67 | | 100 | 99.7 | 99.6 | 98.9 | 97.9 | 96.5 | 95.1 | 94.0 | 92.2 | RG-67 | 52 | 35 | CH |
| 9/25/98 | RG-68 | | | 100 | 99.6 | 99.1 | 98.4 | 97.3 | 96.3 | 95.3 | 93.6 | RG-68 | 56 | 39 | CH |
| 9/28/98 | RG-69 | | 100 | 99.6 | 99.5 | 98.8 | 97.9 | 96.5 | 95.3 | 94.3 | 92.6 | RG-69 | 54 | 37 | CH |
| 9/29/98 | R-18 | | | | 100 | 99.7 | 99.1 | 98.6 | 98.3 | 98.0 | 97.1 | R-18 | 49 | 32 | CL |
| 9/29/98 | RG-70 | | | 100 | 99.9 | 99.5 | 99.0 | 98.6 | 98.2 | 97.8 | 96.6 | RG-70 | 57 | 39 | CH |
| 9/30/98 | RG-71 | | 100 | 99.7 | 99.6 | 99.1 | 98.2 | 96.9 | 95.7 | 94.7 | 92.9 | RG-71 | 55 | 38 | CH |
| 9/30/98 | RG-72 | | 100 | 99.8 | 99.3 | 98.5 | 97.3 | 95.7 | 94.2 | 92.8 | 90.6 | RG-72 | 54 | 37 | CH |
| 10/1/98 | RG-73 | | 100 | 99.8 | 99.4 | 99.1 | 98.7 | 98.4 | 98.1 | 97.6 | 96.1 | RG-73 | 54 | 37 | CH |
| 10/15/98 | RG-74 | | 100 | 99.8 | 99.0 | 98.2 | 96.8 | 94.6 | 92.2 | 90.0 | 86.4 | RG-74 | 50 | 33 | CH |
| 10/15/98 | RG-75 | | 100 | 99.7 | 99.1 | 98.3 | 97.0 | 95.2 | 93.5 | 91.9 | 89.1 | RG-75 | 51 | 32 | CH |
| 10/15/98 | RG-76 | | 100 | 99.9 | 99.0 | 98.1 | 96.5 | 94.0 | 91.5 | 89.4 | 86.4 | RG-76 | 49 | 31 | CL |
| 6/30/00 | RG-77 | | | 100 | 96.7 | 95.8 | 95.0 | 94.2 | 93.6 | 93.2 | 92.7 | RA-77 | 59 | 43 | CH |
| 6/27/00 | R-19 | | 100 | 99.8 | 99.5 | 98.9 | 97.6 | 95.9 | 94.3 | 93.0 | 91.7 | RA-19 | 58 | 38 | CH |
| | *averages:* | 100.0 | 99.9 | 99.8 | 99.8 | 98.9 | 98.0 | 96.9 | 96.0 | 95.2 | 94.1 | | | | |

**Test Summary:** All heap leach soil classification tests passed the design specification requirements. All Atterberg Limits met plan requirements (LL ≥ 30; PI ≥ 20) and all unified soil classifications were either CH (Fat Clay, 58%) or CL (Lean Clay, 42%).

| | #200 | Liquid Limit | Plastic Index | |
|---|---|---|---|---|
| *Total Number of Tests (N):* | 96 | | | |
| ***average:*** | **94.1** | **50.5** | **32.4** | |
| *minimum:* | 86.4 | 43.0 | 20.0 | |
| *maximum:* | 98.4 | 60.0 | 43.0 | CH: 58% (n=56) |
| *standard deviation:* | 2.5 | 4.0 | 4.1 | CL: 42% (n=40) |

*Total Quantities placed:* 84,857 cubic yards (CY)

*Testing Frequency:* 1 test for every 884 CY, exceeding the 1:1000 CY requirement.

## Table B.6. Heap Leach Radon Barrier Visual Depth Check Documentation

| Date | Depth Check Test ID | Northing | Easting | Radon Barrier Depth (ft) |
|---|---|---|---|---|
| 7/2/97 | 1 | 792310 | 837365 | 1.8 |
| 7/2/97 | 2 | 792153 | 837766 | 1.5 |
| 7/2/97 | 3 | 792029 | 738148 | 1.5 |
| 7/8/97 | 4R | 792005 | 838208 | 1.6 |
| 7/17/97 | 5R | 791667 | 837001 | 1.6 |
| 7/17/97 | 6 | 791734 | 836994 | 1.5 |
| 7/17/97 | 7 | 791801 | 836992 | 1.6 |
| 7/17/97 | 8 | 791680 | 837209 | 1.5 |
| 7/17/97 | 9 | 791680 | 837207 | 1.5 |
| 7/17/97 | 10 | 791746 | 837205 | 1.6 |
| 7/17/97 | 11 | 791813 | 837201 | 1.5 |
| 7/17/97 | 12 | 791580 | 837195 | 1.7 |
| 7/17/97 | 13 | 791946 | 837192 | 2.1 |
| 7/18/97 | 14 | 792065 | 837185 | 1.6 |
| 7/18/97 | 15 | 792152 | 837055 | 1.7 |
| 7/18/97 | 16 | 792111 | 837058 | 1.5 |
| 7/22/06 | 17 | 792170 | 837164 | 1.9 |
| 7/22/06 | 18 | 792165 | 837055 | 1.7 |
| 7/22/06 | 19 | 791560 | 837370 | 1.7 |
| 7/22/06 | 20 | 791510 | 837320 | 1.6 |
| 7/22/06 | 21 | 791500 | 837310 | 1.7 |
| 7/22/06 | 22 | 791455 | 837275 | 1.6 |
| 7/22/06 | 23 | 791355 | 837210 | 1.9 |
| 7/25/06 | 24 | 791419 | 837449 | 1.6 |
| 7/30/06 | 25R | 791224 | 837562 | 1.9 |
| 7/31/97 | 26R | 791224 | 837562 | 1.9 |
| 7/31/97 | 27 | 791204 | 837512 | 1.5 |
| 7/31/97 | 28 | 791026 | 837508 | 2.2 |
| 8/11/97 | 29 | 790720 | 837680 | 1.5 |
| 8/11/97 | 30 | 790940 | 837650 | 1.5 |
| 8/11/97 | 31 | 790805 | 838015 | 1.9 |
| 8/11/97 | 32 | 790640 | 837875 | 1.5 |
| 8/14/97 | 33 | 790770 | 838150 | 1.8 |
| 8/18/97 | 34 | 792430 | 837190 | 2.0 |
| 8/19/97 | 35 | 792341 | 837239 | 1.9 |
| 8/19/97 | 36 | 790777 | 837505 | 1.6 |
| 8/19/97 | 37 | 792375 | 837048 | 1.8 |
| 8/19/97 | 38 | 791615 | 837217 | 2.0 |
| 8/19/97 | 39 | 791540 | 837170 | 1.6 |
| 8/19/97 | 40 | 791408 | 837185 | 1.8 |
| 8/20/97 | 41 | 791334 | 838160 | 1.9 |
| 8/20/97 | 42 | 791745 | 838167 | 1.9 |
| 8/20/97 | 43 | 791734 | 838136 | 1.9 |
| 8/21/97 | 44 | 790728 | 838066 | 2.0 |
| 8/21/97 | 45 | 790685 | 838025 | 1.8 |
| 8/21/97 | 46 | 790796 | 838136 | 1.9 |
| 8/22/97 | 47 | 790561 | 837914 | 1.9 |
| 8/22/97 | 48 | 790482 | 837850 | 2.0 |
| 6/30/00 | 2000-1 | 791975 | 838267 | 1.9 |
| 6/30/00 | 2000-2 | 792060 | 838216 | 1.5 |

Tests in 2000 were for the Heap Leach Gap Tie-In.

| | |
|---|---|
| *N:* | 50 |
| ***average:*** | **1.7** |
| *minimum:* | 1.5 |
| *maximum:* | 2.2 |
| *standard deviation:* | 0.2 |

## Table B.7. Heap Leach Gap Radon Barrier Visual Depth Check Documentation

| Date | Depth Check Test ID | Northing | Easting | Radon Barrier Depth (ft) |
|---|---|---|---|---|
| -- | 1-98 | 792442 | 838232 | 1.9 |
| -- | 2-98 | 792487 | 838140 | 1.8 |
| -- | 3-98 | 792512 | 838043 | 2.1 |
| -- | 4-98 | 792484 | 837949 | 1.9 |
| -- | 5-98 | 792362 | 838325 | 2.0 |
| 8/17/98 | 6-98 | 792287 | 838397 | 1.8 |
| 8/17/98 | 7-98 | 792337 | 838282 | 2.0 |
| 8/20/98 | 12-98 | 792499 | 837496 | 1.5 |
| 8/20/98 | 15-98 | 792589 | 837329 | 2.0 |
| 8/26/98 | 17-98 | 792429 | 837448 | 2.1 |
| 8/26/98 | 18-98 | 792456 | 837300 | 1.6 |
| 8/26/98 | 19-98 | 792462 | 837253 | 1.7 |
| 8/27/98 | 20-98 | 792327 | 837569 | 1.6 |
| 8/27/98 | 21-98 | 792268 | 837755 | 1.8 |
| 9/1/98 | 23-98 | 792226 | 838004 | 1.6 |
| 9/2/98 | 28-98 | 792173 | 838203 | 1.9 |
| 9/2/98 | 29-98 | 792219 | 838235 | 1.8 |

| | |
|---|---|
| *N:* | 17 |
| ***average:*** | **1.8** |
| *minimum:* | 1.5 |
| *maximum:* | 2.1 |
| *standard deviation:* | 0.2 |