Final Construction Completion Report
Gas Hills, Wyoming Site

VOLUME IV

A-9 REPOSITORY DESIGN ENHANCEMENT AND C-18 PIT RECLAMATION

June 2007

Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado 81506

FINAL CONSTRUCTION COMPLETION REPORT INDEX
GAS HILLS, WYOMING SITE

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* Although Volumes II through V are intended to be largely stand-alone reports, Volume I is necessary as it presents important information related to license termination and transfer of the site. It also documents all erosion protection quality control test results—e.g., rock durability and gradation tests—which apply to all construction areas.

For Volumes II through V, two binders are provided. The first includes the main text and appendices documenting the quality control test results. Plates are provided separately in the second binder.

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A-9 Repository Drawings*
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*To facilitate review, final as-built drawings are provided in two formats—in standard plate (24 x 36 inch), to allow detailed examination of all construction details and topographic features and, for easier access and reference, 11 x 17 inch format.

A-9 REPOSITORY DRAWINGS AND PLATES

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Volume IV Contents

Definition of Terms

Acronym / Abbreviation	Definition
11e.(2)	11e.(2) byproduct material, defined under 10 CFR 40 Appendix A
ASTM	American Society for Testing and Materials
cfs	cubic feet per second
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
EPA	U.S. Environmental Protection Agency
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)
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 A-9 Repository and the C-18 Pit 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 *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository* (SMI 1998). This plan was submitted by letter dated October 27, 1998, and was supplemented by submittals dated December 10, 1998 and March 29, 1999 in response to NRC comments. The modified plan was approved by the NRC on December 9, 1999 (License Amendment 42).

1.1 Area Description and Background

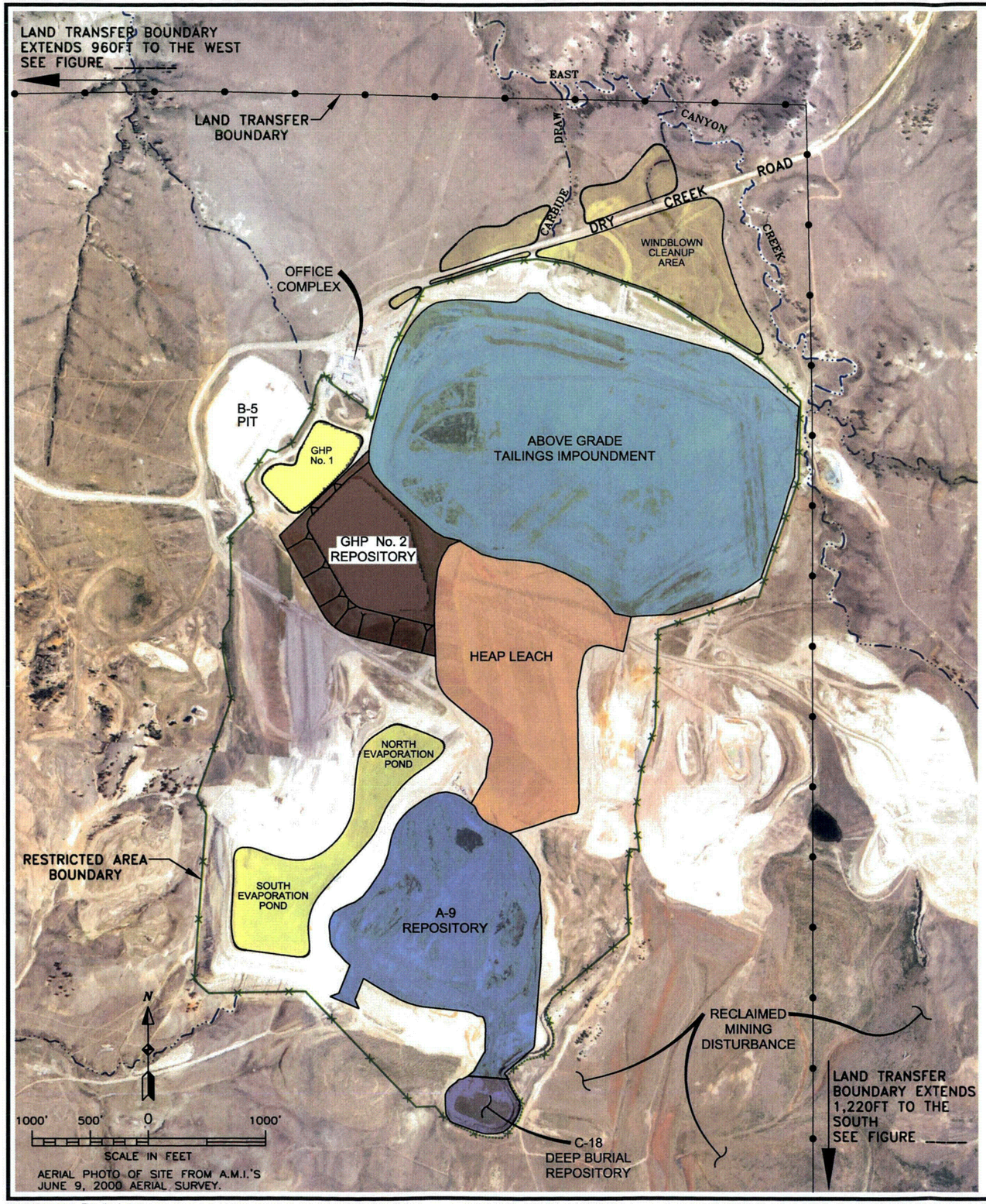
The A-9 Repository is a former open pit uranium mine that was lined with clay and used for tailings disposal between 1979 and 1984. In the NRC-approved 1987 reclamation design for the A-9 cell, the proposed cover consisted of a 1-foot thick interim cover, a 1-foot clay radon barrier, a 1-foot filter layer, a 6.5-foot frost protection/spoil layer, and a 6-inch topsoil layer. This initially proposed cover was ultimately not constructed given the subsequent placement of additional waste and fill material in the cell. An interim cover from 1 to 5 feet thick was placed over the entire A-9 area in 1988 and 1989.

As discussed in the preceding volumes, based on Umetco's re-evaluation of the proposed plan for the Above-Grade Tailings Impoundment (which indicated that a vegetative cover would not provide adequate protection over the design life of the plan), and given the NRC's 1995 policy statement regarding previously-approved reclamation plans, Umetco submitted an enhanced design plan for the A-9 Repository and related areas in 1998. This plan also addressed reclamation of the adjacent C-18 Pit and North and South Evaporation Ponds, which had not been previously addressed. After the NRC's approval of the enhanced reclamation plan in December 1999, full-scale reclamation activities at the A-9 Repository began and continued until 2004. Reclamation (backfilling) of the C-18 Pit began in 2001 and was completed in 2005. This report documents the conduct and completion of those activities.

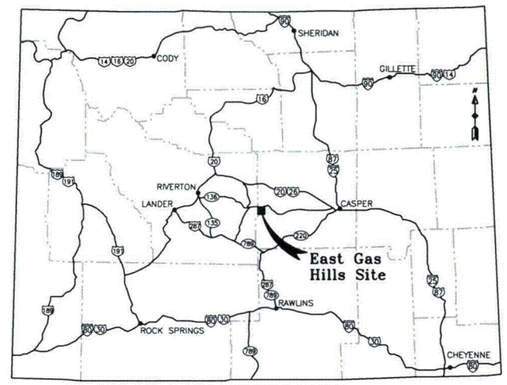
1.2 Scope of Work Addressed in this Report

The scope of work addressed herein, as detailed in the 1998 enhanced reclamation plan and subsequent submittals, includes the following:

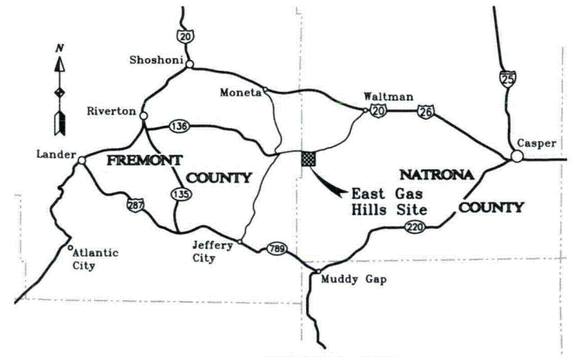
- Enlargement of the A-9 repository to accommodate additional material;
- Placement of a 1.5-foot thick radon barrier;
- Placement of a 4.5-foot thick frost protection layer;



AERIAL PHOTO OF SITE FROM A.M.I.'S JUNE 9, 2000 AERIAL SURVEY.



STATE OF WYOMING
NOT TO SCALE



VICINITY MAP
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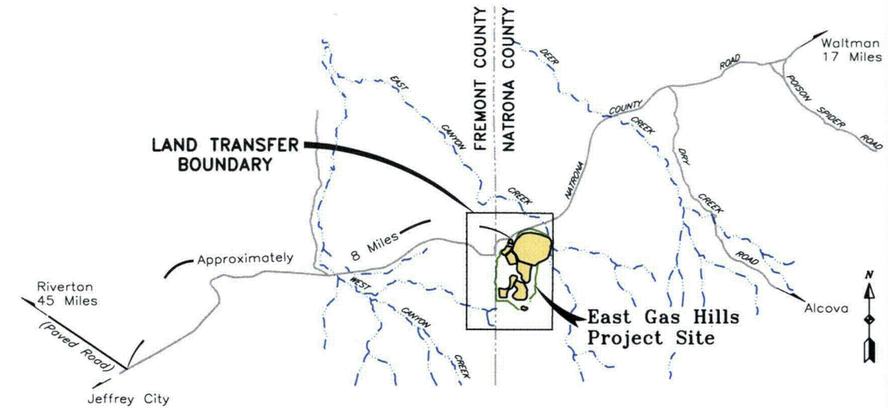


LOCATION MAP
NOT TO SCALE

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

- Erosion protection placement;
- Site grading for proper drainage, including east and west diversion ditches;
- Reclamation of the North and South Evaporation Ponds; and
- Reclamation of the C-18 Pit.

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 submittals related to the areas addressed in this volume—the A-9 Repository, the C-18 Pit, and the North and South Evaporation Ponds—are as follows:

- *Final Status Survey Report, Addendum 1* (September 2, 2004) – This report verified the completed reclamation of the North and South Evaporation Ponds, and was approved by the NRC on September 27, 2004.

- *Final Status Survey Addendum 2* (May 11, 2005) – This report documents the results of the A-9 Repository exposure survey and confirmed that the A-9 (Susquehanna) Haul Road was not contaminated with byproduct material, warranting no further action. This report was approved by the NRC on September 1, 2005.

- *Final Status Survey Report, Addendum 3* (January 22, 2007) – This report, the third and final addendum to the Final Status Survey Report, documents the conformance of the C-18 Pit repository cover with the applicable criteria in 10 CFR 40, Appendix A. This report is undergoing NRC review.

Although the Final Status Survey reports listed above address other endpoints and Gas Hills site areas, only those endpoints pertaining to this report volume are noted above.

1.3 SUA-648 License Condition and Regulatory Framework

The requirements for reclamation of the A-9 Repository and C-18 Pit are established in SUA-648 License Condition 58, the primary license condition pertaining to reclamation of the A-9 Repository, states the following:

> For the A-9 cover, the top 2 feet of frost protection soil will contain an average Ra-226 concentration that does not exceed the NRC-approved Ra-226 value based on data for surface soil surrounding the site. Reclamation of the A-9 Repository, C-18 Pit, and the North and South Evaporation Ponds, and the site grading shall be in accordance with the "Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository" in the licensee's submittal dated October 27, 1998, as modified by submittals dated December 10, 1998, March 29, 1999, and February 7, 2006. [Applicable Amendments: 42, 53, 58].

This report will demonstrate that the conditions of this license condition have been met and that the completed construction at the A-9 Repository and the C-18 Pit satisfies the requirements set forth in 10 CFR 40, Appendix A regarding stability and radon flux.

1.4 Volume IV Organization

The completion of this work in accordance with the approved plan is demonstrated primarily in the 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 (24 x 36 inch) plates, allowing examination of all construction details and final topography and, for easier access and reference, 11 x 17 inch format.

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 history of the A-9 Repository and related areas and the initial design plan submittals. Section 3 presents an overview of the enhanced reclamation plan, providing a cross-reference to the original plan and summarizing the submittal history.

Sections 4 and 5—essentially the crux of this text—document the construction activities and summarize the corresponding quality control test results for the A-9 Repository and the C-18 Pit respectively. These sections also document the final radiological conditions for both areas, including the frost protection radium-226 (Ra-226) content, gamma exposure survey results (reiterated from the Final Status Survey addendum reports), and the results of radon flux (NESHAPS) measurements. Section 6 summarizes the major conclusions of this report; references are provided in Section 7.

Quality control test results are provided in the appendices, which are organized as follows:

Appendix A	A-9 Repository Contaminated Fill
Appendix B	A-9 Repository Radon Barrier
Appendix C	A-9 Repository Frost Protection
Appendix D	A-9 Repository Toe and West Diversion Channel
Appendix E	C-18 Pit Quality Control Test Result Documentation

2.0 BACKGROUND

This section provides historical and background information related to the A-9 Repository, the enhanced design plan evolution, and a brief overview of the completed reclamation of the North and South Evaporation Ponds. Historical information regarding the C-18 Pit is presented in Section 5.

2.1 A-9 Repository History

The A-9 Repository is a former open pit uranium mine that was used for tailings disposal. Only the bottom was lined with 3 feet of compacted clay and was equipped with a decant system to dewater the tailings. From 1979 through 1984, approximately 1.6 million cubic yards of tailings were placed in the repository. Subsequently, between 1988 and 1990, approximately 1.8 million cubic yards of Susquehanna tailings from the Riverton Title I site were placed in the repository. Additional wastes from other licensed in-situ uranium recovery operations and from the Gas Hills mine and mill site were also placed in the repository, yielding a total volume of approximately 3.5 million cubic yards of material prior to development of the enhanced reclamation plan in 1998.

Table 2.1 summarizes the materials placed in the A-9 Repository prior to development of the enhanced reclamation plan. Table 2.2 expands on this summary, identifying dates of initial construction and design plan submittals.

Table 2.1 Materials Placed in the A-9 Repository Prior to the 1998 Design Plan

Waste Type	**Volume** (cubic yards)
1979 - 1984: Umetco Tailings (including mill waste/tailings, mill building debris, off-site byproduct material, and other miscellaneous waste)	1,580,000
1988: Susquehanna Tailings from Riverton Title I Site	1,793,801
Imported Wastes – from Cleveland Cliffs, Malapai, and Bison Basin	5,053
Mine and Mill Debris	103,830
Spook, Wyoming Title I Site Soils (low activity)	800
TOTAL VOLUME:	**3,483,484**

The locations of wastes are shown in plan view on Drawing 2 of the enhanced reclamation plan Design Report (SMI 1998, Part I.)

Table 2.2 A-9 Repository History: 1979-1999

Note: Shaded rows denote pivotal periods in the A-9 Repository construction and Reclamation Design History.

Year or Period	Activity or Event
1979	**Initial design and construction of the A-9 Repository**. The A-9 Repository was constructed in 1979 in the previously mined A-9 Pit. The NRC-approved design was based on the specifications provided in the report entitled *Alternative VII – In-place Dewatered Uranium Tailings Disposal Systems* (Umetco 1979). The North and South Evaporation Ponds were constructed over mine overburden.
1979 - 1984	Approximately 1.6 million cubic yards of tailings from the mill operations—including tailings, off-site byproduct material, mill waste, and mill building debris—were deposited in the A-9 Repository during this period. Aerial photographs from 1984 show that a large pond covered most of the repository surface. Mill operations were suspended in December 1984.
1984 - 1987	Umetco initiated plans to reclaim the A-9 Repository; consolidation and drainage of tailings.
1987	**License Amendment Request and Design Plan Modification**. Umetco submitted a Request for License Amendment to SUA-648 (the first) to authorize disposal of Title I tailings and other contaminated materials from the former Susquehanna Western Mill site in Riverton. Because the Susquehanna tailings could not be accommodated in the existing (1979) design plan, Umetco submitted a revised application and modified design which was finalized in September 1987. The NRC approved the revised plan in October 1987 (License Amendment 1). Between 1987 and 1989, approximately 1.8 million cubic yards of Susquehanna Tailings were placed in the A-9 Repository.
1988 -1989	An interim cover 1 to 5 feet (30.5 to 152 centimeters) thick was placed over the entire A-9 Repository. Upon completion, Umetco began quarterly monitoring of settlement and pore pressure.
1993	The upper portion of the clay liner from the North and South Evaporation Ponds was excavated and placed in the A-9 cell.
1996	Placement of contaminated fill from the construction of the GHP No. 2 Evaporation Pond
1998-1999	**Enhanced Reclamation Plan Submittal and NRC Approval.** The enhanced reclamation plan for the A-9 repository, entitled *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository*, was submitted to the NRC on 10/27/98, and supplemented with additional data on 12/10/98 (SMI 1998). The final supplement to the enhanced design plan was submitted on 3/29/99. The plan was approved by the NRC on December 9, 1999, by License Amendment No. 42.

2.2 Previously-Approved Reclamation Plan and Placement of Interim Cover

The original design report, entitled *Environmental Assessment of Below-Grade Uranium Tailings Disposal in the A-9 Open Pit*, was submitted to the NRC in June 1979 (Dames and Moore 1979). This plan included the following specifications: 1 foot each of interim cover, clay, and filter layers (3 feet total), and 7.5 feet of overburden/backfill, yielding a total cover thickness of 10.5 feet. This plan was approved by the NRC on October 7, 1987.

Subsequent to the plan approval, an interim cover (1 to 5 feet thick) was placed over the A-9 Repository between July 1988 and August 1989. The purpose of the interim cover was to provide stability and isolation of the tailings during the settlement-monitoring period before final cover placement of the radon barrier.

2.3 North and South Evaporation Ponds

One of the initial items in the scope of work in the 1998 A-9 Repository Design Enhancement is the reclamation of the North and South Evaporation Ponds. The completion of this work is addressed in Addendum 1 of the *Final Status Survey Report* (Umetco 2004), which was approved by the NRC on September 27, 2004. Field and geochemical investigations conducted in support of the enhanced reclamation plan indicated that residual byproduct material was not detectable in the rocky material under the pond liners, and therefore a cover was not required for the ponds area (SMI 1998, Design Report 1, Section 6 and Appendix F). The radiological data and analyses supporting this conclusion are discussed in detail in the Design Report (SMI 1998, Part I). Cross-sections showing the locations and extent of contaminated (byproduct) soil removal are provided in Figure 2.1 of the Final Status Survey Report Addendum 1.

In accordance with the 1998 design plan, the remaining 2 feet of clay liner material was removed in June and July 2000 and was disposed of in the A-9 Repository. The total volume of material was 178,590 cubic yards (see Appendix A and Table 5.1). The remaining underlying waste rock was then re-graded in place and the slopes of the ponds were graded to a 5:1 slope or flatter.

3.0 DESIGN ENHANCEMENT RECLAMATION PLAN OVERVIEW

This section presents an overview of the enhanced reclamation plan—*Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository* (SMI 1998)—on which the design and construction of the A-9 and C-18 Pit repository areas documented herein was based. This plan was submitted by letter dated October 27, 1998, and was supplemented by submittals dated December 10, 1998 and March 29, 1999 in response to NRC comments. The modified plan was approved by the NRC on December 9, 1999 (License Amendment 42). 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. Tables 3.3 and 3.4 summarize the parameters used in radon flux modeling (i.e., the basis for the cover radon attenuation design) for the A-9 Repository and C-18 Pit, respectively.

3.1 Scope of Work

As introduced in Section 1, the major enhancements to the previously approved reclamation for the A-9 Repository included the following:

- Enlarge the A-9 repository to accommodate additional material (this would increase the cell capacity and footprint by approximately 16 acres);
- Increase the thickness of the clay radon barrier from 1 to 1.5 feet;
- Reduce the thickness of the planned frost protection layer from 6.5 feet to 4.5 feet;
- Replacement of the previously approved topsoil/vegetative cover with 6 to 12 inches of riprap erosion protection.
- Grade the site for proper drainage, including east and west diversion ditches;
- Reclaim the North and South Evaporation Ponds; and
- Reclaim the C-18 Pit.

Reclamation of the North and South Evaporation Ponds has been addressed in Section 4. Completion of the remaining activities is demonstrated in the following sections.

3.2 Plan Modifications and NRC Approval

In response to NRC comments and requests for additional information, the 1998 plan was amended by two submittals prior to the NRC's approval of the enhanced reclamation plan in December 1999. These submittals, dated December 10, 1998 and March 29, 1999 and summarized in Table 3.2, included additional information regarding the C-18 Pit and revised radon flux models for both the A-9 Repository and the C-18 Pit. The plan was approved on December 9, 1999 by License Amendment 42.

Table 3.1 A-9 Repository Enhanced Reclamation Plan Summary of Contents

Preface: The enhanced reclamation plan for the A-9 Repository, entitled *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository*, prepared by Shepherd Miller, Inc. (SMI) was submitted on October 27, 1998. This report also addresses the reclamation of the C-18 Pit and the North and South Evaporation Ponds. Because of the extensive scope of the document, the following summary was developed for use as a cross-reference. Asterisked (*) sections document the design and geotechnical testing requirements that are most germane to this reclamation completion report. As documented in the following table, this plan underwent two rounds of comments prior to the NRC's approval of the enhanced reclamation plan and license amendment request on December 9, 1999 (License Amendment 42).

Plan Volume or Section No.	**Title**	**Description of Contents** (left blank if section title is sufficiently descriptive)
Part I: Design Report (Documents technical basis for Part II construction specifications)		
Sections 1 & 2	Introduction & Site Description	Section 2 was later updated/replaced in the December 1998 submittal in response to the NRC's request for additional information (see Table 3.2).
Section 3	Proposed Enhancements * *This section also included in Volume 3, as it was revised in response to NRC comments.*	Further describes the site-wide grading plan, reclamation of the North and South Evaporation Ponds and the C-18 Pit, and erosion protection on the A-9 Repository. This section was also updated in December 1998.
Section 4	Geotechnical Engineering Parameters	Presents the geotechnical characteristics of the A-9 Repository based on the results of the November 1997 field and laboratory investigation.
Section 5	A-9 Repository *Detailed information supporting this section is provided in the appendices listed below.*	Summarizes the results of pore pressure measurements and settlement monitoring, infiltration and seepage-deformation modeling, liquefaction analyses, cracking potential of radon barrier, radon attenuation analyses, and slope stability analyses
Section 6	North and South Evaporation Ponds *This section later updated in response to NRC comments.*	Describes pond construction, the physical composition of the clay liner and underlying waste rock, the composition of pond fluids, the conceptual model underlying SMI's geochemical modeling of the fate of radionuclides in pond liquids, and results of the 1997-1998 field investigations.
Section 7	C-18 Pit * *This section also included in Volume 3, as it was revised in response to NRC comments.*	Describes groundwater conditions, the C-18 Pit reclamation plan, and associated radon attenuation modeling. This section was later updated/replaced in the December 1998 submittal in response to the NRC's request for additional information.
Section 8	Surface Water Hydrology and Erosion Protection	Describes the hydrological basis for the erosion protection design (Design Storm and Basin Discharges), the riprap design (Safety Factors Method and Stephenson Method equations).
Section 9	Radiological Characterization of Borrow Material	

Table 3.1 A-9 Repository Enhanced Reclamation Plan Summary of Contents

Plan Volume or Section No.	Title	Description of Contents (left blank if section title is sufficiently descriptive)
Part I: Design Report, cont.		
Sections 10-11	Summary & References	
Drawings	--	Gas Hills Project Area (#1); Historic Features Reclamation Area (#2); Cross Sections (#3); Site-Wide Grading Plan; Cut and Fill of Contaminated Material (#4); Reclaimed Topography (#5); Riprap Sizes (#6); and Radium Activity of Reclamation Cut Areas (#7)
Appendix A	A-9 Field and Laboratory Investigation	
Appendix B	Infiltration Model Output (HELP Model)	This section was revised as part of the December 1998 revision to incorporate additional information about the C-18 Pit.
Appendix C	Seepage and Deformation Model Output (SEEP/W AND SIGMA/W)	
Appendix D	Slope Stability Analyses Input and Output (SLOPE/W)	
Appendix E	Radon Model Output (Radon Version 1.2) Appendix E.1: A-9 Repository Appendix E.2: C-18 Pit	Presents the radon flux model used in the radon attenuation design and documents the assumed radium (Ra-226) content of the various cell layers (e.g., Susquehanna tailings, windblown tailings and waste), and radon barrier and frost protection cover material. This appendix was revised in response to NRC questions as reflected in the 12/10/98 submittal.
Appendix F	North and South Evaporation Pond Investigation	Documents the results of the field investigation of the ponds conducted in December 1997 and early 1998.
Appendix G	Calculations of Cover Cracking Potential	
Appendix H	Procedure E-14 Gas Hills Soil Sampling Strategy	
Appendix I	Hydrologic Analysis	Presents calculations supporting riprap sizing.
Part II: Construction Specifications		
Sections 1-2	Introduction and General Requirements	
Section 3	General Earthwork Requirements	General specifications for clearing, grading, excavating, subgrade preparation, fill placement, and riprap requirements.

Table 3.1 A-9 Repository Enhanced Reclamation Plan Summary of Contents

Plan Volume or Section No.	Title	Description of Contents (left blank if section title is sufficiently descriptive)
Part II: Construction Specifications, Cont.		
Section 4 *	Construction Segments	Documents specifications for reclamation of the: North and South Evaporation Ponds (Section 4.1), the A-9 Repository (Section 4.2), site-wide grading (Section 4.3); reclamation of the C-18 Pit (Section 4.4), and construction of the East and West diversion channels (Section 4.5).
Construction Drawings	--	Final Reclamation Surface Topography and Cross Section Locations (#1); Cross Sections (#2A-2L); Cut and Fill of Contaminated Material (#3); Final Reclamation Surface Topography and Riprap Locations (#4); Detail Sheet (#5)
Attachment 1	Riprap Gradation Requirements	Note that the Type A gradation was later revised based on Umetco's December 20, 2000 submittal.
Attachment 2	Procedure E-14	Gas Hills Soil Sampling Strategy
Part III: Quality Control Plan		
Sections 1-3	Scope, Objectives, Definitions	
Section 4	Quality Control and Quality Assurance	Provides a general discussion of QA/QC activities and compliance report procedures.
Sections 5-7	Organizational Structure, Changes and Corrective Actions, Documentation	
Section 8 *	Construction Inspection and Testing	Specifies the inspection and testing, QC procedures, and required testing frequencies for all construction work (subgrade preparation, radon barrier, frost protection, riprap, and seeding).
Sections 9 and Appendix A	Quality Control Procedures	Section 9 references Appendix A, which documents all quality control procedures, test methods, and associated documentation and reporting requirements.

Table 3.2 A-9 Repository Design Enhancement Submittal History

Preface: License Condition 58, the primary license condition pertaining to reclamation of the A-9 Repository and the C-18 Pit, states the following: For the A-9 cover, the top 2 feet of frost protection soil will contain an average Ra-226 concentration that does not exceed the NRC-approved Ra-226 value based on data for surface soil surrounding the site. Reclamation of the A-9 Repository, C-18 Pit, and the North and South Evaporation Ponds, and the site grading shall be in accordance with the "Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository" in the licensee's submittal dated October 27, 1998, as modified by submittals dated December 10, 1998, March 29, 1999, and February 7, 2006. [Applicable Amendments: 42, 53, 58]. (*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
Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository (SMI 1998)	October 27, 1998	This report was prepared in support of Umetco's request for a license amendment to modify License Condition 58 to authorize reclamation of the A-9 Repository, the North and South Evaporation Ponds, and the C-18 Pit area according to the enhanced design plan.
November 24, 1998: NRC Interim Request for Additional Information re: C-18 Pit		
Umetco's response to the NRC's November 1998 request for additional information, including revisions and replacement pages for the affected sections of the report.	December 10, 1998	In their November 1998 comments, the NRC requested additional information related to the C-18 Pit, such as more information as to how it had been used, whether or not it would be treated as a disposal site requiring radon flux measurements, how Umetco would demonstrate that the soil radium limit would be met, and whether or not byproduct material had accumulated in the pit. Umetco's December 1998 submittal addressed all these endpoints.
February 16, 1999: NRC Submits Detailed Comments on the Enhanced Reclamation Plan		
Umetco's responses to the NRC's February 1999 detailed comments on the enhanced design plan.	March 29, 1999	Umetco provided detailed responses to the NRC's sixteen comments and submitted additional data in response to NRC's February 1999 information request. The latter included revised radon flux modeling for the A-9 Repository.
The enhanced reclamation plan for the A-9 Repository and related areas, consisting of the three above submittals, was approved by the NRC as License Amendment 42 dated December 9, 1999.		
Umetco request to modify C-18 Pit topsoil cover criteria, changing it from 5 to 10 pCi/g.	February 7, 2006	
The above request was approved by the NRC as License Amendment 58 dated November 2006.		

Table 3.3 RADON Code Input Parameters Used as the Basis for the Reclamation Plan for A-9 Repository Design: Final Values

Input Parameter	Tailings	Radon Barrier	Frost Protection	Comment (Basis)
Radium content (average)	342 pCi/g	3.6 pCi/g	10 pCi/g	Tailings radium value provided by DOE for Susquehanna mill tailings.
Layer Thickness	16 ft	1.5 ft	4.5 ft	Value assumed for tailings value is default
Emanation Coefficient	0.2	0.2005	0.262	Measured values utilized for tailings, radon barrier and frost protection layers, respectively.
Specific Gravity	2.65	2.65	2.65	Default value
Dry Density * (average)	1.86 g/cm^3 (116.1 pcf)	1.58 g/cm^3 (98.6 pcf)	1.78 g/cm^3 (111.1 pcf)	Site-specific measurements
Porosity	0.298	0.404	0.328	RADON-code calculated
Moisture Content (average long-term)	6 %	12.44%	11.48%	Code Default value used for tailings. Measured values used for the radon barrier. Frost value based on heap leach test data of soils.
Diffusion coefficient (all units = cm^2/s)	1.737 x 10^{-2} Calculated	1.23 x 10^{-2} Calculated	5.22 x 10^{-3} Calculated	RADON-code calculated values.

All values and assumptions listed above were accepted by the NRC, as documented in the Technical Evaluation Report (TER) supporting their approval of the A-9 Repository Reclamation Plan and corresponding license amendment (License Amendment 42, December 9, 1999, TER dated November 16, 1999). This modeling yielded radon flux values of 5.7 pCi/m^{2}s for the A-9 Repository. NESHAPS sampling conducted in 2003 yielded an average radon flux of 3.5 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).

Table 3.4 RADON Code Input Parameters Used as the Basis for the Reclamation Plan for C-18 Deep Burial Repository Design: Final Values

Input Parameter	Mine Spoils Layer 1	Mine Spoils Layer 2	Growth Medium	Comment (Basis)
Radium content (average)	40 pCi/g	10 pCi/g	10 pCi/g*	Ra-226 values as specified in C-18 Reclamation Plan.
Layer Thickness	16 ft	2 ft	1 ft	Value assumed for tailings value is default
Emanation Coefficient	0.262	0.262	0.262	Utilized value used for A-9 Frost for all parameters.
Specific Gravity	2.65	2.65	2.65	Default value
Dry Density * (average)	1.78 g/cm^3 (111.1 pcf)	1.78 g/cm^3 (111.1 pcf)	1.5 g/cm^3 (93.6 pcf)	Site-specific measurements
Porosity	0.328	0.328	0.434	RADON-code calculated
Moisture Content (average long-term)	11.48 %	11.48%	6%	Code Default value used for growth median. Mine spoils layers are parameters used for A-9 frost materials.
Diffusion coefficient* (all units = cm^2/s)	5.225×10^{-3} Calculated	5.225×10^{-3} Calculated	3.56×10^{-2} Calculated	RADON-code calculated values.

g/cm^3 grams per cubic centimeter

cm^2/s square centimeters per second

All values and assumptions listed above were accepted by the NRC, as documented in the Technical Evaluation Report (TER) supporting their approval of the A-9 Repository Reclamation Plan and corresponding license amendment (License Amendment 42, December 9, 1999, TER dated November 16, 1999). This modeling yielded a radon flux value of 2.8 pCi/m^2s for the C-18 Repository. NESHAPS sampling conducted in 2006 yielded an average radon flux of 5.2 pCi/m^2s. Both modeled and measured values are well below the 20 pCi/m^2s criterion required by 10 CFR Part 40, Appendix A, Criterion 6(2).

*The assumed radium concentration for the upper one foot of fill was increased from 5 pCi/g to 10 pCi/g, based on the factors documented in detail in the February 2006 license amendment request submittal entitled *Report Amending Final Design and Reclamation Plan for GHP No.2/Mill Area* (Umetco 2006). This modification was approved by the NRC by License Amendment 58 (see Attachment 2).

4.0 A-9 REPOSITORY DESIGN ENHANCEMENT CONSTRUCTION ACTIVITIES AND QUALITY CONTROL TEST RESULTS

This section describes the reclamation construction activities performed for the A-9 Repository and summarizes the results of the corresponding field and laboratory quality control tests. Tables 4.1 and 4.2 summarize the A-9 Repository reclamation activities and corresponding plan specifications. 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 A-9 Repository Site Plan	1
Contaminated Fill	2 – 4
Radon Barrier	5 – 7
Frost Protection	8 and 9
Toe Protection and West Diversion Channel	8 and 9
Erosion Protection	11 and 12

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: 11 x 17 inch format (provided in this volume) and standard plate (following binder). Geotechnical quality control tests conducted during placement of these materials and documented in detail in the appendices include field density tests, laboratory Standard Proctors, gradations, and Atterberg Limits. Although the results discussed in this section reflect only passing tests, the appendices also identify failed tests and document the subsequent re-tests conducted after re-working of the material.

4.1 A-9 Repository 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: 1:1,000 CY All other layers: 1:500 CY	ASTM D2922 ASTM D3017
Sand Cone Correlation	1:10 nuclear gauge test	ASTM D1556 ASTM D2216
Laboratory Compaction (Standard Proctor)	1: 5000 CY	ASTM D698
Soil Classification • Particle Size Analysis • Atterberg Limits	Radon Barrier: 1:1000 CY Frost Protection: 1:2000 CY (NA for Contaminated Fill, Toe and West Diversion Channel)	ASTM D2487 ASTM D4318 ASTM D1140 ASTM D422

CY - cubic yards; NA - Not Applicable

Table 4.1. Summary of A-9 Repository Design Enhancement Reclamation Activities

Year	Activity	Volume
Contaminated Fill Placement (1999-2002)		
1999	Reject fill from the Above-Grade frost protection	33,873
2000	Excavation of the clay liner from the North & South Evaporation Ponds	178,590
2001	Re-shaping of the A-9 Repository contaminated fill (majority), windblown material and GHP-1 cleanup, and IMC wastes*	183,491
2002	Re-shaping of the A-9 Repository contaminated fill and material excavated from Final Status Survey soil cleanup areas (windblown and GHP-1)	177,031
2003	Re-shaping of the A-9 Repository contaminated fill (final fill placement)	27,776
	Total Quantities Placed, Contaminated Fill:	**600,761**
Radon Barrier Layer (18-inches thick)		
2001	Placement and compaction of clay for radon barrier layer	102,828
2002	" "	23,028
2003	Completed placement and compaction of clay for radon barrier	30,153
	Total Quantities Placed, Radon Barrier Layer:	**156,009**
Frost Protection Extension (4.5 feet thick)		
2001	Placement and compaction of the frost protection layer	268,213
2002	" "	91,100
2003	" "	117,309
2004	Completed placement and compaction of the frost protection layer	8,064
	Total Quantities Placed, Frost Protection Layer:	**484,686**
Other – Toe Protection Excavation Backfill and West Diversion Channel		
2004	Placement and compaction of backfilling the toe protection excavation	7,728
2006	West Diversion Channel Fill Placement	1,967
Erosion Protection Placement: 2000-2002		
Type A Rock – Bedding Material for East and West Diversion Channels (Drawing 10)		11,306
Type B Rock – Top of A-9 Repository		26,882
Type C Rock – West Diversion Channel and Downstream Face		36,702
Type D Rock – East Diversion Channel		24,881
	Total Quantities Placed, Erosion Protection:	**99,771**

* IMC wastes consisted of non-11e.(2) byproduct material as described in Umetco submittals dated May 11 and July 12, 2001, as authorized by the NRC on August 10, 2001 (License Amendment No. 46, License Condition 62).

Table 4.2 A-9 Repository Design Enhancement Cover Construction Specifications

Layer	Specifications / Requirements
Contaminated Fill	• Lift thickness ≤ 12 inches (compacted depth) • Percent compaction: ≥ 90 percent of Standard Proctor maximum dry density
Radon Barrier	Soil Characteristics • Classification as CL or CH (based on ASTM D2487) • ≥ 80 % passing the No. 200 sieve • ≥ 90 % passing the No. 4 sieve • Maximum particle size of 1 inch • Liquid limit ≥ 40 • Plasticity index ≥ 15 • Hydraulic conductivity ≤ 1E-7 cm/sec (@ 95 percent compaction)* Placement • Layer thickness: 1.5 feet • Lift thickness ≤ 6 inches (compacted depth) • Percent compaction: ≥ 95 percent of Standard Proctor maximum dry density • Moisture Content ≥ Optimum and ≤ Optimum + 4 percent *Note: Because the homogeneity of the clay borrow material used for radon barrier construction and satisfaction of the ≤ 1E-7 cm/sec hydraulic conductivity requirement had already been demonstrated for the Heap Leach (see Volume I, Section 4), these tests were not repeated for subsequent repository reclamation.
Frost Protection	Soil Characteristics • Classification as SC and/or SM (clayey and/or silty sand) • Average Ra-226 content ≤ 10 pCi/g Placement • Layer thickness: 4.5 feet • Lift thickness ≤ 12 inches when compacted • Percent compaction: ≥ 95 percent of Standard Proctor maximum dry density • Moisture content: ≥ Optimum minus 2 percent
Backfill of Toe Protection and Diversion Channels	• Lift thickness: ≤ 12 inches (compacted depth) • ≥ 95 percent of Standard Proctor maximum density and moisture content ≥ Optimum minus 2 percent except for subgrade portions, for which ≥ 90 percent compaction was required (and no moisture requirement)
Erosion Protection	See Section 4.5.

As demonstrated in the following sections and in Tables 4.3 and 4.4, these frequencies were met and in many cases testing frequencies were much more conservative. 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 ten nuclear gauge tests or higher frequency. Correlations were deemed acceptable if the average of ten nuclear test results vs. sand-cone test results 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.

4.2 Contaminated Fill

Between 1999 and 2003, 600,761 cubic yards of contaminated fill material were placed in the A-9 Repository (Table 4.1, Appendix A, Table A.1). As indicated in Table 4.1, this volume includes 33,873 cubic yards of reject frost protection material from the Above-Grade Tailings impoundment (i.e., material not meeting the 10 picoCuries per gram (pCi/g) Ra-226 criterion). Although this material was placed prior to the December 9, 1999 approval of the enhanced reclamation plan, it is documented here because it was tested in accordance with the plan specifications and, as demonstrated in Appendix A, met the requirements. Additional waste materials placed in the A-9 Repository prior to construction of the radon barrier included the remaining clay liner from the North and South Evaporation Ponds (178,590 cubic yards, placed in 2000) and material excavated from the Final Status Survey soil cleanup conducted in 2000 and 2001.

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 2 shows the final contours and survey verification points; Drawings 3 and 4 show the compaction test locations. Quality control tests results associated with these activities are summarized in Tables 4.3 and 4.4 for field and laboratory tests, respectively.

4.2.1 Placement

In accordance with the enhanced reclamation plan, contaminated 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 dry density (ASTM D698).

Table 4.3 Summary of Field Quality Control Test Results for the A-9 Repository Design Enhancement Cover Construction: Contaminated Fill, Radon Barrier, and Frost Protection

Layer	Total Yards Placed	Design (Plan) Requirements[1]	Nuclear Gauge Test Results				Sand-Cone Correlation
			Frequency / Number of Tests	Dry Density (pcf)	Percent Moisture	Percent Compaction	Frequency / Number of Tests[1]
Contaminated Fill (1999-2003)	600,761 CY	Frequency: 1:1000 CY % Compaction: ≥ 90% % Moisture: NA	1:909 CY (n = 661)	avg = 111.2 min = 99.1 max = 125.2	avg = 12.8 min = 3.3 max = 25.2	avg = 95.6 min = 89.5 max = 107.4	1:5 (n = 137)
Radon Barrier (2001-2003)	156,009 CY	Frequency: 1:500 CY % Compaction: ≥ 95% % Moisture: ≥ Opt., ≤ Opt. +4	1:466 CY (n = 335)	avg = 101.9 min = 96.0 max = 109.0	avg = 21.8 min = 18.7 max = 26.1	avg = 97.7 min = 95.0 max = 104.6	1:9 (n = 38)
Frost Protection (2001-2004)	484,686 CY	Frequency: 1:500 CY % Compaction: ≥ 95% % Moisture: ≥ Opt. -2	1:484 CY (n = 1001)	avg = 115.4 min = 108.6 max = 125.0	avg = 12.6 min = 9.2 max = 19.2	avg = 97.7 min = 94.6 max = 106.2	1:9 (n = 110)

Note: 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 4.4 Summary of Laboratory Quality Control Test Results for the A-9 Repository Design Enhancement Cover Construction: Contaminated Fill, Radon Barrier, and Frost Protection

Layer	Design (Plan) Requirements	Laboratory Standard Proctor Test Results [1]			Atterberg Limit Test Summary			Soil Classification & Gradation
		Number of Tests / Frequency	Maximum Dry Density (pcf)	Optimum Moisture (%)	Number of Tests/ Frequency	Liquid Limit Results	Plastic Index Results	
Contaminated Fill 600,761 CY	NA for all except Proctor frequency	1:4353 CY (n = 138)	avg = 116.4 min = 101.5 max = 121.3	avg = 13.1 min = 11.0 max = 18.8	NA	NA	NA	NA
Radon Barrier 156,009 CY	Test Frequency: 1:1000 CY Liquid limit ≥ 40 Plasticity index ≥ 15 Unified Soil Classification: CL or CH ≥ 80% passing # 200 sieve ≥ 90% passing # 4 sieve Max. particle size = 1"	1:4334 CY (n = 36)	avg = 104.3 min = 101.0 max = 107.5	avg = 20.0 min = 18.0 max = 21.5	1:784 CY (n = 199)	avg = 55.8 min = 42 max = 72	avg = 35.4 min = 18 max = 49	All gradation requirements were met. An average of 100% and 93% passed the #4 and #200 sieves, respectively. All soils were classified as either CH (86%) or CL (14%).
Frost Protection 484,686 CY	Gradation-Atterberg Frequency: 1:2000 CY Unified Soil Classification: SC and/or SM	1:4660 CY (n = 104)	avg = 118.0 min = 114.0 max = 121.8	avg = 12.4 min = 10.4 max = 14.0	1: 1637 CY (n = 296)	avg = 32 min = 3 max = 41	avg = 13 min = 3 max = 25	For all but 5 of the 296 tests, soils met the required classification. Four were soils classified as CL, and 1 as SW-SM

Abbreviations

avg	average (arithmetic mean)
CY	cubic yards
n	number
NA	Not Applicable
pcf	pounds per cubic foot
%	percent

ASTM 2487 Term Definitions

CH	Fat Clay
CL	Lean Clay
SC	Clayey Sand
SM	Silty Sand
SW-SM	Well graded sand/silty sand

4.2.2 Quality Control Test Results

As summarized in Table 4.3, based on 661 passing tests, contaminated fill soils were compacted to an average of 95.6 percent of the maximum dry density, ranging from 89.5 to 107.4 percent. The average dry density and moisture content of this material are summarized in Table 4.3. The maximum dry density and optimum moisture as determined by the Standard Proctors are summarized in Table 4.4.

4.3 Radon Barrier

Construction activities for extension of the radon barrier took place between 2001 and 2003. During this time, 156,009 cubic yards of Cody Shale clay material were placed and compacted for the radon barrier layer.

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 4.3 and 4.4 for field and laboratory tests, respectively.

4.3.1 Placement

Clayey soils used for construction of the radon barrier were excavated from the Clay Borrow area, discussed in detail in Section 4 of Volume I. The radon barrier was placed in equal continuous layers not exceeding 6 inches compacted depth and compacted to a minimum of 95 percent of maximum dry density (ASTM D698), at a moisture content between optimum and 4 percent above optimum (Appendix B, Table B.2). Drawing 5 shows the placement areas, thickness, final grades, and survey verification points for the radon barrier extension along with selected cross-sections. Drawing 6 shows the A-9 Repository 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 18-inch specification. Based on 79 tests at the locations shown on Drawing 7, depths ranged from 1.5 to 2.5 feet, with an average depth of 1.7 feet and standard deviation of 0.2 feet (2 inches). Appendix B, Table B.6 documents the visual depth check results.

4.3.2 Quality Control Test Results

Field Compaction Test Results. As summarized in Table 4.3, based on 335 passing tests, radon barrier soils were compacted to an average of 97.7 percent of the maximum dry density, ranging from 95.0 to 104.6 percent. The average dry density of this material was 101.9 pounds per cubic foot (pcf), ranging from 96.0 to 109.0 pcf. The average moisture content was 21.8 percent, ranging from 18.7 percent to 26.1 percent (Appendix B, Table B.2). Compaction test locations are shown on Drawing 6.

As documented in Table B.4, sand-cone correlation tests indicated good agreement for wet densities and percent moisture, with average percent variations of 1.4 and 0.9 respectively (on absolute value).

A-9 Repository Radon Barrier Field Compaction Test Results

	Dry Density (pcf)	% Moisture	% Compaction
average:	101.9	21.8	97.7
range:	96.0 – 109.0	18.7 – 26.1	95.0 – 104.6
std. deviation:	2.1	1.4	2.0

N = 335; frequency = 1 test for every 466 cubic yards placed

Standard Proctor Test Results. As summarized in Table 4.4, based on 36 tests (frequency of 1:4,334 cubic yards), the maximum standard Proctor dry density of the radon barrier material ranged from 101.0 to 107.5 pcf, with an average of 104.3 pcf. The optimum moisture content ranged from 18.0 percent to 21.5 percent (n = 36 tests), with an average of 20.0 percent. Appendix B, Table B.3 lists all Standard Proctor results.

Soil Classification, Atterberg Limits, and Gradations. The enhanced reclamation plan for the A-9 Repository included the following specifications for radon barrier material characteristics:

- at least 80 percent passing the No. 200 sieve
- at least 90 percent passing the No. 4 sieve
- maximum particle size of 1 inch
- minimum liquid limit of 40 percent; and
- minimum plasticity index of 15
- classification as CL (Lean Clay) or CH (Fat Clay) (ASTM D2487)

As documented in Table B.5 and summarized in Table 4.4, all A-9 repository soil classification tests met the design specifications. The maximum particle size was 3/4", with an average of 93% passing the #200 sieve. Liquid limits and plastic indices were all well above the plan requirements; averages were 55.8 and 35.4 percent, respectively. Soil classifications yielded the following results: 86% of the material placed for the A-9 radon barrier consisted of fat clay (CH) and 14% was lean clay (CL).

4.4 Frost Protection

Construction activities for extension of the frost protection layer took place between 2001 and 2004. During this period, 484,686 cubic yards of frost protection material were placed on the A-9 Repository. 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 4.3 and 4.4 for field and laboratory tests, respectively. Primary findings are discussed below.

4.4.1 Placement

The frost protection layer of the A-9 Repository cover was constructed with soils obtained from borrow areas located east and south of the repository and from the South Evaporation Pond (Volume I, Figure 4.5). Sources and characteristics of this material are discussed in detail in Volume I, Section 4. 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.

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

4.4.2 Quality Control Test Results

Field Compaction Test Results. As summarized in Table 4.3 and in the inset below, based on 1001 passing tests, frost protection soils were compacted to an average of 97.7 percent of the maximum dry density, ranging from 94.6 to 106.2. The average dry density of the compacted material was 115.4 pcf, ranging from 108.6 pcf to 125.0 pcf. The average moisture content was 12.6 percent, ranging from 9.2 percent to 19.2 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 484,686 cubic yards, the testing frequency was 1 test for every 484 cubic yards placed, satisfying plan requirements.

A-9 Repository Frost Protection Layer Field and Laboratory Compaction Test Results

	Dry Density (pcf)	**Percent Moisture**	**Percent Compaction**	**Maximum Dry Density** (pcf)	**Optimum Moisture** (%)
average:	115.4	12.6	97.7	118.0	12.4
range:	108.6 – 125.0	9.2 – 19.2	94.6 – 106.2	114.0 – 121.8	10.4 – 14.0
std. deviation:	2.7	1.6	2.0	1.7	0.7

Nuclear Gauge N = 1001; frequency = 1 test for every 484 cubic yards placed
Correlation results documented in Appendix C indicate good agreement between the nuclear gauge and sand-cone test, with averages of 1.9 and 1.4 percent variation (absolute value) for wet density and moisture, respectively.

Standard Proctor Test Results. Table 4.4 summarizes the Standard Proctor results, which yielded an average maximum dry density for frost protection materials of 118.0 pcf, ranging from 114.0 to 121.8 pcf. The optimum moisture was 12.4 percent, ranging from 10.4 to 14.0 percent.

Soil Classification. The enhanced reclamation plan specified that frost protection materials shall consist of clayey and/or silty sand, classified as SC and/or SM. As documented in Appendix C, Table C.5 and Table 4.4, with the exception of 1 percent clay, these requirements were met. Breakdowns are as follows:

SC (Clayey Sand):	58%
SM (Silty Sand):	37%
SC-SM (Silty-Clayey Sand):	3%
CL (Lean Clay):	1%

Summary. As documented in Appendix C and summarized in Tables 4.3 and 4.4, quality control testing for the AGTI frost protection layer met all design specifications. This conclusion is corroborated in the TER supporting License Amendment 53 (TER dated February 5, 2004, submitted by letter dated February 23, 2004), in which the NRC stated the following:

> *"The final grading, radon barrier, and frost protection layer for the A-9 Repository have now been completed in accordance with the NRC-approved plan."*

4.5 A-9 Toe and West Diversion Channels

Placement (daily load counts) and quality control test records associated with construction of the toe protection and east and west diversion channels are documented in Appendix D. Associated final contours, survey verification points, and compaction test locations are shown in Drawings 9 and 10 (along with those for the frost protection layer). As demonstrated in the supporting tables and the as-built drawings, all construction activities were conducted in accordance with the reclamation plan.

4.6 Erosion Protection

Erosion protection placement at the A-9 Repository began in 2001 and was largely completed in 2003, except for the West Diversion Channel rock placement, which was completed in 2006. During this period, close to 100,000 cubic yards of erosion protection material were placed on the A-9 Repository. As-built Drawing 10 shows the Type A Bedding survey verification points and cross-sections. Drawing 11 shows the placement areas, final contours and survey verification points, and relevant cross-sections for the overlying erosion protection material. Drawing 12 shows the corresponding visual depth check and in-place gradation test locations. For detailed information regarding rock quality, gradation test results, and in-place depth check documentation, the reader is referred to Volume I, Section 5.

Volumes of rock placed during this time period are summarized below:

Rock Type	Cubic Yards
Type A	11,306
Type B	26,882
Type C	36,702
Type E	24,881
Total	99,771

4.6.1 Scope of Work

Four gradations of riprap were used to cover the repository and provide erosion protection at the toe. The four sizes are categorized as Type A, Type B, Type C, and Type D, having median grain sizes (D_{50}) of 0.5, 3.0, 6.0, and 16.0 inches, respectively. For the majority of the cover where the slope is approximately 3 percent, a 6-inch thick layer of Type B rock was used. As shown on Drawing 12, for the steeper slopes of the West Channel and the downstream (southern) face of the repository, a 12-inch layer of Type C rock was used. Riprap was buried to a depth of predicted scour along sections of the toe of the repository and channel outlets susceptible to gully erosion and headcutting. Details regarding the design and underlying assumptions are documented in detail in the enhanced design plan and in the TER accompanying the NRC's December 9, 1999 approval of the plan. In accordance with the A-9 enhanced 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 applicable NRC criteria (STP, NUREG-1623; see tables in Volume I, Section 5).
- Riprap material was placed to the lines and grades shown on 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.

During construction of the A-9 reclamation cover, the highwall on the east side of the repository was used as a borrow source for frost protection material. The resulting final configuration of the highwall area resulted in a different drainage basin configuration which contributes flow to the East Channel of the A-9 Repository. Accordingly, the adequacy of erosion protection for the A-9 East Channel has been evaluated. In the final configuration the drainage basin area for the East Channel results in a peak discharge of 1254 cubic feet per second (cfs) compared to 1158 cfs originally calculated in the design report. The peak discharge of 1254 cfs was conservatively determined using the Rational Formula (q- CiA) assuming a runoff coefficient of 1 and the previously determined Probable Maximum Precipitation of 8.7 inches. The adequacy of riprap for the East Channel was verified using the Safety Factors Method. The resulting Safety Factor for the Type D (minimum median stone size (D_{50}) = 16") for the East Channel is 1.21 or a minimum required D_{50} of 12" compared to minimum required D_{50} of 8.5" shown in the design report. The adequacy of erosion protection for lateral flows entering the East Channel from the highwall area was evaluated using the Stephenson Method (slopes greater then 10 percent). The resulting D_{50} for lateral flows entering the East Channel is 6.6 inches compared to the Type D (D_{50} = 16") actually placed in the channel.

4.6.2 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, gradation test results, and in-place visual depth checks. In-place gradation and depth check locations are shown on Drawing 12.

4.7 A-9 Repository Final Radiological Status

To verify that the completed A-9 Repository cover meets the criteria set forth in 10 CFR 40, Appendix A, Criterion 6(1) and Criterion 6(2), this section summarizes the information already documented in Addendum 2 of the Final Status Survey Report (Umetco 2005). This report provided the results of the gamma exposure rate surveys for the A-9 Repository, data documenting the Ra-226 content of frost protection material soils, and radon emission rate measurements from the repository cover. This report was approved by the NRC on September 1, 2005.

4.7.1 Cover Radium Content: Frost Protection Layer

The frost protection layer for the A-9 Repository cover was constructed with soils obtained from borrow areas located south, east, and west of the repository. Before and during placement, frost protection cover materials were continuously gamma surveyed and the upper two feet sampled and analyzed for Ra-226 content. Composite samples from 23 grids, approximately 300 square feet in area, were collected between October 30, 2001 and March 9, 2005. Analytical results are summarized in Table 4.5 (following page), indicating an average Ra-226 content of 7.7 pCi/g for the 0-1 foot depth profile and 7.8 pCi/g for the 1-2 foot profile, below the 10 pCi/g criterion.

4.7.2 Gamma Exposure Rates

Direct gamma exposure surveys of the A-9 Repository were made over the completed earthen cover on the northern portion of the repository in 2002 and on the southern portion in 2004 upon completion of the frost protection layer and prior to placement of erosion protection. The mean gamma exposure rates for the A-9 Repository were 33 microRoentgen per hour (μR/hr) from the bare detector surveys and 28 μR/hr from the collimated detector surveys. In the TER supporting the September 1 approval, the NRC concluded that the direct gamma exposure from the A-9 Repository has been reduced to background levels in compliance with 10 CFR Part 40, Appendix A, Criterion 6(1).

4.7.3 Radon Emanation (NESHAPS)

10 CFR Part 40, Appendix A, Criterion 6 and applicable technical procedures in 40 CFR Part 61, Appendix B require that Radon-222 emissions from uranium mill tailings are limited to an average of 20 picocuries per meter squared per second (pCi/m^2s) for each region. To demonstrate satisfaction of that requirement, NESHAPS sampling was conducted in May 2002 in the northern portion of the repository (45 locations) and in August 2003 for the southern portion (55 locations), for a total of 100 locations (see Figure 2.3 of Addendum 2 report). These measurements yielded an average radon flux of 3.5 pCi/m^2s, which is well below the 20 pCi/m^2s criterion. In the TER supporting the September 1 approval, the NRC concluded that the radon emission rate from the cover complies with the limit in 10 CFR, Appendix A, Criterion 6(2).

Table 4.5 A-9 Repository Frost Protection Verification Sampling Results

Grid No.	0-1 foot Samples			1-2 foot Samples		
	Sample ID	Date	Ra-226 (pCi/g)	Sample ID	Date	Ra-226 (pCi/g)
1	A9G1A	9/12/02	3.7	A9G1B	9/9/02	4.7
2	A9G2A	9/12/02	5.8	A9G2B	9/12/02	6.4
3	A9G3A	10/30/01	5.8	A9G3B	10/30/01	7.7
4	A9G4A	10/30/01	6.4	A9G4B	10/30/01	7.7
5	A9G5A	9/12/02	6.5	A9G5B	9/12/02	6.2
6	A9G6A	9/12/02	7.1	A9G6B	9/12/02	7.3
7	A9G7A	9/12/02	5.3	A9G7B	9/12/02	6.7
8	A9G8A	10/30/01	8.9	A9G8B	10/30/01	7.9
9	A9G9A	10/30/01	8.4	A9G9B	10/30/01	8.3
10	A9G10A	3/7/05	6.9	A9G10B	6/7/02	6.6
11	A9G11A	3/7/05	9.4	A9G11B	3/2/05	9.9
12	A9G12A	3/2/05	9.6	A9G12B	3/2/05	9.5
13	A9G13A	10/30/01	8.8	A9G13B	10/30/01	7.6
14	A9G14A	10/30/01	8.2	A9G14B	10/30/01	8.0
15	A9G15A	3/9/05	7.7	A9G15B	2/24/04	6.4
16	A9G16A	2/24/04	9.2	A9G16B	2/24/04	8.6
17	A9G17A	7/20/04	4.9	A9G17B	2/24/04	8.5
18	A9G18A	3/2/05	10.3	A9G18B	2/24/04	10.3
19	A9G19A	2/25/04	9.5	A9G19B	2/25/04	9.0
20	A9G20A	2/25/04	10.0	A9G20B	2/25/04	8.2
21	A9G21A	2/25/04	8.4	A9G21B	2/26/04	6.6
22	A9G22A	2/26/04	6.6	A9G22B	2/23/04	7.4
23	A9G23A	3/23/04	10.5	A9G23B	3/27/04	9.5
		average:	7.7			7.8
		std. deviation:	1.9			1.3

5.0 C-18 PIT RECLAMATION CONSTRUCTION ACTIVITIES

The enhanced reclamation plan for the A-9 Repository included backfilling the C-18 Pit and grading the area to drain in accordance with the site-wide grading plan. These activities took place between 2001 and 2005. The reclamation of the C-18 Pit in accordance with the enhanced reclamation plan is demonstrated largely by the quality assurance/quality control records provided in Appendix E and in the following as-built drawings and plates:

Layer/Aspect	Drawing/Plate* No.(s)
Final C-18 Pit Reclamation Site Plan	1
Compaction Test Locations, Backfill, Elevation 6844 to Elevation 6863	2
Compaction Test Locations, Backfill, Elevation 6864 to Elevation 6883	3
Compaction Test Locations, Backfill, Elevation 6884 to Elevation 6902	4

**Plates are provided in the following binder, following the A-9 as-built drawings.*

5.1 Background

The C-18 Pit is located approximately 1,000 feet south of the A-9 Repository and was excavated between 1983 and 1984. Ore from the C-18 Pit was processed through the mill and the tailings were deposited into the A-9 Repository. At the time the enhanced reclamation plan was developed, the C-18 Pit was approximately 80 feet deep (bottom elevation of 6,822 feet), 500 feet wide at the surface, and covered 5.3 acres. Because it was suspected that the pit may have some byproduct material at the bottom from site drainage, Umetco proposed to treat the pit as a repository with an engineered cover that would meet the long-term radon flux limit established in 10 CFR 40, Appendix A. In developing the reclamation plan for the C-18 Pit, the following two primary factors were considered:

1) The drainage basin contributing surface flow to the C-18 Pit is contained within the Gas Hills restricted area and includes the A-9 Repository. Backfill of the pit is necessary to establish surface drainage from the A-9 area; and

2) Cleanup verification of potential 11e.(2) material in the bottom of the C-18 Pit would be difficult to demonstrate, as the bottom of the pit rests on a mineralized ore zone.

As such, the reclamation plan specified that the C-18 Pit be reclaimed by backfilling with soils placed and compacted in accordance with the construction specifications summarized in the following section.

5.2 C-18 Pit Reclamation Plan Requirements

The construction specifications for placement of the C-18 Pit engineered backfill are as follows:

- lift thickness $\leq$ 12 inches (compacted depth);
- percent compaction: $\geq$ 95 percent of Standard Proctor maximum density (ASTM D698); and
- moisture content greater than optimum minus 2 percent,

These specifications essentially comply with the placement criteria established for frost protection soils for other repository areas. Erosion protection was not required due to the depth of the fill (56 feet) and the radiological requirements which resulted from the radon modeling assumptions used as the basis for the design plan. The radiological conditions assumed in the radon model are documented in Table 5.1 and summarized as follows:

- the top layer consisting of 1 foot of soil with Ra-226 concentration of 5 pCi/g (see discussion below);
- the second (underlying) layer consisting of 2 feet with radium concentration of 10 pCi/g
- the underlying layers consisting of soil with radium concentration less than 40 pCi/g.

Given these specifications, verification sampling was conducted at a frequency of one sample one for every 5,000 cubic yards. Additionally, Umetco continuously gamma surveyed all soils placed in the upper 16 feet of the cover backfill.

5.3 C-18 Pit Cover Criteria Modification: License Amendment 58 (November 2006)

As addressed in Volume I (Section 3), ultimately, the 5 pCi/g top foot of cover criterion could not be met due to the highly variable radium concentrations in background soils. As such, Umetco submitted a license amendment request in February 2006 to increase the allowable Ra-226 concentration in the top one-foot of C-18 Pit engineered backfill soils from 5 pCi/g to 10 pCi/g. This request was approved by the NRC on November 22, 2006 (License Amendment 58, TER dated October 21, 1999).

5.4 C-18 Pit Reclamation Activities and Quality Control Test Results

Reclamation of the C-18 Pit involved placement of about 56 feet of backfill to bring the pit to a final grade to promote drainage. Prior to backfilling, remaining water was pumped from the pit to the GHP-2 pond, after which nearly 56,000 cubic yards of backfill material was placed to solidify the remaining liquids and saturated soils (see Appendix E, Tables E.1 and E.2). Figure 5.1 provides photographs showing the sequence of C-18 Pit reclamation activities.

Subsequently, between 2001 and 2005, approximately 414,000 cubic yards of backfill were placed in the pit before the surface was brought to the final grades shown on Drawing 4. Placement records and associated quality control test results are detailed in Appendix E and summarized in Table 5.1. These tables verify that the backfill material was placed according to plan specifications—i.e., maximum lift thicknesses of 12 inches (compacted depth), compaction to a minimum of 95 percent of the Standard Proctor maximum dry density, and at a moisture content greater than optimum minus 2 percent.

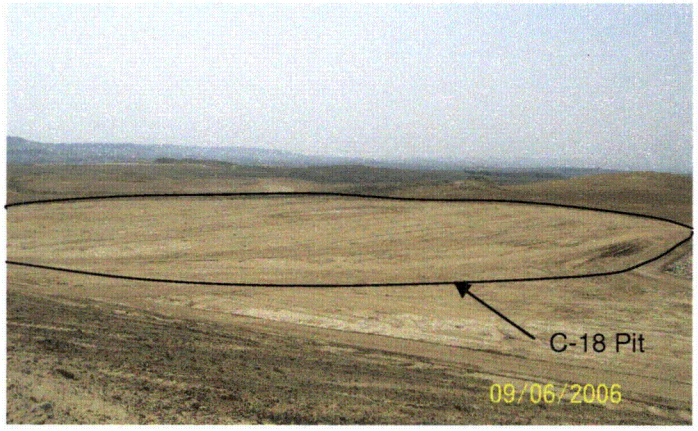
As demonstrated in the inset on page 31 and in the supporting as-builts and Appendix E quality control documentation, all construction activities were performed in accordance with plan requirements.

Figure 5.1. C-18 Pit Reclamation Sequence

Pre-Backfilling: 1996

Pre-Backfilling: April 18,2000
Liquids in C-18 are being pumped to GHP-2

June 6, 2001. Solidification of liquids is almost complete.
Began compaction at elevation 6844.



September 6, 2006, Completed C-18 Pit

C-18 Pit Backfill Field and Laboratory Compaction Test Result Summary

	Dry Density (pcf)	**Percent Moisture**	**Percent Compaction**	**Maximum Dry Density** (pcf)	**Optimum Moisture** (%)
average:	114.4	13.3	97.4	117.4	12.9
range:	106.1 – 133.3	9.2 – 18.9	94.8 – 103.5	111.5 – 120.3	10.9 – 15.5
std. deviation:	2.5	1.7	1.7	1.8	1.0

Nuclear Gauge N = 437 (1:947 CY); Proctor frequency: 1:4705 CY
Correlation results documented in Appendix E indicate good agreement between the nuclear gauge and sand-cone test (averages of 1.4 and 1.5 % variation for wet density and moisture, respectively

5.4 C-18 Pit Final Radiological Conditions

This section summarizes the results of Ra-226 measurements for the C-18 Pit topsoil cover, the gamma exposure rate survey, and the radon emission rate measurements. This information is documented in detail in Addendum 3 of the Final Status Survey Report (Umetco 2007), which is currently (as of June 2007) undergoing NRC review.

5.4.1 Ra-226 in C-18 Pit Cover Soils

In 2005, the final stage of the C-18 Pit backfill, the top one foot of cover materials were continuously gamma surveyed and each one-foot soil horizon in the upper two feet of the repository cover was sampled and analyzed for radium-226 activity. Approximately 9,650 cubic yards of soil were placed in each one-foot layer requiring two composite samples. Five individual samples were collected in each of the sampling grid areas and combined to yield a composite sample. Analytical results are documented in Addendum 3 (see Figure 3.3) and summarized below:

C-18 Repository Cover Average Radium-226 Activity

Grid Location	**Soil Horizon**	**Ra-226** (pCi/g)[a]	**Error Term**
West	0-1 ft	9.26	± 0.49
	1-2 ft	7.96	± 0.40
East	0-1 ft	7.97	± 0.44
	1-2 ft	8.85	± 0.46

[a] Radium-226 results reflect in-growth after 21 days; all count dates on 12/21/06

As indicated above, the average radium-226 activities are 8.95 pCi/g and 8.41 pCi/g for the 0 to 1 foot and 1 to 2 foot soil horizons, respectively. These results satisfy the revised (10 pCi/g) cover criterion discussed in Section 5.3.

In the TER approving Umetco's license amendment request, the NRC concluded that:

> *"...the required value of 5 pCi/g of Ra-226 concentration in the 30-cm growth medium is overly conservative and not a realistic estimate of actual background activity on site."*

5.4.2 C-18 Deep Burial Repository Radon-222 Emission Rate

Radon emission rates were measured from the C-18 Pit in September 2006 for comparison with the regulatory limit in 10 CFR 40, Appendix A, Criterion 6(2) of 20 pCi/m^2s (NESHAPs report submitted January 8, 2001). The average radon-222 emission rate over the C-18 Pit was 5.2 pCi/m^2-s, well below the 20 pCi/m^2-s regulatory limit. Additional information and sample locations are documented in Addendum 3 of the Final Status Survey Report. Individual canister results are in reported in the *National Emissions Standards for Hazardous Air Pollutants, 2006 Radon Flux Measurement Program, C-18 Repository, Gas Hills, Wyoming* (Tellco 2006), which was submitted to the NRC on December 13, 2006.

5.4.3 C-18 Deep Burial Repository Cover 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 were made over the reclaimed/backfilled C-18 Pit area in October 2006. One-meter high bare gamma exposure readings were collected and then averaged over the entire area as documented in Final Status Survey Report, Addendum 3 (Umetco 2007).

The average exposure rate measured over the C-18 Pit was 32.5 μR/hr, which slightly exceeds the 30 μR/hr initially established for Gas Hills site repositories. However, it is below the 40 μR/hr background rate revision approved by the NRC for the GHP-2 cover concomitant with their approval of the revised C-18 Pit topsoil criterion (License Amendment 58). In the TER approving this amendment (provided as Attachment 2 herein), the NRC stated:

> The *previously established background for the Umetco site is 30 μR/hr. 10 CFR Part 40, Appendix A, Criterion 6(1) states that the direct gamma exposure rate should be reduced to background levels. Evaluation of area surveys on and off the site indicates that background values vary greatly, from 16 to 97 μR/hr. Determining an accurate background for the site is subject to bias due to the great variance of the area's radiation levels. An appropriate background would be one that is conservatively estimated considering site background data and radium values in the area. NRC staff has concluded that the proposed value of 40 μR/hr does not pose a significant risk to public health, safety, and the environment. NRC staff has determined that the new average allowable exposure rate of 40 μR/hr satisfies 10 CFR Part 40, Appendix A, Criterion 6(1).*

6.0 SUMMARY AND CONCLUSIONS

In summary, this volume of the Construction Completion Report demonstrates that all work documented herein for the A-9 Repository and the C-18 Pit was performed in accordance with the design and procedures in the approved enhanced reclamation plan. Additionally, it verifies that the completed covers satisfy 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.

A-9 Repository viewed from the South end
of the East Diversion Channel to the North.

C-18 Repository viewed from the Northeast to the Southwest.

7.0 REFERENCES

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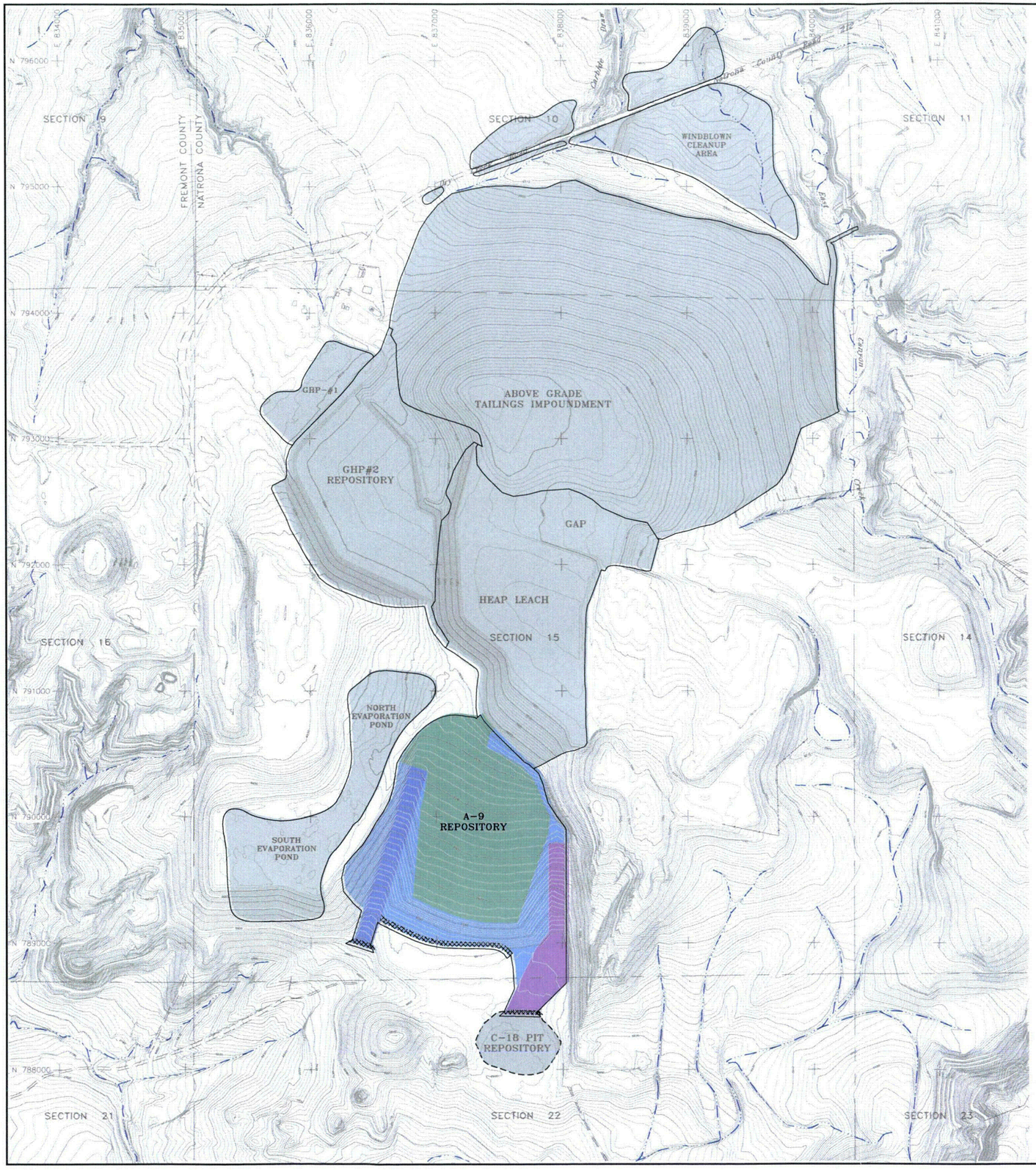
DRAWINGS

A-9 Repository
Drawings

Attachment 1



SHEET NO.	TITLE
1 OF 12	FINAL A-9 REPOSITORY SITE PLAN REFLECTING POST-RECLAMATION CONSTRUCTION FINAL GRADES
2 OF 12	A-9 REPOSITORY FINAL CONTOURS AND SURVEY VERIFICATION POINTS CONTAMINATED FILL LAYER
3 OF 12	A-9 REPOSITORY 1999 AND 2000 COMPACTION TEST LOCATIONS CONTAMINATED FILL AREA
4 OF 12	A-9 REPOSITORY 2001, 2002, AND 2003 COMPACTION TEST LOCATIONS CONTAMINATED FILL AREA
5 OF 12	A-9 REPOSITORY FINAL CONTOURS AND SURVEY VERIFICATION POINTS RADON BARRIER
6 OF 12	A-9 REPOSITORY COMPACTION TEST LOCATIONS RADON BARRIER
7 OF 12	A-9 REPOSITORY VISUAL DEPTH CHECK VERIFICATION TEST LOCATIONS RADON BARRIER
8 OF 12	A-9 REPOSITORY FINAL CONTOURS AND SURVEY VERIFICATION POINTS FROST PROTECTION LAYER, TOE PROTECTION SUBGRADE AND WEST DIVERSION CHANNEL
9 OF 12	A-9 REPOSITORY COMPACTION TEST LOCATIONS FROST PROTECTION LAYER, TOE PROTECTION SUBGRADE AND WEST DIVERSION CHANNEL
10 OF 12	A-9 REPOSITORY SURVEY VERIFICATION POINTS TYPE "A" BEDDING EROSION PROTECTION PLACEMENT
11 OF 12	A-9 REPOSITORY FINAL CONTOURS AND SURVEY VERIFICATION POINTS EROSION PROTECTION PLACEMENT
12 OF 12	A-9 REPOSITORY IN-PLACE GRADATION AND VISUAL DEPTH CHECK TEST LOCATIONS EROSION PROTECTION PLACEMENT

LEGEND

- 7000 — 2006 FINISHED GRADE TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6-INCHES OF RIPRAP TYPE "B" D_{50} = 3.0 INCH
- 12-INCHES OF RIPRAP TYPE "C" D_{50} = 6.0 INCH
- 12-INCHES OF RIPRAP TYPE "C" D_{50} = 6.0 INCH WITH 6-INCHES OF FILTER TYPE "A" D_{50} = 0.5 INCH
- 24-INCHES OF RIPRAP TYPE "D" D_{50} = 16.0 INCH WITH 6-INCHES OF FILTER TYPE "A" D_{50} = 0.5 INCH
- BELOW-GRADE APRON

N

400' 0 400'

SCALE IN FEET
CONTOUR INTERVAL : 2'

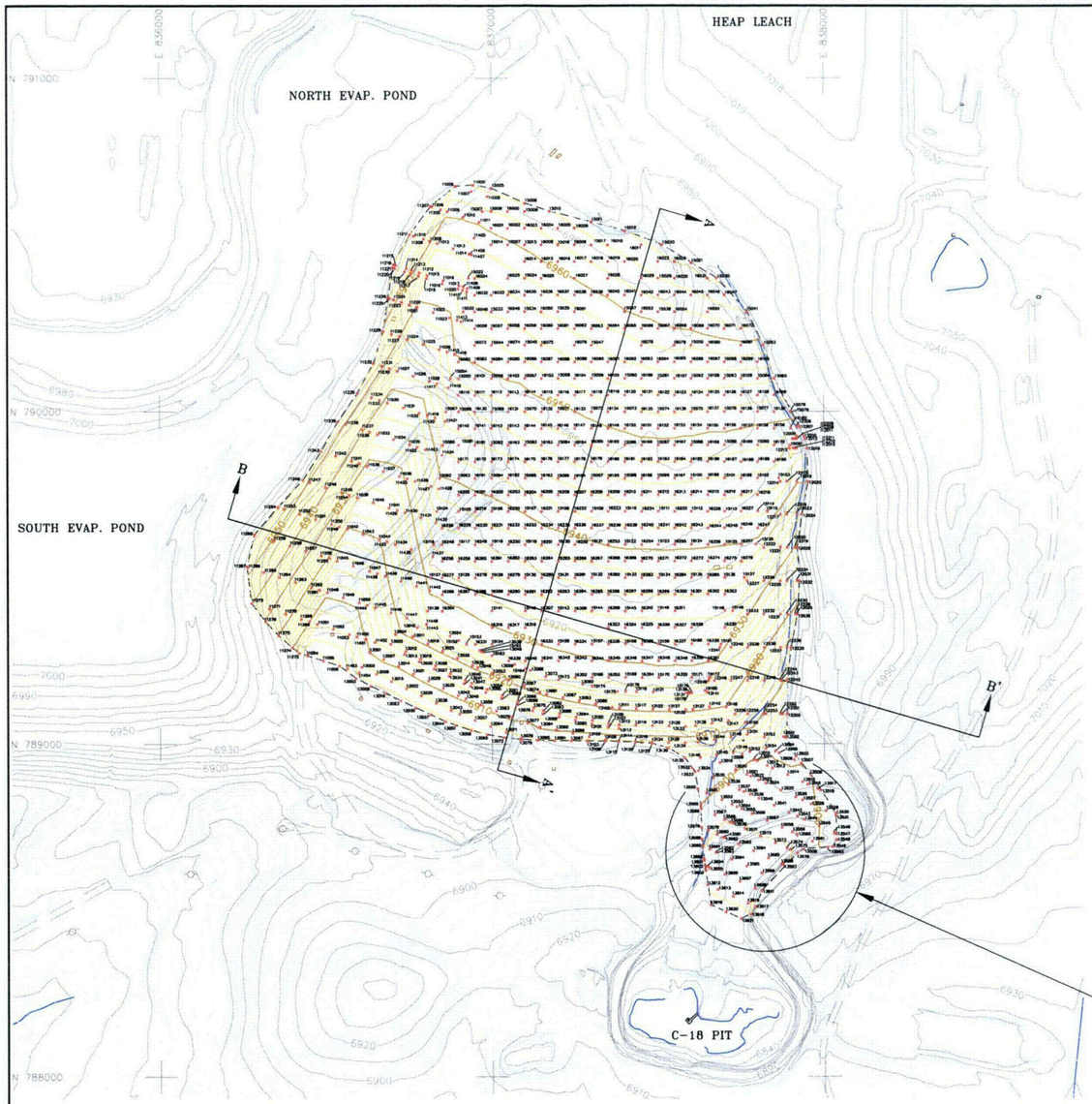
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

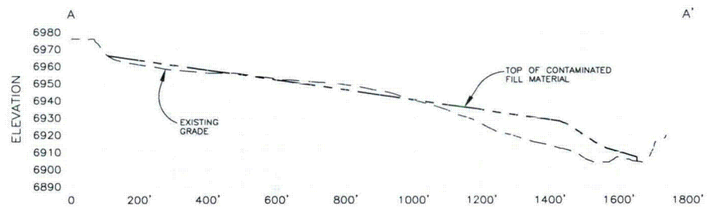
AS BUILT

FINAL A-9 REPOSITORY SITE PLAN REFLECTING POST-RECLAMATION CONSTRUCTION FINAL GRADES

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-01-AB SHEET 1 OF 12





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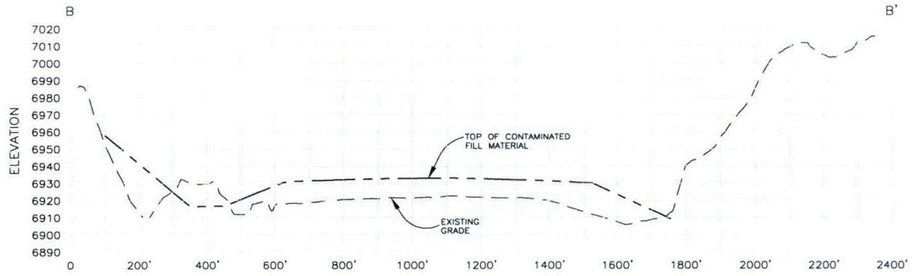
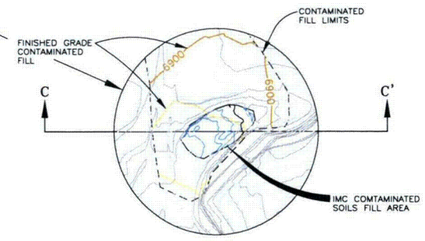
VERT. 1" = 40'



SECTION B–B'
SCALE: HORIZ. 1" = 200'
VERT. 1" = 40'

PROFILE LEGEND:

- EXISTING GRADE 1997 AERIAL TOPOGRAPHY
- TOP OF THE CONTAMINATED FILL



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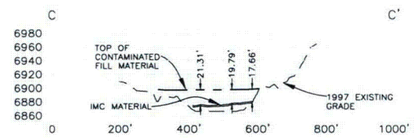


SECTION C–C'
SCALE: HORIZ. 1" = 200'
VERT. 1" = 100'

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
- LIMIT OF CONTAMINATED SOILS

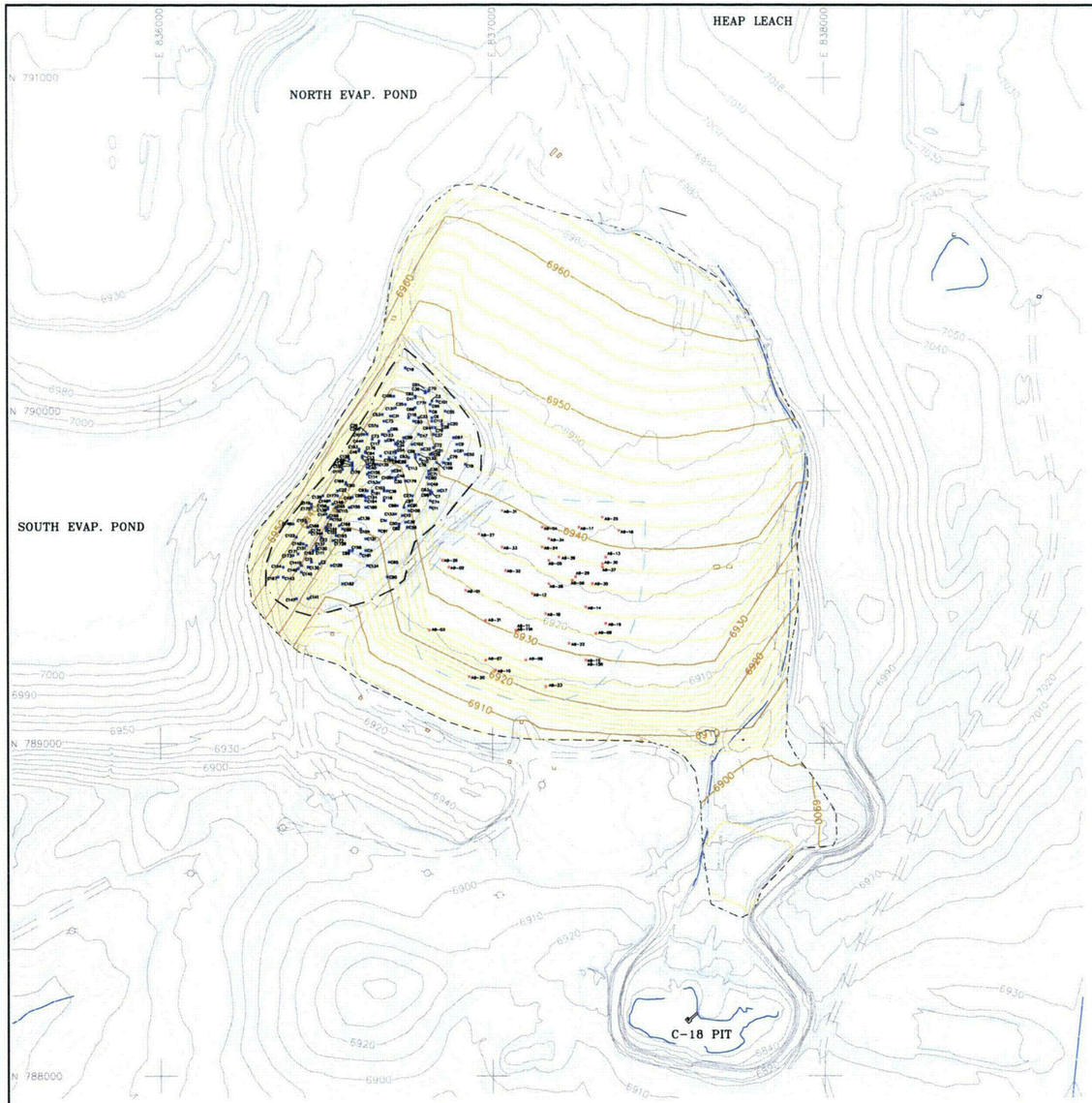
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

A–9 REPOSITORY
FINAL CONTOURS AND SURVEY VERIFICATION POINTS CONTAMINATED FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH–A9–02–AB



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
- LIMIT OF A-9 REPOSITORY CONTAMINATED SOILS
- CONTAMINATED FILL COMPACTION TEST LOCATIONS. 1999 FILL MATERIAL FROM THE ABOVE-GRADE TAILINGS IMPOUNDMENT ENHANCEMENT 1999 CONSTRUCTION. FILL MATERIAL PLACED, COMPACTED AND TESTED IN 1 FOOT LIFTS - 5 LIFTS TOTAL
- LIMITS OF 1999 CONTAMINATED MATERIAL FILL AREA.
- CONTAMINATED FILL COMPACTION TEST LOCATIONS. 2000 FILL MATERIAL FROM THE EXCAVATION OF THE CLAY LINER AND PRESCRIPTIVE DIG OF THE NORTH & SOUTH EVAPORATION PONDS. FILL MATERIAL PLACED, COMPACTED AND TESTED IN 1 FOOT LIFTS - 42 LIFTS TOTAL
- LIMITS OF 2000 CONTAMINATED MATERIAL FILL AREA.

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

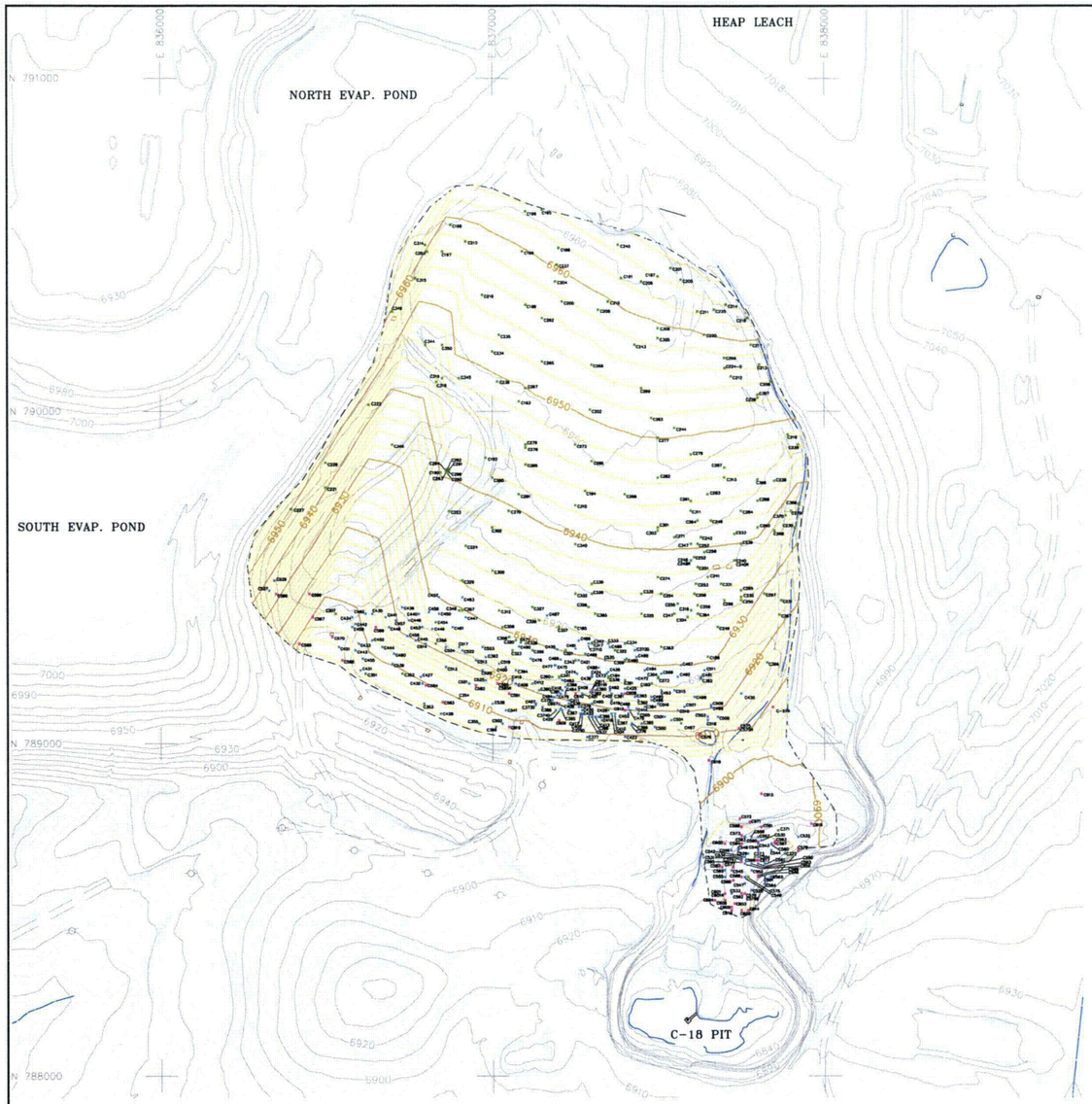
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

A-9 REPOSITORY
1999 AND 2000
COMPACTION TEST LOCATIONS
CONTAMINATED FILL AREA

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-03-AB SHEET 3 OF 12



LEGEND:

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- FINISH GRADE TOPOGRAPHY CONTAMINATED FILL AREA
- LIMIT OF A-9 REPOSITORY CONTAMINATED SOILS
- CONTAMINATED FILL COMPACTION TEST LOCATIONS. 2001 FILL MATERIAL FROM THE RESHAPING OF THE EXISTING A-9 REPOSITORY CONTAMINATED FILL, THE STOCKPILED FILL FROM THE GHP-1 LINER REMOVAL, AND THE WINDBLOWN CLEANUP MATERIAL. FILL MATERIAL PLACED, COMPACTED AND TESTED IN 1 FOOT LIFTS - APPROX. 8 LIFTS
- CONTAMINATED FILL COMPACTION TEST LOCATIONS. 2002 FILL MATERIAL FROM THE RESHAPING OF THE EXISTING A-9 REPOSITORY CONTAMINATED FILL, CONTAMINATED FILL FROM THE CONTRUCTION WATER PIPELINE TRENCH CLEANUP, THE GHP-1 CLEANUP AREA AND THE WINDBLOWN CLEANUP MATERIAL. FILL MATERIAL PLACED, COMPACTED AND TESTED IN 1 FOOT LIFTS - APPROX. 22 LIFTS
- CONTAMINATED FILL COMPACTION TEST LOCATIONS. 2003 FILL MATERIAL FROM THE RESHAPING OF THE EXISTING A-9 REPOSITORY CONTAMINATED FILL. FILL MATERIAL PLACED, COMPACTED AND TESTED IN 1 FOOT LIFTS - APPROX. 8 LIFTS

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

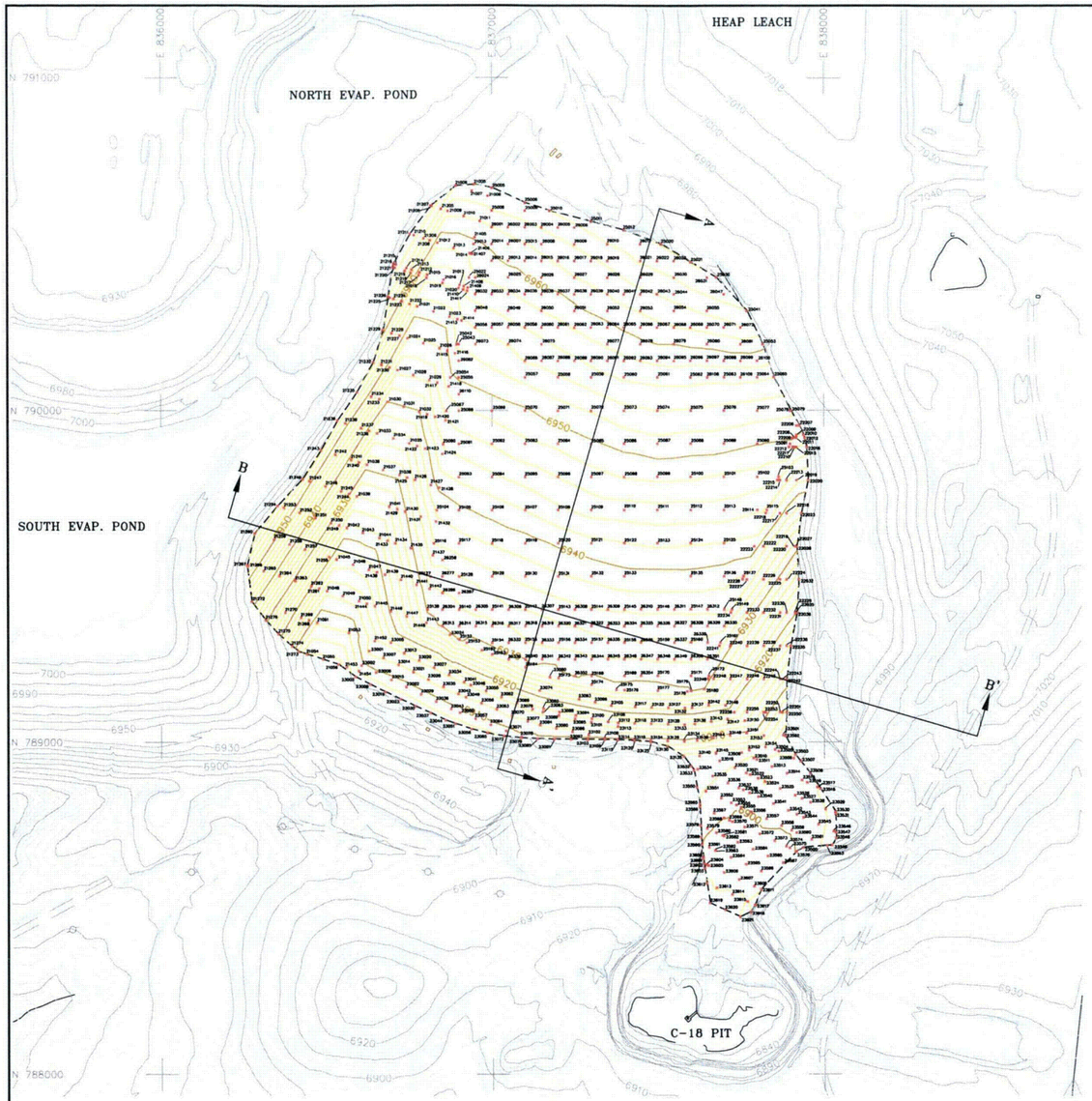
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

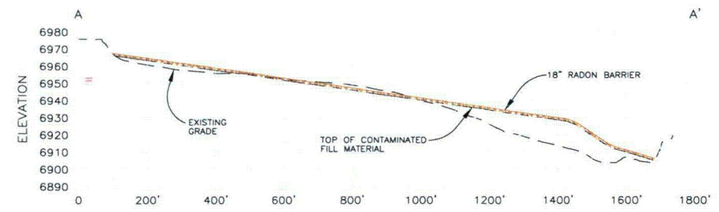
AS BUILT

A-9 REPOSITORY
2001, 2002 AND 2003
COMPACTION TEST LOCATIONS
CONTAMINATED FILL AREA

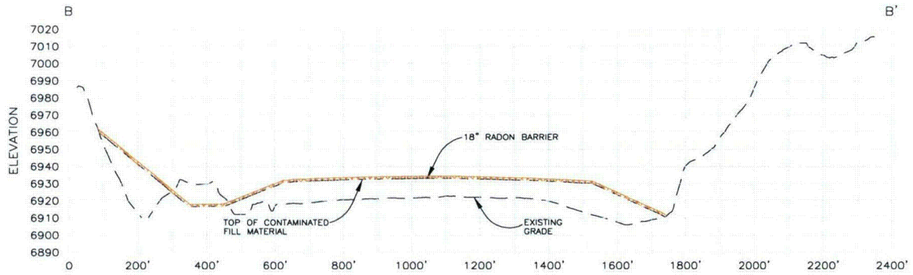
GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-04-AB SHEET 4 OF 12





SECTION A–A'
SCALE: HORIZ. 1" = 200'
VERT. 1" = 40'



SECTION B–B'
SCALE: HORIZ. 1" = 200'
VERT. 1" = 40'

PROFILE LEGEND:

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

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 RADON BARRIER FILL AREA
- RADON BARRIER FILL SURVEY VERIFICATION POINT
- LIMIT OF RADON BARRIER SOILS

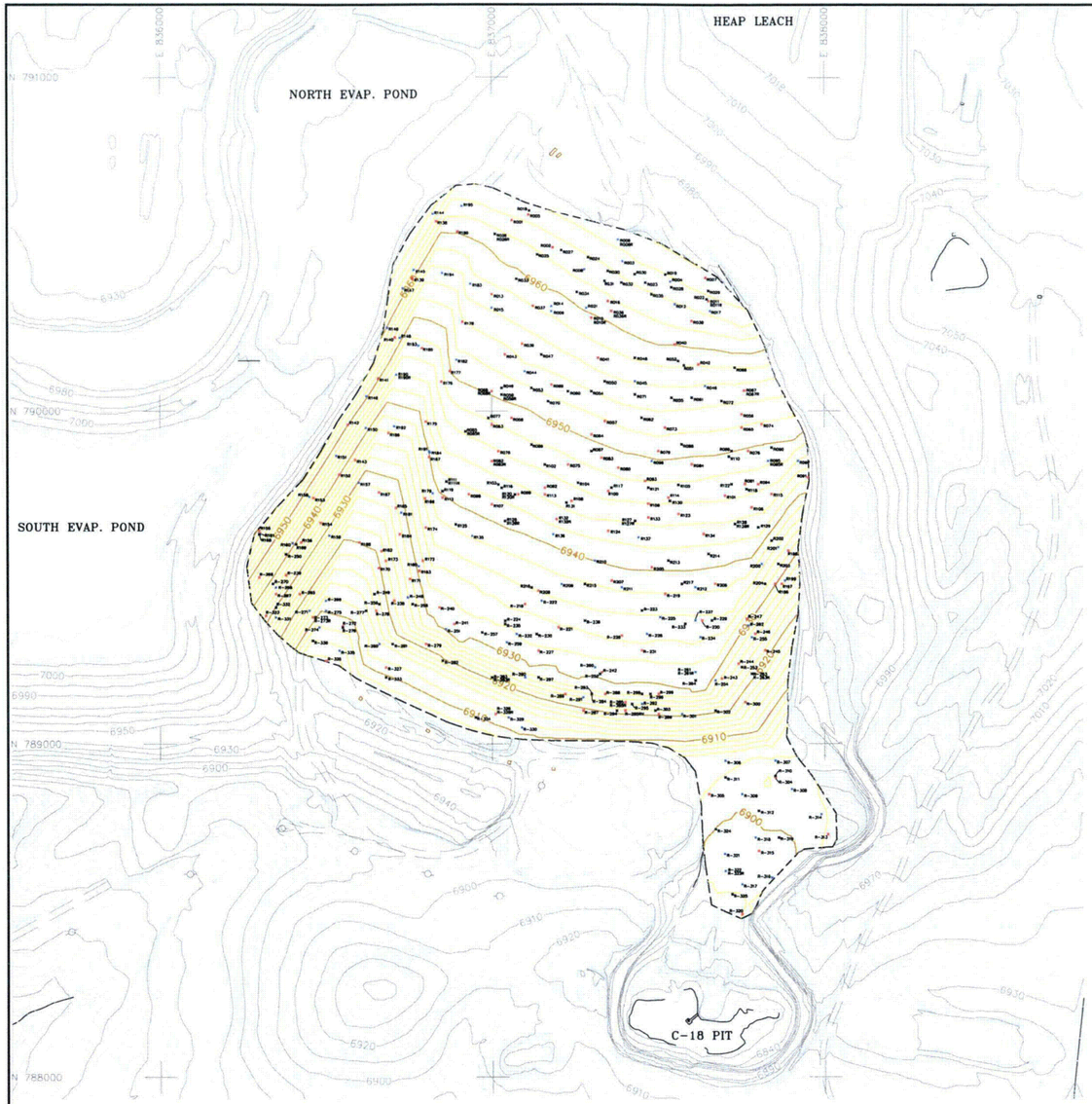
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

A–9 REPOSITORY
FINAL CONTOURS AND SURVEY VERIFICATION POINTS RADON BARRIER

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH–A9–05–AB SHEET 5 OF 12



LEGEND:

- EXISTING 1997 AERIAL TOPOGRAPHY (7000)
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID (N 794,000)
- FINISH GRADE TOPOGRAPHY RADON BARRIER FILL AREA (6960)
- LIMIT OF RADON BARRIER SOILS
- 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'

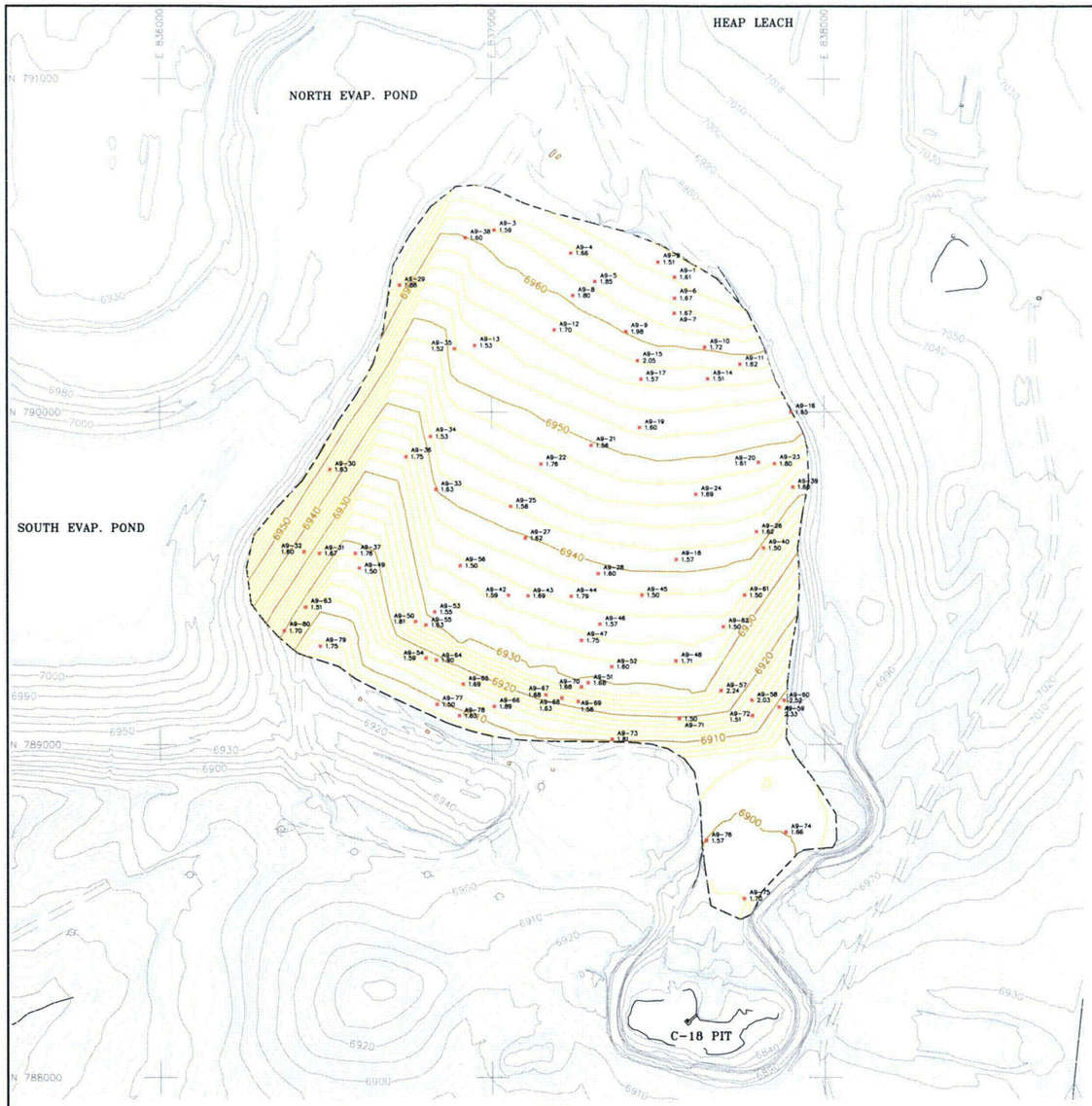
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

A-9 REPOSITORY
COMPACTION TEST LOCATIONS
RADON BARRIER

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-06-AB SHEET 6 OF 12



LEGEND:

- EXISTING 1997 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- FINISH GRADE TOPOGRAPHY RADON BARRIER FILL AREA
- LIMIT OF RADON BARRIER SOILS
- RADON BARRIER FILL VISUAL DEPTH VERIFICATION TEST LOCATION
  A9-18 INDICATES THE VISUAL DEPTH CHECK I.D.
  1.57 INDICATES DEPTH MEASURED IN FEET

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

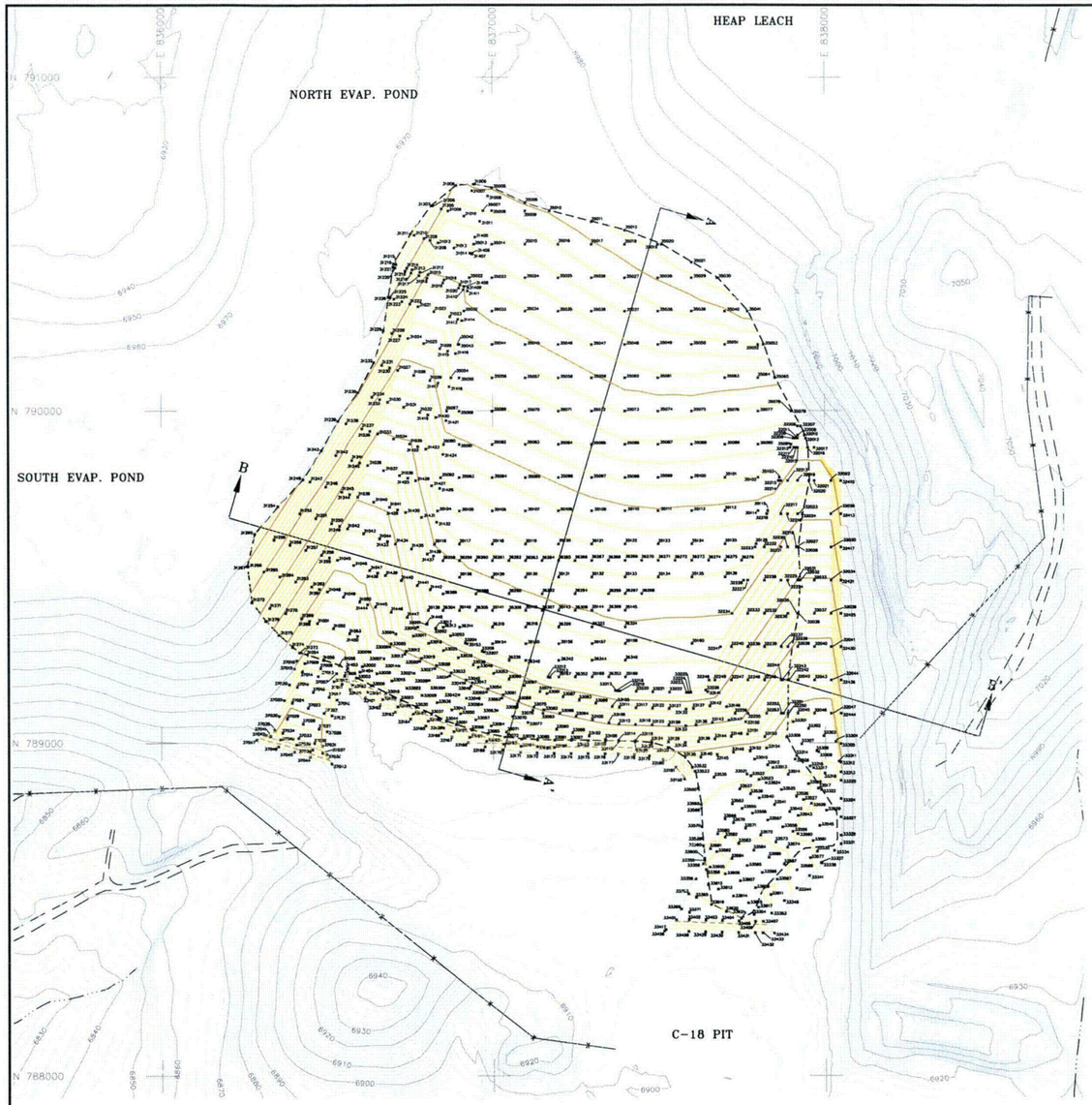
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

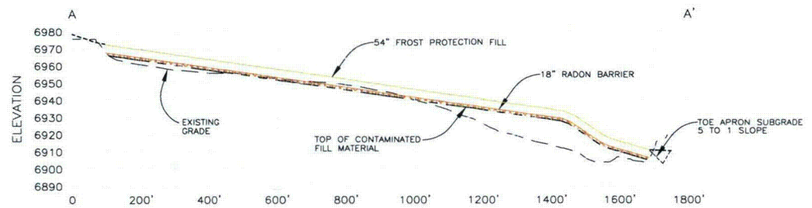
AS BUILT

A-9 REPOSITORY
VISUAL DEPTH CHECK VERIFICATION
TEST LOCATIONS
RADON BARRIER

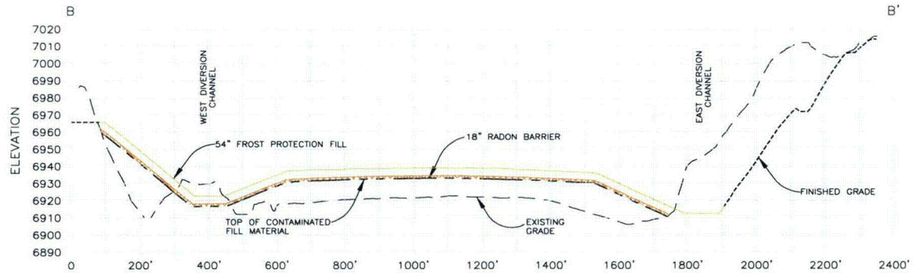
GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-07-AB SHEET 7 OF 12





SECTION A-A'
SCALE: HORIZ. 1" = 200'
VERT. 1' = 40'



SECTION B-B'
SCALE: HORIZ. 1" = 200'
VERT. 1' = 40'

PROFILE LEGEND:

- EXISTING GRADE 1997 AERIAL TOPOGRAPHY
- TOP OF THE CONTAMINATED FILL
- 18" RADON BARRIER
- 54" FROST PROTECTION FILL
- FINISHED GRADING OUTSIDE REPOSITORY

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

LEGEND:

- 7000 — 2000 AERIAL TOPOGRAPHY UPDATED WITH 2006 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY OF THE A-9 REPSOITORY FROST PROTECTION LAYER
- 6910 — FINISH GRADE TOPOGRAPHY OF THE A-9 REPSOITORY TOE APRON EXCAVATION
- FROST PROTECTION FILL AND TOE APRON EXCAVATION SURVEY VERIFICATION POINT
- LIMIT OF RADON BARRIER SOILS

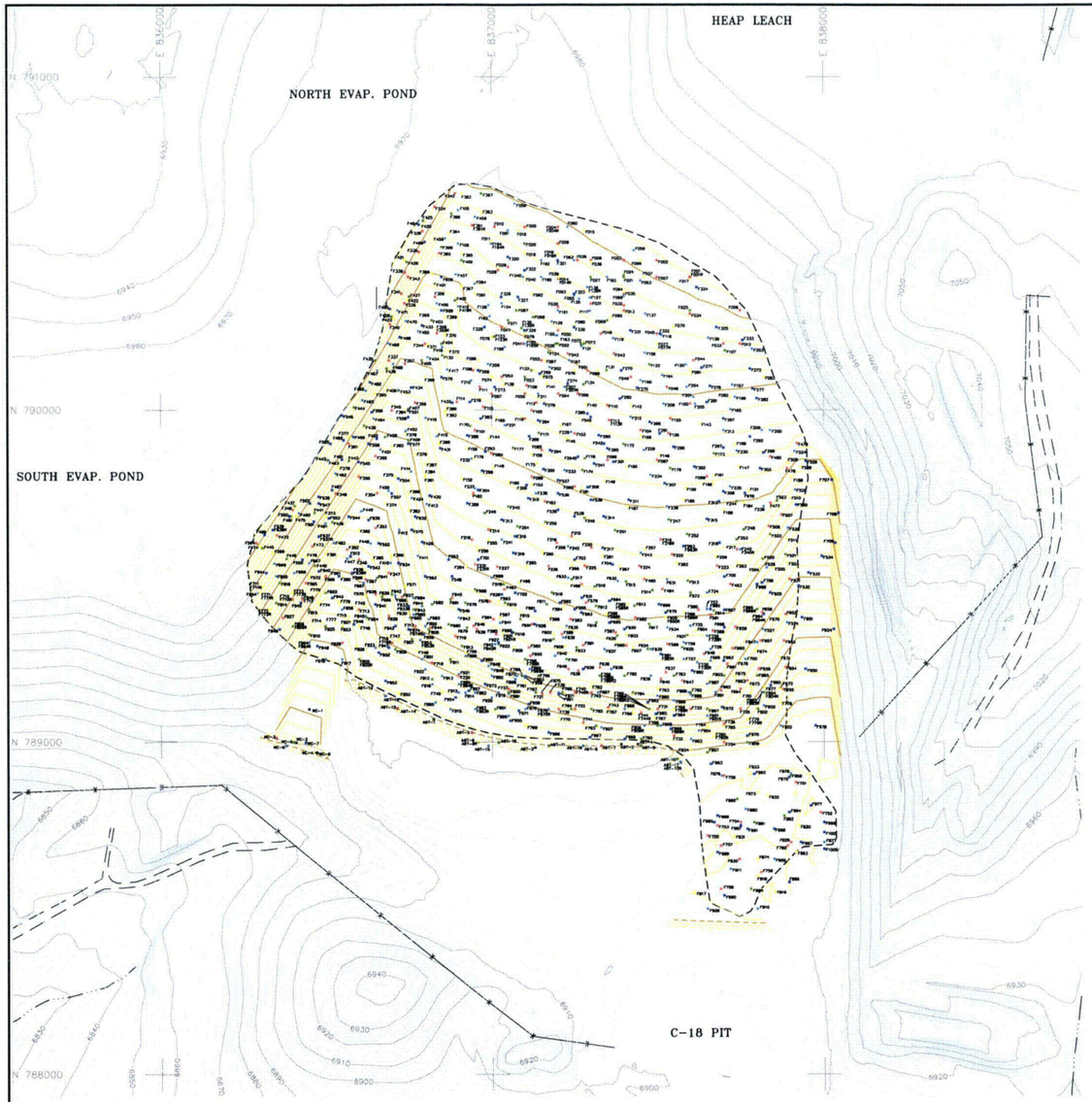
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

A-9 REPOSITORY
FINAL CONTOURS AND SURVEY VERIFICATION POINTS
FROST PROTECTION LAYER
TOE PROTECTION SUBGRADE
AND WEST DIVERSION CHANNEL

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-08-AB



LEGEND:

- 2000 AERIAL TOPOGRAPHY UPDATED WITH 2006 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- FINISH GRADE TOPOGRAPHY OF THE A-9 REPOSITORY FROST PROTECTION LAYER
- LIMIT OF RADON BARRIER SOILS
- FINISH GRADE TOPOGRAPHY OF THE A-9 REPOSITORY TOE APRON EXCAVATION
- 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 FINISHED GRADE
- TOE APRON EXCAVATION SUBGRADE AND BACKFILL COMPACTION TEST LOCATIONS – FILL IN ONE FOOT LIFTS
- WEST DIVERSION CHANNEL EXCAVATION SUBGRADE AND BACKFILL COMPACTION TEST LOCATIONS – FILL IN ONE FOOT LIFTS
- SUBGRADE COMPACTION TEST LOCATIONS

NOTE:

THE SUBGRADE AND THE BACKFILL COMPACTION TESTING FOR THE EAST DIVERSION CHANNEL TOE APRON WAS COMPLETED AND TESTED AS PART OF THE FILL FOR THE C-18 PIT BACKFILL

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

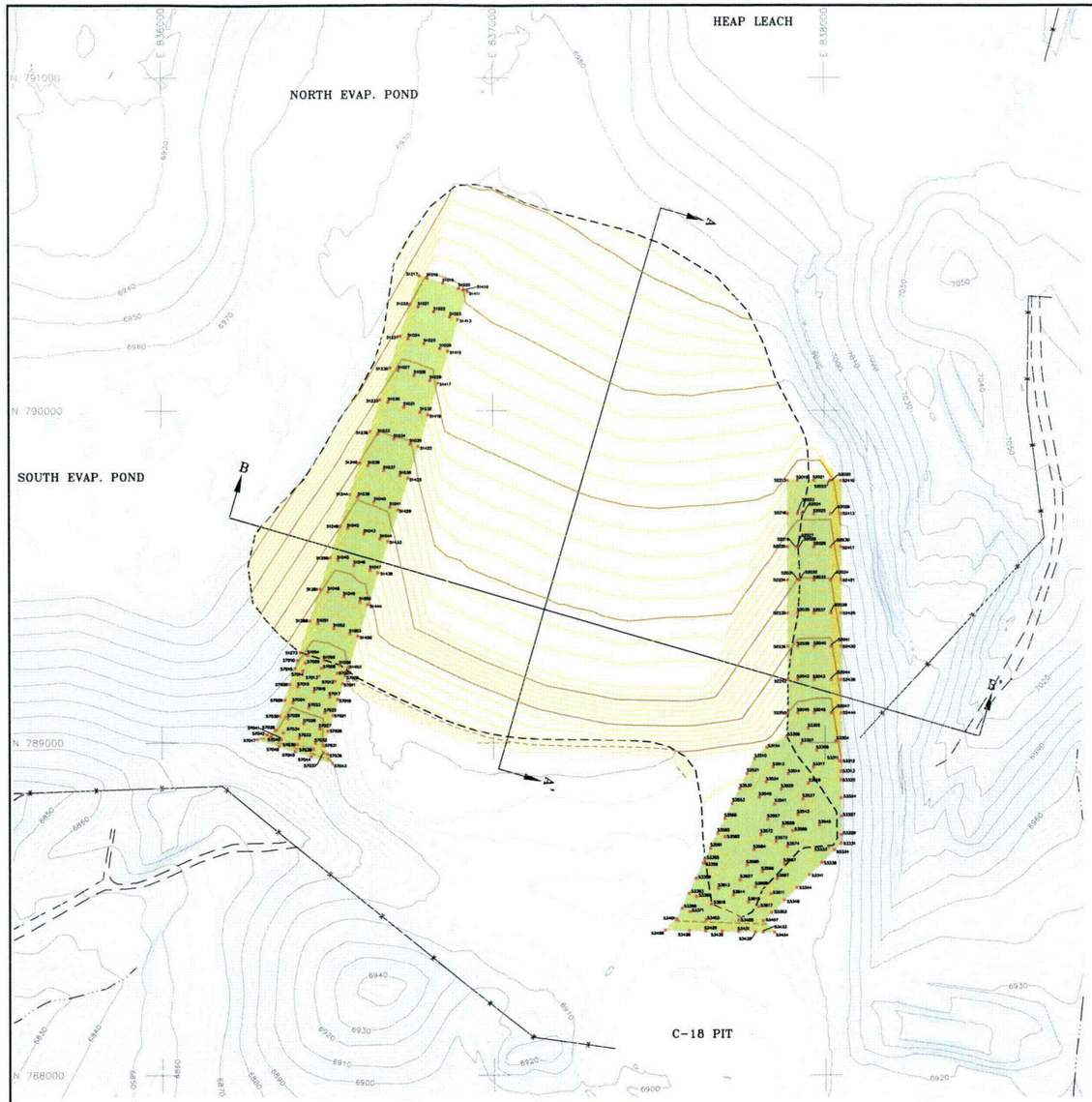
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

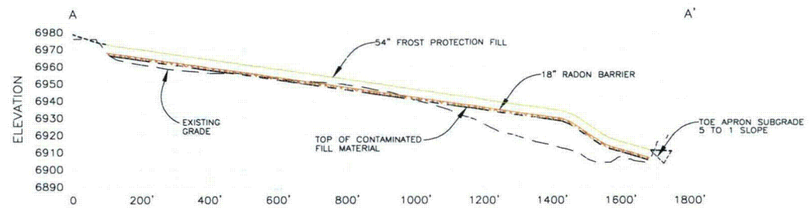
AS BUILT

A-9 REPOSITORY
COMPACTION TEST LOCATIONS
FROST PROTECTION LAYER
TOE PROTECTION SUBGRADE
AND WEST DIVERSION CHANNEL

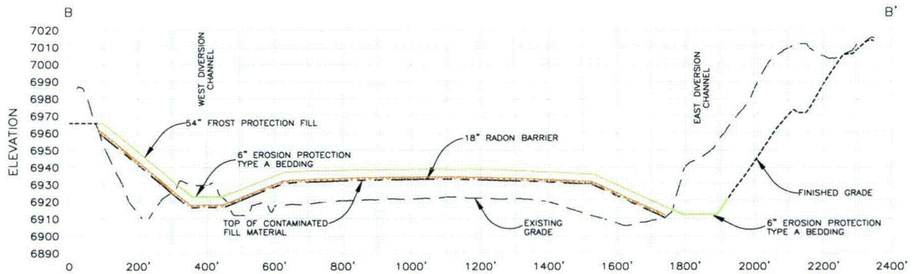
GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-09-AB SHEET 9 OF 12





SECTION A-A'
SCALE: HORIZ. 1" = 200'
VERT. 1" = 40'



SECTION B-B'
SCALE: HORIZ. 1" = 200'
VERT. 1" = 40'

PROFILE LEGEND:

- EXISTING GRADE 1997 AERIAL TOPOGRAPHY
- TOP OF THE CONTAMINATED FILL
- 18" RADON BARRIER
- 54" FROST PROTECTION FILL
- FINISHED GRADING OUTSIDE REPOSITORY
- 6" EROSION PROTECTION TYPE A BEDDING

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

LEGEND:

- 2000 AERIAL TOPOGRAPHY UPDATED WITH 2006 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- FINISH GRADE TOPOGRAPHY OF THE A-9 REPSOITORY FROST PROTECTION LAYER
- FINISH GRADE TOPOGRAPHY OF THE A-9 REPSOITORY TOE APRON EXCAVATION
- TYPE "A" RIPRAP BEDDING SURVEY VERIFICATION POINT
- LIMIT OF RADON BARRIER SOILS

EROSION PROTECTION

- 6-INCHES OF TYPE "A" BEDDING D_{50} = 0.5 INCH

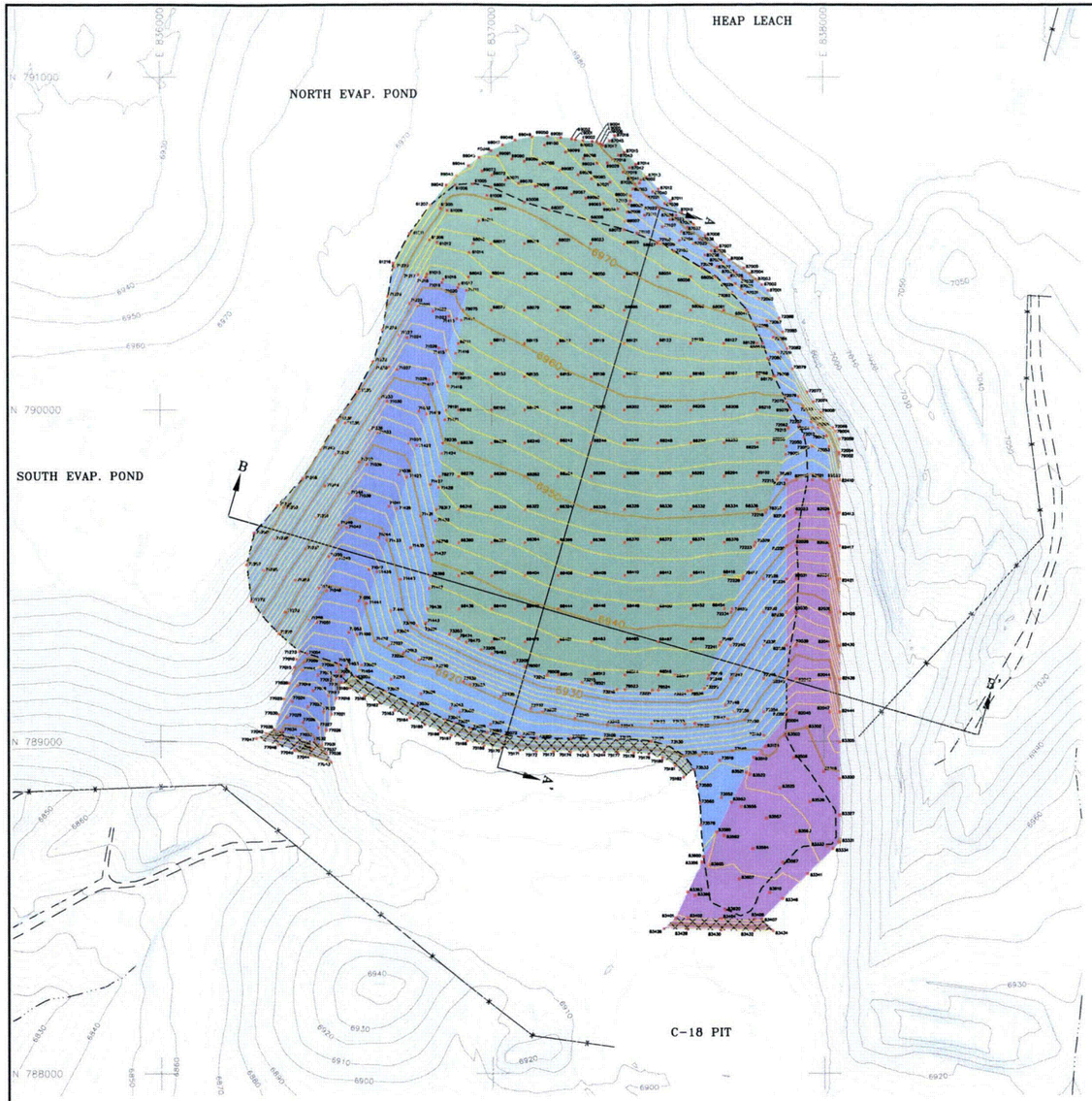
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

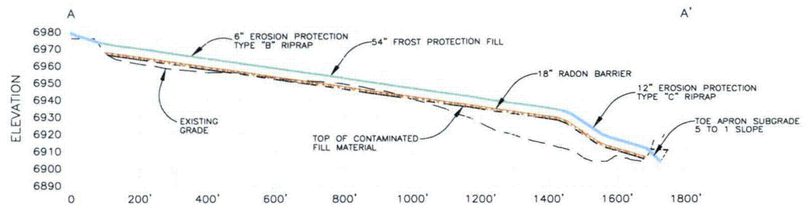
AS BUILT

A-9 REPOSITORY SURVEY VERIFICATION POINTS TYPE "A" BEDDING EROSION PROTECTION PLACEMENT

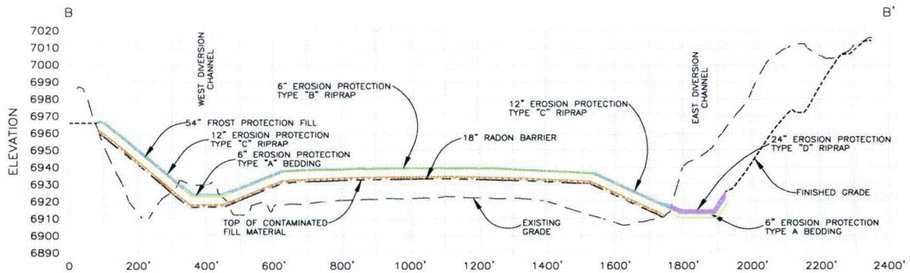
GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-10-AB SHEET 10 OF 12





SECTION A-A'
SCALE: HORIZ. 1" = 200'
VERT. 1' = 40'



SECTION B-B'
SCALE: HORIZ. 1" = 200'
VERT. 1' = 40'

PROFILE LEGEND:

- EXISTING GRADE 1997 AERIAL TOPOGRAPHY
- TOP OF THE CONTAMINATED FILL
- 18" RADON BARRIER
- 54" FROST PROTECTION FILL
- FINISHED GRADING OUTSIDE REPOSITORY
- 6" EROSION PROTECTION TYPE "A" BEDDING
- 6" EROSION PROTECTION TYPE "B" RIPRAP
- 12" EROSION PROTECTION TYPE "C" RIPRAP
- 24" EROSION PROTECTION TYPE "D" RIPRAP

LEGEND:

- 7000 — 2000 AERIAL TOPOGRAPHY UPDATED WITH 2006 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY OF THE A-9 REPSOITORY EROSION PROTECTION LAYER
- RIPRAP SURVEY VERIFICATION POINT
- LIMIT OF RADON BARRIER SOILS

EROSION PROTECTION

- 6-INCHES OF TYPE "B" RIPRAP D_{50} = 3.0 INCH
- 12-INCHES OF TYPE "C" RIPRAP D_{50} = 6.0 INCH
- 12-INCHES OF TYPE "C" RIPRAP D_{50} = 6.0 INCH WITH 6-INCHES OF TYPE "A" BEDDING D_{50} = 0.5 INCH
- 24-INCHES OF TYPE "D" RIPRAP D_{50} = 16.0 INCH WITH 6-INCHES OF TYPE "A" BEDDING D_{50} = 0.5 INCH
- BELOW GRADE TOE APRON

N

200' 0 200'

SCALE IN FEET
CONTOUR INTERVAL : 2'

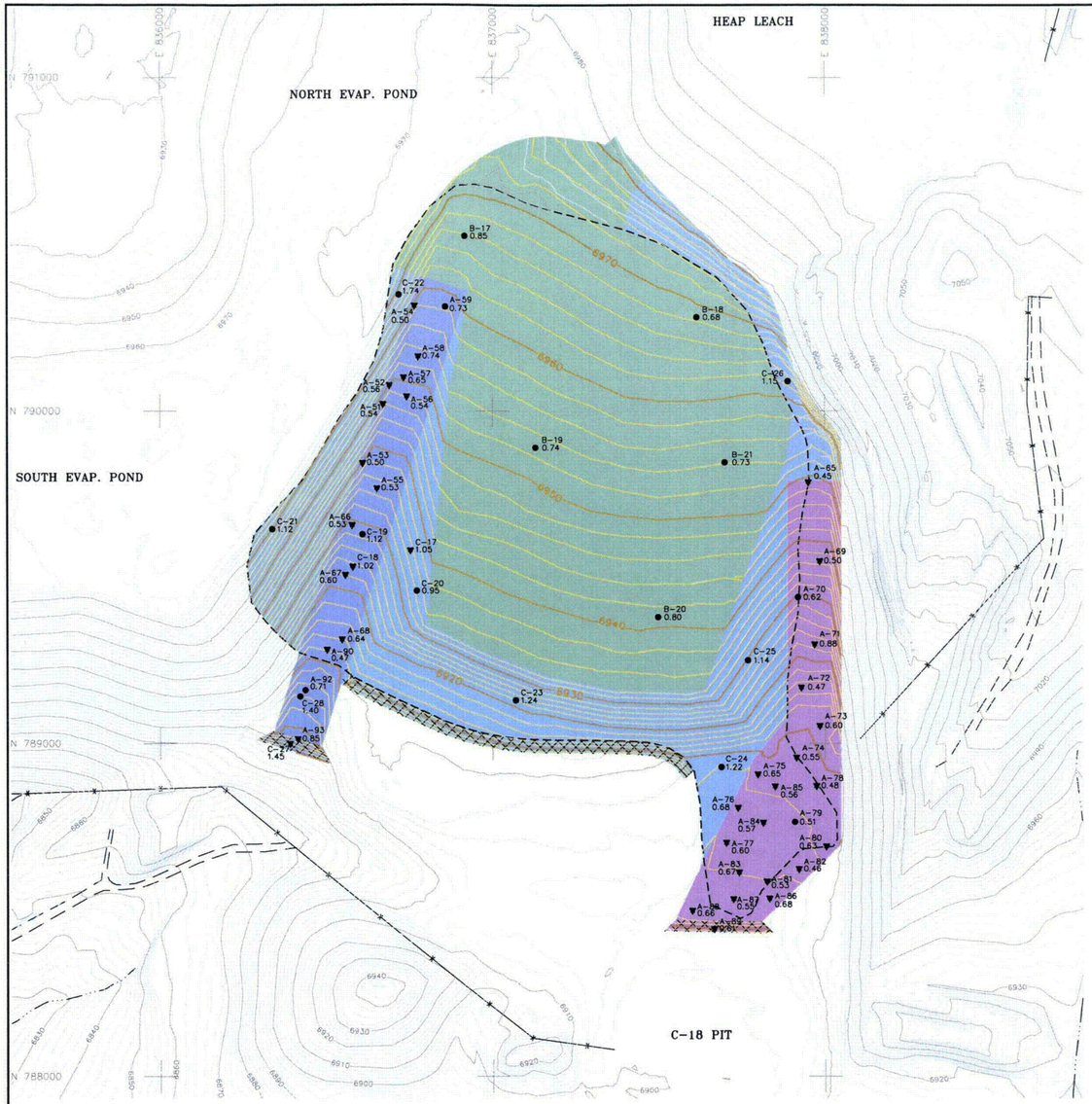
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

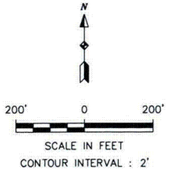
AS BUILT

A-9 REPOSITORY FINAL CONTOURS AND SURVEY VERIFICATION POINTS EROSION PROTECTION PLACEMENT

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-11-AB SHEET 11 OF 12





LEGEND:

- 2000 AERIAL TOPOGRAPHY UPDATED WITH 2006 SURVEYS
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 — UMETCO 1000' SITE GRID
- 6960 — FINISH GRADE TOPOGRAPHY OF THE A-9 REPSOITORY EROSION PROTECTION LAYER
- LIMIT OF RADON BARRIER SOILS
- ● B-21 0.73 — IN-PLACE VISUAL DEPTH CHECK AND IN-PLACE GRADATION SAMPLE
  - A-6 = VISUAL DEPTH CHECK FIELD IDENTIFICATION NUMBER
  - GHP2 A-4 = IN-PLACE GRADATION SAMPLE FIELD IDENTIFICATION NUMBER
  - 0.61 = DEPTH MEASURED IN FEET
- ▼ A-67 0.60 — IN-PLACE VISUAL DEPTH CHECK
  - A-11 = VISUAL DEPTH CHECK FIELD IDENTIFICATION NUMBER
  - 0.53 = DEPTH MEASURED IN FEET
- 6-INCHES OF TYPE "B" RIPRAP D_{50} = 3.0 INCH
- 12-INCHES OF TYPE "C" RIPRAP D_{50} = 6.0 INCH
- 12-INCHES OF TYPE "C" RIPRAP D_{50} = 6.0 INCH WITH 6-INCHES OF TYPE "A" BEDDING D_{50} = 0.5 INCH
- 24-INCHES OF TYPE "D" RIPRAP D_{50} = 16.0 INCH WITH 6-INCHES OF TYPE "A" BEDDING D_{50} = 0.5 INCH
- BELOW GRADE TOE APRON

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

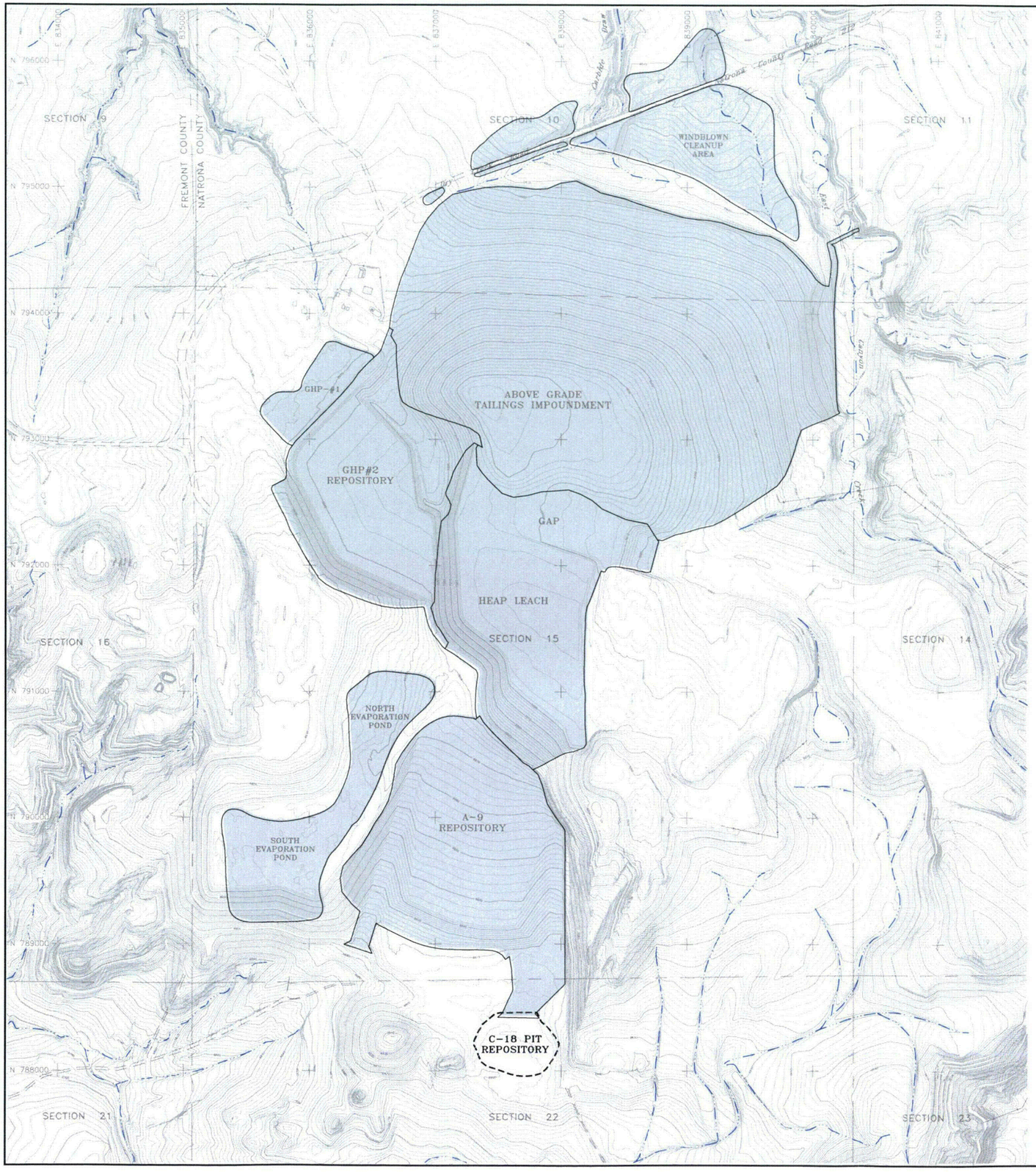
AS BUILT

A-9 REPOSITORY
IN-PLACE GRADATION
AND VISUAL DEPTH CHECK TEST LOCATIONS
EROSION PROTECTION PLACEMENT

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-A9-12-AB SHEET 12 OF 12

C-18 Pit Drawings



SHEET NO.	TITLE
1 OF 4	FINAL C-18 PIT RECLAMATION SITE PLAN REFLECTING POST-RECLAMATION CONSTRUCTION FINAL GRADES
2 OF 4	RECLAMATION OF THE C-18 PIT COMPACTION TEST LOCATIONS BACKFILL MATERIAL ELEVATION 6844 TO ELEVATION 6863
3 OF 4	RECLAMATION OF THE C-18 PIT COMPACTION TEST LOCATIONS BACKFILL MATERIAL ELEVATION 6864 TO ELEVATION 6883
4 OF 4	RECLAMATION OF THE C-18 PIT FINAL CONTOURS AND COMPACTION TEST LOCATIONS BACKFILL MATERIAL ELEVATION 6884 TO ELEVATION 6902

LEGEND

- 2006 FINISHED GRADE TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- N 794,000 UMETCO 1000' SITE GRID
- C-18 BOUNDARY

N

400' 0 400'

SCALE IN FEET
CONTOUR INTERVAL : 2'

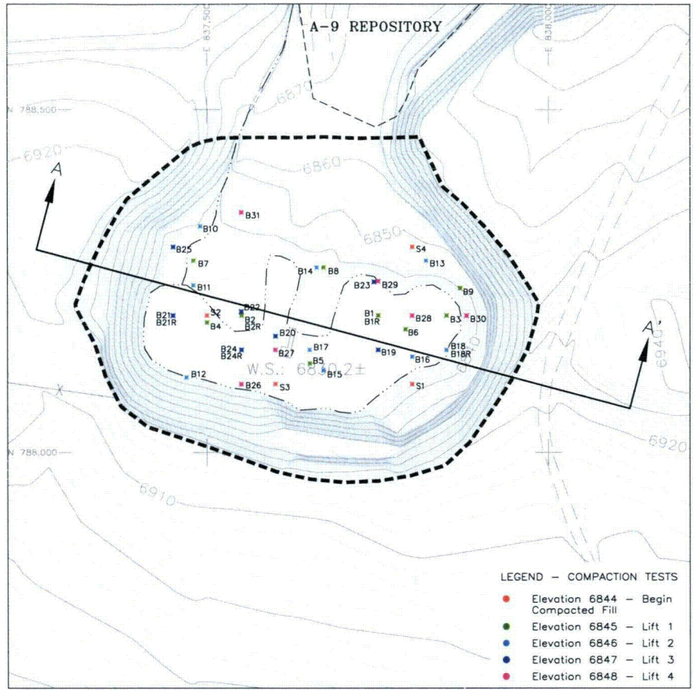
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

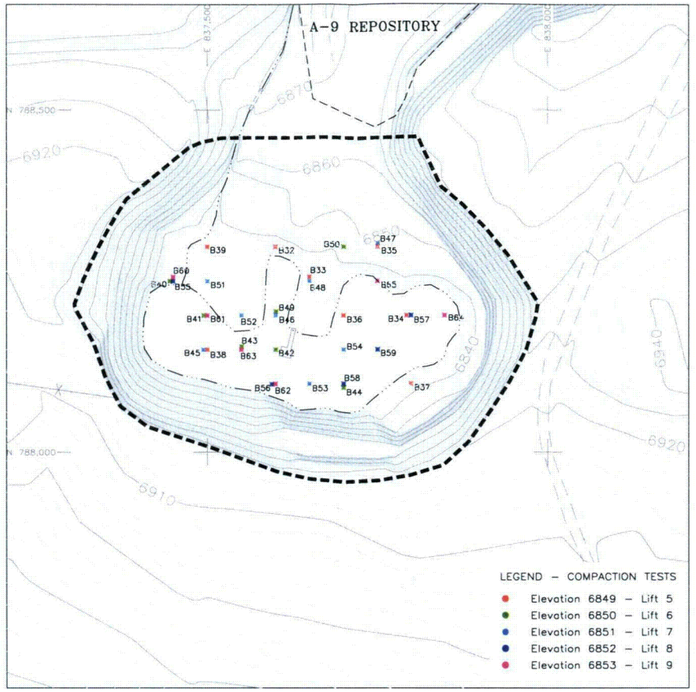
FINAL C-18 PIT RECLAMATION SITE PLAN REFLECTING POST-RECLAMATION CONSTRUCTION FINAL GRADES

GAS HILLS, WYOMING

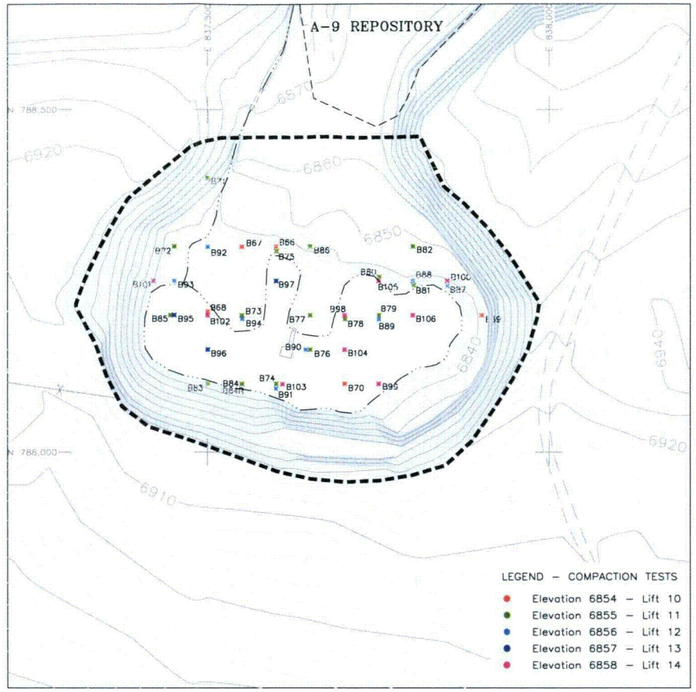
DATE: JUNE 2007 DWG: GH-C18-01-AB SHEET 1 OF 4



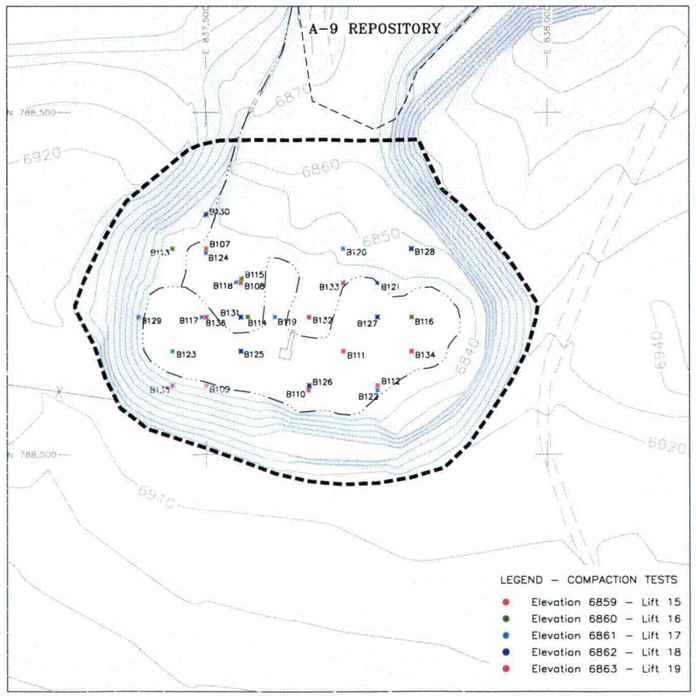
2001 COMPACTION TEST LOCATIONS
ELEVATION 6844 TO 6848



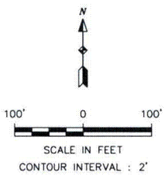
2001 COMPACTION TEST LOCATIONS
ELEVATION 6849 TO 6853



2001 COMPACTION TEST LOCATIONS
ELEVATION 6854 TO 6858

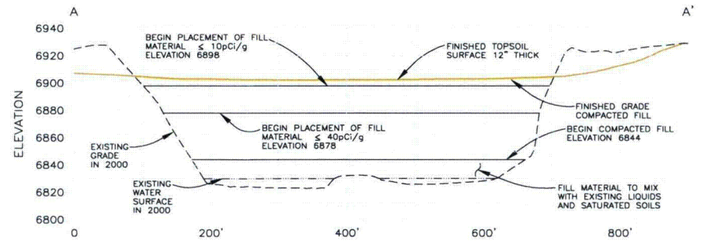


2001 COMPACTION TEST LOCATIONS
ELEVATION 6859 TO 6863



LEGEND:

- EXISTING 2000 AERIAL TOPOGRAPHY
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- C-18 PIT BOUNDARY
- COMPACTION TEST LOCATIONS AS NOTED



SECTION A-A'
SCALE: HORIZ. 1" = 100'
VERT. 1" = 50'

PROFILE LEGEND:

- EXISTING GRADE 2000 AERIAL TOPOGRAPHY
- EXISTING WATER LEVEL 2000 AERIAL TOPOGRAPHY
- FINISHED GRADE COMPACTED FILL – 2005
- FINISHED GRADE TOPSOIL PLACEMENT – 2006

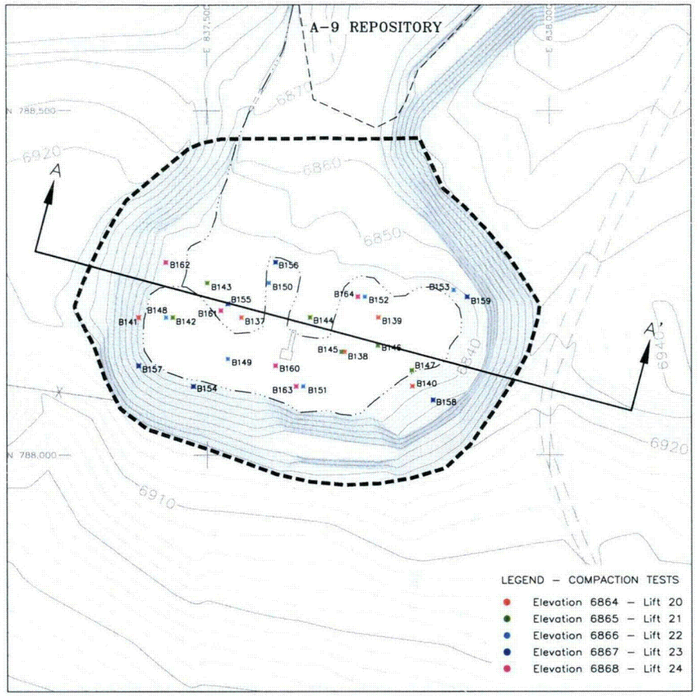
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

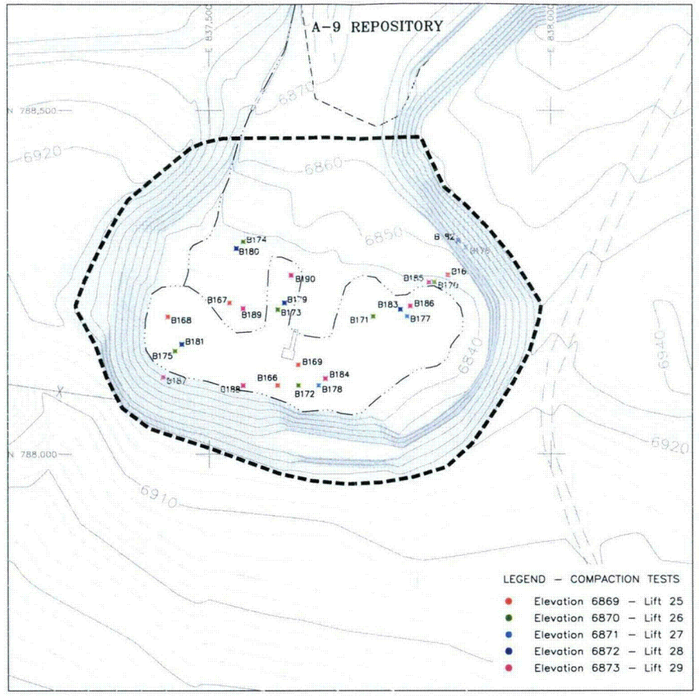
RECLAMATION OF THE C-18 PIT
COMPACTION TEST LOCATIONS
BACKFILL MATERIAL
ELEVATION 6844 TO ELEVATION 6863

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH-C18-02-AB



2001 COMPACTION TEST LOCATIONS
ELEVATION 6864 TO 6868



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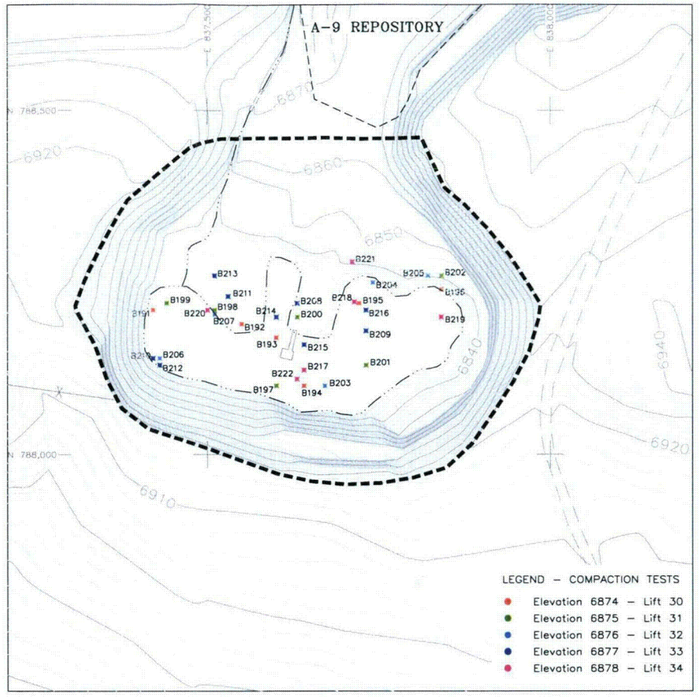
ELEVATION 6869 TO 6873



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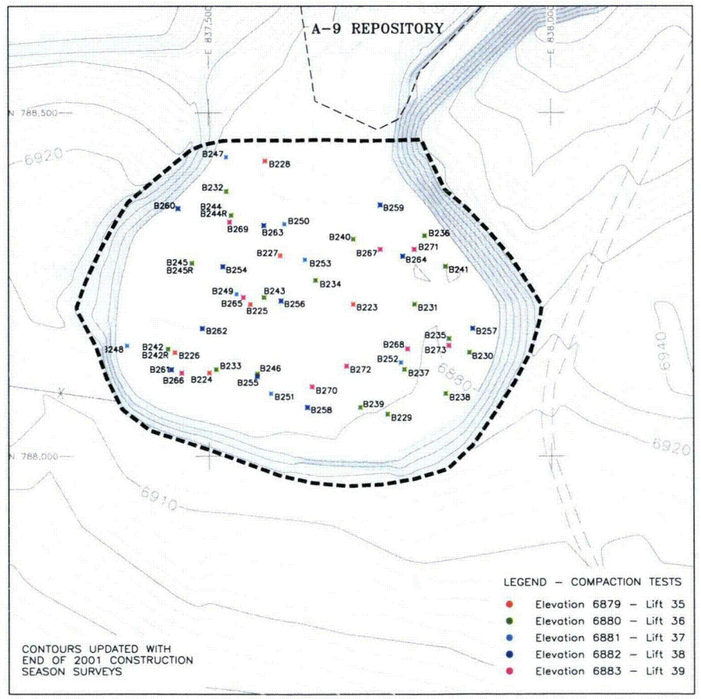
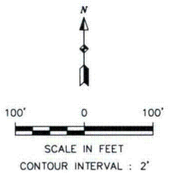
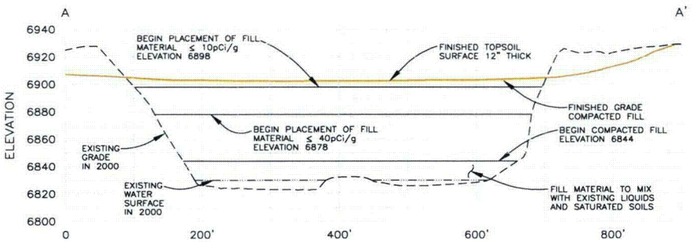


2001-2002 COMPACTION TEST LOCATIONS
ELEVATION 6879 TO 6883



LEGEND:

- EXISTING 2000 AERIAL TOPOGRAPHY CONTOURS UPDATED AS NOTED
- DRAINAGE PATH/PONDED WATER
- UN-PAVED ROADS
- UMETCO 1000' SITE GRID
- C-18 PIT BOUNDARY
- COMPACTION TEST LOCATIONS AS NOTED



SECTION A-A'
SCALE: HORIZ. 1" = 100'
VERT. 1' = 50'

PROFILE LEGEND:

- EXISTING GRADE 2000 AERIAL TOPOGRAPHY
- EXISTING WATER LEVEL 2000 AERIAL TOPOGRAPHY
- FINISHED GRADE COMPACTED FILL – 2005
- FINISHED GRADE TOPSOIL PLACEMENT – 2006

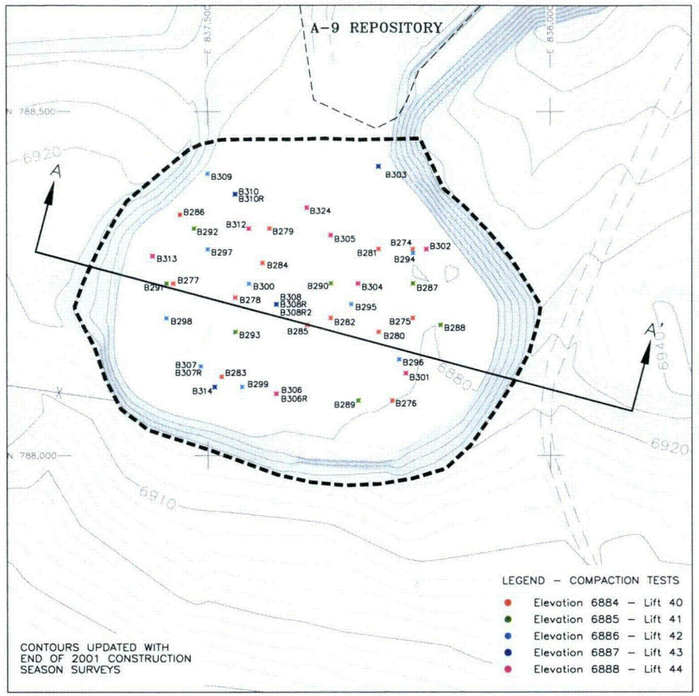
Umetco Minerals Corporation
2754 COMPASS DRIVE, SUITE 280, GRAND JUNCTION, CO 81506

AS BUILT

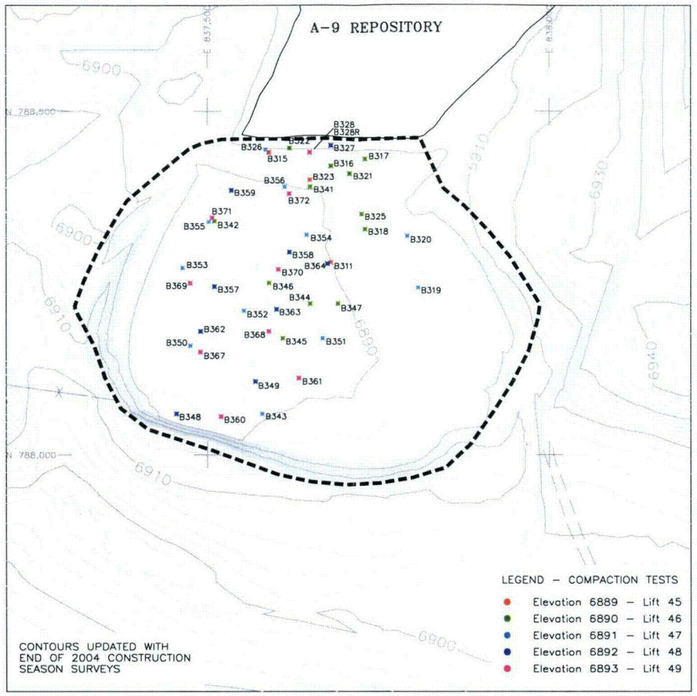
RECLAMATION OF THE C-18 PIT
COMPACTION TEST LOCATIONS
BACKFILL MATERIAL
ELEVATION 6864 TO ELEVATION 6883

GAS HILLS, WYOMING

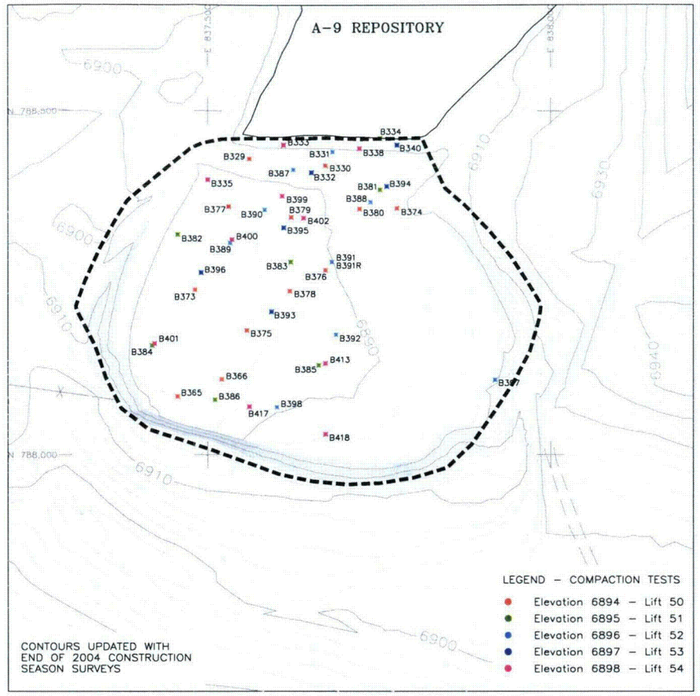
DATE: JUNE 2007 DWG: GH-C18-03-AB SHEET 3 OF 4



2002–2003 COMPACTION TEST LOCATIONS
ELEVATION 6884 TO 6888



2004–2005 COMPACTION TEST LOCATIONS
ELEVATION 6889 TO 6893



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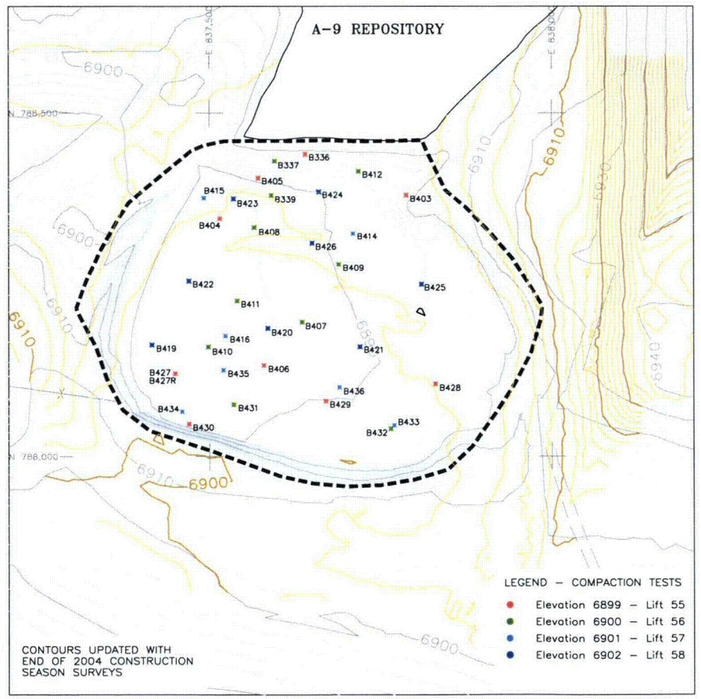
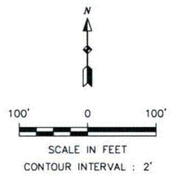
ELEVATION 6894 TO 6898

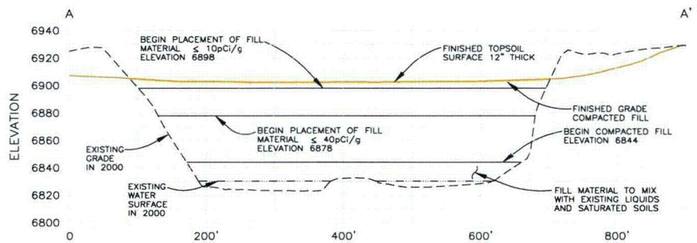


2005 COMPACTION TEST LOCATIONS
ELEVATION 6899 TO 6902



LEGEND:

- EXISTING 2000 AERIAL TOPOGRAPHY CONTOURS UPDATED AS NOTED
- DRAINAGE PATH/PONDED WATER
- UN–PAVED ROADS
- UMETCO 1000' SITE GRID
- C–18 PIT BOUNDARY
- COMPACTION TEST LOCATIONS AS NOTED
- FINISH GRADE TOPOGRAPHY 2006 SURVEY



SECTION A-A'
SCALE: HORIZ. 1" = 100'
VERT. 1' = 50'

PROFILE LEGEND:

- EXISTING GRADE 2000 AERIAL TOPOGRAPHY
- EXISTING WATER LEVEL 2000 AERIAL TOPOGRAPHY
- FINISHED GRADE COMPACTED FILL – 2005
- FINISHED GRADE TOPSOIL PLACEMENT – 2006

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

AS BUILT

RECLAMATION OF THE C–18 PIT
FINAL CONTOURS AND
COMPACTION TEST LOCATIONS
BACKFILL MATERIAL
ELEVATION 6884 TO ELEVATION 6902

GAS HILLS, WYOMING

DATE: JUNE 2007 DWG: GH–C18–04–AB SHEET 4 OF 4

ATTACHMENT 1

NRC Approval of the Enhanced Reclamation Design for the A-9 Repository: License Amendment 42

Submitted by letter dated December 9, 1999
TER dated November 16, 1999

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

December 9, 1999

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

SUBJECT: DESIGN FOR ENHANCEMENT OF THE PREVIOUSLY APPROVED RECLAMATION PLAN FOR THE A-9 REPOSITORY FOR MATERIAL LICENSE SUA-648, AMENDMENT NO. 42 , FOR THE UMETCO MINERALS CORPORATION, GAS HILLS SITE

Dear Mr. Sealy:

The U.S. Nuclear Regulatory Commission (NRC) has completed its review of the enhanced reclamation design for the Umetco Minerals Corporation (Umetco) Gas Hills site A-9 tailings repository submitted with your letter dated October 27, 1998. The plan was supplemented by data in your responses to comments on December 10, 1998, and March 29, 1999. The reclamation cost estimate for the proposed A-9 enhanced reclamation plan was submitted November 20, 1998, and will be approved with the 1999 annual surety update.

An environmental review was considered necessary since this licensing action allows enlargement of the tailings disposal area. An environmental assessment was performed (Enclosure 1) in accordance with 10 CFR 51.21, and the staff concluded that the environmental impacts associated with the proposed licensing action were not significant, considering the mitigation efforts proposed by Umetco. A final finding of no significant impact was prepared in accordance with 10 CFR 51.32, and published in the Federal Register on November 26,1999 (Enclosure 2).

The NRC staff has concluded that Umetco's enhanced reclamation design will meet NRC requirements stated in 10 CFR Part 40, Appendix A, Criteria 4(c), (d), and (e); and 6(1) with regard to reasonable assurance of stability, control of contaminated material, and limitation of radon flux. A copy of the staff's technical evaluation report for this action is provided in Enclosure 3.

Your amendment request and the wording for the revised license condition, as discussed with your staff on October 15, 1999, are acceptable. Therefore, Source Material License SUA-648 will be amended by revising License Condition No. 58 to incorporate the enhanced plan and associated requirements as were discussed with your staff. All other conditions of the license shall remain the same. The license is being reissued to incorporate the above modifications and is provided in Enclosure 4.

If you have any questions concerning this letter or the enclosures, please contact Ms. Elaine Brummett of my staff at (301) 415-6606.

Sincerely,

Thomas H. Essig, Chief
Uranium Recovery and
Low Level Waste Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

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

Enclosures: 1. Environmental Assessment
2. FONSI
3. Technical Evaluation Report
4. Revised License

cc: R. Chancellor, WDEQ
M. Moxley, WDEQ
R. Edge, DOE, CO

TECHNICAL EVALUATION REPORT
UMETCO ENHANCED A-9 RECLAMATION PLAN

DATE: November 16, 1999

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

LICENSEE: Umetco Minerals Corporation

FACILITY: East Gas Hills Uranium Mill Site,
Natrona County, Wyoming,

PROJECT MANAGER: E. Brummett

TECHNICAL REVIEWERS: E. Brummett, D. Rom, T. L. Johnson

SUMMARY AND CONCLUSIONS:

The U.S. Nuclear Regulatory Commission (NRC) staff concludes that the proposed A-9 tailings repository (disposal cell) enhanced design, site-wide grading plan, and reclamation plans for the north and south evaporation ponds, and the C-18 pit 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 ($pCi/m^2/s$) for a period of 1000 years, or in any case, at least 200 years. Compliance with Criterion 6(7), regarding disposal design to minimize further maintenance, and Criterion 12, regarding no on-going active maintenance, were also acceptably demonstrated. Criterion 6(7) also requires 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, the proposed cover design would also control the dispersion into air and surface water of the non-radiological wastes in the disposal cell.

DESCRIPTION OF LICENSEE'S AMENDMENT REQUEST:

The licensee requested approval of a revised reclamation plan for the A-9 disposal cell, the site-wide grading plan, and the reclamation plans for the C-18 pit, and north and south evaporation ponds by letter dated October 27, 1998. The plan was supplemented by data in the licensee's responses to comments on December 10, 1998, and March 29, 1999. Approval of the A-9 Enhanced Reclamation Plan requires an amendment to License Condition No. 58. The A-9 enhanced reclamation plan cost estimate (for surety purposes) was submitted November 20, 1998, and determined adequate by staff. The increased amount has been incorporated by Umetco into the 1999 annual site surety update.

The original reclamation plan for the A-9 cell was approved October 7, 1987. An environmental assessment of the below-grade tailings disposal in the A-9 pit was done (Dames and Moore, 1979), and the Umetco site Final Environmental Statement was published in 1980 (NRC, NUREG-0702). Because the A-9 enhanced reclamation plan includes the site-wide grading plan, enlargement of the A-9 cell, and reclamation of two evaporation ponds, an environmental assessment has been prepared by NRC staff.

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. Reclamation plans have been approved for the two other disposal areas on the site, the heap leach and above-grade impoundments, and their cover construction is nearly complete.

The A-9 pit, a former surface uranium mine, was lined with 3 feet of compacted clay and an underdrain system was installed to move tailings leachate (seepage) to a sump where the fluid was pumped to an evaporation pond. The pit was used for mill tailings disposal from 1979 until 1984. Additional tailings and waste placed since then has brought the total volume of waste to approximately 3.5 million cubic yards (cyds) and an additional 0.5 million cyds may be placed during the final decommissioning activities. In the NRC-approved 1987 reclamation design for the A-9 cell, the cover consisted of a 1-foot (30.5 cm)-thick interim cover, 1-foot (30.5 cm) clay radon barrier, 1-foot (30.5 cm) filter layer, 6.5-foot (76.2 cm) frost protection/spoil layer, and a 6-inch (15.2 cm) topsoil layer. An interim cover from 1 to 5 feet (30.5 to 152 cm) thick was placed over the entire A-9 area in 1988 and 1989. The 1998 enhanced plan proposes major modifications to the 1987 plan that include:

1. Reducing the frost protection soil layer to 4.5 feet (1.37 m) and increase the clay radon barrier to 1.5 feet (45 cm) for a total soil cover thickness of 7 feet (1.8 m) (previously 10 feet (1 m))

2. Changing the vegetative cover to 6 to 12 inches (15 to 30 cm) of riprap (rock)

3. Grading the site for proper drainage, including east and west diversion ditches

4. Reclaiming the north and south evaporation ponds

5. Reclaiming the C-18 pit

The 51-acre A-9 disposal cell will need up to 23 feet (7 m) of fill in some areas to bring the surface to the proposed grade. The enhanced design uses a rock cover to improve the long-term erosion protection for the cover.

The north and south ponds were constructed in 1979 over mine overburden and cover 22 acres. In 1993, the ponds were dry and the upper portion of the clay liner was excavated and placed in the A-9 cell. The plan indicates that the remaining clay liner also will be excavated and placed in the A-9 cell. Umetco provided data indicating that residual byproduct material was not detectable in the rocky material under the pond liners (Design Report Part 1, Section 6), so a cover will not be required for the ponds area.

The C-18 former uranium surface mine pit is about 80 feet (24.4 m) deep, 500 feet (152.4 m) wide at the surface, and covers 5.3 acres. The pit may have some byproduct material at the bottom from site drainage, therefore, Umetco has proposed to treat this pit as a repository with the required engineered cover that meets the long-term radon flux limit.

The A-9 enhanced 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. Decommissioning activities, such as site surface (soil and buildings) and ground-water cleanup are addressed in other documents, but infiltration data for the A-9 and C-18 disposal cell covers and potential effects on groundwater were reviewed.

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 in the A-9 repository with a compacted soil cover protected by a rock cover. The slope of the cover will vary from about 3 percent at the upstream end to a maximum of about 13 percent at the downstream end. The steeper slopes will terminate in a rock apron/toe. In addition, riprap-protected drainage channels will be constructed to convey flood flows away from the site. These channels will also have an apron/toe to prevent gully intrusion into the channel outlet.

The reclamation of the C-18 pit involves placement of about 80 feet (24 m) of backfill into the pit to bring the pit material to surface level. Grading will be done to promote drainage away from the pit, in accordance with the site-wide grading plan. Erosion protection beyond that associated with the site grading plan is not needed because of the depth of fill.

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 8.7 inches (22 cm) 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 A-9 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 cover using the Rational Formula, which provides a standard method for estimating flood discharges for small drainage areas. Umetco estimated the peak

flow rates at various locations along the cover, depending on the slope length and the magnitude of the slope. Based on staff review of the calculations, the estimates are considered to be conservative.

PMF flow rates for the apron were computed similarly to the design flow rate for the cover slope. As discussed above, the flow rates are considered to be conservative.

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 cover slopes (less than 10 percent), 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. Riprap requirements for the steeper cover slopes (greater than 10 percent) 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.

1.3.2 Aprons/Toes

The designs of the aprons at the downstream ends of the cover and at the channel outlets were based on the following criteria: (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 aprons. Additional detailed discussion of the riprap design of various components of the aprons can be found below.

1.3.3 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 cover has been sized to withstand the erosive velocities resulting from a PMP, as discussed above. For a large area of the cover where the slope is about 3 percent, Umetco proposes to use a 6-inch (15-cm)-thick layer of Type B rock with a minimum D_{50} of about 3 inches (7 cm). For the steeper 13 percent slopes of the cover at the downstream end, Umetco proposes to use a 12-inch (30.5 cm) layer of Type C rock with a D_{50} of about 6 inches (15 cm). 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 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 using several methods to determine the extent and depth of the toe. The actual toe area will be an extension of the steeper cover slope where it meets natural ground and will extend to a depth of 6.5 feet (2 m) below grade. Type C riprap, with an average D_{50} of about 6 inches (15 cm) 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 that will occur to the graded natural ground slope just downstream of the toe. Umetco determined that the design condition for the depth of scour would be controlled by gully headcutting into the toe area. Umetco estimated the 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 would be about 6.5 feet (2 m) and proposes to extend the toe to this depth. The maximum scour depths for the channel outlets were determined similarly. Staff review of the proposed gully depths indicates that they have been acceptably 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.

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

For this site, some sediment from the upland drainage areas can be 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. Umetco provided analyses to justify that the channel velocities are high enough to prevent sediment accumulations in 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 thickness 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 Site Grading Plan

Areas of the site will be re-graded in accordance with Umetco's site-wide grading plan that is included in the enhanced reclamation plan. In the grading plan, Umetco will: (1) tie in the

contours for the A-9 repository with the contours for the above-grade impoundment, heap leach area, and Gas Hills Pond No. 2 area; (2) divert an existing drainage channel along the south side of the above-grade impoundment; (3) raise the elevation of the A-9 repository to about 10 feet to accommodate additional byproduct material; (4) flatten the high wall on the east side of the A-9 repository; (5) provide diversion channels on the east and west sides of the A-9 repository; and (6) grade the slopes of the North and South evaporation ponds and other reclaimed areas to provide positive drainage away from the repository.

1.7 Conclusions

The staff review of the design for the A-9 repository and C-18 pit indicates that the designs are acceptable. Based on review of the information submitted by Umetco, the NRC staff concludes that the A-9 cover 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). Criterion 6(7) and 12 have been addressed, because the proposed closure plan minimizes the need for maintenance, and there is no reliance on active maintenance to preserve the isolation of the wastes. Also, the staff determined that the site grading plan meets the requirements of Criterion 4, since a design has been provided to minimize the effects of erosion and to provide long-term stability for the disposal cells.

2.0 GEOTECHNICAL DESIGN AND TESTING

2.1 Introduction

This section of the technical evaluation presents the NRC staff review of the geotechnical engineering aspects of the A-9 repository enhanced reclamation plan. The scope of the geotechnical review consisted primarily of evaluations of the site characterization and geotechnical stability aspects of the A-9 area.

2.2 Site and Material Characterization

2.2.1 Geotechnical Investigations

Exploratory borings and Standard Penetration test drilling were conducted in surface fill, tailings, and clay liner to the underlying bedrock. On completion, the boreholes were sealed with bentonite to protect the liner. Two standpipe and three pneumatic piezometers were installed in the boreholes. Borehole logs were provided by the licensee.

2.2.2 Geotechnical Testing

Western Engineers and Inberg Miller Engineers performed a series of laboratory tests on the materials from the field investigation phase. The tests performed included: 1) water content and density; 2) classification; 3) capillary moisture relationships; 4) hydraulic conductivity using a flexible wall permeameter; 5) consolidated-undrained triaxial compression; and 6) one-dimensional consolidation.

The materials in the proposed reclamation at the site consist of: 1) interim cover/additional waste; 2) Susquehanna tailings; 3) Umetco tailings - sand-sand/slimes; 4) Umetco tailings - slimes; 5) drain sand; 6) clay liner; and 7) foundation soil. A brief description of these is presented below.

Foundation Materials

The A-9 site is underlain by bedrock or otherwise stable soils. Although only limited testing of the foundation soils was performed, shear strength values were rationally assigned based on accepted models such as Holtz and Kovacs (1981). The foundation soils are characterized in Table 5-9 of the plan, which indicates a unit weight of 130.0 pounds per cubic foot (pcf), a Young's Modulus of 1.0×10^6 kips per square foot, and an internal friction value of 35 degrees.

Tailings Material

The tailings materials include sand, sand-slime mixtures, and slimes. Based on results of Proctor compaction tests, triaxial and direct shear tests on remolded samples, an internal friction angle of 33 degrees, cohesive strength of 0 psf, and a unit weight of 131 pcf were used for the Susquehanna Tailings; and an internal friction value of 18 degrees, cohesive strength of 0 psf, and a unit weight of 116 were used for the Umetco tailings in the stability analyses.

Radon Barrier and Clay Liner Material

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 a No. 200 sieve. The maximum Standard Proctor density ranges from 100 to 110 pcf with optimum moisture content ranging from 17 percent to 22 percent. Long-term moisture content was estimated by laboratory measurements of the 15-bar capillary moisture value. For purposes of evaluation, the clay liner was presumed to have strength characteristics similar to those of the radon barrier. Given the similarities in the material, the characterization of the clay liner soils is appropriate.

Frost Protection Soil

The geotechnical properties of the frost protection soil placed on top of the radon barrier layer of the cover and the structural fill placed on top of 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 with optimum moisture content of 11 to 14 percent. Based on results of consolidated undrained triaxial shear tests, an angle of internal friction of 29 degrees, and a cohesive strength of 175 psf were used in the stability analysis.

Drain Sand

The drain sand will have negligible effect on the strength of the cell. The strength values for this material were based on laboratory testing by Inberg Miller, and typical values from Holtz and Kovacs, and Bowles (1988). A unit weight of 112.9 was determined by test. The shear strength (angle of internal friction) of 35 degrees is from acceptable references.

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 materials. 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 Janbu's Simplified methods of stability evaluation using the SLOPE/W computer code) were used, and the lowest factors 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 (1994), and on 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 the 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 A-9 slope were 2.45 for the static condition and 1.16 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

Analyses were conducted to estimate the immediate settlement from additional load, the consolidation settlement, and the long-term creep settlement. The maximum immediate settlement is not expected to exceed 0.2 feet (6 cm). Consolidation settlement estimates ranged from 1.32 to 1.65 feet (40 to 50 cm), depending on the cross-section selected, and long-term settlement estimates are 0.87 feet (26.5 cm). The rationally-derived settlement estimates were used as a basis to determine the potential for post-construction cover cracking.

Cover cracking estimates were made by calculating the potential for tensile strain in the cover. Although a slight potential for cover cracking was found at Section E-E', the conservative nature of the calculations suggests that the design is safe from excessive cover cracking.

2.3.3 Liquefaction

The staff has reviewed the information presented on the potential for liquefaction at the site. The Umetco tailings were slurried into the repository during operation, and the Susquehanna tailings (from the Riverton mill) were placed with compactive effort. Whereas the Umetco

tailings were placed in a saturated condition, the Susquehanna tailings are unsaturated. Since the tailings will continue to drain, there is little long-term potential for liquefaction to occur.

Based on geotechnical investigations, borings, and test data, the A-9 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 A-9 material does not meet these criteria, 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 A-9 repository will not be adversely affected by seismically-induced liquefaction.

2.3.4 Cover Frost Barrier

There will be a total of 66 inches (1.7 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.

2.3.5 C-18 Pit Cover Engineering Parameters

The licensee has determined that sufficient on-site borrow is available to backfill (80 feet) the C-18 pit. The soils will be placed and compacted in accordance with approved methods. Since the C-18 pit reclamation will be limited to backfilling a below-grade excavation, sideslope stability is not a consideration. Similarly, since the hydraulic conductivity of the cover layers will be $1x10^{-7}$ cm/sec or greater, and groundwater mounding will not result, no additional field testing will be required to confirm the design hydraulic conductivity. Differential settlement is not a stability issue based on the below-grade configuration. The substantial depth of soil cover also means that freeze-thaw damage to the upper cover is not a consideration.

2.3.6 Infiltration

A-9 Repository

The A-9 cover soils will be placed and compacted in accordance with approved methods. The construction of the A-9 repository will be such that the buried tailings will continue to dewater with time. Since the hydraulic conductivity of the cover layer will be $1x10^{-7}$ cm/sec or greater, and groundwater mounding will not result, no additional field testing will be required to confirm the design hydraulic conductivity. Sideslope stability, settlement, and frost penetration considerations have been addressed elsewhere in this TER.

C-18 Pit

Since the C-18 pit reclamation will be limited to backfilling a below-grade excavation, the hydraulic conductivity of the cover layers will be $1x10^{-7}$ cm/sec or greater, and groundwater mounding will not result; no additional field testing will be required to confirm the design hydraulic conductivity.

2.4 Geotechnical Construction Details

2.4.1 Construction Methods and Features

The staff has reviewed and evaluated the geotechnical construction criteria and Quality Control Plan provided (Umetco, 1998a). 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). 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

Based on review of the geotechnical engineering aspects of the design of the A-9 repository and C-18 pit 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 A-9 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.

3.0 RADON ATTENUATION DESIGN

3.1 Introduction

This section of the staff evaluation of the enhanced 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 disposed uranium mill tailings reaching the atmosphere is reduced by restricting the gas movement long enough so that radon decays to a solid daughter that remains within the disposal cell. The physical and radiological parameters influencing the amount of radon available to the soil pore spaces and its movement through the soil, 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 enhanced A-9 cover design, Umetco increased the clay layer by 0.5 foot (0.15 m), decreased the approved cover thickness by 3 feet (0.9 m), and replaced the top soil/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 enhanced design, Umetco proposes a 1 to 5-foot interim cover, 1.5-foot (46-cm) clay radon

barrier, and a 4.5-foot (137 cm)-thick frost protection (overburden) layer. The frost protection layer was used in the flux model as it also assists in radon attenuation.

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 and frost protection soils, 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 cover soils used for input into the RADON computer code (NRC Regulatory Guide 3.64) by the licensee. In some cases, conservative estimates or assumptions, instead of measured values, were used for input, and in other cases, limited measurement results were used. 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 ensure that the resulting data would be adequate.

A-9 Cell

The radon flux models presented in Appendix E of the plan represent seven locations within the cell with varying thicknesses of the interim cover and additional waste. The tailings are modeled at 500 cm (16.4 ft), the infinite thickness.

Umetco has indicated that the frost protection soil is mine spoils (overburden soil) that is primarily silty and clayey sand, and is similar to the interim cover and additional fill material to be used in the A-9 cell, as well as the cover material used for the heap leach and above-grade cells. Measured values for these materials are taken from the reclamation plans for the other disposal cells. The same density, code-calculated porosity, and long-term moisture values were used for all three cover layers. The code-calculated diffusion coefficient was used for all layers of the A-9 cell.

The radium (Ra-226) value of 342 pCi/g (12.7 Bq/g) used in the model for the tailings was the average value provided by the Department of Energy for the Riverton (Susquehanna) mill tailings that comprise the upper 10 to 40 feet of tailings in the cell. The Ra-226 value for the estimated 5 feet of windblown tailings and waste was conservatively estimated to be 127 pCi/g. Test data on five samples of radon barrier material in July 1997, indicate that the model Ra-226 value of 3.6 pCi/g for this material was conservative. The frost protection soil was modeled as containing 10 pCi/g (0.37 Bq/g) Ra-226 and Umetco states that the radium content of this layer will be monitored continuously during cover construction. Although the plan sometimes refers

to this cover soil as mine "spoils," Umetco indicated in a phone conversation that the soil was mine pit overburden and had only been stockpiled, not processed.

The radon emanation fraction values in the model for the frost protection and interim cover are based on measured values of similar material as provided in the approved heap leach radon flux model. For the additional waste layer, the default value was chosen.

The long-term moisture value of 6.0 percent used by the licensee for the tailings material is a conservative estimate (code default value). For the radon barrier soil, a measured value of 12.44 percent was used. Umetco indicated (March 1999) that using a value of 9 percent in the model did not significantly affect the flux value. For the other cover materials, a value of 11.48 percent was used based on test data presented in the heap leach reclamation plan. However, both the heap leach and above-grade radon flux models used 6 percent moisture for this upper layer to be conservative.

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 frost protection material and riprap. The silty sandy frost protection soil would tend to collapse and fill in any freeze-thaw cracks or tunnels created by burrowing animals so no adjustments to density or porosity were considered necessary for this layer.

C-18 Pit

Umetco stated that the fill soils for the upper 3 to 20 feet (0.9 to 6 m) of the C-18 pit will contain less than 40 pCi/g. The next cover layer will be 2 feet (0.6 m) of soil with less than 10 pCi/g and the top foot of soil (growth medium) will contain less than 5 pCi/g Ra-226. The two lower layers were modeled with density values of 1.78, long-term moisture 11.48 percent, and emanation coefficient based on the values for the frost protection soil values in the design for the above-grade and heap leach impoundments. The top layer was assigned a density of 1.5, since it will not be compacted, and a long-term moisture value of 6 percent. The porosity and diffusion coefficients for all layers were calculated by the code.

3.3 Modeling Results

Umetco indicated that the average calculated flux from the A-9 cover was 5.7 pCi/m^2/s. Because cracking of the clay layer is possible along the edge (pit wall), Umetco also modeled this area assuming the radon barrier did not exist. The radon flux for the area was 4.9 pCi/m^2/s. For the C-18 pit, Umetco calculated a flux value of 9.8 pCi/m^2/s.

To be reasonably conservative, the staff used moisture values of 8 percent in the radon flux model for the frost protection material with code-calculated diffusion coefficients. The resulting radon flux for a representative area (Section E-E @ 1200 ft) was 16.0 pCi/m^2/s which is higher than the Umetco estimated flux of 7.1. The staff determined that the long-term radon flux for the A-9 cell should be lower than the flux limit of 20 pCi/m^2/s, and that the staff can approve the cover radon attenuation design without accepting all the parameter values used in Umetco's radon flux model. The radon attenuation modeling of the cover for the C-18 pit was determined to be adequate.

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 2 feet (61 cm) of cover required to contain levels of Ra-226 that did not exceed the value of surrounding soils. Umetco provided data in a report submitted to NRC (Umetco, 1999b) supporting the reclamation plan proposal that the upper 2 feet (61 cm) of frost protection material will have an average Ra-226 content of 10 pCi/g (0.37 Bq/g) or less will meet Criterion 6(5). Umetco has committed (Umetco, 1999a) to provide the final Ra-226 data for this material in the reclamation completion report to document compliance with Criterion 6(5). However, the 10 pCi/g value for surrounding soil has not been approved yet by NRC staff. The recommended license condition wording at the end of this report would indicate that Umetco must meet the NRC-approved value in order to comply with Criterion 6(5).

3.5 Cover Integrity

The NRC 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. The staff concludes that the enhanced design 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 should not be required to ensure cover integrity and therefore, complies with Criterion 7 of Appendix A to Part 40.

3.6 Conclusions

The staff has determined that the estimation of long-term radon flux from the covers of the A-9 and C-18 cells are reasonable, although the long-term moisture content of the frost protection layer may not be conservative. The Ra-226 and density values for the waste and cover material yet to be placed appear conservative, but additional data should be provided in the reclamation completion report to confirm the radon flux model (see recommended license condition). 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 A-9 disposal cell will meet the long-term radon emission limit in 10 CFR Part 40, Appendix A Criterion 6(1). However, data on the Ra-226 content of the frost protection material placed (at least upper 2 feet (61 cm)), will need to be provided in the completion report to substantiate that Criterion 6(5) has been met.

4.0 References

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Umetco, "Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository" (Part 1 (Design Report), Appendices, Part II (Construction Specifications), Part III (Quality Control Plan) October 27, 1998a.

Umetco, Response to staff comments on Reclamation Plan and revised Sections 2, 3, 7, and Appendices B and E, December 10, 1998b.

Umetco, Response to staff comments and page changes to Reclamation Plan, March 29, 1999a.

Umetco, Background Radionuclide Concentrations at the Umetco Gas Hills Site, April 14, 1999b.

USBR (U.S. Bureau of Reclamation), Design of Small Dams, 1977.

RECOMMENDED LICENSE CHANGE:

License Condition (LC) No. 58 should be modified to require reclamation of the A-9 disposal cell, north and south evaporation ponds, and C-18 pit, and performance of site-wide grading according to the 1998 enhanced reclamation plan, as revised. Completed items and items obsolete or incorporated into the enhanced plan should be deleted from the existing LC. Two construction related specifications were added to the first paragraph for material to be placed in the future, in order to reflect currently accepted practice. In addition, a sentence was included so that the Ra-226 content of the upper 2 feet of cover soil would be controlled. These changes were discussed with the licensee on October 1 and October 15, 1999. The revised LC would read as follows:

58. Wastes which may be disposed of in the A-9 pit may be from onsite sources (e.g. evaporation pond materials), licensed in situ leach facilities, and up to 10,000 cubic yards per year of other byproduct material provided that NRC approves the waste characteristics and disposal procedures for this other material. The maximum dimension of scrap material disposed shall be limited to 10 feet. Materials shall be placed to prevent nesting that could create large voids.

    Waste and fill disposed in the upper 12 feet of the A-9 repository shall be mapped as to the location, placement density, and radium activity. The potential impact of this material on the required radon cover shall be evaluated in a report (final radon flux estimate) submitted for NRC review and approval at least 3 months prior to initiation of the clay radon cover placement.

    For the A-9 cover, the top 2 feet of frost protection soil will contain an average Ra-226 that does not exceed the NRC-approved Ra-226 value based on data for surface soil surrounding the site.

    Reclamation of the A-9 repository, C-18 pit, and of the north and south evaporation ponds, and the site final grading shall be in accordance with the "Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository" submitted October 27, 1998, as modified by submittals dated December 10, 1998, and March 29, 1999.

ENVIRONMENTAL IMPACT EVALUATION:

During its review of the amendment request, the NRC staff performed an evaluation to determine if the requested activities meet any criterion stated in 10 CFR 51.22 (c) for categorical exclusion from the requirement for the staff to perform an environmental assessment. In accordance with Paragraph (c)(11) of 10 CFR 51.22, a categorical exclusion cannot be given. An environmental assessment has been performed for this licensing action because of the possibility of increased releases of effluents (radioactive dust) and land disturbance associated with the proposed activities of the enhanced reclamation plan. The

requested licensing action does not meet any of the criteria in Part 51.20 requiring an environmental impact statement. A finding of no significant impact for the requested license amendment (enhanced A-9 reclamation plan) was published November 26, 1999.

Attachment 2

ATTACHMENT 2

NRC Technical Evaluation Supporting License Amendment 58: Modified Radiological Cover Criteria for C-18 Pit

Submitted by letter dated November 22, 2006
TER dated October 12, 2006

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

November 22, 2006

Mr. Thomas Gieck, Remediation Manager
Umetco Minerals Corporation
PO Box 1029
Grand Junction, CO 81502

SUBJECT: LICENSE AMENDMENT NO. 58 TO UMETCO MINERALS CORPORATION'S LICENSE SUA-648 - MODIFICATION OF GAS HILLS POND NO. 2 AND C-18 COVERS (TAC LU0143)

Dear Mr. Gieck:

The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of the requests submitted by Umetco Minerals Corporation (Umetco), both dated February 7, 2006. Based on the review of the aforementioned submittals, the staff determined that the Gas Hills Pond No. 2 cover and the C-18 cover designs are adequate. The NRC staff's review is documented in the enclosed technical evaluation report (Enclosure 1).

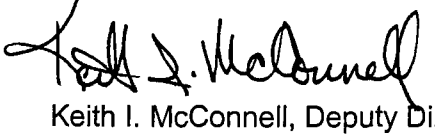
License Condition (LC) 58 has been revised to include the updated soil radium data for the topsoil of the C-18 cover. LC 61 has been revised to include the changes in design for Gas Hills Pond No. 2 cover. License Amendment No. 58 is enclosed (Enclosure 2).

In addition to the above amendments, LC 60 has been revised to reflect NRC organizational changes within the NRC. All correspondence related to this license shall be sent to the following address: Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, Mailstop T7-E18, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by express delivery to 11545 Rockville Pike, Rockville, MD 20852-2738.

If you have any questions concerning this letter or the enclosures, please contact Robert Lukes, at (301) 415-4025, or by e-mail, at rgl@nrc.gov.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at: http://www.nrc.gov/reading-rm/adams.html.

Sincerely,



Keith I. McConnell, Deputy Director
Decommissioning and Uranium Recovery
Licensing Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

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

Enclosures: 1. Technical Evaluation Report
2. License Amendment No. 58

cc: M. Moxley, DEQ WY

TECHNICAL EVALUATION REPORT
FOR UMETCO MINERALS CORPORATION'S
MODIFICATION TO POND NO. 2 AND C-18 COVER DESIGN CRITERIA
AT THE GAS HILLS URANIUM MILL SITE

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

DATE: October 12, 2006

FACILITY: Umetco Minerals Corporation - Gas Hills Uranium Mill Tailings Site, Natrona County, Wyoming

TECHNICAL REVIEWER: Robert Lukes

PROJECT MANAGER: Robert Lukes

BACKGROUND:

By two letters, each dated February 7, 2006, Umetco Minerals Corporation (Umetco) submitted requests for amendments to Source Materials License SUA-648, License Conditions 58 and 61 to U.S. Nuclear Regulatory Commission (NRC) staff (Umetco, 2006a & b). In one letter, modification of License Condition 58, the licensee requested a change to the average allowable radium-226 (Ra-226) content for the C-18 pit topsoil from 5 to 10 picocuries per gram (pCi/g). In the second letter, modification of License Condition 61, the licensee requested that NRC staff change the allowable Ra-226 content in the cover materials of Gas Hills Pond No. 2 (GHP-2) from 10 to 15 pCi/g. Umetco also requested, in the second letter, a change to the allowable background exposure limit on the cover from 30 microRoentgens per hour (μR/hr) to 40 μR/hr. Both issues are being evaluated in a single Technical Evaluation Report because the issues are similar in scope.

During the review of the request to modify License Condition 61 a potential violation was noted by NRC technical reviewers. Subsequently, NRC staff requested that Region IV inspect the Umetco facility. The inspection revealed a violation did occur, as noted in IR04000299-06-001, which involved improper verification of soil materials prior to placement over tailings. This license amendment request is the corrective action to the issued violation.

TECHNICAL EVALUATION:

GHP-2 Frost Protection and Exposure Rate Criteria

Radon Attenuation

The limit for the average long-term release of radon-222 (Rn-222) from uranium byproduct materials to the atmosphere is 20 picocuries per square meter per second ($pCi/m^2/s$) from the surface of the tailings cell for 1000 years, to the extent reasonably achievable, but at least 200

years, as stated in Criterion 6(1) of 10 CFR Part 40, Appendix A. Rn-222, the decay product of Ra-226, is a gas with a short half-life, that decays to a solid particle. The long-term Rn-222 flux rate can be estimated from the physical and radiological characteristics of the contaminated and barrier materials using a series of hand calculations or a computer code.

Radon Flux Model Parameters:

The staff evaluated the licensee's input used in the RADON computer code to ensure that the values are either based on site-specific testing or conservative estimates. The staff also evaluated the licensee's justification and assumptions made in choosing these values and confirmed that each input value was representative of the proposed material, consistent with anticipated construction specifications, and based on long-term conditions.

The licensee's flux model used a contaminated material thickness of 500 centimeters (cm), which is conservative. Data from recent subgrade samples indicate that the Ra-226 activity levels have decreased and range from 21 to 31pCi/g. Additionally, sampling also indicated that an emanation coefficient of 0.17 and a diffusion coefficient of 0.0031 centimeters squared per second (cm^2/s) are more realistic values than that of the default radon code parameters. The contaminated material density value of 1.75 grams per cubic centimeter (g/cm^3) was based on test results and used to calculate a porosity of 0.34. The diffusion coefficient was the code calculated value and the long-term moisture content of the contaminated material was a conservative estimate of 6 percent.

The average Ra-226 value for the frost protection layer used in the model is 15 pCi/g. After reviewing site background data, NRC staff determined that a Ra-226 activity of 15 pCi/g for the frost protection layer is a more realistic value than the previously approved 10 pCi/g. This complies with Appendix A, Criterion 6(5) that states "...near surface cover must be essentially the same, as far as radioactivity is concerned, as that of surrounding surface soils." To be conservative, Umetco used the cover Ra-226 values in the model, although it is not required (the standard applies only to the radon emissions from byproduct material).

Modeling Results:

Umetco used the RADON computer code to calculate the long-term radon flux (NRC Regulatory Guide 3.64, 1989). The Umetco flux model results indicate that the proposed change to the Ra-226 activity level along with the more realistic tailings data will change the expected radon flux from the previously calculated 14.3 $pCi/m^2/s$ to 14.6 $pCi/m^2/s$. The NRC staff also performed modeling using higher Ra-226 levels (62 pCi/g), a more conservative emanation coefficient (.20), and the code calculated diffusion coefficient (.01277 cm^2/s) which resulted in flux levels that were also less then the limit of 20.0 $pCi/m^2/s$.

Conclusions:

The NRC staff determined that the radon flux was calculated appropriately. NRC staff has determined the cover is adequate to meet the requirements set forth in Criterion 6(1) of 10 CFR Part 40, Appendix A.

Cover Gamma Attenuation and Radioactivity Content

Umetco radiation surveys of the GHP-2 cover indicate that the average exposure rate over the cover is 38 μR/hr. The previously established background for the Umetco site is 30 μR/hr. 10 CFR Part 40, Appendix A, Criterion 6(1), states that the direct gamma exposure rate should be reduced to background levels. Evaluation of area surveys on and off the site indicate that background values vary greatly from 16 - 97 μR/hr. Determining an accurate background for the site is subject to bias due to the great variance of the area's radiation levels. An appropriate background would be one that is conservatively estimated considering site background data and radium levels in the area. NRC staff has concluded that the proposed value of 40 μR/hr is appropriate considering Ra-226 activity and area radiation levels. Furthermore, changing the allowable average exposure rate inside the site boundary from 30 to 40 μR/hr does not pose a significant risk to public health, safety, and the environment. NRC staff has determined that the new average allowable exposure rate of 40 μR/hr satisfies 10 CFR Part 40, Appendix A, Criterion 6(1).

Top Soil Criteria for the C-18 Pit

NRC staff agrees that the required value of 5 pCi/g of Ra-226 concentration in the 30-cm growth medium is overly conservative and not a realistic estimate of actual background activity on site. NRC staff has reviewed the survey data and agrees that the appropriate background activity can be estimated to be 10 pCi/g for areas within the site boundary. Additionally, NRC staff calculated the radon exit flux from the elevated Ra-226 concentration in the top soil and found it to be much less than the required 20.0 $pCi/m^2/s$. The elevated Ra-226 level in the top soil does not pose a significant risk to the public health, safety, and the environment and is a conservative estimate of Ra-226 concentration background within the site boundary.

ENVIRONMENTAL IMPACT EVALUATION:

The requested changes to the approved reclamation plan for Pond No. 2 and the C-18 pit are minor and meet regulatory criteria. Additionally, there is no significant change in the types or significant increase in the amounts of any effluents that may be released offsite, no significant increase in individual or cumulative occupational exposure, and no increase in potential for radiological accidents due to the requested action. Furthermore, no significant construction impact due to the requested action is expected. Therefore, in accordance with the categorical exclusion contained in Paragraph (c)(11) of 10 CFR 51.22, concerning a change in process operations, an environmental assessment is not required for this licensing action, and submittal of an environmental report is not necessary.

PROPOSED LICENSE CONDITION CHANGES:

License Condition 58 should be revised as follows:

For the A-9 cover, the top 2 feet of frost protection soil will contain an average Ra-226 concentration that does not exceed the NRC-approved Ra-226 value based on data for surface soil surrounding the site. Reclamation of the A-9 Repository, C-18 pit, and of the north and south evaporation ponds, and the site grading shall be in accordance with the "Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository" in the

licensee's submittal dated October 27, 1998, as modified by submittals dated December 10, 1998, March 29, 1999, and February 7, 2006.

[Applicable Amendments: 42, 53, 58]

License Condition 60 has been revised to reflect NRC organizational changes within the NRC:

All correspondence related to this license shall be sent to the following address: Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, Mailstop T7-E18, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by express delivery to 11545 Rockville Pike, Rockville, MD 20852. Required telephone notification shall be made to the NRC Operations Center at (301) 816-5100, unless otherwise specified.

[Applicable Amendments: 32, 45, 58, 58]

License Condition 61 should be revised as follows:

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, and February 11 and 13, 1998, and December 20, 2000.

The reclamation of Pond No. 2 will be performed according to the final plan submitted on September 11, 2003, as supplemented by a revised submittal dated February 7, 2006. In addition, the Ra-226 data for the solidified pond sludge shall be submitted to the NRC, before radon barrier placement begins, to justify that the Ra-226 values used in the radon flux model are representative. If the measured values are significantly higher than the estimated values, Umetco will provide a revised radon flux model to demonstrate that the long-term radon flux from the cover should meet the limit in Criterion 6(1).

[Applicable Amendments: 38, 44, 52, 58]

REFERENCES:

U.S. Nuclear Regulatory Commission, 1989. "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers," Regulatory Guide 3.64, Washington, D.C.

U.S. Nuclear Regulatory Commission, 2003. "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act." NUREG-1620, Rev. 1., Washington , D.C.

Umetco Minerals Corporation, "Final Status Survey Plan", September 30, 2000, [ADAMS Accession No. ML003752893]

Umetco Minerals Corporation, "Final Background Characterization Report", September 30, 2000, [ADAMS Accession No. ML003752978]

U.S. Nuclear Regulatory Commission (2001a) Environmental Assessment for Umetco Minerals Corporation's, Gas Hills Uranium Mill Site, East Gas Hills, Natrona County, Wyoming. February 23, 2001 [Adams Accession No. ML010460319]

U.S. Nuclear Regulatory Commission (2001b) Finding of No Significant Impact in *Federal Register* concerning Approval of Amendment to Source Material License SUA-648 for Soil Decommissioning. February 23, 2001 [Adams Accession No. ML010580211]

Umetco Minerals Corporation, "Revision 1 of Final Design & Reclamation Plan for GHP No. 2/Mill Area - Umetco Gas Hills. Pages 1 Through Appendex A.", September 30, 2003, [ADAMS Accession No. ML032660329]