Umetco Minerals Corporation

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September 2, 2004

Ms. Elaine Brummett, Project Manager
U. S. Nuclear Regulatory Commission
Fuel Cycle Licensing Branch, NMSS, Mail Stop T-8-F-42
Two White Flint North, 11545 Rockville Pike
Rockville, MD 20852-2738

Re: **Response to NRC Request for Revised *Final Status Survey Report* Documents (October 2003, Revised April 2004 and August 2004) Volume I (Text Only, Sections 1.0 through 9.0) Addendum 1 (Text Only, Sections 1.0 through 6.0)**

Ref: **Materials License SUA-648, Docket No. 40-0299 (TAC No. LU0013)**

Dear Ms. Brummett:

Enclosed please find one (1) copy each of the revised texts of Umetco's *Final Status Survey Report, Gas Hills, Wyoming Site* documents:

Volume I, Sections 1.0 through 9.0 (October 2003, Revised April 2004, Revised August 2004)
Addendum 1, Sections 1.0 through 6.0 (April 2004, Revised August 2004)

Only the texts have been revised. These revised texts should replace previous texts. Revision dates, as applicable, are noted in the footers of each page. All appendices, attachments, and figures remain unchanged and should be retained. For your convenience I have also enclosed tracked versions of these revised texts.

If you have any further questions or comments, please contact me at (970) 256-8889 or by e-mail at gieckte@dow.com .

Sincerely,

Tom E. Gieck /ses

Thomas E. Gieck
Remediation Leader

TEG:ses
c: Mark Moxley – WDEQ-LQD
Ed Ley
Gas Hills File

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FINAL STATUS SURVEY REPORT

Gas Hills, Wyoming Site

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

October 2003
Revised April 2004
Revised August 2004

Contents

Contents

Appendices(Volume II)

Contents

Tables

Figures (Volume II)

Contents

Figures (Volume II) continued

Contents

Contents

Definition of Terms

Acronym	Definition
11e.(2)	11e.(2) byproduct material, defined under 10 CFR 40 Appendix A – tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content
AGTI	Above-Grade Tailings Impoundment (primary source of windblown contamination)
ALARA	As Low As Reasonably Achievable
ATV	All-Terrain Vehicle
BLM	Bureau of Land Management
cm	centimeter
cpm	counts per minute
cu yds	cubic yards
DM	Data Management (codes defined in Appendix A)
DOE	Department of Energy
dpm	disintegration per minute
EA	Environmental Assessment
ECC	East Canyon Creek
FSSP	Final Status Survey Plan
GHP	Gas Hills Pond (e.g., GHP-1)
GIS	Geographic Information System
GPS	Global Positioning System
IX/RO	Ion Exchange/Reverse Osmosis
LC	License Condition
LTCB	Long-Term Care Boundary
m / m^2	meter / square meters
NA	Not Applicable
NEPA	National Environmental Policy Act
NORM	Naturally Occurring Radioactive Minerals
NRC	U. S. Nuclear Regulatory Commission
NWB	North Windblown (project area)

Definition of Terms (continued)

Acronym	Definition
pCi/g	picoCuries per gram
QA/QC	Quality Assurance/Quality Control
Ra-226	Radium-226
RMGPS	Radiological Measurement Global Positioning System
SMI	Shepherd Miller, Inc.
SWB	South Windblown (project area)
TENORM	Technically Enhanced Naturally Occurring Radioactive Material
Th-230	Thorium-230
UCC	Union Carbide Corporation
Umetco	Umetco Minerals Corporation
UMTRCA	Uranium Mill Tailings Radiation Control Act
U-nat	Natural Uranium
USFWS	U.S. Fish and Wildlife Service

Executive Summary

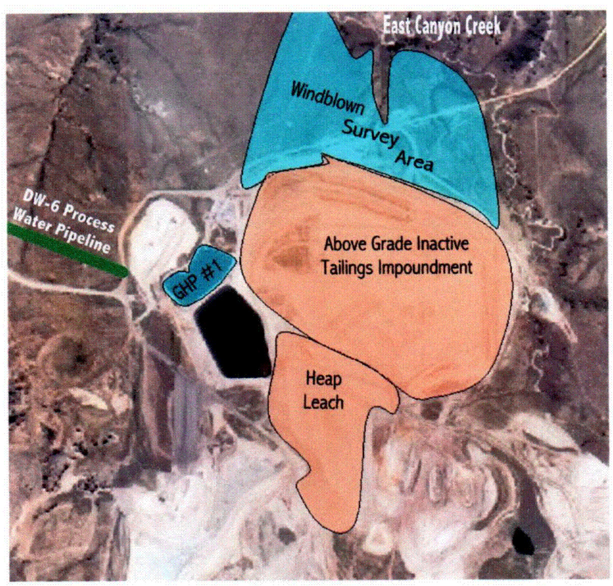
INTRODUCTION

This report presents the results of the *Final Status Survey* conducted by Umetco Minerals Corporation (Umetco) for its facility located in Gas Hills, Wyoming. Operating under U.S. Nuclear Regulatory Commission (NRC) Source Materials License SUA-648, Docket No. 40-0299, Union Carbide Corporation (UCC) and its wholly owned subsidiary Umetco conducted uranium milling operations at the site between 1960 and 1984. The mill was shut down in 1987, shortly after which decommissioning activities were initiated.

SITE DESCRIPTION

Gas Hills is located in Fremont and Natrona Counties, Wyoming, approximately 60 miles east of Riverton in a remote area of central Wyoming (Figure E.1). The site is located within the Gas Hills Uranium District of the Wind River Basin, in portions of Sections 10, 15, 16, and 22, Township 33 North, Range 89 West. The restricted area, including the tailings disposal and heap leach areas, consists of approximately 542 acres, of which Umetco Minerals Corporation (Umetco) owns 280 acres. The Final Status Survey areas assessed in this report are shown in Figure E.1 (below).

Figure E.1 Site Plan Map Showing Final Status Survey Areas



Source: Aerial photo, June 2000.

REGULATORY FRAMEWORK

The Final Status Survey documented herein was conducted in accordance with the final revised Soil Decommissioning Plan. This plan, which was submitted on September 15 and November 17, 2000, is composed of four submittals, including the *Final Status Survey Plan* (Umetco

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2000a), the *Final Background Characterization Report* (Umetco 2000b), the *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed* (SMI 1999a, 2000), and the clarifying Umetco letter dated November 17, 2000 (Umetco 2000c). The Revised Soil Decommissioning Plan was approved by the NRC in April 2001 (NRC 2001), and as such replaces corresponding portions of the approved 1990 Decommissioning Plan authorized under Gas Hills License Condition (LC) 30B.

FINAL STATUS SURVEY SCOPE AND OBJECTIVES

The Final Status Survey cleanup and characterization activities focused on those areas affected with 11e.(2) byproduct material that are not covered with an NRC-approved cover. These areas, shown above in Figure E.1, include:

1) Gas Hills Pond (GHP)-1, the former evaporation pond located northwest of the former mill facilities;

2) the Windblown Area, the area affected with windblown byproduct material located directly north and northeast (downwind) of the Above-Grade Tailings Impoundment (AGTI); and

3) the former DW-6 Process Water Pipeline.

This report also discusses the results of the penetrating radiation exposure (direct gamma) scans conducted for the AGTI and the Heap Leach. Since removal from service, approved reclamation covers have been completed for both these areas. Direct gamma surveys were conducted upon completion of the frost protection layer and prior to placement of erosion protection.

The purpose of the Final Status Survey documented herein is to: 1) demonstrate cleanup of 11e.(2) byproduct material, hereafter referred to as byproduct material, to satisfy the requirements of 10 CFR 40, Appendix A; and 2) determine the final condition of the final status survey study areas after cleanup activities are complete.

FINAL STATUS SURVEY APPROACH

The primary approach used in the final status survey was the use of a real-time data collection technique or Global Positioning System (GPS). The GPS, a receiver which receives satellite transmissions to determine land surface coordinates (northing, easting, and elevation), was used in conjunction with a gamma detector, thereby allowing real-time measurement of surface gamma readings (for estimation of soil Ra-226) or exposure rate determination. The GPS system was used in conjunction with a Geographic Information System (GIS) software package, ArcView®, which allowed the management, display, and analysis of the site characterization data as it was being generated. Using these tools, data were displayed on maps to both guide and verify the cleanup activities in a dynamic, iterative manner.

The general approach used in the final status survey is summarized in the table below.

Table E.1 Generalized Final Status Survey Approach by Area

Final Status Survey Area	Final Status Survey Approach
GHP-1 and the 11e.2 Windblown Area	Gamma survey followed by soil sampling in a subset (minimum 5%) of selected 10-m x 10-m ($100m^2$) verification grids, typically those exhibiting the highest gamma readings. Areas contaminated with byproduct material in excess of 5 pCi/g Ra-226 plus background were identified based on gamma survey and 11e.2 byproduct identification procedures, soils were excavated (minimum depth of 6 inches), and the area subsequently re-surveyed to verify attainment of cleanup criterion.
DW-6 pipeline, the approximate 3-mile pipeline segment located just west of the B-5 pit	Direct gamma surveys along the pipeline segments potentially containing tailings residuals. Determinations were made based on visual observation and meter readings. Tailings were excavated to a depth of 3 to 4 feet; these areas were then resurveyed as part of the final verification activities.
AGTI and Heap Leach	1-meter high bare gamma readings, taken approximately 10 meters apart at a rate $\leq$ 0.5 meters per second. Surveys were made over the completed earthen cover prior to placement of erosion protection materials.

FINAL STATUS SURVEY RESULTS

Background Re-Assessment

As a prelude to the summary of results which follows, it is important to re-evaluate the basis for the background levels and corresponding cleanup criteria initially applied in this evaluation. In their review of the *Final Status Survey Plan* scope and approach, the NRC acknowledged that the reclaimed mining areas adjacent to the site to the east and west create "a high soil background for the same radionuclides as exist in the 11e.(2) byproduct material that is to be remediated" (NRC 2001). This high soil background stems not only from the residual radioactivity in the reclaimed mining areas, but also (and perhaps more so) from the still undisturbed naturally occurring radioactive material (NORM) that is prevalent throughout the entire Gas Hills region, where uranium ore bodies are areally extensive, occurring in sandstone and conglomerate beds of the Wind River Formation.

Umetco attempted to account for the presence of NORM in deriving the soil background Radium-226 (Ra-226) values for the windblown and other "site-wide" areas (Umetco 2000b), and these values served as the basis for the corresponding cleanup criteria in accordance with the Criterion 6(6) rule. Although the background values were more realistic than those that had been suggested in preceding evaluations, they still did not encapsulate the full range of variability exhibited in background areas. The latter approach was taken to both address the NRC's initial concerns expressed during the comment period, as well as to address "As Low As Reasonably Achievable" (ALARA) considerations. However, NRC staff corroborated what Umetco had previously identified, in determining that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001).

The final status survey results and findings presented herein underscore the importance of the issues discussed above, as cleanup and subsequent characterization activities revealed that the previous background levels (and corresponding cleanup levels) were not sufficiently high to account for the prevalence and magnitude of NORM at and around the site. In the case of GHP-1 and selected windblown and pipeline areas, cleanup of byproduct material led to the exposure of underlying NORM soils exhibiting Ra-226 levels even higher than those previously measured in affected soils. However, in areas where NORM materials were not encountered, cleanup of identified windblown byproduct and subsequent verification were very effective.

GHP-1 Final Status Survey Results

Approximately 30,000 cubic yards of material was excavated from GHP-1, to address both byproduct related and residual petroleum contamination. Geochemical investigation findings combined with field observations indicate that all impacted material has been removed from this area, thereby satisfying Criterion 6(6). Post-cleanup gamma survey results indicated no reduction in average soil Ra-226 content however, and in some cases notable increases were apparent. The latter findings are due to the prevalence of NORM in underlying soils.

Windblown Area Results

Significant cleanup of windblown byproduct material was undertaken during the final status survey, entailing the removal of approximately 4,950 cubic yards of soil. An additional 6,700 cubic yards of material was removed from Carbide Draw, but contamination in this area was attributable to a former breach in the tailings impoundment (not windblown).

Cleanup and subsequent verification of windblown byproduct in areas where NORM materials were not encountered was very effective. The windblown veneer was identified, removed, and documented by subsequent verification surveys. The effectiveness of these cleanup efforts is evidenced by the Ra-226 reduction in non-NORM areas which is highly apparent in the preceding figures. Attempted cleanup of windblown byproduct material in areas where NORM was present was very difficult, however, resulting in several iterations of excavation and survey which ultimately resulted in increased Ra-226 concentrations. Considering the underlying NORM which exists within the survey boundary, and the results of the recent germanium detector in situ study confirming that such material is indistinguishable from windblown (11e.2-impacted material), an optimal cleanup of the windblown area has been achieved. Additional soil removal north of the excavated areas will likely expose additional natural mineralization, loss of topsoil, potential disturbance of cultural resources, and increased surface Ra-226 concentrations.

Other Areas

- The excavation/cleanup of the DW-6 pipeline, entailing the removal of 18,000 cubic yards of material, resulted in the reduction of Ra-226 concentrations to levels at or below corresponding background levels.

- Final status survey activities are complete for the AGTI and the Heap Leach. The average exposure rate measured over these areas was 27 μR/hr, thereby satisfying the 30 μR/hr criterion (Plates 1 and 2).

Discussion

Final status survey investigations at the Gas Hills site confirmed some of the issues raised previously in the Final Status Survey Plan – in particular, how blurry the distinction is between affected and unaffected areas. As demonstrated previously, cleanup of GHP-1 resulted in a slight overall increase in average Ra-226 content, vs. the reduction that would be expected concomitant with a 30,000 cubic yard volume removal. Also, the discovery of NORM within the windblown project area indicates that in undertaking additional cleanup, underlying Ra-226 levels in many areas might actually increase.

Considering the underlying NORM which exists within the GHP-1, windblown, and DW-6 pipeline final status survey areas, Umetco believes that an optimal cleanup of all areas has been achieved. At GHP-1 and the DW-6 process water line, there is likely little, if any, byproduct material remaining. That remaining in the windblown area, although apparent in some areas, is indistinguishable from the immediate area background. Additionally, the potential dose associated with current Ra-226 levels will be low because this area will be deeded to the Department of Energy for perpetual care.

1.0 INTRODUCTION

This report presents the results of the *Final Status Survey* conducted by Umetco Minerals Corporation (Umetco) for its facility located in Gas Hills, Wyoming. Operating under U.S. Nuclear Regulatory Commission (NRC) Source Materials License SUA-648, Docket No. 40-0299, Union Carbide Corporation (UCC) and its wholly owned subsidiary Umetco conducted uranium milling operations at the site between 1960 and 1984. The mill was shut down in 1987, shortly after which decommissioning activities were initiated.

In support of soil decommissioning, a survey to determine the final radiological status of the Gas Hills site was performed in 2001 and 2002. This report presents the results of that survey and documents associated soil cleanup activities and geochemical investigations. The survey results and findings will demonstrate that the Gas Hills facility satisfies the NRC regulations for site decommissioning, and that the cleanup of 11e.(2) byproduct material, herein referred to as byproduct material, satisfies the requirements of 10 CFR 40, Appendix A, Criterion 6(6).

1.1 Regulatory Framework

The Final Status Survey was conducted in accordance with the final revised Soil Decommissioning Plan. This plan, which was submitted on September 15 and November 17, 2000, is composed of the following four submittals:

- *Final Status Survey Plan, Gas Hills, Wyoming Site* (Umetco 2000a, referred to often herein as the FSSP);
- *Final Background Characterization Report, Gas Hills, Wyoming Site* (Umetco 2000b);
- *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed, Gas Hills, Wyoming* (SMI 1999a) and associated addendum (SMI 2000); and
- Umetco letter dated November 17, 2000 (Umetco 2000c).

The Revised Soil Decommissioning Plan was approved by the NRC in April 2001 (NRC 2001), and as such replaces corresponding portions of the approved 1990 Decommissioning Plan authorized under Gas Hills License Condition (LC) 30B.

1.2 Site Description

Gas Hills is located in Fremont and Natrona Counties, Wyoming, approximately 60 miles east of Riverton in a remote area of central Wyoming (Figure 1.1). The site is located within the Gas Hills Uranium District of the Wind River Basin, in portions of Sections 10, 15, 16, and 22, Township 33 North, Range 89 West. The restricted area, including the tailings disposal and heap leach areas, consists of approximately 542 acres, of which Umetco Minerals Corporation (Umetco) owns 280 acres. Figures 1.1 and 1.2 show the location and layout of the site, the current restricted area, and the proposed Long-Term Care Boundary (LTCB)—the land slated for future transfer to the U.S. Department of Energy (DOE) for long-term surveillance and maintenance.

1.3 Final Status Survey Scope and Objectives

The Final Status Survey cleanup and characterization activities focused on those areas affected with 11e.(2) byproduct material that are not covered with an NRC-approved cover. These areas are shown in Figure 1.2 and include:

1) Gas Hills Pond (GHP)-1, the former evaporation pond located northwest of the former mill facilities;
2) the Windblown Area, the area affected with windblown byproduct material located directly north and northeast (downwind) of the Above-Grade Tailings Impoundment (AGTI);
3) the former DW-6 Process Water Pipeline; and
4) Carbide Draw south of the County Road.

This report also discusses the results of the penetrating radiation exposure (direct gamma) scans conducted for the AGTI and the Heap Leach. Since removal from service, approved reclamation covers have been completed for both these areas. Direct gamma surveys were conducted upon completion of the frost protection layer and prior to placement of erosion protection. This report does not address GHP-2 or the A-9 and C-18 Pits, as final surveys will be done upon completion of the cover for those areas. Also, the uncovered section of the former A-9 haul road slated for characterization/verification in the *Final Status Survey Plan* will be assessed when the A-9 cover construction is completed and the remaining haul road reclaimed. Any byproduct material encountered will be placed in the GHP No. 2 cell.

The purpose of the Final Status Survey documented herein is to: 1) demonstrate cleanup of 11e.(2) byproduct material, hereafter referred to as byproduct material, to satisfy the requirements of 10 CFR 40, Appendix A; and 2) determine the final condition of the final status survey study areas after cleanup activities are complete. Umetco will also demonstrate that the supporting data and associated quality assurance/quality control (QA/QC) procedures meet the applicable standards for license termination.

1.4 Background Characterization

In the NRC's review of the *Final Status Survey Plan* scope and approach, the staff acknowledged that the reclaimed mining areas adjacent to the site to the east and west create "a high soil background for the same radionuclides as exist in the 11e.(2) byproduct material that is to be remediated" (NRC 2001). This high soil background stems from the naturally occurring radioactive material (NORM) that is prevalent throughout the entire Gas Hills site, in both reclaimed mining areas and in undisturbed ore-containing areas. These uranium ore bodies are laterally extensive, occurring in sandstone and conglomerate beds of the Wind River Formation.

Umetco attempted to account for the presence of NORM in deriving the soil background Radium-226 (Ra-226) values for the windblown and other "site-wide" areas (Umetco 2000b), and these values served as the basis for the corresponding cleanup criteria in accordance with the Criterion 6(6) rule. Although the background values were more realistic than those that had been suggested in preceding evaluations, they still did not encapsulate the full range of variability exhibited in background areas. The latter approach was taken to both address the NRC's initial concerns expressed during the comment period, as well as to address "As Low As Reasonably Achievable" (ALARA) considerations. However, in the review of the background characterization (Umetco 2000b), NRC staff corroborated what Umetco had previously identified, in determining that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001).

The final status survey results and findings presented herein underscore the importance of the issues discussed above, as cleanup and subsequent characterization activities revealed that the previous background levels (and corresponding cleanup levels) were not sufficiently high to account for the prevalence and magnitude of NORM at and around the site. However, in areas where NORM materials were not encountered, cleanup of identified windblown byproduct and subsequent verification efforts were very effective.

In the case of GHP-1 and selected windblown and pipeline areas, cleanup of byproduct material led to the exposure of underlying NORM soils exhibiting Ra-226 levels even higher than those previously measured in affected soils. As such, Umetco is requesting alternate criteria as allowed in the introduction to Appendix A of 10 CFR 40.

1.5 Organization and Contents

Following this introduction, Section 2 discusses the site history and decommissioning status, the impacts of historical milling and mining activities, and other pertinent background information. Section 3 presents an overview of the methods used in the Final Status Survey—for surface activity measurements, exposure rate measurements, and soil sampling and analysis techniques. Section 4 discusses the important factors related to data quality, presentation, and interpretation. Sections 5, 6, and 7 document the Final Status Survey results for GHP-1, the Windblown Area, and other areas (e.g., the DW-6 process water pipeline and the AGTI/Heap Leach), respectively. Section 8 summarizes the findings of this report. References are provided in Section 10, and detailed supporting information is provided in the appendices.

2.0 BACKGROUND

2.1 Site History and Decommissioning Status

Properties in the Gas Hills Mining District were acquired by UCC between 1956 and 1958 and the mill was constructed in 1959, at which time mining operations were initiated. Milling began in 1960, followed much later by heap leaching in 1976. The mill ceased operations in 1984, at which time it was put on standby status until 1987, when the mill was shut down. Decommissioning activities conducted since mill shutdown have included:

- Mill building decommissioning (1988 - 1993);
- Mill ancillary structure decommissioning (1993 - present);
- 1993 above-grade mill building area soil cleanup; and
- 1996 construction of GHP No. 2 (a 17-acre evaporation pond) in the former mill processing area, resulting in placement of significant volumes of 11e.(2) contaminated soils in the A-9 repository.

Planning associated with mill demolition and contaminated soil cleanup began in April 1990 when Umetco submitted a draft Decommissioning Plan to the NRC (Umetco 1990a). Umetco revised the plan through subsequent submissions to the NRC (Umetco 1990b, 1991a, 1991b, 1992, and 1995), culminating in the submission of the four 1999-2000 submittals discussed in Section 1.2 (Umetco 2000a, 2000b, 2000c, and SMI 1999a, 2000). These submittals constitute the Revised Soil Decommissioning Plan authorized under Gas Hills License Condition (LC) 30B, which was approved by the NRC in April 2001 (NRC 2001).

An Environmental Assessment (EA) was prepared in accordance with 10 CFR 51.21 and 51.30 to document compliance with the National Environmental Policy Act (NEPA) for the soil decommissioning. Based on the EA, a notice was published in the March 1, 2001 Federal Register, indicating a finding that no significant impact should result from implementation of the decommissioning plan.

The mill and related structures were demolished and buried within an engineered disposal cell according to an approved plan. The only building currently remaining in the restricted area is a mobile soils laboratory, which will be surveyed and released for unrestricted use when site reclamation is complete. The buildings outside the restricted area will be surveyed for contamination using acceptable methods and removed when they meet release criteria.

2.2 Mill-Related Impacts

Before final status survey activities were initiated, information about the nature and extent of mill-related contamination at the Gas Hills site was based on the results of the following three characterization investigations:

- the 1995-1996 Radiological Investigation Program, documented in *Background Land Conditions at the Gas Hills Uranium Project* (Umetco 1997);

- the 1998 Background Investigation, documented in *Background Radionuclide Concentrations at the Umetco Gas Hills Site* (SMI 1999b), and superseded by the *Final Background Characterization Report*, Rev. 1 (Umetco 2000b); and

- the 1998 Gamma Survey of Windblown Deposition Areas, documented in *Gamma Survey of Windblown Deposition Areas, Gas Hills, Wyoming* (SMI 1999c).

Detailed results of these investigations are discussed in the *Final Status Survey Plan* and corresponding *Background Characterization Report* (Umetco 2000b); only a brief summary is provided here. Windblown byproduct material impacts are most apparent in the area immediately north/northeast (downwind) of the AGTI, as evidenced by elevated Ra-226 activity in shallow (0-1 in or 0-6 cm) surface soils. As demonstrated later in this report (see Figure 6.5, the initial 2001 Windblown "snapshot"), this activity gradually attenuates with increasing downwind distance. Beyond, and even within, the immediate downwind locations, however, many areas with naturally occurring mineralization have been encountered exhibiting similar, and sometimes higher, levels of radioactivity. These findings were verified during the more recent final status survey investigations documented herein.

The first major investigations of mill-related impacts associated with GHP-1 and the former process water pipeline were done as part of the final status survey. Therefore, the reader is referred to the corresponding sections (Sections 5.0 and 7.1, respectively). Mill-related impacts associated with waterborne pathways are not within the scope of this final status survey and therefore are not discussed here (refer to Umetco 2000a and Section 2.4).

2.3 Naturally Occurring Mineralization and Mining-Related Impacts

Within the Gas Hills district, a major uranium-producing region of the United States, uranium occurs in an area approximately five miles wide and twenty miles long in three north-trending belts known as East, Central, and West Gas Hills (Figure 2.1). These ore trends are areally extensive and occur in sandstone and conglomerate beds of the Wind River Formation. As shown in Figure 2.1, the East Gas Hills ore trend extends a significant distance to the north and south of the site. The presence of this ore, or NORM, accounts (obviously) for the historical prevalence of open pit uranium mining activities and resulting mining-related impacts both on and surrounding the Gas Hills site.

Although the issue of mining-related impacts has been discussed at length in previous documents (e.g., Umetco 1997, 2000a, 2000b), it is important to reiterate here.[2] Uranium was mined from open pits in the Wind River Formation upgradient, crossgradient, within, and downgradient of the Umetco project area. These mines were developed by Pathfinder, TVA, Umetco, PRI, and others. As a result of these activities, and subsequent mined-land reclamation efforts, adjacent lands to the west, south, and east of the mill site exhibit elevated radioactivity. This finding is

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[2] Another useful reference is the *Application for Alternate Concentration Limits*, submitted by Umetco in November 2001 and approved by the NRC in March 2002 (Umetco 2001a). This document discusses at length the mineralogical and geochemical characteristics exhibited in Gas Hills region NORM areas, as well as areas impacted by mining and reclamation activities. Although discussed largely in the context of groundwater impacts, the ACL discussion is germane to this soils evaluation as well.

particularly apparent for adjacent areas west of the site (the area exhibiting the most elevated radioactivity), coinciding with Pathfinder's prior mining and reclamation activities. These mining-disturbed lands meet the NRC's definition of naturally occurring radioactive material or NORM (NRC 2003) — i.e., background radiation. As discussed in subsequent sections, the prevalence and magnitude of background radiation posed a challenge during the final status survey, as these soils were often intermixed and/or underlying affected (e.g., windblown impacted) soils.

2.4 Areas Not Addressed Herein

As discussed in the preceding sections, soil decommissioning at the Gas Hills site has been an iterative process since activities first began in 1988. This document focuses on three primary areas—GHP-1, windblown-affected soils north of the AGTI, and the DW-6 process water pipeline. The results of the penetrating radiation exposure scans of the AGTI and the Heap Leach are also addressed, but these areas receive secondary focus. To facilitate understanding of the status of the site as a whole, a brief summary of the areas that are not addressed herein is warranted (see Table 2.1 below).

Table 2.1 Areas Not Addressed in the Final Status Survey

Category	Location / Description	Rationale for Exclusion from Final Status Survey
East Canyon Creek (ECC) drainage	North and east of site (Figures 1.1 and 1.2)	Results of the risk assessment (SMI 1999a), combined with recent findings related to critical wetlands, ecological habitat, and archaeological resources, led to approval of a no-action alternative for this area (NRC 2001).
Onsite mining areas affected with 11e.(2) solutions	North and South Evaporation Ponds	Cleanup rationale and supporting documentation provided in enhanced design for A-9 repository, License Amendment 45 (April 20, 2001).
Mining disturbed areas (onsite and offsite)	Non-shaded areas within the restricted area boundary shown in Figure 1.2 and adjacent surrounding mining-disturbed lands	Previous surveys and studies found no clear evidence of NRC-licensed material or radiation levels exceeding the site background value, as such. These areas were not included in the Final Status Survey.

Due to the sensitive ecological environment that exists within the East Canyon Creek drainage, combined with other factors warranting special consideration (e.g., cultural resources and wetlands), Umetco proposed a no-action alternative for the East Canyon Creek drainage, including Carbide Draw north of Dry Creek Road (Umetco 2000a). The NRC subsequently determined that the proposed no-action alternative protects the sensitive ecological conditions in the creek and that it would achieve a level of protection for public health, safety, and the environment that would satisfy the requirements of Criterion 6(6). The NRC concluded by stating that the "long-term ecological damage, potential harm to threatened and endangered species, and high costs of remediation are not justified by any benefit that would result from soil remediation in ECC" (NRC 2001).

Onsite mining areas affected with 11e.(2) solutions—i.e., the north and south evaporation ponds—will not be verified or characterized further because the NRC has approved the previous characterization and decommissioning plan for these areas (NRC 1999b). Mining disturbed areas located within and outside the restricted area boundary were also not addressed, as these areas have been characterized at length, and impacts resulting from former mining and/or reclamation activities are already well established (Umetco 1997, Umetco 1999, and Umetco 2000a).

2.5 Proposed Long-Term Care Boundary

The results presented herein must be interpreted acknowledging the future use of the study areas in question. The presence of residual radioactivity in uncovered areas at the site—which, as will be demonstrated in the following sections is indistinguishable from background—will not pose any measurable incremental risk because these areas are within the proposed Long-Term Care Boundary (LTCB). The land within this boundary is slated for future transfer to the U.S. Department of Energy (DOE) for long-term surveillance and maintenance. This proposed LTCB is shown on Figures 1.1 and 1.2 and the relevant data maps that follow.

The anticipated implementation of the LTCB and corresponding land transfer is as follows: Termination of Umetco's license will occur upon completion and acceptance of reclamation activities. Because the State of Wyoming declined to take title (letter of July 15, 1994 from D. Hemmer to J. Virgona), Umetco anticipates that long-term custodial care will be transferred to the DOE.[3,4] All land within the proposed LTCB is currently under the control of either Umetco or the Bureau of Land Management (BLM). At this time, Umetco anticipates completion of reclamation obligations and transfer of the site in 2005.

2.6 Final Status Survey Cleanup Objectives

2.6.1 Soil Measurement Endpoints

Previous sampling results indicated a strong correlation between Ra-226 and Thorium-230 (Th-230) in samples collected from the majority of the final survey area addressed herein, in particular soils impacted with windblown byproduct material (Umetco 2000a). Consequently, any soil cleanup required to meet the Ra-226 criterion would remove residual Th-230 as well.

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[3] The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 (42 USC § 7901) as amended, provides for reclamation and regulation of uranium mill tailings at two categories of mill tailings sites— *i.e.*, Title I and Title II. Title I includes former uranium mill sites that were unlicensed, as of January 1, 1978, and essentially abandoned. Title II includes uranium mill sites under specific license as of January 1, 1978. In both cases, the licensing agency is the NRC, or in the case of certain Title II disposal sites, an Agreement State. The Umetco Gas Hills, Wyoming site is a Title II site under UMTRCA. The State of Wyoming is not an Agreement State, and ownership of Section 16 changed from the State of Wyoming to Umetco last year. That is, no land within the LTCB is currently owned by the State of Wyoming.

[4] Specific regulatory requirements with respect to land and license transfer are established in 10 CFR 40. 10 CRF 40, Appendix A, Criterion 11C states in part: *"Title to the byproduct material licensed under the Part and land, including any interest therein (other than land owned by the United States or by a State) which is used for the disposal of any such byproduct material, or is essential to ensure the long term disposal of any such byproduct material, or is essential to ensure the long term stability of such disposal site must be transferred to the United States or the State in which such land is located, at the option of the State."* 10 CFR § 40.28 establishes licensing requirements upon termination of Umetco's license and states in part: *"The licensee will be the Department of Energy, another Federal agency designated by the President, or a State where the disposal site is located."*

Also, based on site history and previous soil analyses, elevated uranium resulting from the milling operation is not expected. The tailings are generally uranium deplete, as this material was extracted as part of previous milling activities. In fact, historical background sampling results indicate that U-nat concentrations are generally higher in surrounding mineralized areas (e.g., east of the A-9 Pit) than in areas affected with byproduct material (Umetco 1997).

Given the above findings and subsequent NRC concurrence and approval, Ra-226 was the primary endpoint of the final status survey sampling and analysis plan (NRC 2001). The only exception to the above was made for GHP-1 which, because of its location coinciding with the former mill, warranted analysis for Th-230 and U-Nat as well as Ra-226 (refer to Section 5).

2.6.2 Cleanup Objectives and Release Guidelines

Based on the investigations cited above and the associated statistical analyses (Umetco 1997, 2000), site-specific background concentrations were developed for Ra-226 and external radiation exposure rates (direct gamma). These background levels formed the basis for the final status survey soil cleanup objectives, summarized below.

Table 2.2 Cleanup Criteria Applied in the Final Status Survey

Final Status Survey Area	Endpoint	Cleanup Criterion	Underlying Background Value	Background Value Basis (Source: Umetco 2000b)
GHP-1, DW-6 pipeline, and other "site-wide" soils	Soil Ra-226	15 pCi/g (background + 5 pCi/g)	10 pCi/g	geometric mean (GM) plus the geometric standard deviation (GSD) of the site-wide data set
Northern windblown cleanup area	Soil Ra-226	11.1 pCi/g (background + 5 pCi/g), in accordance with 10 CFR 40, Appendix A, Criterion 6(6)	6.1 pCi/g	99th upper confidence limit (UCL) on the geometric mean and median of the northern area background data set
Repository covers	external exposure rate (direct gamma)	Reduction of area-averaged direct gamma exposures to background (30 μR/hr), in accordance with Criterion 6(1)	30 μR/hr	geometric mean of background direct gamma exposure rates, as derived in Appendix A of the background characterization report

2.6.3 Discussion

As discussed in Section 1.4, the background levels listed above do not appear to be sufficiently high to account for the magnitude of NORM encountered during final status survey verification investigations. Post-cleanup survey results for GHP-1 exceeded the approved background value as the excavation extended into the underlying mineralized (NORM) areas within the pond. Similar observations were made during the post-verification survey conducted for the former DW-6 process water pipeline, in particular the segment directly adjacent to the B5 Pit. Therefore, Umetco suggests alternate criteria to demonstrate cleanup in this area using the adjacent B5 Pit Ra-226 levels as a specific local reference area. Results of a geochemical investigation conducted to identify the extent of 11e.(2) contamination in GHP-1 is provided in Section 5.3 to support Umetco's request.

The northern windblown background level and corresponding cleanup criterion were also found to be too low. Based on soil Ra-226 measured in soil samples collected from known NORM areas within the windblown study area (Section 6), combined with a re-assessment of previous background characterization data (Section 4), 10-15 pCi/g represents a more representative range of northern windblown background conditions than the previously estimated 6.1 pCi/g. Utilization of a single background statistic for a site of this nature—i.e., one that is situated within a mineralized ore zone exhibiting highly variable levels of naturally occurring radioactive material—has resulted in a difficult analysis. In fact, if it were used as the sole decision rule, much unnecessary cleanup (and ecological degradation) would occur.

3.0 FINAL STATUS SURVEY METHODS

This section describes the general methods and procedures that were applied in the final status survey. Supporting detailed information is provided in the procedures documented in Umetco's *Quality Control Program for Final Status Surveys* (Umetco 2002).

3.1 Overview

The primary approach used in the final status survey was the use of a real-time data collection technique or Global Positioning System (GPS). The GPS, a receiver which receives satellite transmissions to determine land surface coordinates (northing, easting, and elevation), was used in conjunction with a gamma detector, thereby allowing real-time measurement of surface gamma readings (for estimation of soil Ra-226) or exposure rate determination. The GPS system was used in conjunction with a Geographic Information System (GIS) software package, ArcView®, which allowed the management, display, and analysis of the site characterization data as it was being generated. Using these tools, data were displayed on maps to both guide and verify the cleanup activities in a dynamic, iterative manner.

These methods are similar to those used in the Adaptive Sampling and Analysis Programs (ASAPs), which have been successfully applied at various DOE sites (DOE 2001). Ultimately, this GPS/GIS survey technology allowed for a much more comprehensive and efficient characterization of the final status survey areas than that which would have resulted from a traditional soil sampling program with offsite soils analysis.

3.2 Final Status Survey Approach

The general approach used in the final status survey is summarized in the bulleted items below. For GHP-1 and the 11e.2 windblown area, compliance with 10 CFR 40, Appendix A, Criterion 6(6) was assessed on a 100-square-meter (100 m^2) grid basis. This was not the case for the DW-6 process water pipeline, which has a linear configuration. The survey approach used for the DW-6 process water pipeline was based on Umetco's opinion as to the appropriate method for documenting cleanup. Since this approach was not discussed with the NRC, Umetco is proposing a deviation from the standard procedures with respect to the DW-6 process water pipeline.

- A gamma survey was conducted over the study area to identify locations where Ra-226 concentrations potentially exceeded the cleanup criterion of background plus 5 pCi/g.

- For those grids with survey readings indicating an exceedance of criteria, 11e.(2) byproduct material identification procedures (e.g., visual examination of soils) were used to assess whether the elevated radioactivity was attributable to byproduct presence and/or NORM.

- If 11e.(2) byproduct contamination above the soil criterion was apparent, the area was excavated and the material was hauled to the A-9 for disposal. Windblown areas were excavated to a depth of 6 inches, whereas GHP-1 and the DW-6 pipeline were excavated several feet.

- Excavated areas were then re-surveyed to verify that the Ra-226 cleanup criterion was attained, and additional remedial action and follow-up surveys were performed if necessary.

- For GHP-1 and the windblown area, nine-sample composite soil samples were collected in five percent of the 10-meter by 10-meter (100 m^2) grids. The subset of grids to be sampled generally reflected those grids exhibiting the highest estimated average Ra-226 concentrations, as indicated by the gamma survey. These samples were collected to verify the efficacy of the gamma correlation and to demonstrate the attainment of cleanup objectives.

- Soil sampling from the pipeline, although collected from a 150-square meter grid, can be utilized to demonstrate compliance, as the FSSR calls for sampling of 5% of the highest grids. Soil sampling from the pipeline represents sampling of 100% of the pipeline sections in which tailings were identified. Sampling from the pipeline trench was meter and visual driven, meaning areas of elevated meter readings and soils exhibiting appearance similar to tailings were utilized to construct the composite soil sample. This sampling approach would generate the worst case scenario of soil conditions in the excavated pipeline trench.

- The licensee viewed this approach for soil sampling given the linear configuration of the trench as appropriate for demonstration of cleanup.

These steps are summarized in the following table (Table 3.1) according to area. Note that detailed survey methods and approaches were unique for each area. Any exceptions to the general procedures discussed in this section are identified in the subsequent area-specific presentation of results (Sections 5 through 7).

Table 3.1 Generalized Final Status Survey Approach by Area*

Final Status Survey Area	Final Status Survey Approach
GHP-1 and the 11e.2 Windblown Area	Gamma survey followed by soil sampling in a subset (minimum 5%) of selected 10-m x 10-m (100m^2) verification grids, typically those exhibiting the highest gamma readings. Areas contaminated with byproduct material in excess of 5 pCi/g Ra-226 plus background were identified based on gamma survey and 11e.2 byproduct identification procedures, soils were excavated (minimum depth of 6 inches), and the area subsequently re-surveyed to verify attainment of cleanup criterion.
DW-6 pipeline, the approximate 3-mile pipeline segment located just west of the B-5 pit	Direct gamma surveys along the pipeline segments potentially containing tailings residuals. Determinations were made based on visual observation and meter readings. Tailings were excavated to a depth of 3 to 4 feet; these areas were then resurveyed as part of the final verification activities.
AGTI and Heap Leach	1-meter high bare gamma readings, taken approximately 10 meters apart at a rate $\leq$ 0.5 meters per second. Surveys were made over the completed earthen cover prior to placement of erosion protection materials.

* *Refer to Figures 1.1 and 1.2 for Final Status Survey area locations.*

The final status survey procedures used to verify compliance with Criterion 6(6) are listed in Table 3.2.[5]

Table 3.2 Summary of Procedures Applied in the Final Status Survey †

Procedure	Title (Revision)	Endpoint Addressed
R-16*	Direct Radiation Verification Surveys of Open Land Surface Soil (Rev. 1) **Salient portions of this procedure are provided in Appendix A.*	Direct radiation surveys of open land, including instrument calibration, gamma survey measurements and data management, mapping, and documentation.
R-17	Penetrating Radiation Surveys of Closed Byproduct Material Repositories (Rev. 1)	Survey procedure for repositories
R-18	Final Status Survey Soil Sample Preparation (Rev. 0)	Soil sample preparation
R-19	Final Status Survey Surface Soil Sampling Procedure (Rev. 0)	Surface soil sample collection
R-20	Identification of 11e.(2) Byproduct Material in Soil (Rev. 0)	11e.(2) byproduct material identification
R-21	Final Status Survey Soil Sample Management (Rev. 0)	Soil sample management
R-22	Calibration Procedure for Portable Survey Instruments Used for Final Status Surveys of Open Lands (Rev. 0)	Portable survey instrument calibration and gamma survey/soil Ra-226 correlation development

† All revisions above are dated July 3, 2002. These procedures were subjected to a third-party audit conducted in June 2002 by Waste Engineering, Inc. (WEI 2002), which concluded that Umetco staff are "producing sufficient, accurate, and representative data to guide field construction activities at the site."

3.3 Direct Radiation Verification Surveys

As discussed above, all onsite, or direct field, open land final status surveys were conducted using a Radiological Measurement Global Positioning System (RMGPS). This system is composed of a gamma scintillation radiation measurement system, coupled to a global positioning system, which is carried in a backpack or mounted on an all-terrain vehicle (ATV). The following two verification scanning survey techniques were employed:

- scanning from an all-terrain vehicle with a collimated 2"x 2" NaI detector mounted 12" (1 ft) above the land surface (this was the primary survey method), and
- scanning on foot with a collimated 2"x2" sodium iodide (NaI) detector carried at 12" above the land surface (used for verification only).

[5] NRC staff (J. Lusher) reviewed these procedures during the most recent site inspection conducted on July 31, 2002.

During the final status survey, the ATV-mounted system was the primary means of GPS data collection. The backpack-mounted configuration was employed only if use of the ATV posed a safety concern, if the satellite signal was lost (this happened rarely), and/or for verification purposes—e.g., to verify gamma measurements within a grid or grids. Collimated-detector scans were used to estimate Ra-226 soil concentrations and bare-detector scans conducted at 1 meter above ground surface were used to estimate exposure rates. The NRC had previously determined that instrument sensitivity was adequate to reliably identify the proposed guideline levels (NRC 2001).

As summarized in Table 3.1, prior to soil sampling, final status survey areas were gamma scanned (dynamic, in motion), pursuant to Umetco procedure number R-16. This procedure is referenced in Table 3.2, and portions relevant to the Final Status Survey are provided in detail in Appendix A. Gamma scans are used to identify the presence of elevated direct radiation that might indicate residual gross activity or hot spots and to assess the average Ra-226 soil concentration in any 100 m^2 verification area. Soil activity scans for Ra-226 were conducted with the detector at 1 foot above the surface, except for traditional scans which were performed with the detector kept as close to the surface as possible.

Scans were conducted on approximately parallel offsetting traverses of the survey area while moving along the traverse at a speed of about 0.5 meters per second. For optimum detection sensitivity during scanning, changes in the instrument response were monitored via the audible output to identify areas exhibiting elevated direct radiation levels.

3.4 Penetrating Radiation Surveys of Repositories

Direct gamma radiation exposure rates on the AGTI and the Heap Leach were determined by conducting RMGPS scans over the completed earthen cover prior to placing riprap erosion protection materials, pursuant to Umetco procedure number R-17. RMGPS scintillation exposure rate scans were conducted with a bare detector one-meter above the repository cover surface; most areas were driven with an ATV. Scans were conducted on approximately parallel offsetting traverses of the cover approximately 10 meters apart, while moving along the traverse at a rate not exceeding 0.5 meters per second.

3.5 Surface Soil Sampling and Analysis

At GHP-1 and the windblown area, soil samples were collected in 5 percent of the 100 m^2 grid blocks exhibiting the highest gamma values. Soil samples were obtained from nine locations within each grid block in the manner discussed below. Subsurface soil sampling methods—which applied primarily to the test pit sampling conducted at GHP-1—are discussed in Section 5 and Appendix B-3.

3.5.1 Sample Collection and Preparation

For the composite soil sampling, nine 0-6" (0-15 cm) soil samples were collected in each 100 m^2 verification grid, with points located 2.5 meters from the grid corners and then equidistantly spaced within the grid. Samples were collected using a decontaminated shovel; each sample weighed approximately one kilogram. Two collimated readings were taken at each discrete sampling location—one at the surface and the other at the base of the hole (6-inch depth). These readings were documented in the field logbook. Although the full data set is not provided herein, some of these measurements were useful in identifying NORM areas within the windblown study area. As discussed in Section 6 and Appendix C-4, some of the most notable NORM examples showed significant (>20%) increases when comparing initial vs. final survey readings at the discrete sample locations.

The nine sub-sample aliquots were then combined and homogenized to form one composite soil sample. Samples were taken to the onsite soils lab, where a portion of each sample was blended by placing the sample through a splitter six times (the remainder of the sample was archived). Samples were then prepared in accordance with Procedure R-18. A 400-gram aliquot was collected from each of the nine discrete sample aliquots and then blended to yield the approximate 3600-gram grid composite sample. The composited samples were dried for approximately twenty-four hours, then further processed using a jaw crusher to approximately ¼ inch in size, and finally through a pulverizer to achieve a size of approximately –200 mesh.

3.5.2 Sample Analysis

All GHP-1 soil samples were shipped to an outside laboratory, as these samples were analyzed for Th-230 and U-Nat in addition to Ra-226. All windblown area samples, however, were analyzed in Umetco's onsite laboratory. These samples were analyzed for Ra-226 in the manner described below and a subset (approximately 5 percent) was sent to the contract laboratory for confirmatory analysis.

The onsite laboratory was used for analysis of windblown area samples for two primary reasons. First, previous comparison with Acculabs' results and periodic analysis of external reference samples (e.g., blind duplicates) indicated that the onsite data met or exceeded data quality objectives and that results were within the standard margin of error (e.g., the Ra-226 uncertainty term. Second, on-site measurement allowed earlier identification of samples exceeding cleanup objectives, and therefore more timely/rapid mitigation of previously unidentified affected areas (e.g., false negatives based on survey results).

For both GHP-1 and the windblown area, a portion of each composite verification sample was archived, as were the discrete sample portions of those composites. These archived samples will be stored until the NRC approves the Final Status Survey Report (e.g., for potential future confirmatory analysis).

<u>Onsite Analysis of Windblown Area Samples</u>

Upon completion of the sample preparation procedures described above, an approximately 1000-gram aliquot of the pulverized sample was placed into a marinelli beaker, sealed, and counted for 30 minutes in Umetco's gamma spectrometer. Samples were analyzed three times—initially (upon sample preparation), a second time (7-14 days later), and the final count was taken at ingrowth (at least 21 days after the sample was containerized). Daily calibration and QA/QC checks were performed on the gamma spectrometer and documentation is on file at the site.

3.6 Identification of Byproduct Material Contaminated Soils

Due to the prevalence of NORM at and around the site, a byproduct material identification methodology was developed to make the necessary distinction between naturally mineralized and/or mining-disturbed soils and soils contaminated with byproduct materials, thereby ensuring that the remedial action would be directed at NRC-regulated materials.

As documented in Procedure R-20 (Umetco 2002), the byproduct material identification process included one or more of the following steps:

1. evaluating the environmental setting of the subject open land area;
2. visually examining general soil characteristics;
3. determining soil Munsell color;
4. assessing soil texture and reflective properties;
5. examination of microscopic soil particles;
6. assessment of soil radionuclide equilibria; and/or
7. assessment of vertical Ra-226 soil concentration gradients.

The first two steps served as the primary means of distinguishing between byproduct material impacts and NORM during final status survey activities. Step 6 was used at GHP-1 but results were not compelling—i.e., there were no significant differences in Ra-226/U-238 isotopic ratios when results from suspected NORM areas were compared with those from known impacted areas (and vice versa). Step 7 was useful in the windblown area to identify NORM areas, but note that this endpoint was assessed based on gamma survey readings—e.g., comparing collimated measurements taken at soil sampling locations (see Section 3.5.1). Increases in Ra-226 magnitude with depth were also apparent in some areas that had already been excavated, where post-cleanup verification surveys yielded similar and in some cases higher gamma survey readings.

3.7 Establishment of Gamma-Radium Correlation

As indicated above, the final status survey relied heavily on the GPS gamma survey approach. As such, the primary method used to demonstrate compliance with 10 CFR 40, Appendix A, Criterion 6(6) was in situ determination of Ra-226 concentrations in soil through the use of a site-specific gamma-radium correlation.

These correlations were initially established based on the results of the *Windblown Correlation Study*, which was undertaken in April and May 2001 (Umetco 2001b). As part of this pilot study, radiological surveys of twenty-one 10-m by 10-m study grid were conducted using the GPS mounted on a backpack or an ATV. All 21 grids were located in the south windblown cleanup area (i.e., south of Dry Creek Road). Each grid block was surveyed by conducting four passes with a collimated detector 12 inches (0.3 m) above ground surface at a scan rate of approximately 0.5 meters per second. The grids were then sampled using the same nine-sample composite approach described in Section 3.5 and then analyzed for Ra-226 (results ranged from 5 to 25 pCi/g). Correlations were derived based on the average reading per grid vs. the corresponding laboratory Ra-226 determined by the off-site contract laboratory analysis (Acculabs) for the composite soil sample.[6]

All equations were derived using a nonlinear piecewise regression equation with a breakpoint, using the following generalized equation[7]:

For cpm < 13510:
Ra-226 = (cpm * 0.0011) - 3.3565

For cpm ≥ 13510:
Ra-226 = (cpm * 0.0053) – 60.2018

Although these equations indicated strong correlations based on the study results ($r^2 > 0.9$), ultimately they were not suitable for any of the final status survey project areas. For example, based on soil samples collected in GHP-1, most GHP-1 grid average Ra-226 concentrations were overestimated (note high residuals in Appendix B-2). Alternatively, grid average concentrations for the windblown area tended to be underestimated by about 2.3 pCi/g, with a relative percent difference (RPD) of 21.3% when comparing predicted concentrations with onsite lab results. Given these findings, the algorithms based on the correlation study were not used. The gamma-radium correlation for GHP-1 was revised based on the April 2001 soil sampling effort and corresponding gamma survey results (see Appendix B-2). The revised GHP-1 algorithm was also applied to the survey results for the adjacent DW-6 pipeline. Windblown area gamma-radium correlations were also re-established, as discussed in Section 6 and in Appendix C-2.

The disagreement between the Ra-226 estimates based on the correlation study and corresponding soil Ra-226 results is probably attributable to two primary factors: the well-documented lateral variability—even within very localized (< 25 m^2) areas, but perhaps even more so to the *vertical* variability apparent in many of the study grids. These factors are discussed at greater length in the following sections.

3.8 Data Management

The final status survey results presented in the following sections encompass four major project areas: GHP-1 (9 acres), the windblown area (111 acre survey area), the DW-6 pipeline (3 miles in length), and the AGTI/Heap Leach exposure survey area (approximately 200 acres). As such, spatially comprehensive gamma or exposure surveys were conducted over a total area exceeding 300 acres (see Figure 1.1). The soil and test pit sampling conducted at GHP-1 and the windblown area added to this extensive data set. Two survey data sets were generated for GHP-1 (2001 and 2002), and the windblown area—due to the iterative nature of the cleanup and subsequent verification surveys—required careful data coordination. As such, the data management effort was extensive; corresponding procedures are documented in Appendix A. Attachment A of that appendix includes the RMGPS survey documentation forms, and Attachment B presents the data management and mapping procedure implemented when using

[6] This method was very similar to that previously applied by SMI in their previous investigations at the site (SMI 1999).

[7] The correlation study equations cited above were developed for Ludlum meter L221-434, the meter used most often during the final status survey, but those for other meters had very similar slopes and y-intercepts.

ArcView®, the mapping and data visualization software used for most of the results presented herein.

4.0 DATA QUALITY, PRESENTATION, AND INTERPRETATION

This section identifies some of the pertinent factors to consider with respect to both data quality and data interpretation—and how these factors ultimately affect the decision-making process and the conclusions drawn herein.

4.1 Data Quality

As documented in Appendix A, quality assurance and quality control (QA/QC) procedures were consistently implemented to minimize analytical and sampling uncertainties associated with the gamma survey and soil sampling efforts. Given these procedures and the results of verification re-surveys and soil sampling, the quality of the final status survey data is sufficient to demonstrate compliance with Criterion 6(6). However, as identified in the following sections and supporting appendices, some discrepancies do exist between some gamma survey predictions and soil sampling results. These discrepancies are inevitable in a characterization survey of this nature and magnitude, as they reflect a combination of heterogeneity, NORM, and the spatial and temporal variability that is inherent in any field sampling program.

Despite some disagreement between soil results and survey results, this did not adversely affect the validity of the conclusions drawn herein. First, comparison of gamma survey results with the corresponding soil sample results were still within an acceptable margin of error (relative percent difference (RPD) less than 15%. Second, the gamma survey data measurements (expressed in cpm or converted to Ra-226 estimates) provide a level information that soil sample data alone could never provide. As demonstrated in the following sections, in particular for the windblown area, spatial contamination trends were most clearly identified by plotting the gamma survey data points. In the windblown area figures (Section 6), contamination patterns and cleanup effectiveness are clearly apparent, much more so than any soils data could provide. A recent paper by the EPA (2001) discusses many issues that are germane to this analysis, one of them being that a much more accurate picture of the site is gained when many samples are analyzed, even if the analytical method itself—in this case, the gamma survey methodology—is somewhat less accurate (relative to traditional soil sampling and analysis).

4.2 Data Presentation and Interpretation

As discussed in the previous section, the data were managed, interpreted and mapped in the following figures using ArcView®.[8] This GIS software was used because of its broad data analysis and presentation capabilities, facilitating exploratory analysis and allowing simultaneous review of multiple data layers. Although the final status survey was conducted on a 10-meter by 10-meter grid basis, contamination patterns are most apparent when the individual survey data points are plotted. As such, many of the results presented in this section are plotted using graduated color maps (for either cpm readings or corresponding estimated Ra-226 concentrations). In reviewing such figures, the actual breakdowns are not important—rather, the spatial pattern is the primary purpose. Color-coded maps showing grid statistics (i.e., estimated grid average Ra-226 concentrations) are also provided, allowing demonstration of Criterion 6(6) attainment.

[8] In these figures, the focus is the data presentation, and not necessarily detailed labeling of site features. For detailed contour and scale information, the reader should refer to the initial Autocad figure(s) provided in each section.

5.0 GHP-1

The presentation of final status survey results begins with the discussion of GHP-1, in part because what was observed in this area—the spatial heterogeneity and significant NORM presence—holds true for the Gas Hills site as a whole. Based upon the results of extensive scientific and geochemical evaluation, supporting an area-specific background level much higher than the previously determined 10 pCi/g regulatory basis, this section will demonstrate that final status survey objectives for GHP-1 have been attained.

5.1 Background

GHP-1, located west of the AGTI and east of the B5 Pit (Figure 1.1), was constructed in November 1990 as a double-lined evaporation pond on native soils. Its location corresponds with former mill facilities, most notably the mill solvent catch basin (Figure 5.2). During pond construction, material exhibiting byproduct material impacts was encountered. Approximately 9,370 cubic yards of this material were then excavated and hauled to the A-9 repository for disposal. Pond construction then resumed, including excavation and site grading adjacent to the existing B5 Pit, construction of a lower clay liner, and construction of a 40 mil HDPE upper liner. The pond was then used for storage of reject water pumped from the ion exchange/reverse osmosis (IX/RO) operations.

IX/RO operations were shut down in April 1991 after a leak was detected in the liner system. The pond was dewatered to the North Evaporation Pond, the liner was repaired, and the pond was placed back in service in May 1991. In August 2000, the pond liner was removed and 18,162 cubic yards of material were excavated from the pond. Table 5.1 presents a chronology of the salient aspects of GHP-1 history and the subsequent final status survey activities that are documented below. Figure 5.1 shows the GHP-1 plan view showing locations of historical mill facilities. Figure 5.2 shows the final status survey 100 m^2 grid layout (n = 383) and the composite soil sample and test pit locations.

The final status survey investigation of GHP-1 consisted essentially of three phases:

1. the initial post-cleanup gamma survey and soil sampling investigation conducted in 2001 (Phase I);

2. the geochemical investigation initiated in April 2002 (Phase II); and

3. the additional excavation of impacted material and subsequent final gamma survey conducted in May 2002 (Phase III).

The results of these verification surveys and investigations are presented in the following sections. Appendix B provides supporting detailed information—Appendix B-1 presents gamma survey and soil sampling documentation; Appendix B-2 documents the analyses supporting the revised gamma-radium correlation; and Appendix B-3 presents the *Lithologic and Geochemical Evaluation* prepared by Lidstone and Associates (2002).

Table 5.1 Summary of GHP-1 History and Final Status Survey Activities

Date / Period	Final Status Survey Observations and Activities
November 1990 – April 1991	GHP-1 was constructed as a double-lined evaporation pond for the storage of process-related water (see Figure 5.1). During construction, material exhibiting byproduct material impacts was encountered. Approximately 9,370 cubic yards of this material was then excavated and hauled to the A-9 repository for disposal.
April 1991	Dewatering and IX/RO operations were shut down after discovery of a leak in the liner system. The pond was dewatered and the liner was inspected for leaks and then repaired.
May 1991	IX/RO operations resumed.
August 2000	The liner was removed and 18,162 cubic yards of material were excavated from the pond.
June – July 2001	Initial gamma survey. Four gamma surveys were conducted over an approximate one-month period: June 6, June 7 (2 separate surveys), and July 2, 2001. Ludlum Meter L2221-434 was used for all surveys. Corresponding gamma data are shown in Figure 5.3. At about the same time, a large ore fragment was encountered, exhibiting gamma readings of 26,000 cpm as measured from a pancake probe, equivalent to 1.1E+06 dpm/cm^2.
August 2001	Twenty 0-6" nine-sample composites were collected and analyzed for Ra-226, Th-230, and U-238. The samples with the highest levels of these constituents were collected in the ore-containing (NORM) area located in the southwest portion of the pond.
November 2001	Three test pits were excavated and sampled for Ra-226, Th-230, and U-Nat: one, the southwest trench, in the ore-containing area, one in the northern pond section considered most likely to exhibit mill-related impacts, and the third along the B-5 Highwall, the background reference location.
April 2002	To verify previous conclusions regarding NORM presence in selected pond areas, and to better characterize the vertical extent of potentially impacted areas, a geochemical investigation of the pond was undertaken by Lidstone & Associates and Summit Geoscience. As part of this investigation, 12 test pits were excavated, 2 of which were located in the B-5 Pit background reference area. Soil samples were collected from 10 test pits (4 to 5 samples per location) and analyzed for radionuclides, inorganics, and other parameters (see Table 5.3). Results of this investigation are summarized in Section 5.3; the report in its entirety is provided in Appendix B-3.
May 2002	Petroleum affected soils were identified in northern pond section, coinciding with the location of the former mill solvent catch basin (see Figure 5.1).
May 2002	Based on the findings of Lidstone's investigation, and to mitigate the residual petroleum impacts described above, an additional 11,904 cubic yards of material were excavated from the pond. Excavation depths ranged from 2 to 6 feet, depending on location, with the greatest excavation depths—about 6 feet—coinciding with the location of the petroleum cleanup. Excavation depths for remaining areas ranged from 3 to 4 feet.
May 22, 2002	Final gamma survey for GHP-1, again using Ludlum Meter L2221-434. Survey results indicated increases in activity in a large portion of the GHP-1 study grids. These increases are due to underlying NORM.

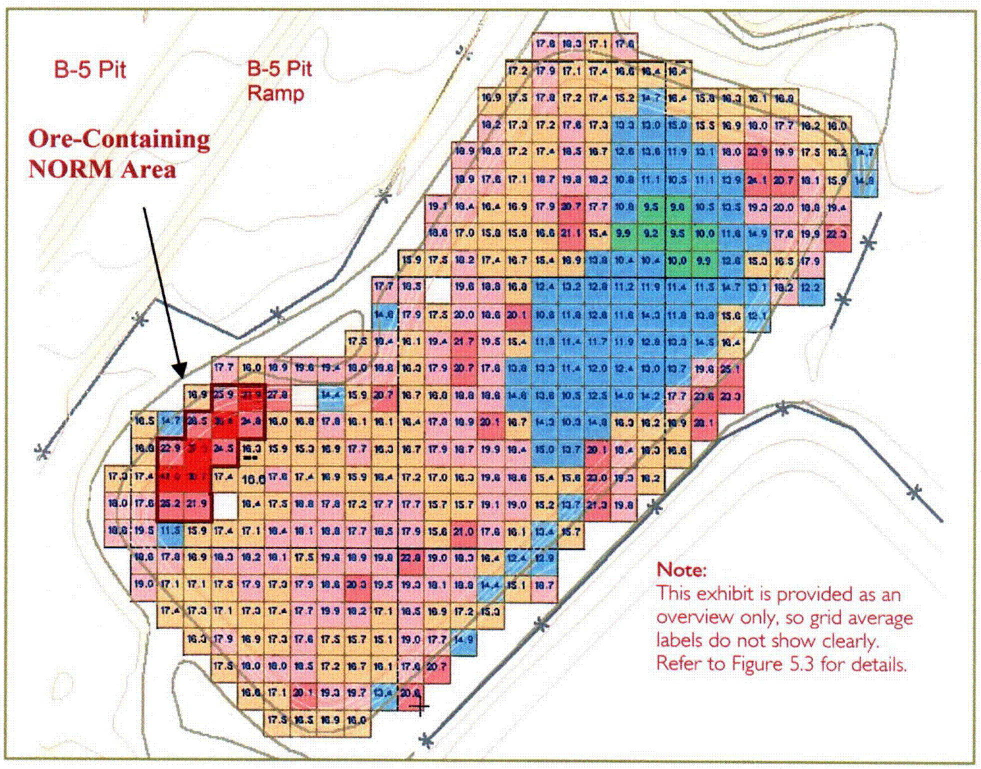
5.2 Phase I Final Status Survey Activities and Findings: June – November 2001

Phase I final status survey activities commenced in June 2001. The purpose of these efforts was to characterize pond conditions after the August 2000 liner removal and excavation and to evaluate the potential presence of 11e.(2) byproduct materials in the underlying soils. This project phase consisted of a gamma survey and soil and test pit sampling, described below.

5.2.1 Gamma Survey

To assess the pond status after liner removal and excavation, a survey of GHP-1 was conducted between June and August 2001 (Appendix B, Table 1). Figures 5.3 and 5.4 show the results of this initial 2001 survey: Figure 5.3 shows the grid averages (with no data points shown for clarity), and Figure 5.4 shows the corresponding point distribution of gamma survey data. An inset of Figure 5.3 is provided below.

2001 Gamma Survey Results



Legend:

Ra-226 in pCi/g

Symbol	Value	Label
(green)	9.2 - 10	9.2 - 10
(blue)	10 - 15	10 - 15
(tan)	15 - 17.5	15 - 17.5
(light pink)	17.5 - 20	17.5 - 20
(pink)	20 - 30	20 - 30
(red)	30 - 41	30 - 41
(white)		No Data

In Figure 5.3 and the preceding inset, note the elevated NORM area in the southwest pond section, where ore was encountered in April 2001. Corresponding gamma survey readings ranged between approximately 26,000 cpm and 50,000 cpm. As reflected above and in Figure 5.5, most grids are in the 15-20 pCi/g (estimated based on survey results), above the 15 pCi/g site-wide Ra-226 criterion. The remainder of this section will demonstrate that this range is well within background ranges for this area of the site.

C02

Figure 5.5 presents graphical summaries of both grid and gamma data summary statistics. This and the preceding exhibits are self-explanatory, and will not be discussed at length here. Rather, refer to the comparative statistics—i.e., 2001 vs. post-cleanup 2002 data—provided later in this section.

Note that the correlation algorithm for Meter 434 derived during the August 2001 correlation study was not appropriate for GHP-1. Therefore, the gamma-radium correlation for GHP-1 was derived using the August 28, 2001 composite sample results (addressed below) and the corresponding gamma survey data. The equation is noted on Figure 5-3; detailed supporting documentation is provided in Appendix B-2.

5.2.2 August 2001 Soil Sampling

Twenty soil samples were collected in a subset of grids exhibiting the highest gamma survey readings—i.e., the highest estimated average Ra-226.[9] Samples were sent to Acculabs and analyzed for Ra-226, Th-230, and U-238. Results are presented in Table 5.2 and shown in Figure 5.6. Appendix B-1, Table 3 presents the detailed Acculabs results. The results of this sampling effort indicate that, although most results exceeded the 15 pCi/g Ra-226 soil cleanup level, the highest values—ranging up to 45 pCi/g—were encountered in the area where ore-grade uranium was encountered underneath the pond liner. Differences in magnitude are shown graphically in Figure 5.6, where the soil results are relative to the corresponding gamma survey results. These results corroborated the results of the gamma survey in that they demonstrate that Ra-226 measured in samples collected in the southwest NORM area were the highest of those sampled.

5.2.3 November 2001 Test Pit Sampling

Although the previous survey efforts (gamma survey and soil sampling) combined with visual observations seemed to clearly identify NORM areas within the pond, a vertical characterization was still needed. Therefore, three test pits were excavated and sampled for Ra-226, Th-230, and U-Nat. The South Trench was located in the ore-containing area, the North Trench in the northern pond section considered most likely to exhibit mill-related impacts, and the third was located along the B-5 Highwall, the background reference location. The B5 Highwall samples represented naturally occurring mineralization and served as a reasonable comparison of known native material to potentially impacted material underlying GHP-1. These test pit/trench locations are shown in Figures 5.2 and 5.6. Corresponding analytical results are provided in Table 5.2, and shown graphically in Figure 5.7.

As demonstrated in Figure 5.7, the results of this effort again confirmed previous findings. However, they were inconclusive with respect to the potential impact of mill byproduct residues on materials that existed beneath the clay liner of the former pond, and as such were not sufficient to conclusively support no further action. Therefore, a geochemical investigation including a second round of sampling was initiated in April 2002.

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[9] Note: This subset does not correspond directly with a descending sort of the 2001 grid averages reported herein. This is because a different gamma-radium correlation algorithm was used to define the soil sampling subset (see the revised gamma-radium correlation provided in Appendix B-2).

Table 5.2 Phase I GHP-1 Soil Analytical Results: August 2001 Composites and November 2001 Trenches

Field ID	Grid No. / Location (* denotes ore area)	Sample Date	Ra-226 (pCi/g)			Th-230 (pCi/g)			U-238 (pCi/g)			Acculabs ID
GHp135851	35851	8/28/01	17.2	+/-	3	23.5	+/-	3.6	25.9	+/-	4.4	G01090348-06A
GHp136241	36241	8/28/01	15.2	+/-	2.7	23.5	+/-	3.6	20.5	+/-	3.5	G01090351-05A
GHp136242	36242 *	8/28/01	22.4	+/-	3.9	29.1	+/-	4.5	24.1	+/-	4.1	G01090351-06A
GHp136243	36243 *	8/28/01	20.5	+/-	3.6	27.3	+/-	4.3	20.1	+/-	3.4	G01090351-03A
GHp136441	36441	8/28/01	26.9	+/-	4.7	39.7	+/-	6.2	28.1	+/-	4.7	G01090350-02A
GHp136442	36442 *	8/28/01	23.7	+/-	4.2	38.4	+/-	6.1	23.1	+/-	3.9	G01090350-03A
GHp136443	36443 *	8/28/01	19.0	+/-	3.4	35.2	+/-	5.6	22.4	+/-	3.7	G01090351-04A
GHp136642	36642 *	8/28/01	14.7	+/-	2.7	25.1	+/-	4	20.4	+/-	3.5	G01090351-01A
GHp136643	36643 *	8/28/01	24.5	+/-	4.3	34.2	+/-	5.3	31.9	+/-	5.5	G01090348-08A
GHp136644	36644 *	8/28/01	15.0	+/-	2.7	25.1	+/-	3.9	24.4	+/-	4.1	G01090348-07A
GHp136843	36843 *	8/28/01	34.4	+/-	6	50.9	+/-	7.8	96.0	+/-	19	G01090350-04A
GHp136844	36844 *	8/28/01	25.1	+/-	4.4	43.1	+/-	6.6	50.1	+/-	9	G01090350-01A
GHp136845	36845 *	8/28/01	19.4	+/-	3.5	30.3	+/-	4.6	27.1	+/-	4.6	G01090348-05A
GHp136853	36853	8/28/01	17.2	+/-	3.1	26.4	+/-	4.1	23.1	+/-	3.8	G01090348-03A
GHp136854	36854	8/28/01	24.0	+/-	4.2	32.2	+/-	5.0	26.4	+/-	4.4	G01090348-04A
GHp137045	37045 *	8/28/01	45.5	+/-	7.9	50.4	+/-	7.8	19.1	+/-	3.1	G01090350-05A
GHp137453	37453	8/28/01	20.4	+/-	3.6	28.1	+/-	4.4	21.2	+/-	3.5	G01090348-02A
GHp138257	38257	8/28/01	14.4	+/-	2.6	25.5	+/-	4.1	27.2	+/-	4.6	G01090348-01A
GHp138854	38854	8/28/01	17.4	+/-	3.1	22.2	+/-	3.5	19.6	+/-	3.3	G01090350-06A
GHp138864	38864	8/28/01	22.9	+/-	4	23.4	+/-	3.7	24.9	+/-	4.2	G01090351-02A
B5HWALL 2'	B5 Highwall	11/19/01	16.3	+/-	2.9	19.8	+/-	3.3	36.7	+/-	8	G01110347-13A
B5HWALL 4'	B5 Highwall	11/19/01	24.5	+/-	4.3	26.6	+/-	4.5	53.0	+/-	12	G01110347-14A
B5HWALL 6'	B5 Highwall	11/19/01	14.2	+/-	2.5	17.1	+/-	2.8	14.8	+/-	2.9	G01110347-15A
B5HWALL 8'	B5 Highwall	11/19/01	9.6	+/-	1.7	12.8	+/-	2.1	8.8	+/-	1.7	G01110347-16A
B5HWALL 10'	B5 Highwall	11/19/01	11.7	+/-	2.1	13.9	+/-	2.3	16.6	+/-	3.5	G01110347-17A
NTRENCH 2'	North Pond Trench	11/19/01	14.5	+/-	2.6	18.6	+/-	3.2	17.2	+/-	3.4	G01110347-01A
NTRENCH 4'	North Pond Trench	11/19/01	2.5	+/-	0.49	2.3	+/-	0.56	1.6	+/-	0.34	G01110347-02A
NTRENCH 6'	North Pond Trench	11/19/01	13.1	+/-	2.3	16.3	+/-	2.9	12.5	+/-	2.4	G01110347-03A
NTRENCH 8'	North Pond Trench	11/19/01	5.0	+/-	1.0	4.0	+/-	0.76	4.1	+/-	0.78	G01110347-04A
NTRENCH 10'	North Pond Trench	11/19/01	16.6	+/-	2.9	16.5	+/-	2.9	16.2	+/-	3.2	G01110347-05A
NTRENCH 12'	North Pond Trench	11/19/01	20.1	+/-	3.5	21.7	+/-	3.7	20.7	+/-	4.2	G01110347-06A
STRENCH 2'	South Trench *	11/19/01	32.9	+/-	5.8	52.3	+/-	8.6	68.0	+/-	17	G01110347-07A
STRENCH 4'	South Trench *	11/19/01	31.0	+/-	5.4	39.6	+/-	6.6	79.0	+/-	21	G01110347-08A
STRENCH 6'	South Trench *	11/19/01	39.7	+/-	6.9	42.7	+/-	7.3	17.7	+/-	3.6	G01110347-09A
STRENCH 8'	South Trench *	11/19/01	8.3	+/-	1.5	10.4	+/-	1.7	10.8	+/-	2.1	G01110347-10A
STRENCH 10'	South Trench *	11/19/01	32.6	+/-	5.7	50.5	+/-	8	43.7	+/-	9.9	G01110347-11A

The 8/28/01 GHP-1 grid results are for 0-6" composite samples, analyzed between 10/25 and 10/31/01. These results are documented in three Acculabs reports dated October 31, 2001. Trench sample results are documented in the Acculabs report dated January 8, 2002. These samples were analyzed on 12/8 - 12/11/01 (Th-230), 12/15/01 (U-238), and 1/7/02 (Ra-226). **NOTE:** *With the exception of the B5 Highwall background sample, the results above are no longer valid given the subsequent excavation that occurred in April - May 2002.*

5.3 Phase II GHP-1 Geochemical Investigation: April 2002

The objective of the geochemical investigation was to: (1) determine whether or not pond liquids had impacted the underlying materials, and (2) if so, to define the lateral and vertical extent of the impacted area. The investigation was two-tiered: The first level included backhoe test pits, sedimentologic observations, soil (test pit) sampling, and analysis for radiological and geochemical parameters. Based on the analytical results, the second level utilized mineralogic and petrographic[10] analysis to establish a depth of fluid movement and to recommend a cleanup depth and volume if necessary. This effort was conducted by Lidstone and Associates and Summit Geoscience (Lidstone 2002). Their efforts and findings are summarized here; the report is presented in its entirety in Appendix B-3.

5.3.1 Materials and Methods

Sample Collection

Soil samples were collected from GHP-1 in April 2002 from a series of test pits excavated to a depth of approximately 8 feet (Figure 5-2). Anecdotal information indicates that leakage occurred in the northern portion of GHP-1; therefore, test pit sampling was focused on this area. Test pits TP-1 through TP-6 were sampled along a west to east transect at the northern end of the pond, while TP-7, TP-8, TP-20, and TP-21 were sampled along a transect extending toward the southern end of GHP-1. Comparative soil samples were also collected from the B5 Pit Highwall (B5HW) and from a test pit located between the B5 Mine Pit and GHP-1 (B5RIM). Samples were collected at discrete and repeatable intervals starting at the surface and continuing along 2-foot intervals to a depth of 8 feet. Typically four samples were collected in this manner from each test pit. A deeper (10-ft) sample was collected from the B5 Rim test pit. A second set of samples was collected as part of the sedimentology study as described in Appendix B-3.

Chemical and Radiological Analyses

All wet chemistry samples were shipped to ACZ Laboratories (Steamboat Springs, CO) for radiological and chemical analyses. Radiological analyses included both total (strong-acid extractable) and soluble U-nat, Ra-226, and Th-230. Additional chemical analyses were conducted to determine pH, total sulfur, soluble sulfate, and soluble chloride. Soluble soil constituents were determined following EPA's Synthetic Precipitation Leaching Procedure (Method SW1312).

Mineralogical Analyses

Seventeen samples from five test pits—TP-1 (n=4), TP-4 (n=4), TP-5 (n=3), TP-20 (n=2), and the B5 Rim (n=4)—were submitted to AMEC Earth & Environmental Limited for mineralogical testing. Representative samples were analyzed using X-ray diffraction analysis (XRD), petrographic examinations, and scanning electron microscopy (SEM) in conjunction with energy dispersive X-ray analysis (EDXA) to determine the elemental composition.

[10] Petrographic refers to the description and classification of rocks.

Geochemical Modeling

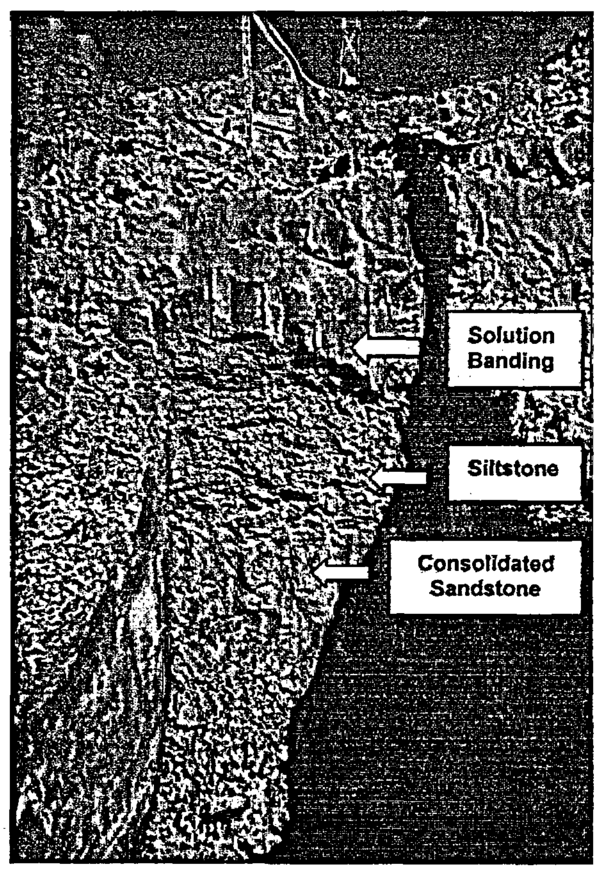
The geochemical speciation model PHREEQC (Parkhurst and Appelo 1999) was used to calculate the distribution of solution species for the former GHP-1 pond water using an aqueous ion-association model. This model calculated saturation index (SI) values to provide an indication of the ultimate fate of radionuclides in the pond water. The conceptual approach, methods, and results associated with this modeling effort are discussed in detail in Appendix B-3.

5.3.2 Results and Discussion

Field Observations

Detailed observations made during the test pit logging effort are discussed in Appendix B-3; these are not reiterated in this section unless particularly germane to the conclusions drawn herein. An observation that is noteworthy, however, is that distinct orange horizontal bands overlying black laminae were evident in TP-4, -5, and –6. These solution bands, shown in the photo below, were generally observed between 2 and 4 feet below ground surface (bgs) and were later found to be indicative of mill-related impacts.

Test Pit 5 Profile with Orange and Black Solution Banding Identified



The southernmost test pits—TP-8, TP-20, and TP-21—exhibited very similar characteristics as B5HW and B5RIM and were logged as native undisturbed strata. Given these observations, only samples from TP-8 were submitted for wet chemistry analysis (TP-20 and TP-21 were not analyzed).

Chemical and Radiological Results

Chemical and radiological results are summarized in Table 5.3 and discussed in detail in Appendix B-3, where a complete tabulation of all results is provided (see Appendix B, Table 1 of Lidstone's report). Vertical trends of key constituents are shown in Figures 3 through 11 of that appendix. The figures in this report focus on radiological parameters, in particular Ra-226, as these were the focus of GHP-1 cleanup efforts. As such, Figures 5.8 and 5.9 provide a graphical summary of results for Ra-226, Th-230, and U-Nat. Figure 5.8 gives a comparative context, comparing the B5 Pit background reference samples with GHP-1 sample results; an excerpt of which is provided in the exhibit below.

Radionuclide Distributions in April 2002 Test Pit Samples

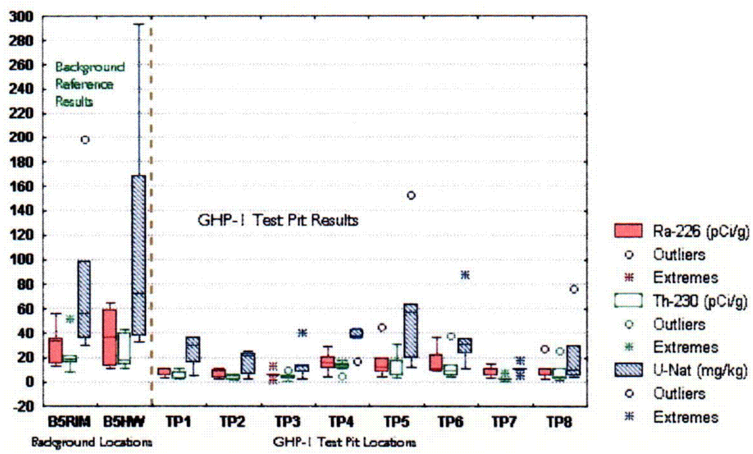


Figure 5.9 shows photos of each test pit, graphs the corresponding results by depth, and summarizes the findings of the geochemical investigation (i.e., impact vs. non-impact determinations). Figure 5.10 plots the isotopic ratios (Ra-226 / 0.5*U-Nat, and Ra-226/Th-230), demonstrating that no notable differences between B5 background and GHP-1 samples are apparent for this endpoint.

The results shown in Figure 5.8 and in Appendix B-3 (Attachment A, Figures 3 through 5) of indicate that the concentrations of total U-nat, Ra-226, and Th-230 in the GHP-1 samples generally decrease between the surface and the 2-foot depth, but then increase with depth below 2 feet. The depth at which subsurface radionuclide concentrations begin to increase in the GHP-1 samples correlates with the approximate 2-foot thick surface that was identified as topsoil in some locations in the GHP-1 test pits. The trends in decreasing surface concentrations are not attributed to impacts from process solutions, but rather are the result of a chemical discontinuity resulting from the presence of topsoil material overlying the native Wind River subsurface strata.

Table 5.3 Phase II GHP-1 Soil Analytical Results: April 2002 Geochemical Investigation Test Pit Sampling

Sample Description		Total Analyses			Soluble Radiochemistry & Inorganic Analyses					Other Soil Analysis Parameters		
Sample ID/ Depth	Comment	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-Nat (mg/kg)	Ra-226 (pCi/L)	Th-230 (pCi/L)	U-Nat (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Total Sulfur (%)	Paste pH (s.u.)	Moisture Content (%)
B5RIM-0'	Background	13.0	8.6	29.7	0.6	0.32	0.0045	<10	1.0	0.04	7.8	1.0
B5RIM-2'	Location	14.8	16.1	36.2	3.7	-0.78	0.0029	<10	1.0	0.04	8.0	0.8
B5RIM-4'	"	35.7	15.8	99.0	7.9	0.16	0.0188	140	5.0	0.31	8.0	1.3
B5RIM-6'	"	32.3	19.4	62.7	6.4	-0.33	0.0006	330	1.0	0.54	7.7	0.8
B5RIM-8'	"	56.8	51.7	198.0	0.8	0.24	0.0154	<10	1.0	0.24	6.8	1.3
B5RIM-10'	"	34.4	22.0	48.8	0.1	-0.46	0.0003	10	1.0	0.26	4.2	2.2
B5HW-0'	Background	13.2	11.1	33.0	1.6	0.57	0.0005	<10	11.0	0.06	7.6	0.8
B5HW-2'	Location	11.2	14.2	37.4	0.9	-0.10	0.0013	10	9.0	0.04	8.0	0.5
B5HW-4'	"	35.5	17.1	71.9	1.4	6.30	0.0225	100	19.0	0.36	8.2	0.8
B5HW-6'	"	59.2	40.2	293.0	1.1	-0.68	0.0167	20	2.0	0.26	4.2	1.2
B5HW-8'	"	64.9	43.4	169.0	1.5	-0.35	0.0022	30	2.0	0.18	3.9	2.0
GHP-TP1-0'	No evidence	11.4	11.5	36.8	1.5	0.19	0.0078	50	3.0	0.19	7.6	1.1
GHP-TP1-2'	of impacts from	10.0	7.7	36.4	0.6	2.05	0.0082	40	27.0	0.10	7.6	0.9
GHP-TP1-4'	pond solutions	5.2	3.0	15.7	0.4	-0.49	0.0174	20	22.0	0.04	7.5	1.4
GHP-TP1-6'	at this location.	11.2	8.5	29.5	2.9	0.13	0.0148	70	7.0	0.16	7.5	1.1
GHP-TP1-8'		3.7	2.4	5.2	0.9	0.32	<0.0001	20	2.0	0.04	7.8	0.6
GHP-TP2-0'	No evidence	9.4	6.9	23.0	0.9	-0.04	0.0108	430	25.0	0.48	7.8	1.7
GHP-TP2-2'	of impacts from	2.5	1.7	2.4	0.2	-0.36	0.0001	10	14.0	0.04	7.7	1.6
GHP-TP2-4'	pond solutions	3.4	2.1	6.0	0.5	3.36	0.0001	<10	2.0	0.05	8.0	1.0
GHP-TP2-6'	at this location.	9.6	6.0	24.9	0.6	-0.21	0.0005	<10	1.0	0.04	8.4	0.2
GHP-TP2-8'		11.0	5.3	20.5	0.7	-0.59	0.0008	<10	1.0	0.02	7.9	0.3
GHP-TP3-0'	No evidence	5.5	4.9	13.6	1.1	-0.55	0.0016	90	75.0	0.15	7.4	1.5
GHP-TP3-2'	of impacts from	1.7	0.9	2.6	1.0	5.53	0.0003	10	6.0	0.02	7.6	1.5
GHP-TP3-4'	pond solutions	5.3	2.7	8.3	0.3	-0.21	0.0005	<10	1.0	0.03	8.0	0.7
GHP-TP3-6'	at this location.	13.1	9.2	40.1	4.8	0.99	0.0008	20	3.0	0.04	7.7	1.7
GHP-TP3-8'		5.4	4.4	12.1	0.2	-0.49	0.0005	20	1.0	0.04	7.9	0.5

Note 1: Test pit samples were collected on April 10 and 11, 2002, and analyzed by ACZ in May and June 2002 (Ra-226 between 6/22 and 6/30/02). The results above are documented in the ACZ report dated June 27, 2002 (Project No. L36584). Corresponding error terms are provided in Appendix B-3 (Appendix B, Table 1).

Table 5.3 Phase II GHP-1 Soil Analytical Results: April 2002 Geochemical Investigation Test Pit Sampling

Sample Description		Total Analyses			Soluble Radiochemistry & Inorganic Analyses					Other Soil Analysis Parameters		
Sample ID/ Depth	Comment	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-Nat (mg/kg)	Ra-226 (pCi/L)	Th-230 (pCi/L)	U-Nat (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Total Sulfur (%)	Paste pH (s.u.)	Moisture Content (%)
GHP-TP4-0'	Impacts from	11.6	13.3	36.5	2.4	0.32	0.0498	270	140.0	0.37	7.4	1.3
GHP-TP4-2'	pond solution	4.7	4.8	16.9	3.6	-0.93	0.0004	90	1.0	0.06	7.8	0.5
GHP-TP4-4'	suggested by	14.8	11.5	36.0	3.6	0.54	0.0017	210	18.0	0.39	7.5	1.9
GHP-TP4-6'	elevated Cl, etc.	28.9	17.6	43.3	0.4	-0.76	0.0017	30	27.0	0.84	7.3	2.4
GHP-TP4-8'	(see Section 5.x)	21.1	15.1	44.1	0.4	-0.28	0.0005	20	17.0	0.95	6.9	1.2
GHP-TP5-0'	Test pit area	10.8	5.2	19.7	1.3	-5.56	0.0044	160	19.0	0.34	7.7	0.9
GHP-TP5-2'	likely impacted	4.6	3.9	12.0	0.2	-0.87	0.002	10	1.0	0.03	8.4	0.4
GHP-TP5-4'	by pond solution	19.4	17.4	64.3	0.4	1.48	0.0041	20	4.0	0.06	7.6	1.1
GHP-TP5-6'		44.9	31.4	153.0	0.3	5.90	0.0134	40	25.0	1.29	5.3	1.7
GHP-TP5-8'		8.4	5.5	56.4	-	-0.46	0.0661	20	10.0	0.13	5.3	0.3
GHP-TP6-0'	Test pit area	10.5	8.6	23.5	0.9	0.01	0.0131	30	2.0	0.18	7.4	0.7
GHP-TP6-2'	likely impacted	9.2	4.9	11.0	(0.0)	-1.00	0.0009	<10	2.0	0.32	8.2	1.0
GHP-TP6-4'	by pond solution	22.1	14.1	30.1	1.0	-0.29	0.0003	30	37.0	0.34	7.7	1.0
GHP-TP6-6'		36.7	37.8	87.5	0.5	-0.32	0.001	20	41.0	0.94	7.3	1.3
GHP-TP6-8'		9.3	5.1	35.7	0.5	0.77	0.0022	<10	13.0	0.26	7.5	0.3
GHP-TP7-0'	No evidence	5.6	2.8	10.7	0.5	-0.98	0.0037	110	2.0	0.16	7.8	1.1
GHP-TP7-2'	of impacts from	3.9	2.1	5.9	1.5	1.29	0.0006	10	1.0	0.02	6.2	0.5
GHP-TP7-4'	pond solutions	14.9	7.8	17.9	1.1	-1.14	0.0001	10	1.0	0.31	3.5	1.3
GHP-TP7-6'	at this location.	11.1	1.2	9.8	1.8	0.43	<0.0001	<10	1.0	0.08	3.5	1.1
GHP-TP7-8'		10.4	1.8	10.5	3.8	-1.22	<0.0001	<10	1.0	<0.01	3.8	0.4
GHP-TP8-0'	No evidence	11.4	10.8	30.4	1.1	-0.25	0.0196	430	6.0	0.71	7.6	1.5
GHP-TP8-2'	of impacts from	2.5	1.8	4.8	0.2	-0.15	0.0008	<10	1.0	0.04	7.8	0.9
GHP-TP8-4'	pond solutions	5.7	2.5	5.7	0.1	-0.28	0.0002	<10	1.0	0.02	7.9	0.6
GHP-TP8-6'	at this location.	5.8	3.2	9.7	0.3	0.24	0.0003	<10	1.0	0.15	8.0	0.8
GHP-TP8-8'		27.6	25.1	76.3	2.7	0.36	0.0012	<10	1.0	0.04	7.8	2.0

Note 2: As noted in Table 5.2, most of the GHP-1 test pit results listed above are no longer valid, given the subsequent excavation that occurred shortly after the geochemical investigation (see text). Excavation depths ranged from 2 to 6 feet, depending on location (average of 3 to 4 ft). However, the results are still valid with respect to the conclusions drawn in the geochemical investigation.

Unlike concentration trends in the GHP-1 samples, radionuclide concentrations in the B5 Rim samples were generally lowest at the surface and increased continually with depth (Figure 5.8 and Appendix B-3, Figures 3 through 5). Concentrations of U-nat, Ra-226, and Th-230 were generally higher in subsurface B5 Rim samples compared to the GHP-1 samples, suggesting the presence of an isolated ore body, which are common in the Gas Hills region.

Leachable concentrations of U-nat, Ra-226, and Th-230 were generally not elevated when compared to native B5 Rim samples collected from the same depths (Appendix B-3, Figures 6 through 8). Relatively higher leachable concentrations of radionuclides would be expected if the soils had been significantly impacted by acidic pond solutions. Sulfate and chloride have relatively higher mobilities and were elevated in most samples relative to the B5 Rim samples (Appendix B-3, Figures 9 and 10). Elevated soluble SO_4 concentrations could be due to localized concentrations of naturally-occurring gypsum ($CaSO_4 \bullet 2H_2O$). The high soluble chloride concentrations may be more indicative of potential impacts from pond solutions, especially those in surface samples from TP-4 (Table 5.3 and Appendix B-3, Figure 10).

Mineralogical Results

Results of the petrographic examination and X-ray diffraction analyses are discussed in Appendix B-3 (refer to Appendix C of the Lidstone report), and are only briefly summarized here. A noteworthy finding based on these analyses is that comparison of the EDXA grain spectra from the B5 Rim samples to the GHP-1 samples indicates that these coatings have characteristically different geochemical signatures. For example, Mn:Fe ratios of the black coatings in the samples from affected GHP-1 test pits were generally greater than 1, whereas those from the B5 Rim were less than one (see Figures 5.11 and 5.12). Significant Cl peaks were also observed in association with the black surface coatings from TP-4, where solution banding was observed. This information suggests that subsurface materials in TP-4 were impacted by process waters elevated in Mn and Cl. This finding is discussed in greater detail below.

5.3.3 Conceptual Geochemical Model

A conceptual geochemical model was developed to aid in identifying the degree to which underlying materials would have been impacted by acidic pond fluids. Chemical analysis of the GHP-1 pond solutions (April 3, 1996) shows that the fluids were Na-SO_4-Cl type waters, acidic in nature (low pH), and containing high total dissolved solids concentrations (Table 5.4):

During the operative period of GHP-1, evaporative concentration of pond water would have caused solids to precipitate from solution. Precipitation of the various solids likely exerted a significant control on the solution chemistry and the fate of U-nat, Ra-226, and Th-230. The results of geochemical speciation modeling indicate that the pond waters were oversaturated with respect to various iron, aluminum, and sulfate minerals, while undersaturated with respect to iron and manganese hydroxides (Table 5.5).

Table 5.4. Major Ion and Radionuclide Concentrations for the GHP-1 Evaporation Pond.

Major Ion Chemistry (mg/L)		Radionuclides (pCi/L)	
Calcium	446	Uranium	4,739
Chloride	5,500	Radium-226	13
Iron	334	Radium-228	3.2
Magnesium	278	Th-230	233
Manganese (estimated)	50	Pb210	5
Potassium	40	Gross Alpha	3,600
pH	2.87		
Sodium	2,380		
Sulfate	4,800		

Source: Umetco GHP-1 site records, April 3, 1996.

The minerals listed as oversaturated in Table 5.5 (shaded) likely precipitated from the pond water, and many of the minerals that formed in the ponds are effective scavengers of other trace metals and radionuclides (Alpers *et al.* 1994).

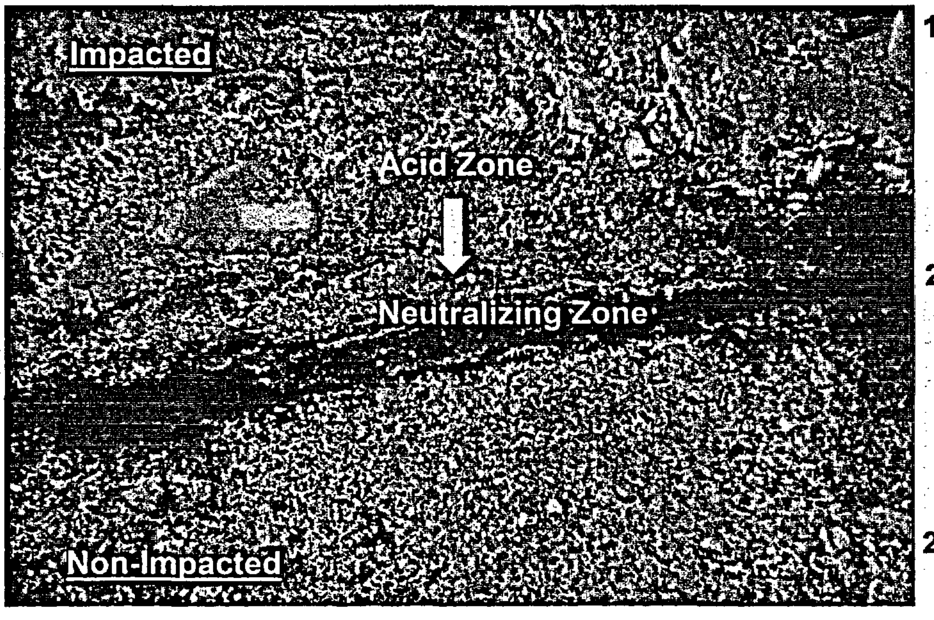
Table 5.5. Calculated Mineral Saturation Index Values for the GHP-1 Fluid.

Mineral Phase	Saturation Index Value	Saturation State
Alunite [$KAl_3(SO_4)_2(OH)_6$]	+ 1.1	Oversaturated
Barite [$BaSO_4$]	+ 0.47	Oversaturated
Ferrihydrite [$Fe(OH)_3$]	- 0.63	Undersaturated
Manganite (MnOOH)	-13	Undersaturated
Gypsum [$CaSO_4 \bullet 2H_2O$]	- 0.20	Undersaturated
Jurbanite [$AlOHSO_4$]	0.60	Oversaturated
$Al(OH)_3$ (a)	- 5.0	Undersaturated
Thorium Sulfate [$Th(SO_4)_2$]	+ 0.34	Oversaturated

Acidic pond fluids migrating into the subsurface create an advancing front where calcite dissolution and acid neutralization control the extent of migration of acidic water. Behind the advancing front, the *acid zone* will contain water whose chemistry is very similar to the pond seepage (Table 5.5). The acid zone is characterized by lower pH, calcite depletion, and residual iron and aluminum oxides. The acid zone may also contain residual radionuclides not completely removed from solution by precipitating pond minerals.

The reaction front, or *neutralizing zone*, is the zone of active calcite dissolution where higher pH conditions exist. These geochemical zones—the *acid zone* and the *neutralizing zone*—are shown in Figure 5.13 and in the exhibit below. Reaction with calcite causes gypsum, $Al(OH)_3$, and $Fe(OH)_3$ to become oversaturated and precipitate. Precipitated iron and aluminum hydroxides have large metal adsorption capacities and will effectively attenuate metals and radionuclides. Therefore, trace metals and radionuclides that were not removed by the pond minerals would continue to be removed from solution within this neutralizing zone, thereby minimizing their migration below the former clay liner.

Conceptual Geochemical Model Showing Impacted Zones in GHP-1 Test Pit 4



1.5 ft bgs

2.0 ft bgs

2.5 ft bgs

Synopsis: **The depth at which black solution bands have been identified in test pits—2 to 4 feet below ground surface—therefore corresponds to the location of the original reaction front, indicating the maximum depth of potential 11e.(2) contamination.**

The sequence of metals precipitation for the GHP-1 water was simulated by incremental reaction with calcite (as a proxy for depth) using the geochemical model PHREEQC, described in detail of Appendix B-3. The geochemical modeling results are consistent with the conceptual model and support field observations where orange bands (presumably iron and aluminum oxides) overlying black laminae (consistent with the color of manganese oxides) were observed. The locations of these solution bands therefore indicate the position of a former acid front and, as identified above, are assumed to be indicative of the maximum depth of potential 11e.(2) contamination.

5.3.4 Summary of Geochemical Investigation Findings

Field observations and analytical data collected during the geochemical evaluation indicate that materials underlying the former pond had been impacted, although only to a limited extent, from leakage of acidic pond solutions in the northern section of GHP-1. The following bulleted items document the primary findings:

- Calcite was depleted in surface samples from Test Pits in the northern section of GHP-1.
- Solution banding characteristic of the neutralized zone of an acidic front was identified between 2 and 4 feet bgs in the north GHP-1 Test Pits.
- EDXA spectra of grains from areas of solution banding indicated that manganese oxide coatings have different geochemical signatures compared to native oxide occurrences.
- Chloride was identified in association with manganese oxide grain coatings in GHP-1 samples, and high soluble chloride concentrations were also present in some samples.
- Coffinite (ore-grade uranium) was found in excavations below the GHP-1 pond liner. This presence of NORM, redox conditions and natural weathering of the minerals complicated the interpretation of the impacts of solution chemistry.

Impacts to the underlying materials were minimal, however, as indicated by the low degree of alteration of feldspar grains, the incomplete acidification of the subsurface materials from the low pH solutions, and the shallow depths (2 to 4 ft) at which solution banding was identified. Based on the field observations—e.g., the zone of impact identified in TP-4 (Figures 5.9 and 5.13)—Lidstone recommended removal of 3 to 4 feet of impacted material from the northern section of GHP-1 (Lidstone 2002). Note that this recommendation (i.e., the evidence of impacts) was based primarily on the migration of chloride and sulfate in the test pits, and *not* the vertical trends exhibited by either total or soluble radionuclide parameters.

5.4 Phase III: May 2002 GHP-1 Cleanup and Final Verification Survey

5.4.1 May 2002 Cleanup and Excavation

At about the same time that the geochemical investigation was underway (April 2002), petroleum affected soils were identified in the northern pond section, coinciding with the location of the former mill solvent catch basin and former leach field (see Figure 5.1). Therefore, the cleanup/excavation plan designed to address the 11e.(2) byproduct impacts described above was augmented to mitigate the petroleum affected soils. As a conservative measure, a minimum of 2 feet was removed from the entire pond, but cleanup efforts focused on the impacted areas. In response to Lidstone's recommendations, 3 to 4 feet of material was removed from the northern byproduct affected area. To ensure adequate cleanup and driven by ALARA considerations, an additional 2 feet was excavated below the impacted horizon. An additional 11,904 cubic yards of material were excavated from the pond as part of this effort. Excavation depths ranged from 2 to 6 feet, depending on location, with the greatest excavation depths—about 6 feet—coinciding with the areas where byproduct impacts were identified and/or where petroleum residues were identified. Excavation depths for remaining areas ranged from 3 to 4 feet. All excavated material was removed from the GHP-1 pond and properly disposed at the A-9 tailings pond. As such, all byproduct/impacted material was removed, leaving only the underlying material naturally present within the Wind River Formation. The elevated levels in this NORM material are demonstrated in the radionuclide results for subsurface samples in Table 5.3 and in Figures 5.8 and 5.9. They are also reflected in the final status survey results, discussed below.

5.4.2 May 2002 Gamma Survey

Contaminated soil removal consisted of removing approximately 30,000 cubic yards of soil (18,000 cubic yards initially, and 12,000 cubic yards to address apparent impacts).

The final gamma survey for GHP-1 was conducted on May 22, 2002 using the same meter that had been used for previous surveys—Ludlum meter L-2221/434. Figure 5.14 maps the results of this final survey, showing the average Ra-226 estimated for each grid based on the survey readings. As reflected in this figure and in Figure 5.15, little change is evident in results when compared to 2001. In fact, pond-wide average Ra-226 concentrations increased slightly. Figure 5.16 shows these changes as a function of elevation changes—i.e., areas where the excavation was deepest correspond to those grids exhibiting the greatest increases in average Ra-226e concentrations. These increases are visually apparent in Figure 5.17, which compares the unconverted cpm distributions for the initial 2001 vs. 2002 data set.

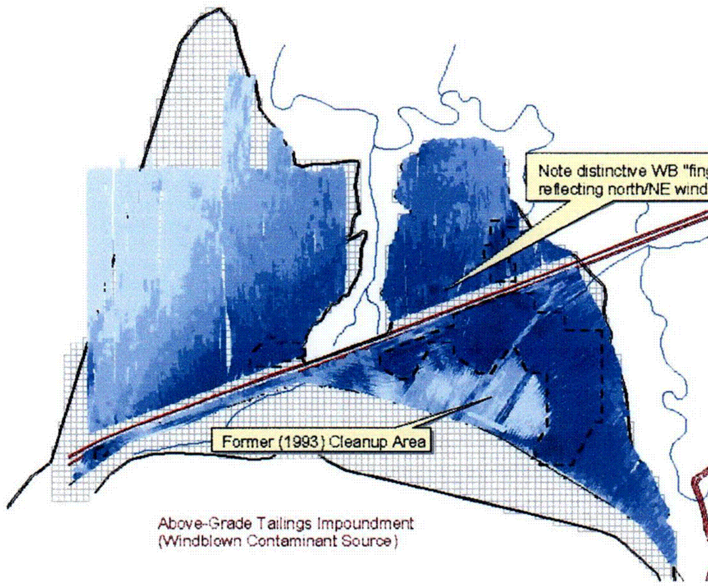
5.5 Summary Discussion

Although 30,000 cubic yards of byproduct affected soils were removed from GHP-1, the Final Status Survey did not result in a reduction of Ra-226 concentrations because underlying ore zone areas were exposed. Ra-226 concentrations measured in GHP-1 are within the range of concentrations measured in the adjacent B5 Pit. Accordingly, Umetco is proposing alternate criteria to demonstrate cleanup in this area using the adjacent B5Pit Ra-226 levels as a specific local background reference area. Results of a geochemical investigation conducted to identify the extent of byproduct contamination in GHP-1 has been provided in Section 5.3 in support of Umetco's request.

6.0 WINDBLOWN AREA

The windblown area, shown in Figures 1.1, 1.2, and 6.1, has been characterized by a thin surficial veneer (typically 0-0.5") of windblown deposited 11e.(2) byproduct material. As discussed in the FSSP, the primary source of windblown contamination is the Above-Grade Tailings Impoundment (AGTI). The contamination pattern reflects the prevailing north/northeast wind direction, visually apparent in the diagram below[11]:

Initial Windblown 2001 Snapshot



The windblown survey area was aerally extensive (Figures 1.1, 1.2, and 6.1)—the gamma data survey coverage encompassed approximately 111 acres, about 70 acres of which exhibited potential windblown impacts. As such, the data collection and management effort was even more extensive than that documented in the preceding section for GHP-1. Because the magnitude of this data set precluded even concise tabular summaries, the majority of the findings in this section are presented in a visual (graphic) format. Detailed supporting information is provided in Appendix C. Appendix C-1 presents the gamma survey documentation, including source file and data management information for over 30 distinct surveys and more than 235,000 data points. Appendix C-2 presents the soil sampling documentation, and Appendix C-3 presents the data and exploratory analyses supporting the revised gamma-radium correlation equation derivation.

[11]As discussed in Section 4.2, although the final status survey was conducted on a 10-meter by 10-meter grid basis, contamination patterns are most apparent when the individual survey data points are plotted. Therefore, as shown above and in many of the figures associated with this section, gamma survey data (Ra-226 estimates) are plotted using graduated color maps and a "Natural Breaks" classification method. For the windblown area figures, legends for all graduated color point data maps are based on that developed for the initial (2001) windblown snapshot. This was done to ensure consistency and the validity of figure comparisons—e.g., 2001 vs. 2002 (see Figure 6.5 addendum). In some cases, slight adjustments are made to reflect revised upper or lower bounds, but otherwise the classifications remain the same. Again, in reviewing such figure
es, the actual breakdowns are not important—rather, the visual spatial pattern is the primary purpose.

C04

6.1 Background Characterization Refinement

Final status survey investigations of the windblown area yielded some similar findings to those determined for GHP-1. First, like GHP-1, the previously established background and corresponding cleanup levels (6.1 and 11.1 pCi/g, respectively) were not sufficiently high to account for the prevalence and magnitude of NORM within and surrounding the windblown project area. Second, cleanup of byproduct impacted material in some areas led to the exposure of underlying NORM-containing soils exhibiting similar or higher Ra-226 levels than the overlying windblown particles, sometimes confounding the demonstration of cleanup.

As discussed in Sections 1.4 and Section 2.6, the 6.1 pCi/g Ra-226 northern area background value was established after extensive discussion with the NRC, and was essentially a negotiated value. Both parties acknowledged that NORM areas exhibiting Ra-226 levels higher than this background level were likely to be encountered, but this factor was to be addressed by using the byproduct material identification procedures—i.e., allowing for some discretion in the field (Section 3.6). Ultimately, due to the prevalence of NORM within the windblown project area, the latter provision was not sufficient to allow for a clear demonstration of attainment of the (background plus 5 pCi/g) cleanup criterion—when in fact that is the case. To better demonstrate these findings, a summary of the previous background data set (SMI 1999b, SMI 1999c, Umetco 2000b) is warranted. This summary is provided largely in a graphical manner, as reflected in Figures 6.2 through 6.4. Detailed information is provided in the cited reports.

The first factor to reiterate is that the background data set was a combination of two data sets derived in SMI's investigations: the first based on the extensive discrete sampling conducted for their background study, and the second based on a later investigation designed to determine the extent of windblown contamination (Windblown Scoping Study; SMI 1999c). The northernmost samples from the latter investigation were later determined to be valid background locations. Based on observations made during the final status survey and a re-examination of SMI's background data, the northernmost composite samples collected in SMI's windblown scoping study were probably much better indicators of a reasonable range of background than SMI's (1999b) background data set—in terms of both magnitude and sample collection methods.[12] The NRC review of the background data set also suggested that samples further north of the site appeared to be a different population (NRC 2001), and indeed this is the case, as shown in Figures 6.2 and 6.3. Figure 6.4 demonstrates how NORM at depth in SMI's initial conservative data set was not reflected, as subsurface Ra-226 (> 6" bgs) was not used to establish background.

It is beyond the scope of this document to undertake a detailed re-analysis of background conditions. Furthermore, it is not considered necessary—as identified previously, the NRC determined that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001). Accordingly, if it is not possible to derive a background statistic, it is not reasonable to derive a single cleanup level.

[12] The windblown scoping study samples were collected in the same manner as the final status survey verification samples—i.e., blended 0-6" composites from discrete locations within a 10-meter by 10-meter study grid. Alternatively, their background evaluation utilized discrete samples; this was done in part to characterize vertical trends.

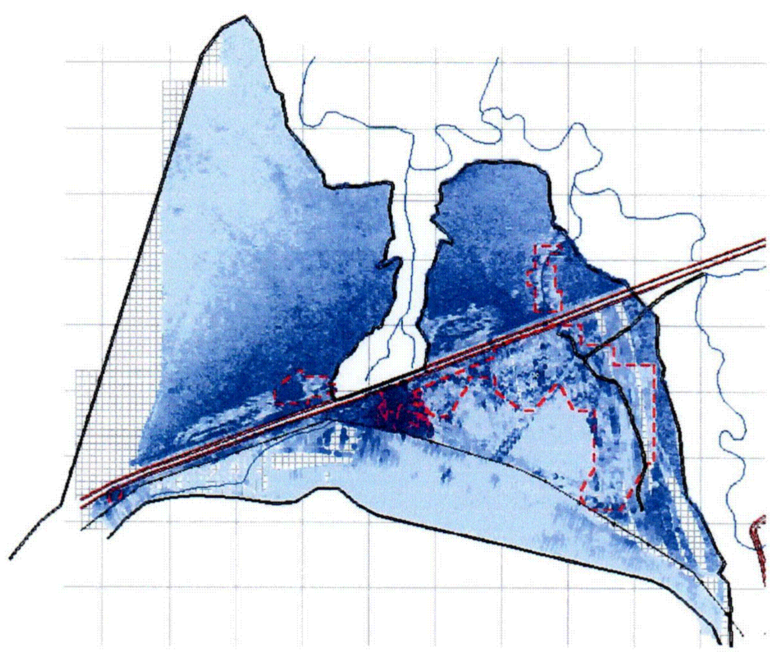
However, for the purpose of reviewing and interpreting the findings presented in the following sections, 10-15 pCi/g Ra-226 is considered a more representative range of windblown area background conditions than the previously estimated 6.1 pCi/g. This conclusion is based on the issues discussed above and on the soil Ra-226 measured in soil samples collected from known NORM areas during the windblown area final status survey.

6.2 Characterization, Cleanup Areas, and Verification Survey Summary

The final status survey for the windblown area was performed over the area encompassing the survey boundary shown in Figure 6.1. The windblown final status survey area encompassed 4400 sequentially numbered 10-meter by 10-meter grids, approximately 3800 of which were located in potentially impacted areas. The extended survey coverage (largely to the north) allowed Umetco to better delimit the windblown contamination extent. Methods used in the final status survey for the windblown area are discussed in Section 3 and in Appendix A.

Windblown area final status survey efforts began in May 2001, when the initial "pre-excavation" gamma survey was undertaken. Results of this initial characterization survey are shown in Figure 6.5 (and are reflected in the introductory diagram on page 33). Based on these initial survey results, significant excavation—entailing the removal of approximately 3,100 cubic yards of material—was undertaken in the areas outlined in Figure 6.5. Figure 6.6. shows the initial 2002 "snapshot" reflecting this excavation: as shown in the exhibit below, the effectiveness of the 2001 cleanup is apparent.

Initial Windblown 2002 Snapshot, Reflecting 2001 Cleanup



Above exhibit adapted from Figure 6.6.
- - - -indicates approximate 2001 cleanup area
•indicates increased gamma survey readings in Carbide Draw (see text below)

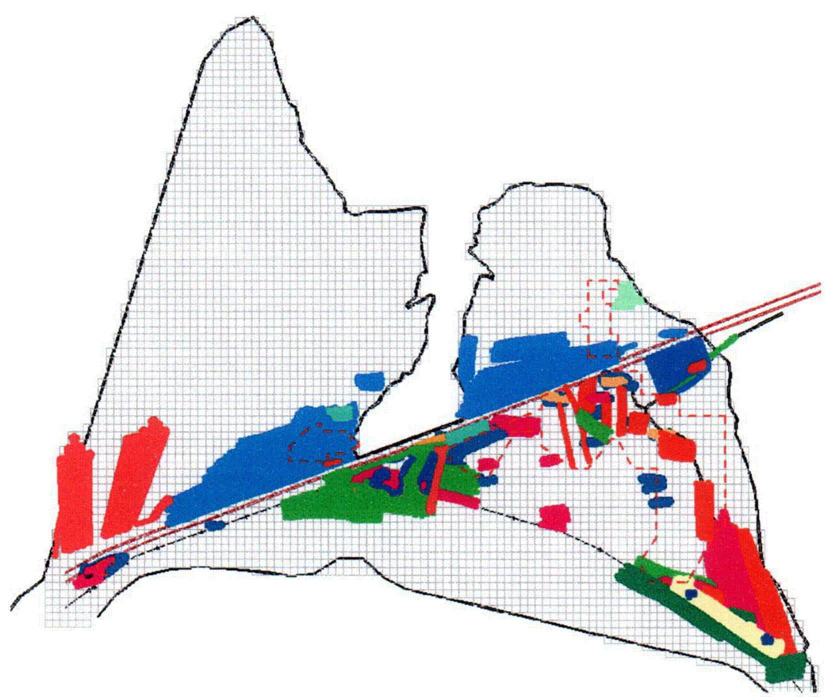
C05

The only exception to the latter finding (re: cleanup effectiveness) was observed in the south Carbide Draw area, where gamma survey readings increased significantly. The May-June 2001 survey indicated the need for remediation of localized areas within Carbide Draw, and these excavations were undertaken. However, in the process of cleanup, gamma levels increased and could not—unlike other windblown areas—be attributed solely to NORM. Rather, the findings in this area likely reflect the breach in the tailings impoundment that had occurred during the operational period of the mill and/or accumulation of sediment from the site and the AGTI. As such, the south Carbide excavation proceeded, as described in the discussion of 2002 survey efforts below.

6.2.1 2002 Cleanup and Post-Cleanup Verification Surveys

Although the 2001 cleanup effort resulted in the effective remediation of some large areas, the initial 2002 characterization survey results indicated the need for further localized remediation. The subsequent cleanup and verification efforts were performed in an iterative fashion throughout the 2002 field construction season. Approximately 1,500 cubic yards of material were excavated in 2002 (excluding Carbide Draw). The approximate cleanup areas are shown in subsequent figures presenting results (Figures 6.8 through 6.15), but are probably best reflected in mapping the post-verification survey data. Figure 6.7 demonstrates the iterative nature and extent of the verification surveys, whereby each uniquely colored symbol reflects a distinct cleanup and/or survey effort. An abbreviated version of this figure is provided in the diagram below.

Overview of 2002 Final Status Re-Survey and Excavation Areas



Above exhibit adapted from Figure 6.7.
- - - -indicates approximate 2001 cleanup area

C06

As shown in Figure 6.7 and the exhibit above, several of the 2002 re-survey areas had been excavated in 2001. Additional cleanup was undertaken under the assumption that windblown material still remained (and this could have been the case), but later it was revealed that in some areas, NORM was accounting for the still elevated Ra-226. The total volume of material removed and disposed of in the A-9 during the 2001-2002 windblown area final status survey efforts is summarized in the table below.

Table 6.1 Summary of Windblown Area Cleanup Efforts

Area	Year	Volume Removed	Description
Windblown (inc. Carbide Draw)	2001	3,128 cu yds	Corresponding to major windblown impacts shown in Figures 6.5 and 6.6
Windblown (exc. Carbide Draw)	2002-2003	1,572 cu yds	Iterative cleanup driven by gamma surveys (Carbide Draw excavation treated separately; see below.)
Total Windblown	**2001-2003**	**4,952 cu yds**	**(Excludes Carbide Draw below)**
Carbide Draw	2002	6,324 cu yds	Initial cleanup in 2001 revealed underlying mill-related material exhibiting levels significantly higher than previous surficial readings. This material was not technically windblown, but rather resulted from the previous breach of the tailings impoundment.

Given the magnitude of the Carbide Draw excavation, some discussion of the field observations made during this effort is warranted. As discussed on the preceding page, original surveys of the Carbide Draw area south of the county road indicated the need for localized cleanup. However, early in the excavation it became clear that the contamination in this area was not strictly due to windblown material; rather it reflected in part the accumulation of sediments resulting from the previous breach in the tailings impoundment. As the excavation progressed (becoming wider and deeper), gamma survey readings continued to increase, and it was difficult to distinguish between NORM and potential byproduct material

The area was evaluated by Lidstone & Associates to assess sediment depositional characteristics and to better distinguish between native material and affected soils. Drainage channels were identified based on the historical photographs and the geological characteristics of the area. Upon completion of the excavation, Lidstone returned to the site and verified that materials had been removed to native ground. This finding must be acknowledged in reviewing the final status survey results that follow (e.g., those shown in Figure 6.11), as elevated Ra-226—i.e., NORM—is apparent in some areas.

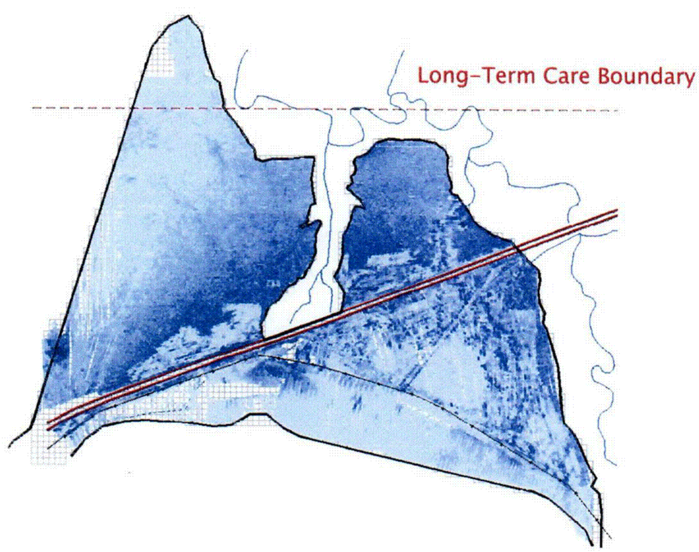
6.3 Gamma Survey Findings and Results

The results presented in this section reflect the final Windblown Area final status survey snapshot, as of October 2002, and as such reflect the merged results of multiple characterization and post-cleanup verification surveys conducted throughout the 2002 field season. The figures referenced in this section are self-explanatory and therefore warrant little accompanying discussion. Therefore, the text is generally limited to a discussion of salient findings.

The results of the 2002 windblown area final status survey are shown in Figures 6.8 through 6.17. Figure 6.8 shows the grid average Ra-226 estimated for each 100 m^2 survey grid. Given the large spatial extent of the windblown study area, and to facilitate review of the results shown in Figure 6.8, six sub-areas were defined as shown in Figure 6.9 Corresponding detailed results are provided in Figures 6.10 through 6.15. In addition to grid-specific information, these figures also include the gamma survey coverage, soil sampling results, and identify cleanup and NORM areas. In these figures, grid average Ra-226 estimates and gamma survey data points are color-coded to reflect Ra-226 magnitude, and these categories—e.g., 3 - 7.5 pCi/g, 7.6 - 8.9 pCi/g, 9.0 - 11.1 pCi/g, 11.2 - 13.3 pCi/g etc.—preserve the context of the previously established 11.1 pCi/g cleanup level.[13] Note, however, that, based on the background characterization refinement presented in Section 6.1 and the final status survey results for known NORM areas documented in the subsequent figures and exhibits, all of the results shown in Figures 6.1 through 6.16 are considered to be in attainment of the Criterion 6(6) background plus 5 pCi/g Ra-226 cleanup criterion.

Figure 6.16 plots the gamma survey data for the final (October 2002) windblown area snapshot vs. those based on the initial (April-May 2001) characterization survey. Comparison of the two maps (2002 vs. 2001) demonstrates the effectiveness of the 4,700 cubic yard windblown cleanup effort. An adapted version of this figure is provided in the exhibit below.

Windblown Area Final Status Survey "Final Snapshot"



[13] The 8.9 pCi/g and 13.3 pCi/g category bounds correspond to 11.1 pCi/g +/- 20 percent.

As shown above and in Figure 6.16, elevated radiological characteristics are still apparent in selected areas (e.g., the darker band north of the county road), but the gamma survey readings and corresponding Ra-226 estimates are within the range of observed background. Figure 6.16 also identifies several NORM areas, but three—all located north of the county road—are noteworthy. These areas are numbered on Figure 6.16 and described in detail in Exhibits 6.1 through 6.3, provided at the end of this section. These exhibits provide a visual and textual chronicle of the field observations and final status survey results for each NORM area, all supporting the conclusion that further remediation of the windblown area (particularly north of the county road) will not guarantee reduction in Ra-226 magnitude. In fact, levels might increase.

Figure 6.17 provides an alternate view. Note that survey results exceeding 15 pCi/g are all within known or suspected NORM areas. Figure 6.18 provides a graphical statistical summary of the windblown area final status survey grid-specific results. In this figure, grid average Ra-226 estimates based on the gamma survey were categorized as follows:

1) Main windblown area grids—including the area south of the county road and the darker-colored areas in Figure 6.5;

2) Secondary windblown area—corresponding to the darker band on Figure 6.16 just north of the cleanup areas;

3) Known NORM areas—e.g., those addressed in Exhibits 6.1 through 6.3;

4) Possible NORM grids—defined based on field observations, but where evidence is not compelling enough to warrant a (true) NORM designation; and

5) Non-mined (undisturbed) background—corresponding to the northernmost gamma survey area (the pale-blue section shown in Figure 6.16, with detailed view provided in Figure 6.13). This area exhibits some of the lowest gamma survey readings, was not mined (as evidenced by the lack of exploration holes), and as such is considered the most conservative representation of background for this area (see Figures 6.2 through 6.4 for context).

Corresponding summary statistics for Ra-226 grid averages based on the gamma survey data are tabulated as follows (all values are in units of pCi/g except Valid N):

Category	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Minimum	Maximum	Std.Dev.
Windblown Primary	2749	8.9	8.8	8.9	3.0	14.3	1.8
Windblown Secondary	940	9.0	8.9	9.0	7.0	11.6	0.8
Known NORM	46	12.2	11.6	12.8	7.7	19.3	2.1
Potential NORM	26	11.2	10.8	11.6	9.3	13.9	1.0
Undisturbed Background	639	7.2	7.1	7.2	5.9	8.4	0.4

Figure 6.18 demonstrates that the windblown area results are well within the range observed for both known and potential NORM areas. Also, in the context of the gamma survey results (cpm

converted to Ra-226 estimates), the range of background is higher than that previously defined—around 7 to 8 pCi/g as shown in Figure 6.17. Again, the latter represents a very conservative estimate of background, as the more elevated NORM areas illustrated in Figure 6.2 and Exhibits 6.1 through 6.3 are not reflected.

Summary statistics for all windblown area study grids are provided in Appendix C-2. To examine the impact that additional cleanup would have on the overall Ra-226 areal average, all grids with Ra-226 averages exceeding 11.1 pCi/g were re-assigned a value of 11.1 pCi/g. This was done for three areas: 1) all windblown study grids, including non-impacted areas (n = 4400 grids); 2) the main windblown area, defined above (n = 2801), and 3) main and secondary (also defined above) areas combined (n = 3761). Results of these calculations are provided below:

Area	No. of Grids	Current Avg. Ra-226	Avg. Ra-226 if all ≤ 11.1 pCi/g
All Windblown Grids	4400	8.7 pCi/g	8.6 pCi/g
Main Windblown Area	2801	8.9 pCi/g	8.8 pCi/g
Main + Secondary	3761	9.0 pCi/g	8.9 pCi/g

As indicated above, cleanup of grids exceeding the previously defined 11.1 pCi/g Ra-226 cleanup level (many of which are NORM and/or within the range of background) would result in only a 0.1 pCi/g (1%) reduction in the average Ra-226 content. Granted, the above summary ignores spatial weighting issues, but the overall findings—i.e., the projected nominal reduction in Ra-226—would likely be corroborated by further assessment.

6.4 Soil Sampling Results

Soil samples were collected in an iterative manner throughout the final status survey. Grids to be sampled were selected based on those exhibiting the highest gamma survey readings, but assumed not to exceed the 11.1 pCi/g Ra-226 cleanup level. After ensuring that adequate ingrowth had occurred (the earliest results were available in late July), initial results indicated the need for cleanup in areas previously thought to be below the 11.1 pCi/g cleanup level. [These conclusions were drawn before the magnitude and prevalence of NORM had been clearly established.] Also, Ra-226 estimates based on the previous algorithm established in the windblown correlation study appeared to be too low, underestimated by about 2 pCi/g.

Over 200 samples were collected during the windblown area final status survey investigation (approximately 5% of the study grids), 150 of which are considered valid (i.e., no subsequent cleanup was undertaken). The valid sample results are mapped on Figure 6.19, and shown in detail in the smaller-scale (zoom) results provided in Figures 6.10 through 6.15. Detailed results are provided in Appendix C-2, and the corresponding revised gamma-radium correlation equation is documented in Appendix C-3.[14] [Correlations were valid for 130 of the 150 valid sample results.] Corresponding Ra-226 estimates were then compared with the soil analytical

[14] Correlations were valid for 130 of the 150 valid sample results. The 20 results considered to be invalid for correlation purposes had either insufficient spatial coverage or multiple survey dates (e.g., for grids with only partial cleanup or those peripheral to cleanup areas).

results and residuals were calculated. Despite some disagreement between soil sample results and corresponding survey estimates, the predictions were still within an acceptable margin of error (RPD less than 15%; Appendix C-3). Also, in many cases the Ra-226 estimates were in very close agreement with the corresponding soil results (e.g., see Figures 6.10 through 6.15).

Establishing a revised gamma-correlation equation for this project area was very difficult. This difficulty is apparent in reviewing Figure 6.19, which plots the range of grid-average cpm's vs. the corresponding soil analytical result. As shown in this figure, the majority of the soil samples were collected in grids with average survey readings ranging between 11,000 and 12,000 cpm. The graph in the lower portion of this figure demonstrates the wide range in soil results corresponding to this cpm range: 7.2 to 18.5 pCi/g Ra-226. Many permutations were attempted in defining the new gamma-radium equation. For example, subsets were defined based on area (north windblown vs. south), NORM presence or absence, meter, etc. Subset definition did not yield any compelling results—in fact, the correlations were weaker than that defined for the original data set. Ultimately, outliers were defined for each cpm range and then excluded from the data set as documented in Appendix C-3. This revised data set, excluding outlier (marked) points, was then used to define the gamma-radium correlation equation used to estimate Ra-226 for the windblown area.

As discussed in Section 4.1, it is important to acknowledge that the discrepancies discussed above are inevitable in a characterization survey of this nature and magnitude, especially given the prevalence of NORM and the heterogeneity which characterizes the windblown area (see Section 4.1).

All windblown area soil samples were analyzed in the on-site laboratory as discussed in Section 3. Ten samples were sent to an outside vendor, ACZ, for confirmatory analysis. Comparison of the onsite laboratory results with ACZ's indicates general agreement (16% RPD) as documented in Appendix C-2.

6.5 September 2003 Germanium Detector Evaluation

Given the prevalence of NORM within and surrounding the windblown study area, and the difficulty in distinguishing between NORM and windblown 11e.(2) material, a qualitative evaluation was undertaken in September 2003 in an attempt to better elucidate distinctions, if any, between these areas.

6.5.1 Study Rationale and Objectives

In the measurement of gamma-ray energies above several hundred keV, only two detector categories of major importance: inorganic scintillators—e.g., NaI(Tl), used throughout the Final Status Survey—and germanium (Ge) semiconductor detectors. Although there are many other potential factors, the choice in a given application most often revolves about a trade-off between counting efficiency and energy resolution (Knoll 1989). While scintillators provide good counting efficiency, their energy resolution is poor. Conversely, germanium detectors provide excellent energy resolution but have lower photopeak efficiencies. Given the difficulty in distinguishing between NORM and 11e.(2) affected areas on the basis of Ra-226 magnitude alone (with NORM areas often exhibiting higher Ra-226 than windblown impacted areas), an evaluation allowing better resolution between photopeaks was undertaken in September 2003.

Eleven locations were selected for study, representing 3 primary categories: 11e.(2)/windblown impacted areas, disturbed NORM areas (e.g., those discussed previously and addressed in Exhibits 6.1 through 6.3), and undisturbed NORM areas. These locations are shown on Figure 6.21; more detailed descriptions and supporting rationales are provided on Table 6.2 (see following page). The study was conducted on September 3rd and 4th, 2003 using an Orsat™ Ge(Be) detector. Results of this evaluation are documented below.

6.5.2 Results

Figure 6.22 plots gamma spectrum results for each location; larger versions of each plot are provided in Appendix D. In reviewing these results, four peaks are of primary importance: Pb-212, a Th-232 decay product; Pb-214 and Bi-214 (both decay products of Ra-222), and Cs-137. Because this study is essentially qualitative (vs. quantitative), the magnitude of the peaks is not as important as the ratios between them. Therefore, in reviewing Figure 6.22, it is important to focus on the pattern established by the primary (highest) peaks for the endpoints of concern, and not necessarily the magnitude.

Primary Findings: Even with the heightened resolution provided by the Ge detector, no compelling differences were found between 11e.(2)/windblown affected and disturbed NORM areas. The corresponding Ra-226 measurements, although approximate, are generally consistent with previous field and gamma spec Ra-226 measurements (Figure 6.22). Pb-212 and Pb-214 appear to be elevated in relation to Bi-214 at 11e.(2) affected locations—namely grid 45962 (closest to AGTI source) and the East Canyon Creek location, but this pattern is also found at the known NORM location (grid 54550) and the B-5 pit. A prominent "step-down" pattern (Pb-212 vs. Pb-214 vs. Bi-214) is apparent in many of the plots.

Table 6.2 Germanium Field Evaluation Locations and Rationales for Study

No.	Grid No.	Location / Description	Category	Comment / Rationale
1	45962	Windblown, closest to source, near Restricted Area fence	11e.(2) / Windblown	Closest to source, and with previous (pre-cleanup) soil sample gamma spec result of 13.7 pCi/g. A portion of this grid and the surrounding area was remediated in Sep-03.
2	NA	East Canyon Creek, north of county road	11e.(2) / Windblown	Part of area evaluated in the East Canyon Creek risk assessment (SMI 1999c), outside of Final Status Survey Scope (see Section 6.1).
3	51963	Northeast SWB	11e.(2) / Windblown	Soil result of 15.2 pCi/g here. Windblown presence likely (within sagebrush heads), but still within range of background (Figure 6.10).

4	52331	Windblown area north of NWB cleanup, in vicinity of known NORM areas	11e.(2) / Windblown	Area north of cleanup areas exhibiting windblown characteristics but also close to known NORM areas. The gamma spec result was higher than most in this area (15.2 pCi/g). Purpose of inclusion is to determine whether this is distinguishable from NORM.
5	49511	"Oxidized zone" NORM area	NORM	See Figure 6.13 and Exhibit 6.1.
6	51535	MW-18 NORM Area	NORM	See Figure 6.15 and Exhibit 6.2.
7	54550	"No-Name Draw" NORM area	NORM	See Figure 6.15 and Exhibit 6.3. The gamma spec Ra-226 measured for this grid was the highest of all samples collected: 18.5 pCi/g.
8	49279	NORM Area, west NWB	Suspected NORM	Elevated Ra-226 based on gamma survey, but the location and magnitude of measurements is not consistent with AGTI windblown material. A gas line was encountered here, so results could be due to mine spoils used as fill.
9	58104	Northwestern-most windblown final status survey area	Undisturbed NORM, low range	Based on previous background evaluations and final status survey results, this grid and the surrounding area likely represents the low range of background Ra-226 for the site.
10	NA	Background area approx. 950 m (0.6 miles) north of county road, well beyond 11e.2 affected areas	Undisturbed NORM, intermediate	Background area evaluated during SMI's 1999 windblown scoping study, near an outcropping exhibiting elevated Ra-226.
11	NA	B-5 Pit	NORM, Mine Spoils	Coincides with B-5 sample locations shown in Figure 5.2

Note that in some grids categorized as windblown/11e.2, there is the potential for NORM admixture. For example, the area around grid 45962 exhibited some evidence of mine spoil material (see Figure 6.22).

AGTI Above-Grade Tailings Impoundment (primary windblown contaminant source)
NA Not Applicable
NORM Naturally Occurring Radioactive Material
NWB North Windblown area
SWB South Windblown area

The only endpoint signaling any compelling difference between the locations is Cs-137, by which disturbed areas are readily distinguished from undisturbed areas. Figure 6.23 plots the ratios of Pb-212: Pb-214 and Pb-212: Bi-214 obtained for all locations, as well as the corresponding Cs-137 peaks. Again, no compelling differences are found based on the peak ratios alone. Figure 6.24 provides alternate exploratory analysis plots, underscoring the previous conclusion. The cluster analysis provided in this figure (a semi-quantitative means of grouping cases based on multiple variables) shows the three primary undisturbed locations clustering together, but apart from that, no obvious groupings are apparent.

In summary, the results of the recent Ge detector in situ field study corroborate Umetco's previous findings that, in this heterogeneous area where the mill site was situated within the mining area, it is not possible to quantitatively distinguish between NORM and 11e.(2) and windblown affected material.

6.6 Summary Discussion

Cleanup and subsequent verification of windblown byproduct in areas where NORM materials were not encountered was very effective. The windblown veneer was identified, removed, and documented by subsequent verification surveys. Attempted cleanup of windblown byproduct material in areas where NORM was present was very difficult, resulting in several iterations of excavation and survey which ultimately resulted in increased Ra-226 concentrations. Additional soil removal north of the excavated areas will likely expose additional natural mineralization, loss of topsoil, potential disturbance of cultural resources, and increased surface Ra-226 concentrations.

Considering the underlying NORM which exists within the survey boundary, and the results of the recent germanium detector in situ study confirming that disturbed NORM areas are indistinguishable from windblown (11e.(2) impacted material, Umetco believes that an optimal cleanup of the windblown area has been achieved. Remaining windblown byproduct, if any, is indistinguishable from the immediate area background. Application of the "as low as reasonably achievable" (ALARA) principle would not create a health risk (as indicated based on the previous East Canyon Creek risk assessment, SMI 1999a) and is reasonable under the circumstance of highly variable background values. The potential dose after remediation of the northern area will be low because, as discussed in Section 2.5, this area is part of the parcel that will be deeded to the Department of Energy for perpetual care. Significant cleanup has occurred in the windblown area—approximately 11,000 cubic yards (including Carbide Draw)—as evidenced by the Ra-226 reduction in non-NORM areas which is highly apparent in the preceding figures. Based on the findings presented in this section and the issues discussed above, no further remediation of the windblown area is warranted.

7.0 REMAINING 2001-2002 FINAL STATUS SURVEY AREAS

This section presents the final status survey results for the remaining areas investigated in 2002. Section 7.1 discusses the cleanup and characterization results for the DW-6 former process water pipeline. Section 7.2 presents the final exposure survey results for the above grade and the heap leach. Section 7.3 summarizes the status of the trash pits discussed in Section 4.3.2 of the FSSP. As identified previously, the uncovered section of the former A-9 haul road, shown in Figure 7.1, will be assessed when the A-9 cover construction is completed and the remaining haul road reclaimed.[15]

7.1 DW-6 Process Water Pipeline

In accordance with the FSSP, the DW-6 pipeline was investigated in Spring 2002 to assess the potential presence of byproduct material contamination. This pipeline is the process waterline extending west (offsite) from the former mill area wash facilities (Figure 7.1). The reason that byproduct material contamination was suspected here is that, according to anecdotal information, tailings sand was used as bedding material around the piping in selected portions of the waterline.

7.1.1 Study Area Description

This pipeline is 6 inches in diameter, running from the site to a deep well approximately 3 miles west of the site (Figure 7.1). This pipeline is currently used to provide construction water for site reclamation activities. Prior to replacement of the line (see Section 7.1.2 below), the pipeline had been in place for approximately 40 years, and portions of it had been replaced or repaired on several occasions (specific areas are not known). Although no contaminated materials had been identified during the previous reparation activities, confirmatory investigation was considered warranted.

7.1.2 Final Status Survey Activities

DW-6 pipeline final status survey activities consisted of the following:

1. Excavation of the entire pipeline, and replacement of the previous line with Drisco pipe;
2. Gamma survey of the entire line in accordance with Umetco procedure R-16 (see Section 3.1); and
3. Where indicated based on both on both gamma survey readings and visual observations, removal of tailings and subsequent verification gamma surveys.

In areas where tailings were encountered (see Figure 7.2 and the discussion below), gamma survey readings ranged from 45,000 to 150,000 cpm. Portions of the pipeline that tailings were encountered were fiberglass piping with a tailings bedding material of approximately 6 inches on top of the piping for protection of the piping from puncture by rocks. Use of tailings as a bedding for the fiberglass pipe was visually identifiable as tailings sands were white in color and

[15] Figure 7.1 shows the location of the A-9 haul road and the haul route portion that is not currently under the footprint of the Heap Leach or GHP-2 covers, as denoted by the solid red line between the A-9 Repository and the Heap Leach.

for the most part, contrasting with native soils utilized as backfill. Material resembling ore was encountered in the area near the B-5, consistent with observations made for GHP-1. Gamma survey readings in these NORM areas averaged approximately 25,000 cpm. Evidence of tailings was also found in a small area near the intersection of Dry Creek Road and West Canyon Creek (near Deep Well 6), but NORM was again encountered in underlying soils.

As part the DW-6 final status survey investigation, a total of 18,338 cubic yards of material was excavated and placed in the A-9. This excavation took place in the verification survey areas identified in Figure 7.2. The initial excavation occurred along the eastern third of the pipeline—the approximate 1-mile long segment extending west from the B-5 Pit. Another excavation was undertaken in the western segment of the pipeline, near the intersection of West Canyon Creek and Dry Creek Road. To ensure cleanup of the bedding material around the pipe, most areas were excavated 3 to 4 feet in depth and 4 feet wide. The gaps in the survey shown in Figure 7.2 are areas where there was no evidence of tailings, based on both visual observation and preliminary survey results. As such, the verification survey results presented in this section reflect the areas where tailings were encountered and removed. These areas—shown as Areas 1 through 4 in Figure 7.2—are defined as follows:

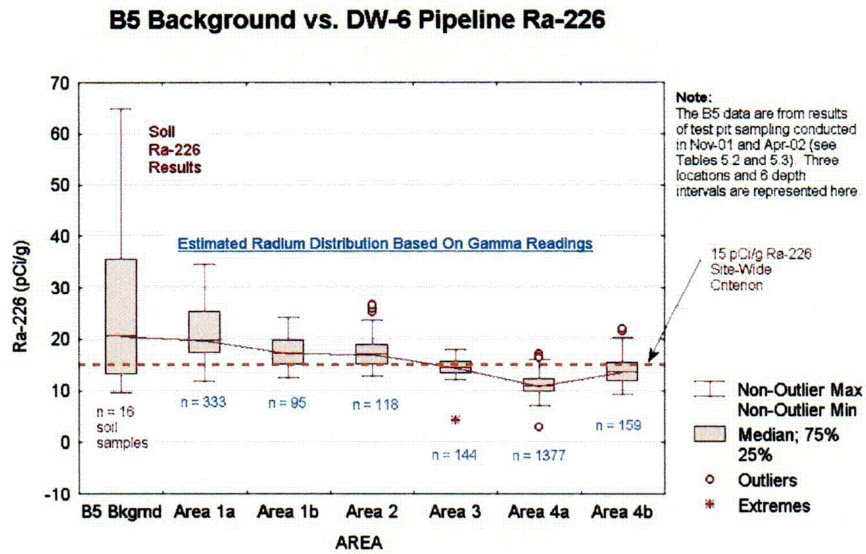
Area	Location	Survey Date(s)	Meter No(s)
Area 1a	Just east of B-5	4/9/02	434
Area 1b	" "	3/5/02	372
Area 2	see Figure 7.2	2/27/02	372
Area 3	" "	2/27/02	372
Area 4a	Westernmost segment (see Fig. 7.2)	2/13/02	372
Area 4b	" "	4/9/02	434

The subareas listed above were defined because of 1) the discontinuity in survey segments reflected in Figures 7.2 and 7.4 and 2) the different survey dates and instruments. Survey results were initially converted to Ra-226 estimates using previous meter-specific gamma-radium correlation equations, therefore requiring subarea definitions. Ultimately, Ra-226 was estimated using the correlation equation derived for GHP-1, and as such might be slightly overestimated (see Appendix B-2).

7.1.3 Verification Survey Results

Post-verification survey results are shown in Figures 7.2 through 7.4 and summarized in the following exhibit and the tables below. Although all residual tailings had been removed during the pipeline excavation (18,338 cubic yards), post-cleanup gamma survey levels in some areas exceed the 10 pCi/g background for mining disturbed areas +15 pCi/g 10 CFR 40, Appendix A, Criterion 6(6) of 25 pCi/g for materials greater than 15 cm below the surface. Verification soil sampling performed in the pipeline shows soil cleanup efforts in the pipeline trench would meet the Ra-226 surface cleanup standard of 15 pCi/g for this area. Soil samples collected from the pipeline utilized for comparison purposes show that Ra-226, Th-230 and U-nat levels appear to be in equilibrium for 10 of the 12 samples collected. The 2 outlying samples show Ra-226 to U-nat ratios that are consistent with low grade uranium (NORM) ratios observed from the B5 Pit

(Table 5.2, B5HWALL 6'-10') and Site Background Study. To establish that cleanup efforts were successful, Umetco employed visual examination, meter survey, and soil sampling and comparing survey and soil sampling results to known NORM areas for equilibrium and statistical analysis. Given these findings, Umetco is proposing an alternate criteria to demonstrate cleanup using the B5 Pit as a specific reference area.



Adapted from Figure 7.3.

Table 7.1 DW-6 Pipeline Post-Excavation Survey Results: Ra-226 Estimates (pCi/g)

Area	N	mean	min	max	stdev	
Area 1a	333	21.1	11.7	34.6	5.4	this area closest to B5 background area
Area 1b	95	17.3	12.4	24.1	3.1	
Area 2	118	17.9	12.8	26.7	4.0	
Area 3	144	14.4	4.3	17.9	2.0	
Area 4a	1377	11.0	2.9	17.1	1.6	
Area 4b	159	13.8	9.3	21.9	2.6	
Combined:	2226	13.6	2.9	34.6	4.7	

The above compared with 16 B5 soil background results from the adjacent B5 highwall and rim: results with mean of 28 pCi/g, range of 9.6 - 64.9 pCi/g (standard deviation of 9.6 pCi/g).

Table 7.2 DW-6 Pipeline Survey Results: Unconverted cpm Measurements

Area	Survey Date(s)	Meter No(s)	N	mean	min	max	stdev
Area 1a	4/9/02	434	333	15,687	8,646	25,843	4,028
Area 1b	3/5/02	372	95	12,850	9,165	17,966	2,320
Area 2	2/27/02	372	118	13,337	9,504	19,909	3,025
Area 3	2/27/02	372	144	10,692	3,059	13,345	1,493
Area 4a	2/13/02	372	1377	8,133	2,007	12,709	1,214
Area 4b	4/9/02	434	159	10,191	6,878	16,282	1,978
		Combined:	2226	10,052	2,007	25,843	3,525

C08

7.2 Penetrating Radiation Surveys of the Above-Grade Tailings Impoundment and the Heap Leach

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, gamma exposure surveys are required at all areas of the site that are to be covered for long-term stabilization. These areas include the Above-Grade Tailings Impoundment, the Heap Leach facility, GHP-2, and the A-9 and C-18 Pits (Figure 1.2). Exposure survey results for the first two areas are discussed below. Final surveys of GHP-2 and the A-9 and C-18 Pits will be done upon completion of the cover for those areas.

Since removal from service, approved reclamation covers have been completed for the AGTI and the Heap Leach. Between April and July 2001, direct gamma surveys of these areas were made over the completed earthen cover, upon completion of the frost protection layer, and prior to placement of erosion protection. One-meter high bare gamma exposure readings were collected and then averaged over the entire area in the manner described below.

7.2.1 Methods

As discussed in Section 3.4, direct gamma radiation exposure rates on the Above-Grade Tailings Impoundment and the Heap Leach were determined by conducting RMGPS scans prior to placing riprap erosion protection materials, pursuant to Umetco procedure number R-17. RMGPS scintillation exposure rate scans were conducted with a bare detector one-meter above the repository cover surface; most areas were driven with an ATV.

Scans were conducted on approximately parallel offsetting traverses of the cover, approximately 10 meters, apart while moving along the traverse at a rate of approximately 0.5 meters per second.

7.2.2 Results

The results of the exposure surveys for the AGTI and the Heap Leach are shown in Plates 1 and 2, respectively. The average exposure rate measured over both the AGTI and the Heap Leach was 27 μR/hr, thereby satisfying the 30 μR/hr criterion (see Plates 1 and 2). As such, final status survey activities for these areas are complete.

It is important to note that peripheral readings in the northeastern-most grids of the Heap Leach, adjacent to the B-Spoils area, were some of the highest measured: 35 to 36 μR/hr (Plate 2). This influence from adjacent background areas must be acknowledged for ultimate surveys of the A-9 pit, where the 30 μR/hr may not be feasible, given likely shine from the north and south evaporation pond mine spoils to the west, and the A-9 and C-18 highwall rims to the east.

7.3 Other Areas

During site reclamation activities conducted in July and August 2000, three small former trash pits were uncovered. One pit was located on the northern boundary of the north evaporation pond, a second was located southeast of the tailings impoundment along the restricted area boundary, and the third in the B-spoils area (see Figure 4.1 of the FSSP). The B-spoils area is considered a background reference area as mining activities took place here. The trash in these pits consisted of general refuse and laboratory waste—e.g., scrap metal, rusted barrels, and used gloves and protective Tyvek clothing. The approximate size of the trash pits after excavation:

- Trash Pit 1 – 120 feet long, 60 feet wide, 20 feet deep
- Trash Pit 2 – 60 feet long, 25 feet wide, 8 feet deep
- Trash Pit 3 – 30 feet long, 15 feet wide, 5 feet deep

Prior to excavation, most gamma scans conducted in the trash pit areas were within background ranges, indicating that no significant byproduct material existed in these areas. For example, readings ranged from 500 cpm to 30,000 cpm, and most were within the 12,000 to 15,000 cpm background range typical for the B-spoils area.[16] However, in some areas where old yellowcake filter press cloth was encountered, readings ranged as high as 1,000,000 cpm.[17]

All pits were excavated to a depth of 1 to 3 feet below residual trash material. The trash was removed and hauled to the A-9 pit; the pits were then backfilled with mine spoils. A sample was then collected from trash pits in the B-spoils area to evaluate the need for additional excavation. The Ra-226 value for this sample was 9.7 pCi/g based on results of on-site gamma spec analysis. Subsequent to this analysis, the trash pits were surveyed and soil samples collected and analyzed by Barringer Labs for Ra-226, Th-230, and U-nat. Results of these analyses are provided below in Table 7.3. Post-excavation gamma survey readings averaged about 11,000 cpm, well below the background range established for this area.

Table 2.1 Soil Sample Results for Mine Spoil Area Trash Pits, August 2000

Location Code	Location	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-nat (pCi/g)
Trash Pit #1	Evap. T-Pit	46 ± 1.3	59 ± 2.9	47.4
Trash Pit #2	Gate 5 T-Pit	7.8 ± 0.53	6.8 ± 1.4	31.8
Trash Pit #3	B Channel T-Pit	5.5 ± 0.46	5.4 ± 1.2	13.5
Trash Pit #3	Slope B Channel	4.1 ± 0.41	4.1 ± 1.1	9.5

Samples were collected in August 2000 after excavation and were analyzed by Barringer Labs. U-nat originally reported in mass units (mg/kg), was converted to activity (pCi/g) by multiplying the mass value by 0.677.

[16] Although 12,000 to 15,000 represents the general background trend for the B-Spoils area, in some cases gamma survey readings were much higher, ranging between 300,000 and 500,000 cpm, depending on ore grade.

[17] Note that these levels posed no inhalation hazard to site workers; rather, risks would be posed only by the ingestion route.

8.0 SUMMARY AND CONCLUSIONS

8.1 Summary of Cleanup Efforts

As part of the Final Status Survey, a significant volume of material was excavated and placed in the A-9. The following table summarizes the results of the corresponding cleanup efforts.

Table 8.1Final Status Survey Cleanup Summary

Area	Year	Volume Removed	Comment
GHP-1	2000	18,162 cu yds	Removal of material coinciding with removal of the pond liner and underlying soils.
GHP-1	2002	11,904 cu yds	Additional removal after discovery of residual petroleum impacts corresponding with the former leach field and identification of possible milling-related impacts to a depth of 2 to 6 feet based on the 2002 geochemical investigation (Lidstone & Associates 2002 & Levy).
Total GHP-1	**2001-2002**	**30,066 cu yds**	
Windblown	2001	3,128 cu yds	Corresponding to major windblown impacts shown in Figures 6.5 and 6.6
Windblown	2002-2003	1,824 cu yds	Iterative cleanup driven by gamma surveys (Carbide Draw excavation treated separately; see below.)
Total Windblown	**2001-2003**	**4,952 cu yds**	
Carbide Draw	2002	6,324 cu yds	Initial cleanup in 2001 revealed underlying mill-related material exhibiting levels significantly higher than previous surficial readings. This material was not technically windblown, but rather resulted from the previous breach of the tailings impoundment.
Pipeline	2002	18,338 cu yds	This material was removed as part of the pipeline excavation encompassing a 3-mile segment. Tailings were removed, but some areas did not "clean up" given the presence of NORM, especially the area in the western portion of the pipeline adjacent to the B5 Pit.
Total, All Areas:	**2001-2003**	**59,680 cu yds**	

8.2 Summary of Survey Results and Findings

The results documented in the previous sections demonstrate that:

- Approximately 30,000 cubic yards of material was excavated from GHP-1, to address both byproduct related and residual petroleum contamination. Geochemical investigation findings combined with field observations indicate that all impacted material has been removed from this area, thereby satisfying Criterion 6(6). Post-cleanup gamma survey results indicated no reduction in average soil Ra-226 content however, and in some cases notable increases were apparent. The latter findings are due to the prevalence of NORM in underlying soils.

- Significant cleanup of windblown byproduct material was undertaken during the final status survey, entailing the removal of approximately 4,950 cubic yards of soil. An additional 6,700 cubic yards of material was removed from Carbide Draw, but contamination in this area was attributable to a former breach in the tailings impoundment (not windblown).

- Cleanup and subsequent verification of windblown byproduct in areas where NORM materials were not encountered was very effective. The windblown veneer was identified, removed, and documented by subsequent verification surveys. The effectiveness of these cleanup efforts is evidenced by the Ra-226 reduction in non-NORM areas which is highly apparent in the preceding figures. Attempted cleanup of windblown byproduct material in areas where NORM was present was very difficult, however, resulting in several iterations of excavation and survey which ultimately resulted in increased Ra-226 concentrations. Considering the underlying NORM which exists within the survey boundary, and the results of the recent germanium detector in situ study confirming that such material is indistinguishable from windblown (11e.2) material), an optimal cleanup of the windblown area has been achieved. Additional soil removal north of the excavated areas will likely expose additional natural mineralization, loss of topsoil, potential disturbance of cultural resources, and increased surface Ra-226 concentrations.

- The excavation/cleanup of the DW-6 pipeline, entailing the removal of 18,000 cubic yards of material, resulted in the reduction of Ra-226 concentrations to levels at or below corresponding background levels.

- Final status survey activities are complete for the AGTI and the Heap Leach. The average exposure rate measured over these areas was 27 μR/hr, thereby satisfying the 30 μR/hr criterion (Plates 1 and 2).

- Observations of NORM and soil sampling results presented herein corroborate previous conclusions about the efficacy of using a single background number (and corresponding cleanup level) for this highly heterogeneous area.

8.3 Discussion

Final status survey investigations at the Gas Hills site confirmed some of the issues raised previously in the Final Status Survey Plan—in particular, how blurry the distinction is between affected and unaffected areas. As demonstrated previously, cleanup of GHP-1 resulted in a slight overall increase in average Ra-226 content, vs. the reduction that would be expected concomitant with a 30,000 cubic yard volume removal.

In the case of the windblown area, in some respects it might have been more cost-effective to remove all known windblown impacted soils (given the definitive "fingerprint" evident based on the gamma survey). The latter would have precluded the iterative cleanup, re-survey and investigative efforts that took place. However, final status survey results demonstrate that in doing so, underlying Ra-226 levels in many areas might actually increase. Also, in the Gas Hills area, the restoration/maintenance of viable ecological habitat and archaeological resource areas is of paramount concern. As a result, Umetco's approach was to achieve a balance: by applying the ALARA principle to cleanup, yet at the same time avoiding unnecessary denudation or removal of topsoil. In doing the latter, the "value added" or concomitant risk/dose reduction associated with cleanup must be considered. In the case of the windblown area, cleanup of grids exceeding the previously defined 11.1 pCi/g Ra-226 cleanup level (later found to be within the range of background) would result in only a 0.1 pCi/g (1%) reduction in the average Ra-226 content. Such a nominal decrease does not warrant further remediation, especially in light of the other factors discussed above.

Considering the underlying NORM which exists within the GHP-1, windblown, and DW-6 pipeline final status survey areas, Umetco believes that an optimal cleanup of all areas has been achieved. At GHP-1 and the DW-6 process water line, there is likely little, if any, byproduct material remaining. That remaining in the windblown area, although apparent in some areas, is indistinguishable from the immediate area background. Additionally, the potential dose associated with current Ra-226 levels will be low because this area will be deeded to the Department of Energy for perpetual care.

8.4 Final Status Survey Activities to be Completed

This report represents the bulk of the final status survey findings. However, several additional activities must be undertaken before site decommissioning is complete. These activities include:

1) <u>Survey of A-9 Haul Road Survey Segment</u>. The small portion of the A-9 haul road between the A-9 tailings area and its exit from the site (Figure 7.1) will be assessed when the A-9 cover construction is completed and the remaining haul road reclaimed. Any byproduct material encountered will be placed in the GHP No. 2 cell.

2) <u>Exposure Surveys of A-9 and C-18 Pits</u>. The exposure rate survey for the A-9 Pit is scheduled to be completed in 2004. That for the C-18 Pit will be performed upon completion of the C-18 backfill.

9.0 REFERENCES

Intermountain Resources. 1998. *Threatened and Endangered Species Survey, Umetco East Canyon Creek Project*, Gas Hills, Wyoming.

Intermountain Resources. 2000. *Wildlife and Wetlands Survey, Umetco East Canyon Creek Project, the Gas Hills, Wyoming*. June 2000.

Lidstone and Associates, Inc. 2002. *Lithologic and Geochemical Evaluation of the GHP-1 Evaporation Pond at Gas Hills, Wyoming*. Technical Memorandum prepared for Umetco Minerals Corporation by Lidstone and Associates and Summit Geoscience. November 5, 2002.

Pronghorn Archaeological Services. 1998. *Class III Cultural Resource Inventory for the East Canyon Creek Project Located in Section 4 and 9, T33N, R89W, Sections 30, 31, 32, and 33, T33N, R89W, Section 25, T34N, R90W, Fremont County, Wyoming*. August 1998.

Pronghorn Archaeology. 2000a. Letter report documenting interim results of recent uncovering of cultural artifacts which occurred during construction of the ECC realignment project. June 7, 2000.

Pronghorn Archaeology. 2000b. *Research Design and Treatment Plan for Site 48NA465*, Natrona County, Wyoming. June 22, 2000.

Shepherd Miller, Inc. (SMI). 1999a. *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed, Gas Hills, Wyoming*. May 1999.

Shepherd Miller, Inc. (SMI). 1999b. *Background Radionuclide Concentrations at the Umetco Gas Hills Site*. March 1999.

Shepherd Miller, Inc. (SMI). 1999c. *Gamma Survey of Windblown Deposition Areas, Gas Hills, Wyoming*. April 14, 1999.

Shepherd Miller, Inc. (SMI). 2000. *Addendum to East Canyon Creek Dose Assessment in Response to NRC Comments*. September 2000.

Umetco Minerals Corporation. 1990a. *Uranium Mill Decommissioning Plan*. Draft Report. May 2, 1990.

Umetco Minerals Corporation. 1990b. Memorandum to U. S. Nuclear Regulatory Commission. June 18, 1990.

Umetco Minerals Corporation. 1991a. *Application for Amendment to Mill Decommissioning Plan for Burial of Mill Debris*. January 10, 1991.

Umetco Minerals Corporation. 1991b. Memorandum to U. S. Nuclear Regulatory Commission. February 11, 1991.

Umetco Minerals Corporation. 1992. Memorandum to U. S. Nuclear Regulatory Commission. April 13, 1992.

Umetco Minerals Corporation. 1995. Memorandum to U. S. Nuclear Regulatory Commission. November 27, 1995.

Umetco Minerals Corporation. 1997. *Background Land Conditions at the Gas Hills Uranium Project*. Draft Rev. 1. June 30, 1997.

Umetco Minerals Corporation. 2000a. *Final Status Survey Plan, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000b. *Final Background Characterization Report, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000c. Letter to P. Ting (U.S. Nuclear Regulatory Commission, Chief, Fuel Cycle Licensing Branch) from T. Gieck, Umetco. RE: "Gas Hills, License Number SUA-648; Docket #40-0299; Final Background Characterization Report and Final Status Survey Plan. Letter dated November 17, 2000.

Umetco Minerals Corporation. 2001a. *Final Application for Alternate Concentration Limits for Gas Hills, Wyoming.* November 2001.

Umetco Minerals Corporation. 2001b. *Windblown Correlation Study Technical Memorandum.* Gas *Hills, Wyoming.* August 3, 2001.

Umetco Minerals Corporation. 2002. *Quality Control Program for Final Status Surveys, Gas Hills, Wyoming Site.* Revision 2. July 3, 2002.

U.S. Department of Energy (DOE). 2001. Adaptive Sampling and Analysis Programs (ASAPs). Characterization, Monitoring, and Sensor Technology Croscutting Program and Subsurface Contaminants Focus Area. DOE/EM-0592. August 2001.

U. S. Environmental Protection Agency (EPA). 1994. *Title 40, Code of Federal Regulations, Environment.* January 1, 1994.

U. S. Environmental Protection Agency (EPA). 2001. Current Perspectives in Site Remediation and Monitoring: Applying the Concept of Effective Data to Environmental Analyses for Contaminated Sites. Written by D. M. Crumbling, EPA, Technology Innovation Office. EPA 542-R-01-013. October 2001.

U. S. Nuclear Regulatory Commission (NRC). 1982. *An Aerial Radiological Survey of the Federal-American Partners, Pathfinder, and Union Carbide Mill Sites and Surrounding Area.* July 1982.

U. S. Nuclear Regulatory Commission (NRC). 1989. *Standard Format and Content of Decommissioning Plans for Licenses Under 10 CFR Parts 30, 40, and 70.* Regulatory Guide 3.65. August 1989.

U. S. Nuclear Regulatory Commission (NRC). 1992. *Manual for Conducting Radiological Surveys in Support of License Termination.* NUREG/CR-5849, Draft Report for Comment.

U. S. Nuclear Regulatory Commission (NRC). 1994. *Title 10, Code of Federal Regulations, "Energy."* January 1, 1994.

U. S. Nuclear Regulatory Commission (NRC). 1996. *NRC Staff Comments on Umetco's Draft Report on Background Land Conditions at the Gas Hills Uranium Project and Radiological Investigation Programs.* September 20, 1996.

U. S. Nuclear Regulatory Commission (NRC). 1997. *NRC Staff Comments on Umetco's Response and Revised Report on Background Land Conditions.* December 12, 1997.

U. S. Nuclear Regulatory Commission (NRC). 1999b. NRC letter approving revisions to License Condition No. 58 re: *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository for Material License SUA-648, Amendment 42.* December 9, 1999.

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

Note: The *Technical Evaluation Report*, referred to extensively herein, was Enclosure 1 of the April 5, 2001 submittal, and the *Environmental Assessment* was Enclosure 4.

U. S. Nuclear Regulatory Commission (NRC). 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 of 1978.* NUREG-1620, Revision 1. June 2003.

U. S. Occupational Safety and Health Administration (OSHA). 1994. *Title 29, Code of Federal Regulations.*

Waste Engineering, Inc. (WEI). 2002. Gas Hills' Site Quality Assurance Audit, Second Quarter 2002. Direct Radiation Verification Surveys of Open Land Surface Soil. Prepared for Umetco Minerals Corporation, July 20.

FINAL STATUS SURVEY REPORT

Gas Hills, Wyoming Site

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

October 2003
Revised April 2004
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Contents

Contents

Appendices(Volume II)

Contents

Tables

Figures (Volume II)

Contents

Figures (Volume II) continued

Contents

Contents

Definition of Terms

Acronym	Definition
11e.(2)	11e.(2) byproduct material, defined under 10 CFR 40 Appendix A – tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content
AGTI	Above-Grade Tailings Impoundment (primary source of windblown contamination)
ALARA	As Low As Reasonably Achievable
ATV	All-Terrain Vehicle
BLM	Bureau of Land Management
cm	centimeter
cpm	counts per minute
cu yds	cubic yards
DM	Data Management (codes defined in Appendix A)
DOE	Department of Energy
dpm	disintegration per minute
EA	Environmental Assessment
ECC	East Canyon Creek
FSSP	Final Status Survey Plan
GHP	Gas Hills Pond (e.g., GHP-1)
GIS	Geographic Information System
GPS	Global Positioning System
IX/RO	Ion Exchange/Reverse Osmosis
LC	License Condition
LTCB	Long-Term Care Boundary
m / m^2	meter / square meters
NA	Not Applicable
NEPA	National Environmental Policy Act
NORM	Naturally Occurring Radioactive Minerals
NRC	U. S. Nuclear Regulatory Commission
NWB	North Windblown (project area)

Contents

Definition of Terms (continued)

Acronym	Definition
pCi/g	picoCuries per gram
QA/QC	Quality Assurance/Quality Control
Ra-226	Radium-226
RMGPS	Radiological Measurement Global Positioning System
SMI	Shepherd Miller, Inc.
SWB	South Windblown (project area)
TENORM	Technically Enhanced Naturally Occurring Radioactive Material
Th-230	Thorium-230
UCC	Union Carbide Corporation
Umetco	Umetco Minerals Corporation
UMTRCA	Uranium Mill Tailings Radiation Control Act
U-nat	Natural Uranium
USFWS	U.S. Fish and Wildlife Service

Executive Summary

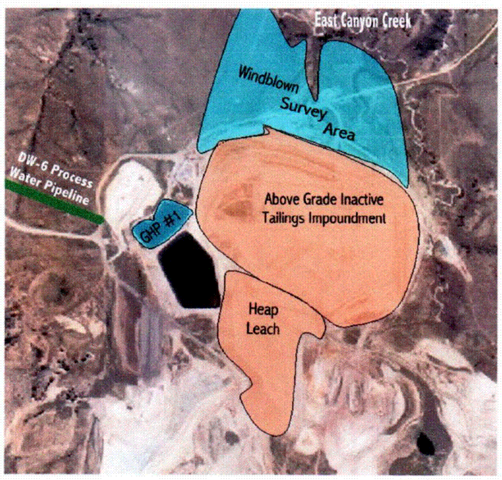
INTRODUCTION

This report presents the results of the *Final Status Survey* conducted by Umetco Minerals Corporation (Umetco) for its facility located in Gas Hills, Wyoming. Operating under U.S. Nuclear Regulatory Commission (NRC) Source Materials License SUA-648, Docket No. 40-0299, Union Carbide Corporation (UCC) and its wholly owned subsidiary Umetco conducted uranium milling operations at the site between 1960 and 1984. The mill was shut down in 1987, shortly after which decommissioning activities were initiated.

SITE DESCRIPTION

Gas Hills is located in Fremont and Natrona Counties, Wyoming, approximately 60 miles east of Riverton in a remote area of central Wyoming (Figure E.1). The site is located within the Gas Hills Uranium District of the Wind River Basin, in portions of Sections 10, 15, 16, and 22, Township 33 North, Range 89 West. The restricted area, including the tailings disposal and heap leach areas, consists of approximately 542 acres, of which Umetco Minerals Corporation (Umetco) owns 280 acres. The Final Status Survey areas assessed in this report are shown in Figure E.1 (below).

Figure E.1 Site Plan Map Showing Final Status Survey Areas



Source: Aerial photo, June 2000.

REGULATORY FRAMEWORK

The Final Status Survey documented herein was conducted in accordance with the final revised Soil Decommissioning Plan. This plan, which was submitted on September 15 and November 17, 2000, is composed of four submittals, including the *Final Status Survey Plan* (Umetco

C09

2000a), the *Final Background Characterization Report* (Umetco 2000b), the *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed* (SMI 1999a, 2000), and the clarifying Umetco letter dated November 17, 2000 (Umetco 2000c). The Revised Soil Decommissioning Plan was approved by the NRC in April 2001 (NRC 2001), and as such replaces corresponding portions of the approved 1990 Decommissioning Plan authorized under Gas Hills License Condition (LC) 30B.

FINAL STATUS SURVEY SCOPE AND OBJECTIVES

The Final Status Survey cleanup and characterization activities focused on those areas affected with 11e.(2) byproduct material that are not covered with an NRC-approved cover. These areas, shown above in Figure E.1, include:

1) Gas Hills Pond (GHP)-1, the former evaporation pond located northwest of the former mill facilities;

2) the Windblown Area, the area affected with windblown byproduct material located directly north and northeast (downwind) of the Above-Grade Tailings Impoundment (AGTI); and

3) the former DW-6 Process Water Pipeline.

This report also discusses the results of the penetrating radiation exposure (direct gamma) scans conducted for the AGTI and the Heap Leach. Since removal from service, approved reclamation covers have been completed for both these areas. Direct gamma surveys were conducted upon completion of the frost protection layer and prior to placement of erosion protection.

The purpose of the Final Status Survey documented herein is to: 1) demonstrate cleanup of 11e.(2) byproduct material, hereafter referred to as byproduct material, to satisfy the requirements of 10 CFR 40, Appendix A; and 2) determine the final condition of the final status survey study areas after cleanup activities are complete.

FINAL STATUS SURVEY APPROACH

The primary approach used in the final status survey was the use of a real-time data collection technique or Global Positioning System (GPS). The GPS, a receiver which receives satellite transmissions to determine land surface coordinates (northing, easting, and elevation), was used in conjunction with a gamma detector, thereby allowing real-time measurement of surface gamma readings (for estimation of soil Ra-226) or exposure rate determination. The GPS system was used in conjunction with a Geographic Information System (GIS) software package, ArcView®, which allowed the management, display, and analysis of the site characterization data as it was being generated. Using these tools, data were displayed on maps to both guide and verify the cleanup activities in a dynamic, iterative manner.

The general approach used in the final status survey is summarized in the table below.

Table E.1 Generalized Final Status Survey Approach by Area

Final Status Survey Area	Final Status Survey Approach
GHP-1 and the 11e.2 Windblown Area	Gamma survey followed by soil sampling in a subset (minimum 5%) of selected 10-m x 10-m ($100m^2$) verification grids, typically those exhibiting the highest gamma readings. Areas contaminated with byproduct material in excess of 5 pCi/g Ra-226 plus background were identified based on gamma survey and 11e.2 byproduct identification procedures, soils were excavated (minimum depth of 6 inches), and the area subsequently re-surveyed to verify attainment of cleanup criterion.
DW-6 pipeline, the approximate 3-mile pipeline segment located just west of the B-5 pit	Direct gamma surveys along the pipeline segments potentially containing tailings residuals. Determinations were made based on visual observation and meter readings. Tailings were excavated to a depth of 3 to 4 feet; these areas were then resurveyed as part of the final verification activities.
AGTI and Heap Leach	1-meter high bare gamma readings, taken approximately 10 meters apart at a rate $\leq$ 0.5 meters per second. Surveys were made over the completed earthen cover prior to placement of erosion protection materials.

FINAL STATUS SURVEY RESULTS

Background Re-Assessment

As a prelude to the summary of results which follows, it is important to re-evaluate the basis for the background levels and corresponding cleanup criteria initially applied in this evaluation. In their review of the *Final Status Survey Plan* scope and approach, the NRC acknowledged that the reclaimed mining areas adjacent to the site to the east and west create "a high soil background for the same radionuclides as exist in the 11e.(2) byproduct material that is to be remediated" (NRC 2001). This high soil background stems not only from the residual radioactivity in the reclaimed mining areas, but also (and perhaps more so) from the still undisturbed naturally occurring radioactive material (NORM) that is prevalent throughout the entire Gas Hills region, where uranium ore bodies are areally extensive, occurring in sandstone and conglomerate beds of the Wind River Formation.

Umetco attempted to account for the presence of NORM in deriving the soil background Radium-226 (Ra-226) values for the windblown and other "site-wide" areas (Umetco 2000b), and these values served as the basis for the corresponding cleanup criteria in accordance with the Criterion 6(6) rule. Although the background values were more realistic than those that had been suggested in preceding evaluations, they still did not encapsulate the full range of variability exhibited in background areas. The latter approach was taken to both address the NRC's initial concerns expressed during the comment period, as well as to address "As Low As Reasonably Achievable" (ALARA) considerations. However, NRC staff corroborated what Umetco had previously identified, in determining that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001).

The final status survey results and findings presented herein underscore the importance of the issues discussed above, as cleanup and subsequent characterization activities revealed that the previous background levels (and corresponding cleanup levels) were not sufficiently high to account for the prevalence and magnitude of NORM at and around the site. In the case of GHP-1 and selected windblown and pipeline areas, cleanup of byproduct material led to the exposure of underlying NORM soils exhibiting Ra-226 levels even higher than those previously measured in affected soils. However, in areas where NORM materials were not encountered, cleanup of identified windblown byproduct and subsequent verification were very effective.

GHP-1 Final Status Survey Results

Approximately 30,000 cubic yards of material was excavated from GHP-1, to address both byproduct related and residual petroleum contamination. Geochemical investigation findings combined with field observations indicate that all impacted material has been removed from this area, thereby satisfying Criterion 6(6). Post-cleanup gamma survey results indicated no reduction in average soil Ra-226 content however, and in some cases notable increases were apparent. The latter findings are due to the prevalence of NORM in underlying soils.

Windblown Area Results

Significant cleanup of windblown byproduct material was undertaken during the final status survey, entailing the removal of approximately 4,950 cubic yards of soil. An additional 6,700 cubic yards of material was removed from Carbide Draw, but contamination in this area was attributable to a former breach in the tailings impoundment (not windblown).

Cleanup and subsequent verification of windblown byproduct in areas where NORM materials were not encountered was very effective. The windblown veneer was identified, removed, and documented by subsequent verification surveys. The effectiveness of these cleanup efforts is evidenced by the Ra-226 reduction in non-NORM areas which is highly apparent in the preceding figures. Attempted cleanup of windblown byproduct material in areas where NORM was present was very difficult, however, resulting in several iterations of excavation and survey which ultimately resulted in increased Ra-226 concentrations. Considering the underlying NORM which exists within the survey boundary, and the results of the recent germanium detector in situ study confirming that such material is indistinguishable from windblown (11e.2-impacted material), an optimal cleanup of the windblown area has been achieved. Additional soil removal north of the excavated areas will likely expose additional natural mineralization, loss of topsoil, potential disturbance of cultural resources, and increased surface Ra-226 concentrations.

Other Areas

- The excavation/cleanup of the DW-6 pipeline, entailing the removal of 18,000 cubic yards of material, resulted in the reduction of Ra-226 concentrations to levels at or below corresponding background levels.

- Final status survey activities are complete for the AGTI and the Heap Leach. The average exposure rate measured over these areas was 27 μR/hr, thereby satisfying the 30 μR/hr criterion (Plates 1 and 2).

Discussion

Final status survey investigations at the Gas Hills site confirmed some of the issues raised previously in the Final Status Survey Plan – in particular, how blurry the distinction is between affected and unaffected areas. As demonstrated previously, cleanup of GHP-1 resulted in a slight overall increase in average Ra-226 content, vs. the reduction that would be expected concomitant with a 30,000 cubic yard volume removal. Also, the discovery of NORM within the windblown project area indicates that in undertaking additional cleanup, underlying Ra-226 levels in many areas might actually increase.

Deleted: In the case of the windblown area, although residual windblown impacts are still apparent in some areas, Ra-226 levels are within the 10-15 pCi/g non-outlier range of background/ NORM and as such, the requirements of 10 CFR 40, Appendix A, Criterion 6(6) are satisfied.

Considering the underlying NORM which exists within the GHP-1, windblown, and DW-6 pipeline final status survey areas, Umetco believes that an optimal cleanup of all areas has been achieved. At GHP-1 and the DW-6 process water line, there is likely little, if any, byproduct material remaining. That remaining in the windblown area, although apparent in some areas, is indistinguishable from the immediate area background. Additionally, the potential dose associated with current Ra-226 levels will be low because this area will be deeded to the Department of Energy for perpetual care.

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1.0 INTRODUCTION

This report presents the results of the *Final Status Survey* conducted by Umetco Minerals Corporation (Umetco) for its facility located in Gas Hills, Wyoming. Operating under U.S. Nuclear Regulatory Commission (NRC) Source Materials License SUA-648, Docket No. 40-0299, Union Carbide Corporation (UCC) and its wholly owned subsidiary Umetco conducted uranium milling operations at the site between 1960 and 1984. The mill was shut down in 1987, shortly after which decommissioning activities were initiated.

In support of soil decommissioning, a survey to determine the final radiological status of the Gas Hills site was performed in 2001 and 2002. This report presents the results of that survey and documents associated soil cleanup activities and geochemical investigations. The survey results and findings will demonstrate that the Gas Hills facility satisfies the NRC regulations for site decommissioning, and that the cleanup of 11e.(2) byproduct material, herein referred to as byproduct material, satisfies the requirements of 10 CFR 40, Appendix A, Criterion 6(6).

1.1 Regulatory Framework

The Final Status Survey was conducted in accordance with the final revised Soil Decommissioning Plan. This plan, which was submitted on September 15 and November 17, 2000, is composed of the following four submittals:

- *Final Status Survey Plan, Gas Hills, Wyoming Site* (Umetco 2000a, referred to often herein as the FSSP);
- *Final Background Characterization Report, Gas Hills, Wyoming Site* (Umetco 2000b);
- *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed, Gas Hills, Wyoming* (SMI 1999a) and associated addendum (SMI 2000); and
- Umetco letter dated November 17, 2000 (Umetco 2000c).

The Revised Soil Decommissioning Plan was approved by the NRC in April 2001 (NRC 2001), and as such replaces corresponding portions of the approved 1990 Decommissioning Plan authorized under Gas Hills License Condition (LC) 30B.

1.2 Site Description

Gas Hills is located in Fremont and Natrona Counties, Wyoming, approximately 60 miles east of Riverton in a remote area of central Wyoming (Figure 1.1). The site is located within the Gas Hills Uranium District of the Wind River Basin, in portions of Sections 10, 15, 16, and 22, Township 33 North, Range 89 West. The restricted area, including the tailings disposal and heap leach areas, consists of approximately 542 acres, of which Umetco Minerals Corporation (Umetco) owns 280 acres. Figures 1.1 and 1.2 show the location and layout of the site, the current restricted area, and the proposed Long-Term Care Boundary (LTCB)—the land slated for future transfer to the U.S. Department of Energy (DOE) for long-term surveillance and maintenance.

1.3 Final Status Survey Scope and Objectives

The Final Status Survey cleanup and characterization activities focused on those areas affected with 11e.(2) byproduct material that are not covered with an NRC-approved cover. These areas are shown in Figure 1.2 and include:

1) Gas Hills Pond (GHP)-1, the former evaporation pond located northwest of the former mill facilities;

2) the Windblown Area, the area affected with windblown byproduct material located directly north and northeast (downwind) of the Above-Grade Tailings Impoundment (AGTI);

3) the former DW-6 Process Water Pipeline; and

4) Carbide Draw south of the County Road.

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This report also discusses the results of the penetrating radiation exposure (direct gamma) scans conducted for the AGTI and the Heap Leach. Since removal from service, approved reclamation covers have been completed for both these areas. Direct gamma surveys were conducted upon completion of the frost protection layer and prior to placement of erosion protection. This report does not address GHP-2 or the A-9 and C-18 Pits, as final surveys will be done upon completion of the cover for those areas. Also, the uncovered section of the former A-9 haul road slated for characterization/verification in the *Final Status Survey Plan* will be assessed when the A-9 cover construction is completed and the remaining haul road reclaimed. Any byproduct material encountered will be placed in the GHP No. 2 cell.

The purpose of the Final Status Survey documented herein is to: 1) demonstrate cleanup of 11e.(2) byproduct material, hereafter referred to as byproduct material, to satisfy the requirements of 10 CFR 40, Appendix A; and 2) determine the final condition of the final status survey study areas after cleanup activities are complete. Umetco will also demonstrate that the supporting data and associated quality assurance/quality control (QA/QC) procedures meet the applicable standards for license termination.

1.4 Background Characterization

In the NRC's review of the *Final Status Survey Plan* scope and approach, the staff acknowledged that the reclaimed mining areas adjacent to the site to the east and west create "a high soil background for the same radionuclides as exist in the 11e.(2) byproduct material that is to be remediated" (NRC 2001). This high soil background stems from the naturally occurring radioactive material (NORM) that is prevalent throughout the entire Gas Hills site, in both reclaimed mining areas and in undisturbed ore-containing areas. These uranium ore bodies are laterally extensive, occurring in sandstone and conglomerate beds of the Wind River Formation.

Umetco attempted to account for the presence of NORM in deriving the soil background Radium-226 (Ra-226) values for the windblown and other "site-wide" areas (Umetco 2000b), and these values served as the basis for the corresponding cleanup criteria in accordance with the Criterion 6(6) rule. Although the background values were more realistic than those that had been suggested in preceding evaluations, they still did not encapsulate the full range of variability exhibited in background areas. The latter approach was taken to both address the NRC's initial concerns expressed during the comment period, as well as to address "As Low As Reasonably Achievable" (ALARA) considerations. However, in the review of the background characterization (Umetco 2000b), NRC staff corroborated what Umetco had previously identified, in determining that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001).

The final status survey results and findings presented herein underscore the importance of the issues discussed above, as cleanup and subsequent characterization activities revealed that the previous background levels (and corresponding cleanup levels) were not sufficiently high to account for the prevalence and magnitude of NORM at and around the site. However, in areas where NORM materials were not encountered, cleanup of identified windblown byproduct and subsequent verification efforts were very effective.

In the case of GHP-1 and selected windblown and pipeline areas, cleanup of byproduct material led to the exposure of underlying NORM soils exhibiting Ra-226 levels even higher than those previously measured in affected soils. As such, Umetco is requesting alternate criteria as allowed in the introduction to Appendix A of 10 CFR 40.

1.5 Organization and Contents

Following this introduction, Section 2 discusses the site history and decommissioning status, the impacts of historical milling and mining activities, and other pertinent background information. Section 3 presents an overview of the methods used in the Final Status Survey—for surface activity measurements, exposure rate measurements, and soil sampling and analysis techniques. Section 4 discusses the important factors related to data quality, presentation, and interpretation. Sections 5, 6, and 7 document the Final Status Survey results for GHP-1, the Windblown Area, and other areas (e.g., the DW-6 process water pipeline and the AGTI/Heap Leach), respectively. Section 8 summarizes the findings of this report. References are provided in Section 10, and detailed supporting information is provided in the appendices.

Deleted: In the case of GHP-1 and selected windblown and pipeline areas, cleanup of byproduct material led to the exposure of underlying NORM soils exhibiting Ra-226 levels even higher than those previously measured in affected soils. This was also the case in selected windblown areas. As such, the survey results and findings will demonstrate that the Gas Hills facility satisfies 10 CFR 40, Appendix A, Criterion 6(6) requirements—i.e., background plus 5 pCi/g Ra-226—but based on background as redefined during the Final Status Survey activities.[1] These issues are discussed at greater length in Sections 4 through 6, but it is important to identify them at the outset.¶

2.0 BACKGROUND

2.1 Site History and Decommissioning Status

Properties in the Gas Hills Mining District were acquired by UCC between 1956 and 1958 and the mill was constructed in 1959, at which time mining operations were initiated. Milling began in 1960, followed much later by heap leaching in 1976. The mill ceased operations in 1984, at which time it was put on standby status until 1987, when the mill was shut down. Decommissioning activities conducted since mill shutdown have included:

- Mill building decommissioning (1988 - 1993);
- Mill ancillary structure decommissioning (1993 - present);
- 1993 above-grade mill building area soil cleanup; and
- 1996 construction of GHP No. 2 (a 17-acre evaporation pond) in the former mill processing area, resulting in placement of significant volumes of 11e.(2) contaminated soils in the A-9 repository.

Planning associated with mill demolition and contaminated soil cleanup began in April 1990 when Umetco submitted a draft Decommissioning Plan to the NRC (Umetco 1990a). Umetco revised the plan through subsequent submissions to the NRC (Umetco 1990b, 1991a, 1991b, 1992, and 1995), culminating in the submission of the four 1999-2000 submittals discussed in Section 1.2 (Umetco 2000a, 2000b, 2000c, and SMI 1999a, 2000). These submittals constitute the Revised Soil Decommissioning Plan authorized under Gas Hills License Condition (LC) 30B, which was approved by the NRC in April 2001 (NRC 2001).

An Environmental Assessment (EA) was prepared in accordance with 10 CFR 51.21 and 51.30 to document compliance with the National Environmental Policy Act (NEPA) for the soil decommissioning. Based on the EA, a notice was published in the March 1, 2001 Federal Register, indicating a finding that no significant impact should result from implementation of the decommissioning plan.

The mill and related structures were demolished and buried within an engineered disposal cell according to an approved plan. The only building currently remaining in the restricted area is a mobile soils laboratory, which will be surveyed and released for unrestricted use when site reclamation is complete. The buildings outside the restricted area will be surveyed for contamination using acceptable methods and removed when they meet release criteria.

2.2 Mill-Related Impacts

Before final status survey activities were initiated, information about the nature and extent of mill-related contamination at the Gas Hills site was based on the results of the following three characterization investigations:

- the 1995-1996 Radiological Investigation Program, documented in *Background Land Conditions at the Gas Hills Uranium Project* (Umetco 1997);

- the 1998 Background Investigation, documented in *Background Radionuclide Concentrations at the Umetco Gas Hills Site* (SMI 1999b), and superseded by the *Final Background Characterization Report*, Rev. 1 (Umetco 2000b); and
- the 1998 Gamma Survey of Windblown Deposition Areas, documented in *Gamma Survey of Windblown Deposition Areas, Gas Hills, Wyoming* (SMI 1999c).

Detailed results of these investigations are discussed in the *Final Status Survey Plan* and corresponding *Background Characterization Report* (Umetco 2000b); only a brief summary is provided here. Windblown byproduct material impacts are most apparent in the area immediately north/northeast (downwind) of the AGTI, as evidenced by elevated Ra-226 activity in shallow (0-1 in or 0-6 cm) surface soils. As demonstrated later in this report (see Figure 6.5, the initial 2001 Windblown "snapshot"), this activity gradually attenuates with increasing downwind distance. Beyond, and even within, the immediate downwind locations, however, many areas with naturally occurring mineralization have been encountered exhibiting similar, and sometimes higher, levels of radioactivity. These findings were verified during the more recent final status survey investigations documented herein.

The first major investigations of mill-related impacts associated with GHP-1 and the former process water pipeline were done as part of the final status survey. Therefore, the reader is referred to the corresponding sections (Sections 5.0 and 7.1, respectively). Mill-related impacts associated with waterborne pathways are not within the scope of this final status survey and therefore are not discussed here (refer to Umetco 2000a and Section 2.4).

2.3 Naturally Occurring Mineralization and Mining-Related Impacts

Within the Gas Hills district, a major uranium-producing region of the United States, uranium occurs in an area approximately five miles wide and twenty miles long in three north-trending belts known as East, Central, and West Gas Hills (Figure 2.1). These ore trends are areally extensive and occur in sandstone and conglomerate beds of the Wind River Formation. As shown in Figure 2.1, the East Gas Hills ore trend extends a significant distance to the north and south of the site. The presence of this ore, or NORM, accounts (obviously) for the historical prevalence of open pit uranium mining activities and resulting mining-related impacts both on and surrounding the Gas Hills site.

Although the issue of mining-related impacts has been discussed at length in previous documents (e.g., Umetco 1997, 2000a, 2000b), it is important to reiterate here.[2] Uranium was mined from open pits in the Wind River Formation upgradient, crossgradient, within, and downgradient of the Umetco project area. These mines were developed by Pathfinder, TVA, Umetco, PRI, and others. As a result of these activities, and subsequent mined-land reclamation efforts, adjacent lands to the west, south, and east of the mill site exhibit elevated radioactivity. This finding is

[2] Another useful reference is the *Application for Alternate Concentration Limits*, submitted by Umetco in November 2001 and approved by the NRC in March 2002 (Umetco 2001a). This document discusses at length the mineralogical and geochemical characteristics exhibited in Gas Hills region NORM areas, as well as areas impacted by mining and reclamation activities. Although discussed largely in the context of groundwater impacts, the ACL discussion is germane to this soils evaluation as well.

particularly apparent for adjacent areas west of the site (the area exhibiting the most elevated radioactivity), coinciding with Pathfinder's prior mining and reclamation activities. These mining-disturbed lands meet the NRC's definition of naturally occurring radioactive material or NORM (NRC 2003) — i.e., background radiation. As discussed in subsequent sections, the prevalence and magnitude of background radiation posed a challenge during the final status survey, as these soils were often intermixed and/or underlying affected (e.g., windblown impacted) soils.

2.4 Areas Not Addressed Herein

As discussed in the preceding sections, soil decommissioning at the Gas Hills site has been an iterative process since activities first began in 1988. This document focuses on three primary areas—GHP-1, windblown-affected soils north of the AGTI, and the DW-6 process water pipeline. The results of the penetrating radiation exposure scans of the AGTI and the Heap Leach are also addressed, but these areas receive secondary focus. To facilitate understanding of the status of the site as a whole, a brief summary of the areas that are not addressed herein is warranted (see Table 2.1 below).

Table 2.1 Areas Not Addressed in the Final Status Survey

Category	Location / Description	Rationale for Exclusion from Final Status Survey
East Canyon Creek (ECC) drainage	North and east of site (Figures 1.1 and 1.2)	Results of the risk assessment (SMI 1999a), combined with recent findings related to critical wetlands, ecological habitat, and archaeological resources, led to approval of a no-action alternative for this area (NRC 2001).
Onsite mining areas affected with 11e.(2) solutions	North and South Evaporation Ponds	Cleanup rationale and supporting documentation provided in enhanced design for A-9 repository, License Amendment 45 (April 20, 2001).
Mining disturbed areas (onsite and offsite)	Non-shaded areas within the restricted area boundary shown in Figure 1.2 and adjacent surrounding mining-disturbed lands	Previous surveys and studies found no clear evidence of NRC-licensed material or radiation levels exceeding the site background value, as such. These areas were not included in the Final Status Survey.

Deleted: Because radioactivity in these areas is not discernible from background, these areas were not included in the Final Status Survey.

Due to the sensitive ecological environment that exists within the East Canyon Creek drainage, combined with other factors warranting special consideration (e.g., cultural resources and wetlands), Umetco proposed a no-action alternative for the East Canyon Creek drainage, including Carbide Draw north of Dry Creek Road (Umetco 2000a). The NRC subsequently determined that the proposed no-action alternative protects the sensitive ecological conditions in the creek and that it would achieve a level of protection for public health, safety, and the environment that would satisfy the requirements of Criterion 6(6). The NRC concluded by stating that the "long-term ecological damage, potential harm to threatened and endangered species, and high costs of remediation are not justified by any benefit that would result from soil remediation in ECC" (NRC 2001).

Onsite mining areas affected with 11e.(2) solutions—i.e., the north and south evaporation ponds—will not be verified or characterized further because the NRC has approved the previous characterization and decommissioning plan for these areas (NRC 1999b). Mining disturbed areas located within and outside the restricted area boundary were also not addressed, as these areas have been characterized at length, and impacts resulting from former mining and/or reclamation activities are already well established (Umetco 1997, Umetco 1999, and Umetco 2000a).

2.5 Proposed Long-Term Care Boundary

The results presented herein must be interpreted acknowledging the future use of the study areas in question. The presence of residual radioactivity in uncovered areas at the site—which, as will be demonstrated in the following sections is indistinguishable from background—will not pose any measurable incremental risk because these areas are within the proposed Long-Term Care Boundary (LTCB). The land within this boundary is slated for future transfer to the U.S. Department of Energy (DOE) for long-term surveillance and maintenance. This proposed LTCB is shown on Figures 1.1 and 1.2 and the relevant data maps that follow.

The anticipated implementation of the LTCB and corresponding land transfer is as follows: Termination of Umetco's license will occur upon completion and acceptance of reclamation activities. Because the State of Wyoming declined to take title (letter of July 15, 1994 from D. Hemmer to J. Virgona), Umetco anticipates that long-term custodial care will be transferred to the DOE.[3,4] All land within the proposed LTCB is currently under the control of either Umetco or the Bureau of Land Management (BLM). At this time, Umetco anticipates completion of reclamation obligations and transfer of the site in 2005.

2.6 Final Status Survey Cleanup Objectives

2.6.1 Soil Measurement Endpoints

Previous sampling results indicated a strong correlation between Ra-226 and Thorium-230 (Th-230) in samples collected from the majority of the final survey area addressed herein, in particular soils impacted with windblown byproduct material (Umetco 2000a). Consequently, any soil cleanup required to meet the Ra-226 criterion would remove residual Th-230 as well.

[3] The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 (42 USC § 7901) as amended, provides for reclamation and regulation of uranium mill tailings at two categories of mill tailings sites— *i.e.*, Title I and Title II. Title I includes former uranium mill sites that were unlicensed, as of January 1, 1978, and essentially abandoned. Title II includes uranium mill sites under specific license as of January 1, 1978. In both cases, the licensing agency is the NRC, or in the case of certain Title II disposal sites, an Agreement State. The Umetco Gas Hills, Wyoming site is a Title II site under UMTRCA. The State of Wyoming is not an Agreement State, and ownership of Section 16 changed from the State of Wyoming to Umetco last year. That is, no land within the LTCB is currently owned by the State of Wyoming.

[4] Specific regulatory requirements with respect to land and license transfer are established in 10 CFR 40. 10 CRF 40, Appendix A, Criterion 11C states in part: *"Title to the byproduct material licensed under the Part and land, including any interest therein (other than land owned by the United States or by a State) which is used for the disposal of any such byproduct material, or is essential to ensure the long term disposal of any such byproduct material, or is essential to ensure the long term stability of such disposal site must be transferred to the United States or the State in which such land is located, at the option of the State."* 10 CFR § 40.28 establishes licensing requirements upon termination of Umetco's license and states in part: *"The licensee will be the Department of Energy, another Federal agency designated by the President, or a State where the disposal site is located."*

Also, based on site history and previous soil analyses, elevated uranium resulting from the milling operation is not expected. The tailings are generally uranium deplete, as this material was extracted as part of previous milling activities. In fact, historical background sampling results indicate that U-nat concentrations are generally higher in surrounding mineralized areas (e.g., east of the A-9 Pit) than in areas affected with byproduct material (Umetco 1997).

Given the above findings and subsequent NRC concurrence and approval, Ra-226 was the primary endpoint of the final status survey sampling and analysis plan (NRC 2001). The only exception to the above was made for GHP-1 which, because of its location coinciding with the former mill, warranted analysis for Th-230 and U-Nat as well as Ra-226 (refer to Section 5).

2.6.2 Cleanup Objectives and Release Guidelines

Based on the investigations cited above and the associated statistical analyses (Umetco 1997, 2000), site-specific background concentrations were developed for Ra-226 and external radiation exposure rates (direct gamma). These background levels formed the basis for the final status survey soil cleanup objectives, summarized below.

Table 2.2 Cleanup Criteria Applied in the Final Status Survey

Final Status Survey Area	Endpoint	Cleanup Criterion	Underlying Background Value	Background Value Basis (Source: Umetco 2000b)
GHP-1, DW-6 pipeline, and other "site-wide" soils	Soil Ra-226	15 pCi/g (background + 5 pCi/g)	10 pCi/g	geometric mean (GM) plus the geometric standard deviation (GSD) of the site-wide data set
Northern windblown cleanup area	Soil Ra-226	11.1 pCi/g (background + 5 pCi/g), in accordance with 10 CFR 40, Appendix A, Criterion 6(6)	6.1 pCi/g	99th upper confidence limit (UCL) on the geometric mean and median of the northern area background data set
Repository covers	external exposure rate (direct gamma)	Reduction of area-averaged direct gamma exposures to background (30 μR/hr), in accordance with Criterion 6(1)	30 μR/hr	geometric mean of background direct gamma exposure rates, as derived in Appendix A of the background characterization report

2.6.3 Discussion

As discussed in Section 1.4, the background levels listed above do not appear to be sufficiently high to account for the magnitude of NORM encountered during final status survey verification investigations. Post-cleanup survey results for GHP-1 exceeded the approved background value as the excavation extended into the underlying mineralized (NORM) areas within the pond. Similar observations were made during the post-verification survey conducted for the former DW-6 process water pipeline, in particular the segment directly adjacent to the B5 Pit. Therefore, Umetco suggests alternate criteria to demonstrate cleanup in this area using the adjacent B5 Pit Ra-226 levels as a specific local reference area. Results of a geochemical investigation conducted to identify the extent of 11e.(2) contamination in GHP-1 is provided in Section 5.3 to support Umetco's request.

Deleted: are not

Deleted: In fact, post-cleanup results for GHP-1 essentially negated the validity of the 10 pCi/g background level and corresponding 15 pCi/g Ra-226 cleanup criterion, as soil Ra-226 concentrations measured in underlying ore-containing (NORM) areas within the pond and in the adjacent B5 Pit background reference area were much higher than this level. Similar observations were made during the post-verification survey conducted for the former DW-6 process water pipeline, in particular the easternmost segment directly adjacent to the B5.

The northern windblown background level and corresponding cleanup criterion were also found to be too low. Based on soil Ra-226 measured in soil samples collected from known NORM areas within the windblown study area (Section 6), combined with a re-assessment of previous background characterization data (Section 4), 10-15 pCi/g represents a more representative range of northern windblown background conditions than the previously estimated 6.1 pCi/g. Utilization of a single background statistic for a site of this nature—i.e., one that is situated within a mineralized ore zone exhibiting highly variable levels of naturally occurring radioactive material—has resulted in a difficult analysis. In fact, if it were used as the sole decision rule, much unnecessary cleanup (and ecological degradation) would occur.

3.0 FINAL STATUS SURVEY METHODS

This section describes the general methods and procedures that were applied in the final status survey. Supporting detailed information is provided in the procedures documented in Umetco's *Quality Control Program for Final Status Surveys* (Umetco 2002).

3.1 Overview

The primary approach used in the final status survey was the use of a real-time data collection technique or Global Positioning System (GPS). The GPS, a receiver which receives satellite transmissions to determine land surface coordinates (northing, easting, and elevation), was used in conjunction with a gamma detector, thereby allowing real-time measurement of surface gamma readings (for estimation of soil Ra-226) or exposure rate determination. The GPS system was used in conjunction with a Geographic Information System (GIS) software package, ArcView®, which allowed the management, display, and analysis of the site characterization data as it was being generated. Using these tools, data were displayed on maps to both guide and verify the cleanup activities in a dynamic, iterative manner.

These methods are similar to those used in the Adaptive Sampling and Analysis Programs (ASAPs), which have been successfully applied at various DOE sites (DOE 2001). Ultimately, this GPS/GIS survey technology allowed for a much more comprehensive and efficient characterization of the final status survey areas than that which would have resulted from a traditional soil sampling program with offsite soils analysis.

3.2 Final Status Survey Approach

The general approach used in the final status survey is summarized in the bulleted items below. For GHP-1 and the 11e.2 windblown area, compliance with 10 CFR 40, Appendix A, Criterion 6(6) was assessed on a 100-square-meter (100 m^2) grid basis. This was not the case for the DW-6 process water pipeline, which has a linear configuration. The survey approach used for the DW-6 process water pipeline was based on Umetco's opinion as to the appropriate method for documenting cleanup. Since this approach was not discussed with the NRC, Umetco is proposing a deviation from the standard procedures with respect to the DW-6 process water pipeline.

Deleted: precluding such an approach

- A gamma survey was conducted over the study area to identify locations where Ra-226 concentrations potentially exceeded the cleanup criterion of background plus 5 pCi/g.

- For those grids with survey readings indicating an exceedance of criteria, 11e.(2) byproduct material identification procedures (e.g., visual examination of soils) were used to assess whether the elevated radioactivity was attributable to byproduct presence and/or NORM.

- If 11e.(2) byproduct contamination above the soil criterion was apparent, the area was excavated and the material was hauled to the A-9 for disposal. Windblown areas were excavated to a depth of 6 inches, whereas GHP-1 and the DW-6 pipeline were excavated several feet.

- Excavated areas were then re-surveyed to verify that the Ra-226 cleanup criterion was attained, and additional remedial action and follow-up surveys were performed if necessary.

- For GHP-1 and the windblown area, nine-sample composite soil samples were collected in five percent of the 10-meter by 10-meter (100 m^2) grids. The subset of grids to be sampled generally reflected those grids exhibiting the highest estimated average Ra-226 concentrations, as indicated by the gamma survey. These samples were collected to verify the efficacy of the gamma correlation and to demonstrate the attainment of cleanup objectives.

- Soil sampling from the pipeline, although collected from a 150-square meter grid, can be utilized to demonstrate compliance, as the FSSR calls for sampling of 5% of the highest grids. Soil sampling from the pipeline represents sampling of 100% of the pipeline sections in which tailings were identified. Sampling from the pipeline trench was meter and visual driven, meaning areas of elevated meter readings and soils exhibiting appearance similar to tailings were utilized to construct the composite soil sample. This sampling approach would generate the worst case scenario of soil conditions in the excavated pipeline trench.

- The licensee viewed this approach for soil sampling given the linear configuration of the trench as appropriate for demonstration of cleanup.

These steps are summarized in the following table (Table 3.1) according to area. Note that detailed survey methods and approaches were unique for each area. Any exceptions to the general procedures discussed in this section are identified in the subsequent area-specific presentation of results (Sections 5 through 7).

Table 3.1 Generalized Final Status Survey Approach by Area*

Final Status Survey Area	Final Status Survey Approach
GHP-1 and the 11e.2 Windblown Area	Gamma survey followed by soil sampling in a subset (minimum 5%) of selected 10-m x 10-m (100m^2) verification grids, typically those exhibiting the highest gamma readings. Areas contaminated with byproduct material in excess of 5 pCi/g Ra-226 plus background were identified based on gamma survey and 11e.2 byproduct identification procedures, soils were excavated (minimum depth of 6 inches), and the area subsequently re-surveyed to verify attainment of cleanup criterion.
DW-6 pipeline, the approximate 3-mile pipeline segment located just west of the B-5 pit	Direct gamma surveys along the pipeline segments potentially containing tailings residuals. Determinations were made based on visual observation and meter readings. Tailings were excavated to a depth of 3 to 4 feet; these areas were then resurveyed as part of the final verification activities.
AGTI and Heap Leach	1-meter high bare gamma readings, taken approximately 10 meters apart at a rate $\leq$ 0.5 meters per second. Surveys were made over the completed earthen cover prior to placement of erosion protection materials.

* *Refer to Figures 1.1 and 1.2 for Final Status Survey area locations.*

The final status survey procedures used to verify compliance with Criterion 6(6) are listed in Table 3.2.[5]

Table 3.2 Summary of Procedures Applied in the Final Status Survey †

Procedure	Title (Revision)	Endpoint Addressed
R-16*	Direct Radiation Verification Surveys of Open Land Surface Soil (Rev. 1) **Salient portions of this procedure are provided in Appendix A.*	Direct radiation surveys of open land, including instrument calibration, gamma survey measurements and data management, mapping, and documentation.
R-17	Penetrating Radiation Surveys of Closed Byproduct Material Repositories (Rev. 1)	Survey procedure for repositories
R-18	Final Status Survey Soil Sample Preparation (Rev. 0)	Soil sample preparation
R-19	Final Status Survey Surface Soil Sampling Procedure (Rev. 0)	Surface soil sample collection
R-20	Identification of 11e.(2) Byproduct Material in Soil (Rev. 0)	11e.(2) byproduct material identification
R-21	Final Status Survey Soil Sample Management (Rev. 0)	Soil sample management
R-22	Calibration Procedure for Portable Survey Instruments Used for Final Status Surveys of Open Lands (Rev. 0)	Portable survey instrument calibration and gamma survey/soil Ra-226 correlation development

† All revisions above are dated July 3, 2002. These procedures were subjected to a third-party audit conducted in June 2002 by Waste Engineering, Inc. (WEI 2002), which concluded that Umetco staff are "producing sufficient, accurate, and representative data to guide field construction activities at the site."

3.3 Direct Radiation Verification Surveys

As discussed above, all onsite, or direct field, open land final status surveys were conducted using a Radiological Measurement Global Positioning System (RMGPS). This system is composed of a gamma scintillation radiation measurement system, coupled to a global positioning system, which is carried in a backpack or mounted on an all-terrain vehicle (ATV). The following two verification scanning survey techniques were employed:

- scanning from an all-terrain vehicle with a collimated 2"x 2" NaI detector mounted 12" (1 ft) above the land surface (this was the primary survey method), and
- scanning on foot with a collimated 2"x2" sodium iodide (NaI) detector carried at 12" above the land surface (used for verification only).

[5] NRC staff (J. Lusher) reviewed these procedures during the most recent site inspection conducted on July 31, 2002.

During the final status survey, the ATV-mounted system was the primary means of GPS data collection. The backpack-mounted configuration was employed only if use of the ATV posed a safety concern, if the satellite signal was lost (this happened rarely), and/or for verification purposes—e.g., to verify gamma measurements within a grid or grids. Collimated-detector scans were used to estimate Ra-226 soil concentrations and bare-detector scans conducted at 1 meter above ground surface were used to estimate exposure rates. The NRC had previously determined that instrument sensitivity was adequate to reliably identify the proposed guideline levels (NRC 2001).

As summarized in Table 3.1, prior to soil sampling, final status survey areas were gamma scanned (dynamic, in motion), pursuant to Umetco procedure number R-16. This procedure is referenced in Table 3.2, and portions relevant to the Final Status Survey are provided in detail in Appendix A. Gamma scans are used to identify the presence of elevated direct radiation that might indicate residual gross activity or hot spots and to assess the average Ra-226 soil concentration in any 100 m^2 verification area. Soil activity scans for Ra-226 were conducted with the detector at 1 foot above the surface, except for traditional scans which were performed with the detector kept as close to the surface as possible.

Scans were conducted on approximately parallel offsetting traverses of the survey area while moving along the traverse at a speed of about 0.5 meters per second. For optimum detection sensitivity during scanning, changes in the instrument response were monitored via the audible output to identify areas exhibiting elevated direct radiation levels.

3.4 Penetrating Radiation Surveys of Repositories

Direct gamma radiation exposure rates on the AGTI and the Heap Leach were determined by conducting RMGPS scans over the completed earthen cover prior to placing riprap erosion protection materials, pursuant to Umetco procedure number R-17. RMGPS scintillation exposure rate scans were conducted with a bare detector one-meter above the repository cover surface; most areas were driven with an ATV. Scans were conducted on approximately parallel offsetting traverses of the cover approximately 10 meters apart, while moving along the traverse at a rate not exceeding 0.5 meters per second.

3.5 Surface Soil Sampling and Analysis

At GHP-1 and the windblown area, soil samples were collected in 5 percent of the 100 m^2 grid blocks exhibiting the highest gamma values. Soil samples were obtained from nine locations within each grid block in the manner discussed below. Subsurface soil sampling methods—which applied primarily to the test pit sampling conducted at GHP-1—are discussed in Section 5 and Appendix B-3.

3.5.1 Sample Collection and Preparation

For the composite soil sampling, nine 0-6" (0-15 cm) soil samples were collected in each 100 m^2 verification grid, with points located 2.5 meters from the grid corners and then equidistantly spaced within the grid. Samples were collected using a decontaminated shovel; each sample weighed approximately one kilogram. Two collimated readings were taken at each discrete sampling location—one at the surface and the other at the base of the hole (6-inch depth). These readings were documented in the field logbook. Although the full data set is not provided herein, some of these measurements were useful in identifying NORM areas within the windblown study area. As discussed in Section 6 and Appendix C-4, some of the most notable NORM examples showed significant (>20%) increases when comparing initial vs. final survey readings at the discrete sample locations.

The nine sub-sample aliquots were then combined and homogenized to form one composite soil sample. Samples were taken to the onsite soils lab, where a portion of each sample was blended by placing the sample through a splitter six times (the remainder of the sample was archived). Samples were then prepared in accordance with Procedure R-18. A 400-gram aliquot was collected from each of the nine discrete sample aliquots and then blended to yield the approximate 3600-gram grid composite sample. The composited samples were dried for approximately twenty-four hours, then further processed using a jaw crusher to approximately ¼ inch in size, and finally through a pulverizer to achieve a size of approximately –200 mesh.

3.5.2 Sample Analysis

All GHP-1 soil samples were shipped to an outside laboratory, as these samples were analyzed for Th-230 and U-Nat in addition to Ra-226. All windblown area samples, however, were analyzed in Umetco's onsite laboratory. These samples were analyzed for Ra-226 in the manner described below and a subset (approximately 5 percent) was sent to the contract laboratory for confirmatory analysis.

The onsite laboratory was used for analysis of windblown area samples for two primary reasons. First, previous comparison with Acculabs' results and periodic analysis of external reference samples (e.g., blind duplicates) indicated that the onsite data met or exceeded data quality objectives and that results were within the standard margin of error (e.g., the Ra-226 uncertainty term. Second, on-site measurement allowed earlier identification of samples exceeding cleanup objectives, and therefore more timely/rapid mitigation of previously unidentified affected areas (e.g., false negatives based on survey results).

For both GHP-1 and the windblown area, a portion of each composite verification sample was archived, as were the discrete sample portions of those composites. These archived samples will be stored until the NRC approves the Final Status Survey Report (e.g., for potential future confirmatory analysis).

<u>Onsite Analysis of Windblown Area Samples</u>

Upon completion of the sample preparation procedures described above, an approximately 1000-gram aliquot of the pulverized sample was placed into a marinelli beaker, sealed, and counted for 30 minutes in Umetco's gamma spectrometer. Samples were analyzed three times—initially (upon sample preparation), a second time (7-14 days later), and the final count was taken at ingrowth (at least 21 days after the sample was containerized). Daily calibration and QA/QC checks were performed on the gamma spectrometer and documentation is on file at the site.

3.6 Identification of Byproduct Material Contaminated Soils

Due to the prevalence of NORM at and around the site, a byproduct material identification methodology was developed to make the necessary distinction between naturally mineralized and/or mining-disturbed soils and soils contaminated with byproduct materials, thereby ensuring that the remedial action would be directed at NRC-regulated materials.

As documented in Procedure R-20 (Umetco 2002), the byproduct material identification process included one or more of the following steps:

1. evaluating the environmental setting of the subject open land area;
2. visually examining general soil characteristics;
3. determining soil Munsell color;
4. assessing soil texture and reflective properties;
5. examination of microscopic soil particles;
6. assessment of soil radionuclide equilibria; and/or
7. assessment of vertical Ra-226 soil concentration gradients.

The first two steps served as the primary means of distinguishing between byproduct material impacts and NORM during final status survey activities. Step 6 was used at GHP-1 but results were not compelling—i.e., there were no significant differences in Ra-226/U-238 isotopic ratios when results from suspected NORM areas were compared with those from known impacted areas (and vice versa). Step 7 was useful in the windblown area to identify NORM areas, but note that this endpoint was assessed based on gamma survey readings—e.g., comparing collimated measurements taken at soil sampling locations (see Section 3.5.1). Increases in Ra-226 magnitude with depth were also apparent in some areas that had already been excavated, where post-cleanup verification surveys yielded similar and in some cases higher gamma survey readings.

3.7 Establishment of Gamma-Radium Correlation

As indicated above, the final status survey relied heavily on the GPS gamma survey approach. As such, the primary method used to demonstrate compliance with 10 CFR 40, Appendix A, Criterion 6(6) was in situ determination of Ra-226 concentrations in soil through the use of a site-specific gamma-radium correlation.

These correlations were initially established based on the results of the *Windblown Correlation Study*, which was undertaken in April and May 2001 (Umetco 2001b). As part of this pilot study, radiological surveys of twenty-one 10-m by 10-m study grid were conducted using the GPS mounted on a backpack or an ATV. All 21 grids were located in the south windblown cleanup area (i.e., south of Dry Creek Road). Each grid block was surveyed by conducting four passes with a collimated detector 12 inches (0.3 m) above ground surface at a scan rate of approximately 0.5 meters per second. The grids were then sampled using the same nine-sample composite approach described in Section 3.5 and then analyzed for Ra-226 (results ranged from 5 to 25 pCi/g). Correlations were derived based on the average reading per grid vs. the corresponding laboratory Ra-226 determined by the off-site contract laboratory analysis (Acculabs) for the composite soil sample.[6]

All equations were derived using a nonlinear piecewise regression equation with a breakpoint, using the following generalized equation[7]:

For cpm < 13510:
Ra-226 = (cpm * 0.0011) - 3.3565

For cpm ≥ 13510:
Ra-226 = (cpm * 0.0053) – 60.2018

Although these equations indicated strong correlations based on the study results ($r^2 > 0.9$), ultimately they were not suitable for any of the final status survey project areas. For example, based on soil samples collected in GHP-1, most GHP-1 grid average Ra-226 concentrations were overestimated (note high residuals in Appendix B-2). Alternatively, grid average concentrations for the windblown area tended to be underestimated by about 2.3 pCi/g, with a relative percent difference (RPD) of 21.3% when comparing predicted concentrations with onsite lab results. Given these findings, the algorithms based on the correlation study were not used. The gamma-radium correlation for GHP-1 was revised based on the April 2001 soil sampling effort and corresponding gamma survey results (see Appendix B-2). The revised GHP-1 algorithm was also applied to the survey results for the adjacent DW-6 pipeline. Windblown area gamma-radium correlations were also re-established, as discussed in Section 6 and in Appendix C-2.

The disagreement between the Ra-226 estimates based on the correlation study and corresponding soil Ra-226 results is probably attributable to two primary factors: the well-documented lateral variability—even within very localized (< 25 m^2) areas, but perhaps even more so to the *vertical* variability apparent in many of the study grids. These factors are discussed at greater length in the following sections.

3.8 Data Management

The final status survey results presented in the following sections encompass four major project areas: GHP-1 (9 acres), the windblown area (111 acre survey area), the DW-6 pipeline (3 miles in length), and the AGTI/Heap Leach exposure survey area (approximately 200 acres). As such, spatially comprehensive gamma or exposure surveys were conducted over a total area exceeding 300 acres (see Figure 1.1). The soil and test pit sampling conducted at GHP-1 and the windblown area added to this extensive data set. Two survey data sets were generated for GHP-1 (2001 and 2002), and the windblown area—due to the iterative nature of the cleanup and subsequent verification surveys—required careful data coordination. As such, the data management effort was extensive; corresponding procedures are documented in Appendix A. Attachment A of that appendix includes the RMGPS survey documentation forms, and Attachment B presents the data management and mapping procedure implemented when using

[6] This method was very similar to that previously applied by SMI in their previous investigations at the site (SMI 1999).

[7] The correlation study equations cited above were developed for Ludlum meter L221-434, the meter used most often during the final status survey, but those for other meters had very similar slopes and y-intercepts.

ArcView®, the mapping and data visualization software used for most of the results presented herein.

4.0 DATA QUALITY, PRESENTATION, AND INTERPRETATION

This section identifies some of the pertinent factors to consider with respect to both data quality and data interpretation—and how these factors ultimately affect the decision-making process and the conclusions drawn herein.

4.1 Data Quality

As documented in Appendix A, quality assurance and quality control (QA/QC) procedures were consistently implemented to minimize analytical and sampling uncertainties associated with the gamma survey and soil sampling efforts. Given these procedures and the results of verification re-surveys and soil sampling, the quality of the final status survey data is sufficient to demonstrate compliance with Criterion 6(6). However, as identified in the following sections and supporting appendices, some discrepancies do exist between some gamma survey predictions and soil sampling results. These discrepancies are inevitable in a characterization survey of this nature and magnitude, as they reflect a combination of heterogeneity, NORM, and the spatial and temporal variability that is inherent in any field sampling program.

Despite some disagreement between soil results and survey results, this did not adversely affect the validity of the conclusions drawn herein. First, comparison of gamma survey results with the corresponding soil sample results were still within an acceptable margin of error (relative percent difference (RPD) less than 15%. Second, the gamma survey data measurements (expressed in cpm or converted to Ra-226 estimates) provide a level information that soil sample data alone could never provide. As demonstrated in the following sections, in particular for the windblown area, spatial contamination trends were most clearly identified by plotting the gamma survey data points. In the windblown area figures (Section 6), contamination patterns and cleanup effectiveness are clearly apparent, much more so than any soils data could provide. A recent paper by the EPA (2001) discusses many issues that are germane to this analysis, one of them being that a much more accurate picture of the site is gained when many samples are analyzed, even if the analytical method itself—in this case, the gamma survey methodology—is somewhat less accurate (relative to traditional soil sampling and analysis).

4.2 Data Presentation and Interpretation

As discussed in the previous section, the data were managed, interpreted and mapped in the following figures using ArcView®.[8] This GIS software was used because of its broad data analysis and presentation capabilities, facilitating exploratory analysis and allowing simultaneous review of multiple data layers. Although the final status survey was conducted on a 10-meter by 10-meter grid basis, contamination patterns are most apparent when the individual survey data points are plotted. As such, many of the results presented in this section are plotted using graduated color maps (for either cpm readings or corresponding estimated Ra-226 concentrations). In reviewing such figures, the actual breakdowns are not important—rather, the spatial pattern is the primary purpose. Color-coded maps showing grid statistics (i.e., estimated grid average Ra-226 concentrations) are also provided, allowing demonstration of Criterion 6(6) attainment.

[8] In these figures, the focus is the data presentation, and not necessarily detailed labeling of site features. For detailed contour and scale information, the reader should refer to the initial Autocad figure(s) provided in each section.

5.0 GHP-1

The presentation of final status survey results begins with the discussion of GHP-1, in part because what was observed in this area—the spatial heterogeneity and significant NORM presence—holds true for the Gas Hills site as a whole. Based upon the results of extensive scientific and geochemical evaluation, supporting an area-specific background level much higher than the previously determined 10 pCi/g regulatory basis, this section will demonstrate that final status survey objectives for GHP-1 have been attained.

5.1 Background

GHP-1, located west of the AGTI and east of the B5 Pit (Figure 1.1), was constructed in November 1990 as a double-lined evaporation pond on native soils. Its location corresponds with former mill facilities, most notably the mill solvent catch basin (Figure 5.2). During pond construction, material exhibiting byproduct material impacts was encountered. Approximately 9,370 cubic yards of this material were then excavated and hauled to the A-9 repository for disposal. Pond construction then resumed, including excavation and site grading adjacent to the existing B5 Pit, construction of a lower clay liner, and construction of a 40 mil HDPE upper liner. The pond was then used for storage of reject water pumped from the ion exchange/reverse osmosis (IX/RO) operations.

IX/RO operations were shut down in April 1991 after a leak was detected in the liner system. The pond was dewatered to the North Evaporation Pond, the liner was repaired, and the pond was placed back in service in May 1991. In August 2000, the pond liner was removed and 18,162 cubic yards of material were excavated from the pond. Table 5.1 presents a chronology of the salient aspects of GHP-1 history and the subsequent final status survey activities that are documented below. Figure 5.1 shows the GHP-1 plan view showing locations of historical mill facilities. Figure 5.2 shows the final status survey 100 m^2 grid layout (n = 383) and the composite soil sample and test pit locations.

The final status survey investigation of GHP-1 consisted essentially of three phases:

1. the initial post-cleanup gamma survey and soil sampling investigation conducted in 2001 (Phase I);

2. the geochemical investigation initiated in April 2002 (Phase II); and

3. the additional excavation of impacted material and subsequent final gamma survey conducted in May 2002 (Phase III).

The results of these verification surveys and investigations are presented in the following sections. Appendix B provides supporting detailed information—Appendix B-1 presents gamma survey and soil sampling documentation; Appendix B-2 documents the analyses supporting the revised gamma-radium correlation; and Appendix B-3 presents the *Lithologic and Geochemical Evaluation* prepared by Lidstone and Associates (2002).

Table 5.1 Summary of GHP-1 History and Final Status Survey Activities

Date / Period	Final Status Survey Observations and Activities
November 1990 – April 1991	GHP-1 was constructed as a double-lined evaporation pond for the storage of process-related water (see Figure 5.1). During construction, material exhibiting byproduct material impacts was encountered. Approximately 9,370 cubic yards of this material was then excavated and hauled to the A-9 repository for disposal.
April 1991	Dewatering and IX/RO operations were shut down after discovery of a leak in the liner system. The pond was dewatered and the liner was inspected for leaks and then repaired.
May 1991	IX/RO operations resumed.
August 2000	The liner was removed and 18,162 cubic yards of material were excavated from the pond.
June – July 2001	Initial gamma survey. Four gamma surveys were conducted over an approximate one-month period: June 6, June 7 (2 separate surveys), and July 2, 2001. Ludlum Meter L2221-434 was used for all surveys. Corresponding gamma data are shown in Figure 5.3. At about the same time, a large ore fragment was encountered, exhibiting gamma readings of 26,000 cpm as measured from a pancake probe, equivalent to 1.1E+06 dpm/cm^2.
August 2001	Twenty 0-6" nine-sample composites were collected and analyzed for Ra-226, Th-230, and U-238. The samples with the highest levels of these constituents were collected in the ore-containing (NORM) area located in the southwest portion of the pond.
November 2001	Three test pits were excavated and sampled for Ra-226, Th-230, and U-Nat: one, the southwest trench, in the ore-containing area, one in the northern pond section considered most likely to exhibit mill-related impacts, and the third along the B-5 Highwall, the background reference location.
April 2002	To verify previous conclusions regarding NORM presence in selected pond areas, and to better characterize the vertical extent of potentially impacted areas, a geochemical investigation of the pond was undertaken by Lidstone & Associates and Summit Geoscience. As part of this investigation, 12 test pits were excavated, 2 of which were located in the B-5 Pit background reference area. Soil samples were collected from 10 test pits (4 to 5 samples per location) and analyzed for radionuclides, inorganics, and other parameters (see Table 5.3). Results of this investigation are summarized in Section 5.3; the report in its entirety is provided in Appendix B-3.
May 2002	Petroleum affected soils were identified in northern pond section, coinciding with the location of the former mill solvent catch basin (see Figure 5.1).
May 2002	Based on the findings of Lidstone's investigation, and to mitigate the residual petroleum impacts described above, an additional 11,904 cubic yards of material were excavated from the pond. Excavation depths ranged from 2 to 6 feet, depending on location, with the greatest excavation depths—about 6 feet—coinciding with the location of the petroleum cleanup. Excavation depths for remaining areas ranged from 3 to 4 feet.
May 22, 2002	Final gamma survey for GHP-1, again using Ludlum Meter L2221-434. Survey results indicated increases in activity in a large portion of the GHP-1 study grids. These increases are due to underlying NORM.

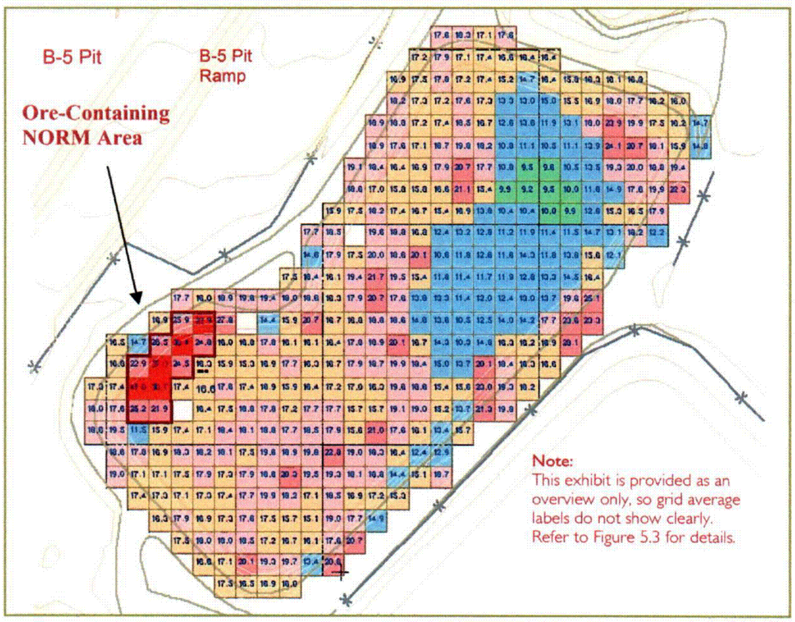
5.2 Phase I Final Status Survey Activities and Findings: June – November 2001

Phase I final status survey activities commenced in June 2001. The purpose of these efforts was to characterize pond conditions after the August 2000 liner removal and excavation and to evaluate the potential presence of 11e.(2) byproduct materials in the underlying soils. This project phase consisted of a gamma survey and soil and test pit sampling, described below.

5.2.1 Gamma Survey

To assess the pond status after liner removal and excavation, a survey of GHP-1 was conducted between June and August 2001 (Appendix B, Table 1). Figures 5.3 and 5.4 show the results of this initial 2001 survey: Figure 5.3 shows the grid averages (with no data points shown for clarity), and Figure 5.4 shows the corresponding point distribution of gamma survey data. An inset of Figure 5.3 is provided below.

2001 Gamma Survey Results



Legend:

Ra-226 in pCi/g

Symbol	Value	Label
	9.2 - 10	9.2 - 10
	10 - 15	10 - 15
	15 - 17.5	15 - 17.5
	17.5 - 20	17.5 - 20
	20 - 30	20 - 30
	30 - 41	30 - 41
		No Data

In Figure 5.3 and the preceding inset, note the elevated NORM area in the southwest pond section, where ore was encountered in April 2001. Corresponding gamma survey readings ranged between approximately 26,000 cpm and 50,000 cpm. As reflected above and in Figure 5.5, most grids are in the 15-20 pCi/g (estimated based on survey results), above the 15 pCi/g site-wide Ra-226 criterion. The remainder of this section will demonstrate that this range is well within background ranges for this area of the site.

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Figure 5.5 presents graphical summaries of both grid and gamma data summary statistics. This and the preceding exhibits are self-explanatory, and will not be discussed at length here. Rather, refer to the comparative statistics—i.e., 2001 vs. post-cleanup 2002 data—provided later in this section.

Note that the correlation algorithm for Meter 434 derived during the August 2001 correlation study was not appropriate for GHP-1. Therefore, the gamma-radium correlation for GHP-1 was derived using the August 28, 2001 composite sample results (addressed below) and the corresponding gamma survey data. The equation is noted on Figure 5-3; detailed supporting documentation is provided in Appendix B-2.

5.2.2 August 2001 Soil Sampling

Twenty soil samples were collected in a subset of grids exhibiting the highest gamma survey readings—i.e., the highest estimated average Ra-226.[9] Samples were sent to Acculabs and analyzed for Ra-226, Th-230, and U-238. Results are presented in Table 5.2 and shown in Figure 5.6. Appendix B-1, Table 3 presents the detailed Acculabs results. The results of this sampling effort indicate that, although most results exceeded the 15 pCi/g Ra-226 soil cleanup level, the highest values—ranging up to 45 pCi/g—were encountered in the area where ore-grade uranium was encountered underneath the pond liner. Differences in magnitude are shown graphically in Figure 5.6, where the soil results are relative to the corresponding gamma survey results. These results corroborated the results of the gamma survey in that they demonstrate that Ra-226 measured in samples collected in the southwest NORM area were the highest of those sampled.

5.2.3 November 2001 Test Pit Sampling

Although the previous survey efforts (gamma survey and soil sampling) combined with visual observations seemed to clearly identify NORM areas within the pond, a vertical characterization was still needed. Therefore, three test pits were excavated and sampled for Ra-226, Th-230, and U-Nat. The South Trench was located in the ore-containing area, the North Trench in the northern pond section considered most likely to exhibit mill-related impacts, and the third was located along the B-5 Highwall, the background reference location. The B5 Highwall samples represented naturally occurring mineralization and served as a reasonable comparison of known native material to potentially impacted material underlying GHP-1. These test pit/trench locations are shown in Figures 5.2 and 5.6. Corresponding analytical results are provided in Table 5.2, and shown graphically in Figure 5.7.

As demonstrated in Figure 5.7, the results of this effort again confirmed previous findings. However, they were inconclusive with respect to the potential impact of mill byproduct residues on materials that existed beneath the clay liner of the former pond, and as such were not sufficient to conclusively support no further action. Therefore, a geochemical investigation including a second round of sampling was initiated in April 2002.

[9] Note: This subset does not correspond directly with a descending sort of the 2001 grid averages reported herein. This is because a different gamma-radium correlation algorithm was used to define the soil sampling subset (see the revised gamma-radium correlation provided in Appendix B-2).

Insert Table 5.2 (Excel sheet) here

5.3 Phase II GHP-1 Geochemical Investigation: April 2002

The objective of the geochemical investigation was to: (1) determine whether or not pond liquids had impacted the underlying materials, and (2) if so, to define the lateral and vertical extent of the impacted area. The investigation was two-tiered: The first level included backhoe test pits, sedimentologic observations, soil (test pit) sampling, and analysis for radiological and geochemical parameters. Based on the analytical results, the second level utilized mineralogic and petrographic[10] analysis to establish a depth of fluid movement and to recommend a cleanup depth and volume if necessary. This effort was conducted by Lidstone and Associates and Summit Geoscience (Lidstone 2002). Their efforts and findings are summarized here; the report is presented in its entirety in Appendix B-3.

5.3.1 Materials and Methods

Sample Collection

Soil samples were collected from GHP-1 in April 2002 from a series of test pits excavated to a depth of approximately 8 feet (Figure 5-2). Anecdotal information indicates that leakage occurred in the northern portion of GHP-1; therefore, test pit sampling was focused on this area. Test pits TP-1 through TP-6 were sampled along a west to east transect at the northern end of the pond, while TP-7, TP-8, TP-20, and TP-21 were sampled along a transect extending toward the southern end of GHP-1. Comparative soil samples were also collected from the B5 Pit Highwall (B5HW) and from a test pit located between the B5 Mine Pit and GHP-1 (B5RIM). Samples were collected at discrete and repeatable intervals starting at the surface and continuing along 2-foot intervals to a depth of 8 feet. Typically four samples were collected in this manner from each test pit. A deeper (10-ft) sample was collected from the B5 Rim test pit. A second set of samples was collected as part of the sedimentology study as described in Appendix B-3.

Chemical and Radiological Analyses

All wet chemistry samples were shipped to ACZ Laboratories (Steamboat Springs, CO) for radiological and chemical analyses. Radiological analyses included both total (strong-acid extractable) and soluble U-nat, Ra-226, and Th-230. Additional chemical analyses were conducted to determine pH, total sulfur, soluble sulfate, and soluble chloride. Soluble soil constituents were determined following EPA's Synthetic Precipitation Leaching Procedure (Method SW1312).

Mineralogical Analyses

Seventeen samples from five test pits—TP-1 (n=4), TP-4 (n=4), TP-5 (n=3), TP-20 (n=2), and the B5 Rim (n=4)—were submitted to AMEC Earth & Environmental Limited for mineralogical testing. Representative samples were analyzed using X-ray diffraction analysis (XRD), petrographic examinations, and scanning electron microscopy (SEM) in conjunction with energy dispersive X-ray analysis (EDXA) to determine the elemental composition.

[10] Petrographic refers to the description and classification of rocks.

Geochemical Modeling

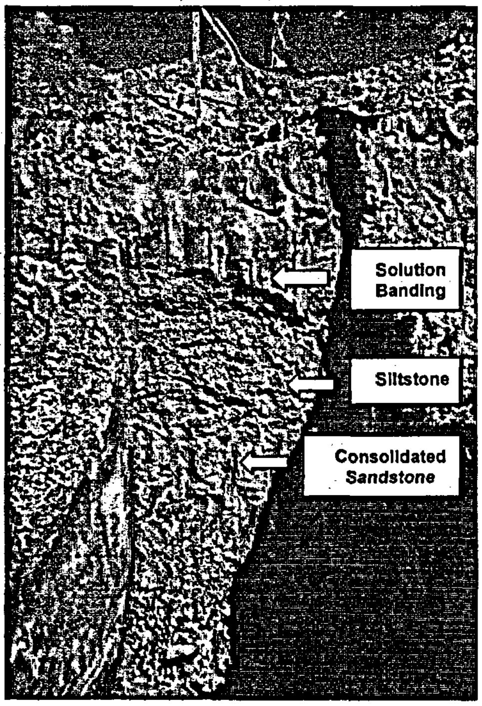
The geochemical speciation model PHREEQC (Parkhurst and Appelo 1999) was used to calculate the distribution of solution species for the former GHP-1 pond water using an aqueous ion-association model. This model calculated saturation index (SI) values to provide an indication of the ultimate fate of radionuclides in the pond water. The conceptual approach, methods, and results associated with this modeling effort are discussed in detail in Appendix B-3.

5.3.2 Results and Discussion

Field Observations

Detailed observations made during the test pit logging effort are discussed in Appendix B-3; these are not reiterated in this section unless particularly germane to the conclusions drawn herein. An observation that is noteworthy, however, is that distinct orange horizontal bands overlying black laminae were evident in TP-4, -5, and -6. These solution bands, shown in the photo below, were generally observed between 2 and 4 feet below ground surface (bgs) and were later found to be indicative of mill-related impacts.

Test Pit 5 Profile with Orange and Black Solution Banding Identified



The southernmost test pits—TP-8, TP-20, and TP-21—exhibited very similar characteristics as B5HW and B5RIM and were logged as native undisturbed strata. Given these observations, only samples from TP-8 were submitted for wet chemistry analysis (TP-20 and TP-21 were not analyzed).

Chemical and Radiological Results

Chemical and radiological results are summarized in Table 5.3 and discussed in detail in Appendix B-3, where a complete tabulation of all results is provided (see Appendix B, Table 1 of Lidstone's report). Vertical trends of key constituents are shown in Figures 3 through 11 of that appendix. The figures in this report focus on radiological parameters, in particular Ra-226, as these were the focus of GHP-1 cleanup efforts. As such, Figures 5.8 and 5.9 provide a graphical summary of results for Ra-226, Th-230, and U-Nat. Figure 5.8 gives a comparative context, comparing the B5 Pit background reference samples with GHP-1 sample results; an excerpt of which is provided in the exhibit below.

Radionuclide Distributions in April 2002 Test Pit Samples

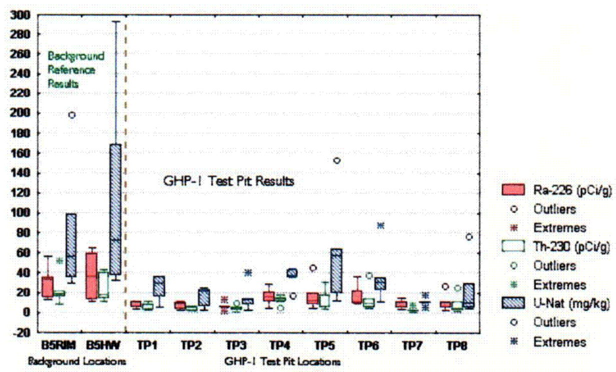


Figure 5.9 shows photos of each test pit, graphs the corresponding results by depth, and summarizes the findings of the geochemical investigation (i.e., impact vs. non-impact determinations). Figure 5.10 plots the isotopic ratios (Ra-226 / 0.5*U-Nat, and Ra-226/Th-230), demonstrating that no notable differences between B5 background and GHP-1 samples are apparent for this endpoint.

The results shown in Figure 5.8 and in Appendix B-3 (Attachment A, Figures 3 through 5) of indicate that the concentrations of total U-nat, Ra-226, and Th-230 in the GHP-1 samples generally decrease between the surface and the 2-foot depth, but then increase with depth below 2 feet. The depth at which subsurface radionuclide concentrations begin to increase in the GHP-1 samples correlates with the approximate 2-foot thick surface that was identified as topsoil in some locations in the GHP-1 test pits. The trends in decreasing surface concentrations are not attributed to impacts from process solutions, but rather are the result of a chemical discontinuity resulting from the presence of topsoil material overlying the native Wind River subsurface strata.

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Table 5.3, page 1 of 2

Table 5.3, page 2 of 2

Unlike concentration trends in the GHP-1 samples, radionuclide concentrations in the B5 Rim samples were generally lowest at the surface and increased continually with depth (Figure 5.8 and Appendix B-3, Figures 3 through 5). Concentrations of U-nat, Ra-226, and Th-230 were generally higher in subsurface B5 Rim samples compared to the GHP-1 samples, suggesting the presence of an isolated ore body, which are common in the Gas Hills region.

Leachable concentrations of U-nat, Ra-226, and Th-230 were generally not elevated when compared to native B5 Rim samples collected from the same depths (Appendix B-3, Figures 6 through 8). Relatively higher leachable concentrations of radionuclides would be expected if the soils had been significantly impacted by acidic pond solutions. Sulfate and chloride have relatively higher mobilities and were elevated in most samples relative to the B5 Rim samples (Appendix B-3, Figures 9 and 10). Elevated soluble SO_4 concentrations could be due to localized concentrations of naturally-occurring gypsum ($CaSO_4 \cdot 2H_2O$). The high soluble chloride concentrations may be more indicative of potential impacts from pond solutions, especially those in surface samples from TP-4 (Table 5.3 and Appendix B-3, Figure 10).

Mineralogical Results

Results of the petrographic examination and X-ray diffraction analyses are discussed in Appendix B-3 (refer to Appendix C of the Lidstone report), and are only briefly summarized here. A noteworthy finding based on these analyses is that comparison of the EDXA grain spectra from the B5 Rim samples to the GHP-1 samples indicates that these coatings have characteristically different geochemical signatures. For example, Mn:Fe ratios of the black coatings in the samples from affected GHP-1 test pits were generally greater than 1, whereas those from the B5 Rim were less than one (see Figures 5.11 and 5.12). Significant Cl peaks were also observed in association with the black surface coatings from TP-4, where solution banding was observed. This information suggests that subsurface materials in TP-4 were impacted by process waters elevated in Mn and Cl. This finding is discussed in greater detail below.

5.3.3 Conceptual Geochemical Model

A conceptual geochemical model was developed to aid in identifying the degree to which underlying materials would have been impacted by acidic pond fluids. Chemical analysis of the GHP-1 pond solutions (April 3, 1996) shows that the fluids were Na-SO_4-Cl type waters, acidic in nature (low pH), and containing high total dissolved solids concentrations (Table 5.4):

During the operative period of GHP-1, evaporative concentration of pond water would have caused solids to precipitate from solution. Precipitation of the various solids likely exerted a significant control on the solution chemistry and the fate of U-nat, Ra-226, and Th-230. The results of geochemical speciation modeling indicate that the pond waters were oversaturated with respect to various iron, aluminum, and sulfate minerals, while undersaturated with respect to iron and manganese hydroxides (Table 5.5).

Table 5.4. Major Ion and Radionuclide Concentrations for the GHP-1 Evaporation Pond.

Major Ion Chemistry (mg/L)		Radionuclides (pCi/L)	
Calcium	446	Uranium	4,739
Chloride	5,500	Radium-226	13
Iron	334	Radium-228	3.2
Magnesium	278	Th-230	233
Manganese (estimated)	50	Pb210	5
Potassium	40	Gross Alpha	3,600
pH	2.87		
Sodium	2,380		
Sulfate	4,800		

Source: Umetco GHP-1 site records, April 3, 1996.

The minerals listed as oversaturated in Table 5.5 (shaded) likely precipitated from the pond water, and many of the minerals that formed in the ponds are effective scavengers of other trace metals and radionuclides (Alpers *et al.* 1994).

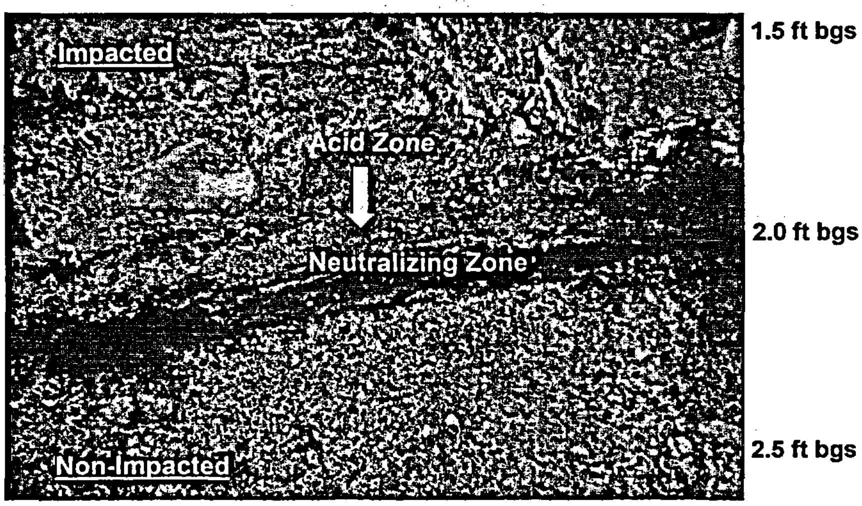
Table 5.5. Calculated Mineral Saturation Index Values for the GHP-1 Fluid.

Mineral Phase	Saturation Index Value	Saturation State
Alunite [$KAl_3(SO_4)_2(OH)_6$]	+ 1.1	Oversaturated
Barite [$BaSO_4$]	+ 0.47	Oversaturated
Ferrihydrite [$Fe(OH)_3$]	- 0.63	Undersaturated
Manganite (MnOOH)	-13	Undersaturated
Gypsum [$CaSO_4 \bullet 2H_2O$]	- 0.20	Undersaturated
Jurbanite [$AlOHSO_4$]	0.60	Oversaturated
$Al(OH)_3$ (a)	- 5.0	Undersaturated
Thorium Sulfate [$Th(SO_4)_2$]	+ 0.34	Oversaturated

Acidic pond fluids migrating into the subsurface create an advancing front where calcite dissolution and acid neutralization control the extent of migration of acidic water. Behind the advancing front, the *acid zone* will contain water whose chemistry is very similar to the pond seepage (Table 5.5). The acid zone is characterized by lower pH, calcite depletion, and residual iron and aluminum oxides. The acid zone may also contain residual radionuclides not completely removed from solution by precipitating pond minerals.

The reaction front, or *neutralizing zone*, is the zone of active calcite dissolution where higher pH conditions exist. These geochemical zones—the *acid zone* and the *neutralizing zone*—are shown in Figure 5.13 and in the exhibit below. Reaction with calcite causes gypsum, $Al(OH)_3$, and $Fe(OH)_3$ to become oversaturated and precipitate. Precipitated iron and aluminum hydroxides have large metal adsorption capacities and will effectively attenuate metals and radionuclides. Therefore, trace metals and radionuclides that were not removed by the pond minerals would continue to be removed from solution within this neutralizing zone, thereby minimizing their migration below the former clay liner.

Conceptual Geochemical Model Showing Impacted Zones in GHP-1 Test Pit 4



Synopsis: **The depth at which black solution bands have been identified in test pits—2 to 4 feet below ground surface—therefore corresponds to the location of the original reaction front, indicating the maximum depth of potential 11e.(2) contamination.**

The sequence of metals precipitation for the GHP-1 water was simulated by incremental reaction with calcite (as a proxy for depth) using the geochemical model PHREEQC, described in detail of Appendix B-3. The geochemical modeling results are consistent with the conceptual model and support field observations where orange bands (presumably iron and aluminum oxides) overlying black laminae (consistent with the color of manganese oxides) were observed. The locations of these solution bands therefore indicate the position of a former acid front and, as identified above, are assumed to be indicative of the maximum depth of potential 11e.(2) contamination.

5.3.4 Summary of Geochemical Investigation Findings

Field observations and analytical data collected during the geochemical evaluation indicate that materials underlying the former pond had been impacted, although only to a limited extent, from leakage of acidic pond solutions in the northern section of GHP-1. The following bulleted items document the primary findings:

- Calcite was depleted in surface samples from Test Pits in the northern section of GHP-1.
- Solution banding characteristic of the neutralized zone of an acidic front was identified between 2 and 4 feet bgs in the north GHP-1 Test Pits.
- EDXA spectra of grains from areas of solution banding indicated that manganese oxide coatings have different geochemical signatures compared to native oxide occurrences.
- Chloride was identified in association with manganese oxide grain coatings in GHP-1 samples, and high soluble chloride concentrations were also present in some samples.
- Coffinite (ore-grade uranium) was found in excavations below the GHP-1 pond liner. This presence of NORM, redox conditions and natural weathering of the minerals complicated the interpretation of the impacts of solution chemistry.

Impacts to the underlying materials were minimal, however, as indicated by the low degree of alteration of feldspar grains, the incomplete acidification of the subsurface materials from the low pH solutions, and the shallow depths (2 to 4 ft) at which solution banding was identified. Based on the field observations—e.g., the zone of impact identified in TP-4 (Figures 5.9 and 5.13)—Lidstone recommended removal of 3 to 4 feet of impacted material from the northern section of GHP-1 (Lidstone 2002). Note that this recommendation (i.e., the evidence of impacts) was based primarily on the migration of chloride and sulfate in the test pits, and *not* the vertical trends exhibited by either total or soluble radionuclide parameters.

5.4 Phase III: May 2002 GHP-1 Cleanup and Final Verification Survey

5.4.1 May 2002 Cleanup and Excavation

At about the same time that the geochemical investigation was underway (April 2002), petroleum affected soils were identified in the northern pond section, coinciding with the location of the former mill solvent catch basin and former leach field (see Figure 5.1). Therefore, the cleanup/excavation plan designed to address the 11e.(2) byproduct impacts described above was augmented to mitigate the petroleum affected soils. As a conservative measure, a minimum of 2 feet was removed from the entire pond, but cleanup efforts focused on the impacted areas. In response to Lidstone's recommendations, 3 to 4 feet of material was removed from the northern byproduct affected area. To ensure adequate cleanup and driven by ALARA considerations, an additional 2 feet was excavated below the impacted horizon. An additional 11,904 cubic yards of material were excavated from the pond as part of this effort. Excavation depths ranged from 2 to 6 feet, depending on location, with the greatest excavation depths—about 6 feet—coinciding with the areas where byproduct impacts were identified and/or where petroleum residues were identified. Excavation depths for remaining areas ranged from 3 to 4 feet. All excavated material was removed from the GHP-1 pond and properly disposed at the A-9 tailings pond. As such, all byproduct/impacted material was removed, leaving only the underlying material naturally present within the Wind River Formation. The elevated levels in this NORM material are demonstrated in the radionuclide results for subsurface samples in Table 5.3 and in Figures 5.8 and 5.9. They are also reflected in the final status survey results, discussed below.

5.4.2 May 2002 Gamma Survey

Contaminated soil removal consisted of removing approximately 30,000 cubic yards of soil (18,000 cubic yards initially, and 12,000 cubic yards to address apparent impacts).

Deleted: The purpose of the final (Phase III) gamma survey effort was to allow a "final snapshot" characterization of pond conditions reflecting the removal of approximately 30,000 cubic yards of material (18,000 cubic yards initially, and 12,000 to address apparent impacts). Note that no final verification soil sampling was performed. This was thought to be unnecessary given the extensive excavation that had occurred and test pit sampling results and field observations indicating the presence of a partial ore zone. Therefore, an additional round of soil sampling for radiological parameters (Ra-226, Th-230, and U-Nat) would likely only verify previous findings. [Alternatively, sulfates and chlorides would likely be reduced.]

The final gamma survey for GHP-1 was conducted on May 22, 2002 using the same meter that had been used for previous surveys—Ludlum meter L-2221/434. Figure 5.14 maps the results of this final survey, showing the average Ra-226 estimated for each grid based on the survey readings. As reflected in this figure and in Figure 5.15, little change is evident in results when compared to 2001. In fact, pond-wide average Ra-226 concentrations increased slightly. Figure 5.16 shows these changes as a function of elevation changes—i.e., areas where the excavation was deepest correspond to those grids exhibiting the greatest increases in average Ra-226e concentrations. These increases are visually apparent in Figure 5.17, which compares the unconverted cpm distributions for the initial 2001 vs. 2002 data set.

5.5 Summary Discussion

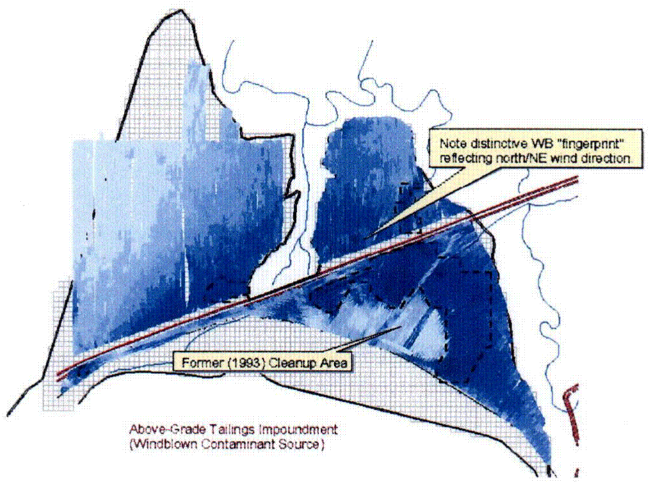
Although 30,000 cubic yards of byproduct affected soils were removed from GHP-1, the Final Status Survey did not result in a reduction of Ra-226 concentrations because underlying ore zone areas were exposed. Ra-226 concentrations measured in GHP-1 are within the range of concentrations measured in the adjacent B5 Pit. Accordingly, Umetco is proposing alternate criteria to demonstrate cleanup in this area using the adjacent B5Pit Ra-226 levels as a specific local background reference area. Results of a geochemical investigation conducted to identify the extent of byproduct contamination in GHP-1 has been provided in Section 5.3 in support of Umetco's request.

Deleted: Based on comprehensive surveys/soil sampling and a rigorous geochemical evaluation, extensive cleanup (30,000 cubic yards of material) was undertaken at GHP-1 to responsibly mitigate both byproduct affected areas as well as petroleum affected soils. However, these efforts did not yield a concomitant reduction in Ra-226 concentrations because underlying ore zone areas were exposed. Ra-226 concentrations measured during the last gamma survey—the majority between 15-20 pCi/g—reflect NORM conditions, and are within the range of concentrations measured in the nearby B5 Pit. As such, the final status survey effort for GHP-1 is considered complete and no further action is planned.

6.0 WINDBLOWN AREA

The windblown area, shown in Figures 1.1, 1.2, and 6.1, has been characterized by a thin surficial veneer (typically 0-0.5") of windblown deposited 11e.(2) byproduct material. As discussed in the FSSP, the primary source of windblown contamination is the Above-Grade Tailings Impoundment (AGTI). The contamination pattern reflects the prevailing north/northeast wind direction, visually apparent in the diagram below[11]:

Initial Windblown 2001 Snapshot



The windblown survey area was aerally extensive (Figures 1.1, 1.2, and 6.1)—the gamma data survey coverage encompassed approximately 111 acres, about 70 acres of which exhibited potential windblown impacts. As such, the data collection and management effort was even more extensive than that documented in the preceding section for GHP-1. Because the magnitude of this data set precluded even concise tabular summaries, the majority of the findings in this section are presented in a visual (graphic) format. Detailed supporting information is provided in Appendix C. Appendix C-1 presents the gamma survey documentation, including source file and data management information for over 30 distinct surveys and more than 235,000 data points. Appendix C-2 presents the soil sampling documentation, and Appendix C-3 presents the data and exploratory analyses supporting the revised gamma-radium correlation equation derivation.

[11]As discussed in Section 4.2, although the final status survey was conducted on a 10-meter by 10-meter grid basis, contamination patterns are most apparent when the individual survey data points are plotted. Therefore, as shown above and in many of the figures associated with this section, gamma survey data (Ra-226 estimates) are plotted using graduated color maps and a "Natural Breaks" classification method. For the windblown area figures, legends for all graduated color point data maps are based on that developed for the initial (2001) windblown snapshot. This was done to ensure consistency and the validity of figure comparisons—e.g., 2001 vs. 2002 (see Figure 6.5 addendum). In some cases, slight adjustments are made to reflect revised upper or lower bounds, but otherwise the classifications remain the same. Again, in reviewing such figure
es, the actual breakdowns are not important—rather, the visual spatial pattern is the primary purpose.

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6.1 Background Characterization Refinement

Final status survey investigations of the windblown area yielded some similar findings to those determined for GHP-1. First, like GHP-1, the previously established background and corresponding cleanup levels (6.1 and 11.1 pCi/g, respectively) were not sufficiently high to account for the prevalence and magnitude of NORM within and surrounding the windblown project area. Second, cleanup of byproduct impacted material in some areas led to the exposure of underlying NORM-containing soils exhibiting similar or higher Ra-226 levels than the overlying windblown particles, sometimes confounding the demonstration of cleanup.

As discussed in Sections 1.4 and Section 2.6, the 6.1 pCi/g Ra-226 northern area background value was established after extensive discussion with the NRC, and was essentially a negotiated value. Both parties acknowledged that NORM areas exhibiting Ra-226 levels higher than this background level were likely to be encountered, but this factor was to be addressed by using the byproduct material identification procedures—i.e., allowing for some discretion in the field (Section 3.6). Ultimately, due to the prevalence of NORM within the windblown project area, the latter provision was not sufficient to allow for a clear demonstration of attainment of the (background plus 5 pCi/g) cleanup criterion—when in fact that is the case. To better demonstrate these findings, a summary of the previous background data set (SMI 1999b, SMI 1999c, Umetco 2000b) is warranted. This summary is provided largely in a graphical manner, as reflected in Figures 6.2 through 6.4. Detailed information is provided in the cited reports.

The first factor to reiterate is that the background data set was a combination of two data sets derived in SMI's investigations: the first based on the extensive discrete sampling conducted for their background study, and the second based on a later investigation designed to determine the extent of windblown contamination (Windblown Scoping Study; SMI 1999c). The northernmost samples from the latter investigation were later determined to be valid background locations. Based on observations made during the final status survey and a re-examination of SMI's background data, the northernmost composite samples collected in SMI's windblown scoping study were probably much better indicators of a reasonable range of background than SMI's (1999b) background data set—in terms of both magnitude and sample collection methods.[12] The NRC review of the background data set also suggested that samples further north of the site appeared to be a different population (NRC 2001), and indeed this is the case, as shown in Figures 6.2 and 6.3. Figure 6.4 demonstrates how NORM at depth in SMI's initial conservative data set was not reflected, as subsurface Ra-226 (> 6" bgs) was not used to establish background.

It is beyond the scope of this document to undertake a detailed re-analysis of background conditions. Furthermore, it is not considered necessary—as identified previously, the NRC determined that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001). Accordingly, if it is not possible to derive a background statistic, it is not reasonable to derive a single cleanup level.

[12] The windblown scoping study samples were collected in the same manner as the final status survey verification samples—i.e., blended 0-6" composites from discrete locations within a 10-meter by 10-meter study grid. Alternatively, their background evaluation utilized discrete samples; this was done in part to characterize vertical trends.

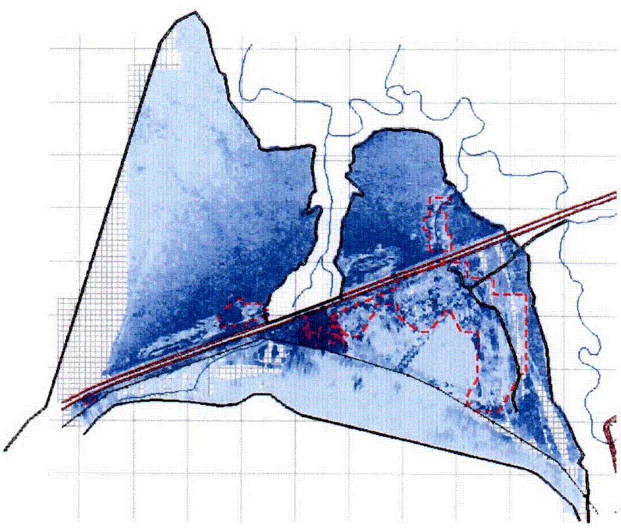
However, for the purpose of reviewing and interpreting the findings presented in the following sections, 10-15 pCi/g Ra-226 is considered a more representative range of windblown area background conditions than the previously estimated 6.1 pCi/g. This conclusion is based on the issues discussed above and on the soil Ra-226 measured in soil samples collected from known NORM areas during the windblown area final status survey.

6.2 Characterization, Cleanup Areas, and Verification Survey Summary

The final status survey for the windblown area was performed over the area encompassing the survey boundary shown in Figure 6.1. The windblown final status survey area encompassed 4400 sequentially numbered 10-meter by 10-meter grids, approximately 3800 of which were located in potentially impacted areas. The extended survey coverage (largely to the north) allowed Umetco to better delimit the windblown contamination extent. Methods used in the final status survey for the windblown area are discussed in Section 3 and in Appendix A.

Windblown area final status survey efforts began in May 2001, when the initial "pre-excavation" gamma survey was undertaken. Results of this initial characterization survey are shown in Figure 6.5 (and are reflected in the introductory diagram on page 33). Based on these initial survey results, significant excavation—entailing the removal of approximately 3,100 cubic yards of material—was undertaken in the areas outlined in Figure 6.5. Figure 6.6. shows the initial 2002 "snapshot" reflecting this excavation: as shown in the exhibit below, the effectiveness of the 2001 cleanup is apparent.

Initial Windblown 2002 Snapshot, Reflecting 2001 Cleanup



Above exhibit adapted from Figure 6.6.
- - - -indicates approximate 2001 cleanup area
•indicates increased gamma survey readings in Carbide Draw (see text below)

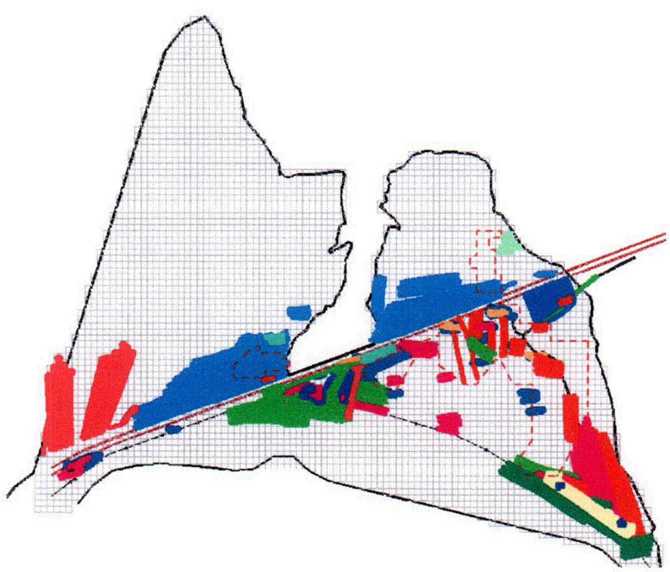
C12A

The only exception to the latter finding (re: cleanup effectiveness) was observed in the south Carbide Draw area, where gamma survey readings increased significantly. The May-June 2001 survey indicated the need for remediation of localized areas within Carbide Draw, and these excavations were undertaken. However, in the process of cleanup, gamma levels increased and could not—unlike other windblown areas—be attributed solely to NORM. Rather, the findings in this area likely reflect the breach in the tailings impoundment that had occurred during the operational period of the mill and/or accumulation of sediment from the site and the AGTI. As such, the south Carbide excavation proceeded, as described in the discussion of 2002 survey efforts below.

6.2.1 2002 Cleanup and Post-Cleanup Verification Surveys

Although the 2001 cleanup effort resulted in the effective remediation of some large areas, the initial 2002 characterization survey results indicated the need for further localized remediation. The subsequent cleanup and verification efforts were performed in an iterative fashion throughout the 2002 field construction season. Approximately 1,500 cubic yards of material were excavated in 2002 (excluding Carbide Draw). The approximate cleanup areas are shown in subsequent figures presenting results (Figures 6.8 through 6.15), but are probably best reflected in mapping the post-verification survey data. Figure 6.7 demonstrates the iterative nature and extent of the verification surveys, whereby each uniquely colored symbol reflects a distinct cleanup and/or survey effort. An abbreviated version of this figure is provided in the diagram below.

Overview of 2002 Final Status Re-Survey and Excavation Areas



Above exhibit adapted from Figure 6.7.
- - - -indicates approximate 2001 cleanup area

C13

As shown in Figure 6.7 and the exhibit above, several of the 2002 re-survey areas had been excavated in 2001. Additional cleanup was undertaken under the assumption that windblown material still remained (and this could have been the case), but later it was revealed that in some areas, NORM was accounting for the still elevated Ra-226. The total volume of material removed and disposed of in the A-9 during the 2001-2002 windblown area final status survey efforts is summarized in the table below.

Table 6.1 Summary of Windblown Area Cleanup Efforts

Area	Year	Volume Removed	Description
Windblown (inc. Carbide Draw)	2001	3,128 cu yds	Corresponding to major windblown impacts shown in Figures 6.5 and 6.6
Windblown (exc. Carbide Draw)	2002-2003	1,572 cu yds	Iterative cleanup driven by gamma surveys (Carbide Draw excavation treated separately; see below.)
Total Windblown	**2001-2003**	**4,952 cu yds**	**(Excludes Carbide Draw below)**
Carbide Draw	2002	6,324 cu yds	Initial cleanup in 2001 revealed underlying mill-related material exhibiting levels significantly higher than previous surficial readings. This material was not technically windblown, but rather resulted from the previous breach of the tailings impoundment.

Given the magnitude of the Carbide Draw excavation, some discussion of the field observations made during this effort is warranted. As discussed on the preceding page, original surveys of the Carbide Draw area south of the county road indicated the need for localized cleanup. However, early in the excavation it became clear that the contamination in this area was not strictly due to windblown material; rather it reflected in part the accumulation of sediments resulting from the previous breach in the tailings impoundment. As the excavation progressed (becoming wider and deeper), gamma survey readings continued to increase, and it was difficult to distinguish between NORM and potential byproduct material

The area was evaluated by Lidstone & Associates to assess sediment depositional characteristics and to better distinguish between native material and affected soils. Drainage channels were identified based on the historical photographs and the geological characteristics of the area. Upon completion of the excavation, Lidstone returned to the site and verified that materials had been removed to native ground. This finding must be acknowledged in reviewing the final status survey results that follow (e.g., those shown in Figure 6.11), as elevated Ra-226—i.e., NORM—is apparent in some areas.

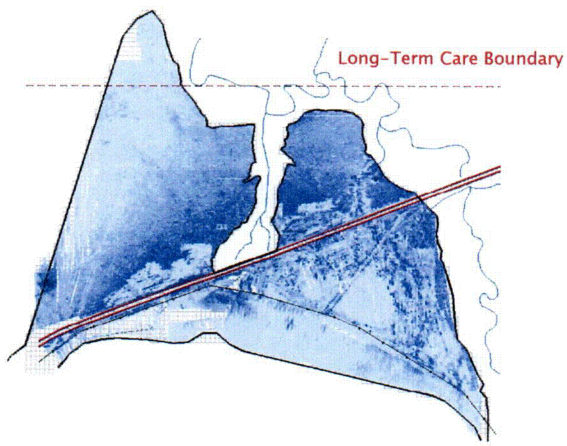
6.3 Gamma Survey Findings and Results

The results presented in this section reflect the final Windblown Area final status survey snapshot, as of October 2002, and as such reflect the merged results of multiple characterization and post-cleanup verification surveys conducted throughout the 2002 field season. The figures referenced in this section are self-explanatory and therefore warrant little accompanying discussion. Therefore, the text is generally limited to a discussion of salient findings.

The results of the 2002 windblown area final status survey are shown in Figures 6.8 through 6.17. Figure 6.8 shows the grid average Ra-226 estimated for each 100 m^2 survey grid. Given the large spatial extent of the windblown study area, and to facilitate review of the results shown in Figure 6.8, six sub-areas were defined as shown in Figure 6.9 Corresponding detailed results are provided in Figures 6.10 through 6.15. In addition to grid-specific information, these figures also include the gamma survey coverage, soil sampling results, and identify cleanup and NORM areas. In these figures, grid average Ra-226 estimates and gamma survey data points are color-coded to reflect Ra-226 magnitude, and these categories—e.g., 3 - 7.5 pCi/g, 7.6 - 8.9 pCi/g, 9.0 - 11.1 pCi/g, 11.2 - 13.3 pCi/g etc.—preserve the context of the previously established 11.1 pCi/g cleanup level.[13] Note, however, that, based on the background characterization refinement presented in Section 6.1 and the final status survey results for known NORM areas documented in the subsequent figures and exhibits, all of the results shown in Figures 6.1 through 6.16 are considered to be in attainment of the Criterion 6(6) background plus 5 pCi/g Ra-226 cleanup criterion.

Figure 6.16 plots the gamma survey data for the final (October 2002) windblown area snapshot vs. those based on the initial (April-May 2001) characterization survey. Comparison of the two maps (2002 vs. 2001) demonstrates the effectiveness of the 4,700 cubic yard windblown cleanup effort. An adapted version of this figure is provided in the exhibit below.

Windblown Area Final Status Survey "Final Snapshot"



[13] The 8.9 pCi/g and 13.3 pCi/g category bounds correspond to 11.1 pCi/g +/- 20 percent.

C14

As shown above and in Figure 6.16, elevated radiological characteristics are still apparent in selected areas (e.g., the darker band north of the county road), but the gamma survey readings and corresponding Ra-226 estimates are within the range of observed background. Figure 6.16 also identifies several NORM areas, but three—all located north of the county road—are noteworthy. These areas are numbered on Figure 6.16 and described in detail in Exhibits 6.1 through 6.3, provided at the end of this section. These exhibits provide a visual and textual chronicle of the field observations and final status survey results for each NORM area, all supporting the conclusion that further remediation of the windblown area (particularly north of the county road) will not guarantee reduction in Ra-226 magnitude. In fact, levels might increase.

Figure 6.17 provides an alternate view. Note that survey results exceeding 15 pCi/g are all within known or suspected NORM areas. Figure 6.18 provides a graphical statistical summary of the windblown area final status survey grid-specific results. In this figure, grid average Ra-226 estimates based on the gamma survey were categorized as follows:

Deleted: , indicating that although residual windblown impacts are still apparent in some areas, Ra-226 is within the 10-15 pCi/g non-outlier range of background/ NORM and as such, the requirements of 10 CFR 40, Appendix A, Criterion 6(6) are satisfied.

1) Main windblown area grids—including the area south of the county road and the darker-colored areas in Figure 6.5;

2) Secondary windblown area—corresponding to the darker band on Figure 6.16 just north of the cleanup areas;

3) Known NORM areas—e.g., those addressed in Exhibits 6.1 through 6.3;

4) Possible NORM grids—defined based on field observations, but where evidence is not compelling enough to warrant a (true) NORM designation; and

5) Non-mined (undisturbed) background—corresponding to the northernmost gamma survey area (the pale-blue section shown in Figure 6.16, with detailed view provided in Figure 6.13). This area exhibits some of the lowest gamma survey readings, was not mined (as evidenced by the lack of exploration holes), and as such is considered the most conservative representation of background for this area (see Figures 6.2 through 6.4 for context).

Corresponding summary statistics for Ra-226 grid averages based on the gamma survey data are tabulated as follows (all values are in units of pCi/g except Valid N):

Category	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Minimum	Maximum	Std.Dev.
Windblown Primary	2749	8.9	8.8	8.9	3.0	14.3	1.8
Windblown Secondary	940	9.0	8.9	9.0	7.0	11.6	0.8
Known NORM	46	12.2	11.6	12.8	7.7	19.3	2.1
Potential NORM	26	11.2	10.8	11.6	9.3	13.9	1.0
Undisturbed Background	639	7.2	7.1	7.2	5.9	8.4	0.4

Figure 6.18 demonstrates that the windblown area results are well within the range observed for both known and potential NORM areas. Also, in the context of the gamma survey results (cpm

converted to Ra-226 estimates), the range of background is higher than that previously defined—around 7 to 8 pCi/g as shown in Figure 6.17. Again, the latter represents a very conservative estimate of background, as the more elevated NORM areas illustrated in Figure 6.2 and Exhibits 6.1 through 6.3 are not reflected.

Summary statistics for all windblown area study grids are provided in Appendix C-2. To examine the impact that additional cleanup would have on the overall Ra-226 areal average, all grids with Ra-226 averages exceeding 11.1 pCi/g were re-assigned a value of 11.1 pCi/g. This was done for three areas: 1) all windblown study grids, including non-impacted areas (n = 4400 grids); 2) the main windblown area, defined above (n = 2801), and 3) main and secondary (also defined above) areas combined (n = 3761). Results of these calculations are provided below:

Area	No. of Grids	Current Avg. Ra-226	Avg. Ra-226 if all ≤ 11.1 pCi/g
All Windblown Grids	4400	8.7 pCi/g	8.6 pCi/g
Main Windblown Area	2801	8.9 pCi/g	8.8 pCi/g
Main + Secondary	3761	9.0 pCi/g	8.9 pCi/g

As indicated above, cleanup of grids exceeding the previously defined 11.1 pCi/g Ra-226 cleanup level (many of which are NORM and/or within the range of background) would result in only a 0.1 pCi/g (1%) reduction in the average Ra-226 content. Granted, the above summary ignores spatial weighting issues, but the overall findings—i.e., the projected nominal reduction in Ra-226—would likely be corroborated by further assessment.

6.4 Soil Sampling Results

Soil samples were collected in an iterative manner throughout the final status survey. Grids to be sampled were selected based on those exhibiting the highest gamma survey readings, but assumed not to exceed the 11.1 pCi/g Ra-226 cleanup level. After ensuring that adequate ingrowth had occurred (the earliest results were available in late July), initial results indicated the need for cleanup in areas previously thought to be below the 11.1 pCi/g cleanup level. [These conclusions were drawn before the magnitude and prevalence of NORM had been clearly established.] Also, Ra-226 estimates based on the previous algorithm established in the windblown correlation study appeared to be too low, underestimated by about 2 pCi/g.

Over 200 samples were collected during the windblown area final status survey investigation (approximately 5% of the study grids), 150 of which are considered valid (i.e., no subsequent cleanup was undertaken). The valid sample results are mapped on Figure 6.19, and shown in detail in the smaller-scale (zoom) results provided in Figures 6.10 through 6.15. Detailed results are provided in Appendix C-2, and the corresponding revised gamma-radium correlation equation is documented in Appendix C-3.[14] [Correlations were valid for 130 of the 150 valid sample results.] Corresponding Ra-226 estimates were then compared with the soil analytical

[14] Correlations were valid for 130 of the 150 valid sample results. The 20 results considered to be invalid for correlation purposes had either insufficient spatial coverage or multiple survey dates (e.g., for grids with only partial cleanup or those peripheral to cleanup areas).

results and residuals were calculated. Despite some disagreement between soil sample results and corresponding survey estimates, the predictions were still within an acceptable margin of error (RPD less than 15%; Appendix C-3). Also, in many cases the Ra-226 estimates were in very close agreement with the corresponding soil results (e.g., see Figures 6.10 through 6.15).

Establishing a revised gamma-correlation equation for this project area was very difficult. This difficulty is apparent in reviewing Figure 6.19, which plots the range of grid-average cpm's vs. the corresponding soil analytical result. As shown in this figure, the majority of the soil samples were collected in grids with average survey readings ranging between 11,000 and 12,000 cpm. The graph in the lower portion of this figure demonstrates the wide range in soil results corresponding to this cpm range: 7.2 to 18.5 pCi/g Ra-226. Many permutations were attempted in defining the new gamma-radium equation. For example, subsets were defined based on area (north windblown vs. south), NORM presence or absence, meter, etc. Subset definition did not yield any compelling results—in fact, the correlations were weaker than that defined for the original data set. Ultimately, outliers were defined for each cpm range and then excluded from the data set as documented in Appendix C-3. This revised data set, excluding outlier (marked) points, was then used to define the gamma-radium correlation equation used to estimate Ra-226 for the windblown area.

As discussed in Section 4.1, it is important to acknowledge that the discrepancies discussed above are inevitable in a characterization survey of this nature and magnitude, especially given the prevalence of NORM and the heterogeneity which characterizes the windblown area (see Section 4.1).

All windblown area soil samples were analyzed in the on-site laboratory as discussed in Section 3. Ten samples were sent to an outside vendor, ACZ, for confirmatory analysis. Comparison of the onsite laboratory results with ACZ's indicates general agreement (16% RPD) as documented in Appendix C-2.

6.5 September 2003 Germanium Detector Evaluation

Given the prevalence of NORM within and surrounding the windblown study area, and the difficulty in distinguishing between NORM and windblown 11e.(2) material, a qualitative evaluation was undertaken in September 2003 in an attempt to better elucidate distinctions, if any, between these areas.

6.5.1 Study Rationale and Objectives

In the measurement of gamma-ray energies above several hundred keV, only two detector categories of major importance: inorganic scintillators—e.g., NaI(Tl), used throughout the Final Status Survey—and germanium (Ge) semiconductor detectors. Although there are many other potential factors, the choice in a given application most often revolves about a trade-off between counting efficiency and energy resolution (Knoll 1989). While scintillators provide good counting efficiency, their energy resolution is poor. Conversely, germanium detectors provide excellent energy resolution but have lower photopeak efficiencies. Given the difficulty in distinguishing between NORM and 11e.(2) affected areas on the basis of Ra-226 magnitude alone (with NORM areas often exhibiting higher Ra-226 than windblown impacted areas), an evaluation allowing better resolution between photopeaks was undertaken in September 2003.

Eleven locations were selected for study, representing 3 primary categories: 11e.(2)/windblown impacted areas, disturbed NORM areas (e.g., those discussed previously and addressed in Exhibits 6.1 through 6.3), and undisturbed NORM areas. These locations are shown on Figure 6.21; more detailed descriptions and supporting rationales are provided on Table 6.2 (see following page). The study was conducted on September 3rd and 4th, 2003 using an Orsat™ Ge(Be) detector. Results of this evaluation are documented below.

6.5.2 Results

Figure 6.22 plots gamma spectrum results for each location; larger versions of each plot are provided in Appendix D. In reviewing these results, four peaks are of primary importance: Pb-212, a Th-232 decay product; Pb-214 and Bi-214 (both decay products of Ra-222), and Cs-137. Because this study is essentially qualitative (vs. quantitative), the magnitude of the peaks is not as important as the ratios between them. Therefore, in reviewing Figure 6.22, it is important to focus on the pattern established by the primary (highest) peaks for the endpoints of concern, and not necessarily the magnitude.

Primary Findings: Even with the heightened resolution provided by the Ge detector, no compelling differences were found between 11e.(2)/windblown affected and disturbed NORM areas. The corresponding Ra-226 measurements, although approximate, are generally consistent with previous field and gamma spec Ra-226 measurements (Figure 6.22). Pb-212 and Pb-214 appear to be elevated in relation to Bi-214 at 11e.(2) affected locations—namely grid 45962 (closest to AGTI source) and the East Canyon Creek location, but this pattern is also found at the known NORM location (grid 54550) and the B-5 pit. A prominent "step-down" pattern (Pb-212 vs. Pb-214 vs. Bi-214) is apparent in many of the plots.

Table 6.2 Germanium Field Evaluation Locations and Rationales for Study

No.	Grid No.	Location / Description	Category	Comment / Rationale
1	45962	Windblown, closest to source, near Restricted Area fence	11e.(2) / Windblown	Closest to source, and with previous (pre-cleanup) soil sample gamma spec result of 13.7 pCi/g. A portion of this grid and the surrounding area was remediated in Sep-03.
2	NA	East Canyon Creek, north of county road	11e.(2) / Windblown	Part of area evaluated in the East Canyon Creek risk assessment (SMI 1999c), outside of Final Status Survey Scope (see Section 6.1).
3	51963	Northeast SWB	11e.(2) / Windblown	Soil result of 15.2 pCi/g here. Windblown presence likely (within sagebrush heads), but still within range of background (Figure 6.10).

4	52331	Windblown area north of NWB cleanup, in vicinity of known NORM areas	11e.(2) / Windblown	Area north of cleanup areas exhibiting windblown characteristics but also close to known NORM areas. The gamma spec result was higher than most in this area (15.2 pCi/g). Purpose of inclusion is to determine whether this is distinguishable from NORM.
5	49511	"Oxidized zone" NORM area	NORM	See Figure 6.13 and Exhibit 6.1.
6	51535	MW-18 NORM Area	NORM	See Figure 6.15 and Exhibit 6.2.
7	54550	"No-Name Draw" NORM area	NORM	See Figure 6.15 and Exhibit 6.3. The gamma spec Ra-226 measured for this grid was the highest of all samples collected: 18.5 pCi/g.
8	49279	NORM Area, west NWB	Suspected NORM	Elevated Ra-226 based on gamma survey, but the location and magnitude of measurements is not consistent with AGTI windblown material. A gas line was encountered here, so results could be due to mine spoils used as fill.
9	58104	Northwestern-most windblown final status survey area	Undisturbed NORM, low range	Based on previous background evaluations and final status survey results, this grid and the surrounding area likely represents the low range of background Ra-226 for the site.
10	NA	Background area approx. 950 m (0.6 miles) north of county road, well beyond 11e.2 affected areas	Undisturbed NORM, intermediate	Background area evaluated during SMI's 1999 windblown scoping study, near an outcropping exhibiting elevated Ra-226.
11	NA	B-5 Pit	NORM, Mine Spoils	Coincides with B-5 sample locations shown in Figure 5.2

Note that in some grids categorized as windblown/11e.2, there is the potential for NORM admixture. For example, the area around grid 45962 exhibited some evidence of mine spoil material (see Figure 6.22).

AGTIAbove-Grade Tailings Impoundment (primary windblown contaminant source)
NANot Applicable
NORMNaturally Occurring Radioactive Material
NWBNorth Windblown area
SWBSouth Windblown area

The only endpoint signaling any compelling difference between the locations is Cs-137, by which disturbed areas are readily distinguished from undisturbed areas. Figure 6.23 plots the ratios of Pb-212: Pb-214 and Pb-212: Bi-214 obtained for all locations, as well as the corresponding Cs-137 peaks. Again, no compelling differences are found based on the peak ratios alone. Figure 6.24 provides alternate exploratory analysis plots, underscoring the previous conclusion. The cluster analysis provided in this figure (a semi-quantitative means of grouping cases based on multiple variables) shows the three primary undisturbed locations clustering together, but apart from that, no obvious groupings are apparent.

In summary, the results of the recent Ge detector in situ field study corroborate Umetco's previous findings that, in this heterogeneous area where the mill site was situated within the mining area, it is not possible to quantitatively distinguish between NORM and 11e.(2) and windblown affected material.

6.6 Summary Discussion

Cleanup and subsequent verification of windblown byproduct in areas where NORM materials were not encountered was very effective. The windblown veneer was identified, removed, and documented by subsequent verification surveys. Attempted cleanup of windblown byproduct material in areas where NORM was present was very difficult, resulting in several iterations of excavation and survey which ultimately resulted in increased Ra-226 concentrations. Additional soil removal north of the excavated areas will likely expose additional natural mineralization, loss of topsoil, potential disturbance of cultural resources, and increased surface Ra-226 concentrations.

Considering the underlying NORM which exists within the survey boundary, and the results of the recent germanium detector in situ study confirming that disturbed NORM areas are indistinguishable from windblown (11e.(2) impacted material, Umetco believes that an optimal cleanup of the windblown area has been achieved. Remaining windblown byproduct, if any, is indistinguishable from the immediate area background. Application of the "as low as reasonably achievable" (ALARA) principle would not create a health risk (as indicated based on the previous East Canyon Creek risk assessment, SMI 1999a) and is reasonable under the circumstance of highly variable background values. The potential dose after remediation of the northern area will be low because, as discussed in Section 2.5, this area is part of the parcel that will be deeded to the Department of Energy for perpetual care. Significant cleanup has occurred in the windblown area—approximately 11,000 cubic yards (including Carbide Draw)—as evidenced by the Ra-226 reduction in non-NORM areas which is highly apparent in the preceding figures. Based on the findings presented in this section and the issues discussed above, no further remediation of the windblown area is warranted.

7.0 REMAINING 2001-2002 FINAL STATUS SURVEY AREAS

This section presents the final status survey results for the remaining areas investigated in 2002. Section 7.1 discusses the cleanup and characterization results for the DW-6 former process water pipeline. Section 7.2 presents the final exposure survey results for the above grade and the heap leach. Section 7.3 summarizes the status of the trash pits discussed in Section 4.3.2 of the FSSP. As identified previously, the uncovered section of the former A-9 haul road, shown in Figure 7.1, will be assessed when the A-9 cover construction is completed and the remaining haul road reclaimed.[15]

7.1 DW-6 Process Water Pipeline

In accordance with the FSSP, the DW-6 pipeline was investigated in Spring 2002 to assess the potential presence of byproduct material contamination. This pipeline is the process waterline extending west (offsite) from the former mill area wash facilities (Figure 7.1). The reason that byproduct material contamination was suspected here is that, according to anecdotal information, tailings sand was used as bedding material around the piping in selected portions of the waterline.

7.1.1 Study Area Description

This pipeline is 6 inches in diameter, running from the site to a deep well approximately 3 miles west of the site (Figure 7.1). This pipeline is currently used to provide construction water for site reclamation activities. Prior to replacement of the line (see Section 7.1.2 below), the pipeline had been in place for approximately 40 years, and portions of it had been replaced or repaired on several occasions (specific areas are not known). Although no contaminated materials had been identified during the previous reparation activities, confirmatory investigation was considered warranted.

7.1.2 Final Status Survey Activities

DW-6 pipeline final status survey activities consisted of the following:

1. Excavation of the entire pipeline, and replacement of the previous line with Drisco pipe;
2. Gamma survey of the entire line in accordance with Umetco procedure R-16 (see Section 3.1); and
3. Where indicated based on both on both gamma survey readings and visual observations, removal of tailings and subsequent verification gamma surveys.

In areas where tailings were encountered (see Figure 7.2 and the discussion below), gamma survey readings ranged from 45,000 to 150,000 cpm. Portions of the pipeline that tailings were encountered were fiberglass piping with a tailings bedding material of approximately 6 inches on top of the piping for protection of the piping from puncture by rocks. Use of tailings as a bedding for the fiberglass pipe was visually identifiable as tailings sands were white in color and

[15] Figure 7.1 shows the location of the A-9 haul road and the haul route portion that is not currently under the footprint of the Heap Leach or GHP-2 covers, as denoted by the solid red line between the A-9 Repository and the Heap Leach.

for the most part, contrasting with native soils utilized as backfill. Material resembling ore was encountered in the area near the B-5, consistent with observations made for GHP-1. Gamma survey readings in these NORM areas averaged approximately 25,000 cpm. Evidence of tailings was also found in a small area near the intersection of Dry Creek Road and West Canyon Creek (near Deep Well 6), but NORM was again encountered in underlying soils.

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As part the DW-6 final status survey investigation, a total of 18,338 cubic yards of material was excavated and placed in the A-9. This excavation took place in the verification survey areas identified in Figure 7.2. The initial excavation occurred along the eastern third of the pipeline—the approximate 1-mile long segment extending west from the B-5 Pit. Another excavation was undertaken in the western segment of the pipeline, near the intersection of West Canyon Creek and Dry Creek Road. To ensure cleanup of the bedding material around the pipe, most areas were excavated 3 to 4 feet in depth and 4 feet wide. The gaps in the survey shown in Figure 7.2 are areas where there was no evidence of tailings, based on both visual observation and preliminary survey results. As such, the verification survey results presented in this section reflect the areas where tailings were encountered and removed. These areas—shown as Areas 1 through 4 in Figure 7.2—are defined as follows:

Deleted: In most areas, the depth of the excavation was about 3 to 4 feet

Area	Location	Survey Date(s)	Meter No(s)
Area 1a	Just east of B-5	4/9/02	434
Area 1b	" "	3/5/02	372
Area 2	see Figure 7.2	2/27/02	372
Area 3	" "	2/27/02	372
Area 4a	Westernmost segment (see Fig. 7.2)	2/13/02	372
Area 4b	" "	4/9/02	434

The subareas listed above were defined because of 1) the discontinuity in survey segments reflected in Figures 7.2 and 7.4 and 2) the different survey dates and instruments. Survey results were initially converted to Ra-226 estimates using previous meter-specific gamma-radium correlation equations, therefore requiring subarea definitions. Ultimately, Ra-226 was estimated using the correlation equation derived for GHP-1, and as such might be slightly overestimated (see Appendix B-2).

7.1.3 Verification Survey Results

Post-verification survey results are shown in Figures 7.2 through 7.4 and summarized in the following exhibit and the tables below. Although all residual tailings had been removed during the pipeline excavation (18,338 cubic yards), post-cleanup gamma survey levels in some areas exceed the 10 pCi/g background for mining disturbed areas +15 pCi/g 10 CFR 40, Appendix A, Criterion 6(6) of 25 pCi/g for materials greater than 15 cm below the surface. Verification soil sampling performed in the pipeline shows soil cleanup efforts in the pipeline trench would meet the Ra-226 surface cleanup standard of 15 pCi/g for this area. Soil samples collected from the pipeline utilized for comparison purposes show that Ra-226, Th-230 and U-nat levels appear to be in equilibrium for 10 of the 12 samples collected. The 2 outlying samples show Ra-226 to U-nat ratios that are consistent with low grade uranium (NORM) ratios observed from the B5 Pit

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(Table 5.2, B5HWALL 6'-10') and Site Background Study. To establish that cleanup efforts were successful, Umetco employed visual examination, meter survey, and soil sampling and comparing survey and soil sampling results to known NORM areas for equilibrium and statistical analysis. Given these findings, Umetco is proposing an alternate criteria to demonstrate cleanup using the B5 Pit as a specific reference area.

Deleted: site-wide criterion. However, Figure 7.3 (also shown in the exhibit on the following page), demonstrates that these results are well within the range of concentrations measured in the adjacent B-5 pit, and as such are considered NORM. Given these findings, the final status survey effort for DW-6 is considered complete.

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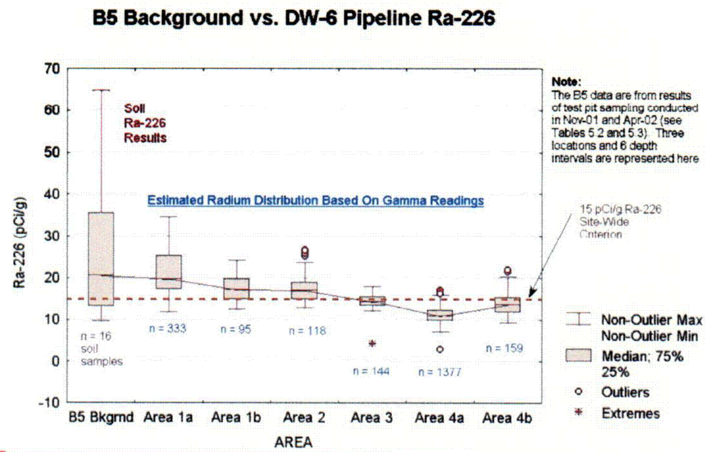
Section Break (Next Page)



Adapted from Figure 7.3.

Table 7.1 DW-6 Pipeline Post-Excavation Survey Results: Ra-226 Estimates (pCi/g)

Area	N	mean	min	max	stdev	
Area 1a	333	21.1	11.7	34.6	5.4	this area closest to B5 background area
Area 1b	95	17.3	12.4	24.1	3.1	
Area 2	118	17.9	12.8	26.7	4.0	
Area 3	144	14.4	4.3	17.9	2.0	
Area 4a	1377	11.0	2.9	17.1	1.6	
Area 4b	159	13.8	9.3	21.9	2.6	
Combined:	2226	13.6	2.9	34.6	4.7	

The above compared with 16 B5 soil background results from the adjacent B5 highwall and rim: results with mean of 28 pCi/g, range of 9.6 - 64.9 pCi/g (standard deviation of 9.6 pCi/g).

Table 7.2 DW-6 Pipeline Survey Results: Unconverted cpm Measurements

Area	Survey Date(s)	Meter No(s)	N	mean	min	max	stdev
Area 1a	4/9/02	434	333	15,687	8,646	25,843	4,028
Area 1b	3/5/02	372	95	12,850	9,165	17,966	2,320
Area 2	2/27/02	372	118	13,337	9,504	19,909	3,025
Area 3	2/27/02	372	144	10,692	3,059	13,345	1,493
Area 4a	2/13/02	372	1377	8,133	2,007	12,709	1,214
Area 4b	4/9/02	434	159	10,191	6,878	16,282	1,978
		Combined:	2226	10,052	2,007	25,843	3,525

C15

7.2 Penetrating Radiation Surveys of the Above-Grade Tailings Impoundment and the Heap Leach

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, gamma exposure surveys are required at all areas of the site that are to be covered for long-term stabilization. These areas include the Above-Grade Tailings Impoundment, the Heap Leach facility, GHP-2, and the A-9 and C-18 Pits (Figure 1.2). Exposure survey results for the first two areas are discussed below. Final surveys of GHP-2 and the A-9 and C-18 Pits will be done upon completion of the cover for those areas.

Since removal from service, approved reclamation covers have been completed for the AGTI and the Heap Leach. Between April and July 2001, direct gamma surveys of these areas were made over the completed earthen cover, upon completion of the frost protection layer, and prior to placement of erosion protection. One-meter high bare gamma exposure readings were collected and then averaged over the entire area in the manner described below.

7.2.1 Methods

As discussed in Section 3.4, direct gamma radiation exposure rates on the Above-Grade Tailings Impoundment and the Heap Leach were determined by conducting RMGPS scans prior to placing riprap erosion protection materials, pursuant to Umetco procedure number R-17. RMGPS scintillation exposure rate scans were conducted with a bare detector one-meter above the repository cover surface; most areas were driven with an ATV.

Scans were conducted on approximately parallel offsetting traverses of the cover, approximately 10 meters, apart while moving along the traverse at a rate of approximately 0.5 meters per second.

7.2.2 Results

The results of the exposure surveys for the AGTI and the Heap Leach are shown in Plates 1 and 2, respectively. The average exposure rate measured over both the AGTI and the Heap Leach was 27 µR/hr, thereby satisfying the 30 µR/hr criterion (see Plates 1 and 2). As such, final status survey activities for these areas are complete.

It is important to note that peripheral readings in the northeastern-most grids of the Heap Leach, adjacent to the B-Spoils area, were some of the highest measured: 35 to 36 µR/hr (Plate 2). This influence from adjacent background areas must be acknowledged for ultimate surveys of the A-9 pit, where the 30 µR/hr may not be feasible, given likely shine from the north and south evaporation pond mine spoils to the west, and the A-9 and C-18 highwall rims to the east.

7.3 Other Areas

During site reclamation activities conducted in July and August 2000, three small former trash pits were uncovered. One pit was located on the northern boundary of the north evaporation pond, a second was located southeast of the tailings impoundment along the restricted area boundary, and the third in the B-spoils area (see Figure 4.1 of the FSSP). The B-spoils area is considered a background reference area as mining activities took place here. The trash in these pits consisted of general refuse and laboratory waste—e.g., scrap metal, rusted barrels, and used gloves and protective Tyvek clothing. The approximate size of the trash pits after excavation:

- Trash Pit 1 – 120 feet long, 60 feet wide, 20 feet deep
- Trash Pit 2 – 60 feet long, 25 feet wide, 8 feet deep
- Trash Pit 3 – 30 feet long, 15 feet wide, 5 feet deep

Prior to excavation, most gamma scans conducted in the trash pit areas were within background ranges, indicating that no significant byproduct material existed in these areas. For example, readings ranged from 500 cpm to 30,000 cpm, and most were within the 12,000 to 15,000 cpm background range typical for the B-spoils area.[16] However, in some areas where old yellowcake filter press cloth was encountered, readings ranged as high as 1,000,000 cpm.[17]

All pits were excavated to a depth of 1 to 3 feet below residual trash material. The trash was removed and hauled to the A-9 pit; the pits were then backfilled with mine spoils. A sample was then collected from trash pits in the B-spoils area to evaluate the need for additional excavation. The Ra-226 value for this sample was 9.7 pCi/g based on results of on-site gamma spec analysis. Subsequent to this analysis, the trash pits were surveyed and soil samples collected and analyzed by Barringer Labs for Ra-226, Th-230, and U-nat. Results of these analyses are provided below in Table 7.3. Post-excavation gamma survey readings averaged about 11,000 cpm, well below the background range established for this area.

Deleted: The trash pits were surveyed and soil samples were collected and analyzed for Ra-226, Th-230, and U-Nat. Ra-226 results (average of 9.7 pCi/g) were below the 15 pCi/g site-wide criterion. Post-excavation gamma survey readings averaged about 11,000 cpm, well below the background range established for this area.

Table 2.1 Soil Sample Results for Mine Spoil Area Trash Pits, August 2000

Location Code	Location	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-nat (pCi/g)
Trash Pit #1	Evap. T-Pit	46 + 1.3	59 + 2.9	47.4
Trash Pit #2	Gate 5 T-Pit	7.8 + 0.53	6.8 + 1.4	31.8
Trash Pit #3	B Channel T-Pit	5.5 + 0.46	5.4 + 1.2	13.5
Trash Pit #3	Slope B Channel	4.1 + 0.41	4.1 + 1.1	9.5

Samples were collected in August 2000 after excavation and were analyzed by Barringer Labs. U-nat originally reported in mass units (mg/kg), was converted to activity (pCi/g) by multiplying the mass value by 0.677.

[16] Although 12,000 to 15,000 represents the general background trend for the B-Spoils area, in some cases gamma survey readings were much higher, ranging between 300,000 and 500,000 cpm, depending on ore grade.

[17] Note that these levels posed no inhalation hazard to site workers; rather, risks would be posed only by the ingestion route.

8.0 SUMMARY AND CONCLUSIONS

8.1 Summary of Cleanup Efforts

As part of the Final Status Survey, a significant volume of material was excavated and placed in the A-9. The following table summarizes the results of the corresponding cleanup efforts.

Table 8.1Final Status Survey Cleanup Summary

Area	Year	Volume Removed	Comment
GHP-1	2000	18,162 cu yds	Removal of material coinciding with removal of the pond liner and underlying soils.
GHP-1	2002	11,904 cu yds	Additional removal after discovery of residual petroleum impacts corresponding with the former leach field and identification of possible milling-related impacts to a depth of 2 to 6 feet based on the 2002 geochemical investigation (Lidstone & Associates 2002 & Levy).
Total GHP-1	**2001-2002**	**30,066 cu yds**	
Windblown	2001	3,128 cu yds	Corresponding to major windblown impacts shown in Figures 6.5 and 6.6
Windblown	2002-2003	1,824 cu yds	Iterative cleanup driven by gamma surveys (Carbide Draw excavation treated separately; see below.)
Total Windblown	**2001-2003**	**4,952 cu yds**	
Carbide Draw	2002	6,324 cu yds	Initial cleanup in 2001 revealed underlying mill-related material exhibiting levels significantly higher than previous surficial readings. This material was not technically windblown, but rather resulted from the previous breach of the tailings impoundment.
Pipeline	2002	18,338 cu yds	This material was removed as part of the pipeline excavation encompassing a 3-mile segment. Tailings were removed, but some areas did not "clean up" given the presence of NORM, especially the area in the western portion of the pipeline adjacent to the B5 Pit.
Total, All Areas:	**2001-2003**	**59,680 cu yds**	

8.2 Summary of Survey Results and Findings

The results documented in the previous sections demonstrate that:

- Approximately 30,000 cubic yards of material was excavated from GHP-1, to address both byproduct related and residual petroleum contamination. Geochemical investigation findings combined with field observations indicate that all impacted material has been removed from this area, thereby satisfying Criterion 6(6). Post-cleanup gamma survey results indicated no reduction in average soil Ra-226 content however, and in some cases notable increases were apparent. The latter findings are due to the prevalence of NORM in underlying soils.

- Significant cleanup of windblown byproduct material was undertaken during the final status survey, entailing the removal of approximately 4,950 cubic yards of soil. An additional 6,700 cubic yards of material was removed from Carbide Draw, but contamination in this area was attributable to a former breach in the tailings impoundment (not windblown).

- Cleanup and subsequent verification of windblown byproduct in areas where NORM materials were not encountered was very effective. The windblown veneer was identified, removed, and documented by subsequent verification surveys. The effectiveness of these cleanup efforts is evidenced by the Ra-226 reduction in non-NORM areas which is highly apparent in the preceding figures. Attempted cleanup of windblown byproduct material in areas where NORM was present was very difficult, however, resulting in several iterations of excavation and survey which ultimately resulted in increased Ra-226 concentrations. Considering the underlying NORM which exists within the survey boundary, and the results of the recent germanium detector in situ study confirming that such material is indistinguishable from windblown (11e.2) material), an optimal cleanup of the windblown area has been achieved. Additional soil removal north of the excavated areas will likely expose additional natural mineralization, loss of topsoil, potential disturbance of cultural resources, and increased surface Ra-226 concentrations.

- The excavation/cleanup of the DW-6 pipeline, entailing the removal of 18,000 cubic yards of material, resulted in the reduction of Ra-226 concentrations to levels at or below corresponding background levels.

- Final status survey activities are complete for the AGTI and the Heap Leach. The average exposure rate measured over these areas was 27 µR/hr, thereby satisfying the 30 µR/hr criterion (Plates 1 and 2).

- Observations of NORM and soil sampling results presented herein corroborate previous conclusions about the efficacy of using a single background number (and corresponding cleanup level) for this highly heterogeneous area.

8.3 Discussion

Final status survey investigations at the Gas Hills site confirmed some of the issues raised previously in the Final Status Survey Plan—in particular, how blurry the distinction is between affected and unaffected areas. As demonstrated previously, cleanup of GHP-1 resulted in a slight overall increase in average Ra-226 content, vs. the reduction that would be expected concomitant with a 30,000 cubic yard volume removal.

In the case of the windblown area, in some respects it might have been more cost-effective to remove all known windblown impacted soils (given the definitive "fingerprint" evident based on the gamma survey). The latter would have precluded the iterative cleanup, re-survey and investigative efforts that took place. However, final status survey results demonstrate that in doing so, underlying Ra-226 levels in many areas might actually increase. Also, in the Gas Hills area, the restoration/maintenance of viable ecological habitat and archaeological resource areas is of paramount concern. As a result, Umetco's approach was to achieve a balance: by applying the ALARA principle to cleanup, yet at the same time avoiding unnecessary denudation or removal of topsoil. In doing the latter, the "value added" or concomitant risk/dose reduction associated with cleanup must be considered. In the case of the windblown area, cleanup of grids exceeding the previously defined 11.1 pCi/g Ra-226 cleanup level (later found to be within the range of background) would result in only a 0.1 pCi/g (1%) reduction in the average Ra-226 content. Such a nominal decrease does not warrant further remediation, especially in light of the other factors discussed above.

Considering the underlying NORM which exists within the GHP-1, windblown, and DW-6 pipeline final status survey areas, Umetco believes that an optimal cleanup of all areas has been achieved. At GHP-1 and the DW-6 process water line, there is likely little, if any, byproduct material remaining. That remaining in the windblown area, although apparent in some areas, is indistinguishable from the immediate area background. Additionally, the potential dose associated with current Ra-226 levels will be low because this area will be deeded to the Department of Energy for perpetual care.

8.4 Final Status Survey Activities to be Completed

This report represents the bulk of the final status survey findings. However, several additional activities must be undertaken before site decommissioning is complete. These activities include:

1) Survey of A-9 Haul Road Survey Segment. The small portion of the A-9 haul road between the A-9 tailings area and its exit from the site (Figure 7.1) will be assessed when the A-9 cover construction is completed and the remaining haul road reclaimed. Any byproduct material encountered will be placed in the GHP No. 2 cell.

2) Exposure Surveys of A-9 and C-18 Pits. The exposure rate survey for the A-9 Pit is scheduled to be completed in 2004. That for the C-18 Pit will be performed upon completion of the C-18 backfill.

9.0 REFERENCES

Intermountain Resources. 1998. *Threatened and Endangered Species Survey, Umetco East Canyon Creek Project*, Gas Hills, Wyoming.

Intermountain Resources. 2000. *Wildlife and Wetlands Survey, Umetco East Canyon Creek Project, the Gas Hills, Wyoming*. June 2000.

Lidstone and Associates, Inc. 2002. *Lithologic and Geochemical Evaluation of the GHP-1 Evaporation Pond at Gas Hills, Wyoming.* Technical Memorandum prepared for Umetco Minerals Corporation by Lidstone and Associates and Summit Geoscience. November 5, 2002.

Pronghorn Archaeological Services. 1998. *Class III Cultural Resource Inventory for the East Canyon Creek Project Located in Section 4 and 9, T33N, R89W, Sections 30, 31, 32, and 33, T33N, R89W, Section 25, T34N, R90W, Fremont County, Wyoming.* August 1998.

Pronghorn Archaeology. 2000a. Letter report documenting interim results of recent uncovering of cultural artifacts which occurred during construction of the ECC realignment project. June 7, 2000.

Pronghorn Archaeology. 2000b. *Research Design and Treatment Plan for Site 48NA465,* Natrona County, Wyoming. June 22, 2000.

Shepherd Miller, Inc. (SMI). 1999a. *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed, Gas Hills, Wyoming.* May 1999.

Shepherd Miller, Inc. (SMI). 1999b. *Background Radionuclide Concentrations at the Umetco Gas Hills Site.* March 1999.

Shepherd Miller, Inc. (SMI). 1999c. *Gamma Survey of Windblown Deposition Areas, Gas Hills, Wyoming.* April 14, 1999.

Shepherd Miller, Inc. (SMI). 2000. *Addendum to East Canyon Creek Dose Assessment in Response to NRC Comments.* September 2000.

Umetco Minerals Corporation. 1990a. *Uranium Mill Decommissioning Plan.* Draft Report. May 2, 1990.

Umetco Minerals Corporation. 1990b. Memorandum to U. S. Nuclear Regulatory Commission. June 18, 1990.

Umetco Minerals Corporation. 1991a. *Application for Amendment to Mill Decommissioning Plan for Burial of Mill Debris.* January 10, 1991.

Umetco Minerals Corporation. 1991b. Memorandum to U. S. Nuclear Regulatory Commission. February 11, 1991.

Umetco Minerals Corporation. 1992. Memorandum to U. S. Nuclear Regulatory Commission. April 13, 1992.

Umetco Minerals Corporation. 1995. Memorandum to U. S. Nuclear Regulatory Commission. November 27, 1995.

Umetco Minerals Corporation. 1997. *Background Land Conditions at the Gas Hills Uranium Project*. Draft Rev. 1. June 30, 1997.

Umetco Minerals Corporation. 2000a. *Final Status Survey Plan, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000b. *Final Background Characterization Report, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000c. Letter to P. Ting (U.S. Nuclear Regulatory Commission, Chief, Fuel Cycle Licensing Branch) from T. Gieck, Umetco. RE: "Gas Hills, License Number SUA-648; Docket #40-0299; Final Background Characterization Report and Final Status Survey Plan. Letter dated November 17, 2000.

Umetco Minerals Corporation. 2001a. *Final Application for Alternate Concentration Limits for Gas Hills, Wyoming.* November 2001.

Umetco Minerals Corporation. 2001b. *Windblown Correlation Study Technical Memorandum.* Gas *Hills, Wyoming.* August 3, 2001.

Umetco Minerals Corporation. 2002. *Quality Control Program for Final Status Surveys, Gas Hills, Wyoming Site.* Revision 2. July 3, 2002.

U.S. Department of Energy (DOE). 2001. Adaptive Sampling and Analysis Programs (ASAPs). Characterization, Monitoring, and Sensor Technology Croscutting Program and Subsurface Contaminants Focus Area. DOE/EM-0592. August 2001.

U. S. Environmental Protection Agency (EPA). 1994. *Title 40, Code of Federal Regulations, Environment.* January 1, 1994.

U. S. Environmental Protection Agency (EPA). 2001. Current Perspectives in Site Remediation and Monitoring: Applying the Concept of Effective Data to Environmental Analyses for Contaminated Sites. Written by D. M. Crumbling, EPA, Technology Innovation Office. EPA 542-R-01-013. October 2001.

U. S. Nuclear Regulatory Commission (NRC). 1982. *An Aerial Radiological Survey of the Federal-American Partners, Pathfinder, and Union Carbide Mill Sites and Surrounding Area.* July 1982.

U. S. Nuclear Regulatory Commission (NRC). 1989. *Standard Format and Content of Decommissioning Plans for Licenses Under 10 CFR Parts 30, 40, and 70.* Regulatory Guide 3.65. August 1989.

U. S. Nuclear Regulatory Commission (NRC). 1992. *Manual for Conducting Radiological Surveys in Support of License Termination.* NUREG/CR-5849, Draft Report for Comment.

U. S. Nuclear Regulatory Commission (NRC). 1994. *Title 10, Code of Federal Regulations, "Energy."* January 1, 1994.

U. S. Nuclear Regulatory Commission (NRC). 1996. *NRC Staff Comments on Umetco's Draft Report on Background Land Conditions at the Gas Hills Uranium Project and Radiological Investigation Programs.* September 20, 1996.

U. S. Nuclear Regulatory Commission (NRC). 1997. *NRC Staff Comments on Umetco's Response and Revised Report on Background Land Conditions.* December 12, 1997.

U. S. Nuclear Regulatory Commission (NRC). 1999b. NRC letter approving revisions to License Condition No. 58 re: *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository for Material License SUA-648, Amendment 42.* December 9, 1999.

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

Note: The *Technical Evaluation Report*, referred to extensively herein, was Enclosure 1 of the April 5, 2001 submittal, and the *Environmental Assessment* was Enclosure 4.

U. S. Nuclear Regulatory Commission (NRC). 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 of 1978.* NUREG-1620, Revision 1. June 2003.

U. S. Occupational Safety and Health Administration (OSHA). 1994. *Title 29, Code of Federal Regulations.*

Waste Engineering, Inc. (WEI). 2002. Gas Hills' Site Quality Assurance Audit, Second Quarter 2002. Direct Radiation Verification Surveys of Open Land Surface Soil. Prepared for Umetco Minerals Corporation, July 20.

FINAL STATUS SURVEY REPORT

Addendum 1

Gas Hills, Wyoming Site

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

April 2004
Revised August 2004

Contents

Attachments and Appendices

Contents

Tables

Exhibits

Contents

Figures

Contents

Definition of Terms

Acronym	Definition
11e.(2)	11e.(2) byproduct material, defined under 10 CFR 40 Appendix A
ALARA	As Low As Reasonably Achievable
AML	State of Wyoming Abandoned Mine Lands (program)
BRDL	Basic Radiation Dose Limit (25 mrem/year)
DCGL	Derived Concentration Guideline Level, analogous to SRSG (below)
DOE	Department of Energy
EA	Environmental Assessment
ECC	East Canyon Creek
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
GHP	Gas Hills Pond (e.g., GHP-1)
GIS	Geographic Information System
GPS	Global Positioning System
LC	License Condition
NORM	Naturally Occurring Radioactive Minerals
NRC	U. S. Nuclear Regulatory Commission
pCi/g	picoCuries per gram
PRI	Power Resources, Inc.
Ra-226	Radium-226
SMI	Shepherd Miller, Inc.
SRSG	Single Radionuclide Soil Guideline (as derived by the NRC RESRAD code)
SRP	Standard Review Plan
TER	Technical Evaluation Report (NRC 2001)
Th-230	Thorium-230
TVA	Tennessee Valley Authority
UCC	Union Carbide Corporation

1.0 INTRODUCTION

1.1 Background and Scope

This report constitutes the first addendum to the report entitled *Final Status Survey Report* (FSSR), submitted to the U.S. Nuclear Regulatory Commission (NRC) by Umetco Minerals Corporation (Umetco) on October 27, 2003 (Umetco 2003). The NRC responded to this submittal by requesting additional information as outlined in nine specific comments documented in a letter dated December 31, 2003 (NRC 2003a). Some of the information requested by the NRC can not be provided at this time—due to either ongoing reclamation efforts within some areas of the site (e.g., GHP No. 2) and/or the fact that further data collection is precluded until weather permits completion of the survey and sampling tasks. Given the additional time required to address these issues, Umetco will submit three addendums:

- This report, Addendum 1, consists of Umetco's comment responses and additional data and information elicited by those comments. This addendum also includes an Alternative Criteria evaluation, evaluating health and environmental impacts resulting from a no further action alternative, as well as costs and associated dose/risk reduction expected under various cleanup scenarios.

- Addendum 2, scheduled to be submitted in June 2004, will document the A-9 Repository gamma survey and A-9 haul road verification data.

- Addendum 3 will document the GHP No. 2 gamma survey, to be completed upon completion of the GHP No. 2 Reclamation Cover.

Figure 1.1 shows the site plan and location map reflecting the status of Final Status Survey efforts for all areas of the site.

1.2 Organization and Contents

Following this section, Section 2 documents the NRC's comments (NRC 2003a) and Umetco's corresponding responses. Table 1 summarizes the general issues and site areas addressed in each comment. Section 3—Alternative Criteria For Gas Hills Site Soil Cleanup—provides a summary characterization of the site radiological setting, followed by dose assessment and cost-benefit analysis in support of the Alternative Criteria Evaluation. Sections 4, 5, and 6 provide supplemental data and information for the DW-6 pipeline, GHP-1, and Carbide Draw, respectively. References are provided in Section 7.

This report should be reviewed referencing the preceding Final Status Survey Report (Umetco 2003), which documents much of the supporting background information and radiological data.

Table 1.1. Summary of NRC Comments on Final Status Survey Report

NRC Comment	Primary Issue	NRC Request	Addendum Section(s) Containing Response
1	Completeness of Final Status Survey Report (FSSR) radiological data—e.g., the A-9 and C-18 pits, GHP-2, soil verification for the A-9 haul road, and the excavated trash pits.	Umetco should provide all available final radiological data for this FSSR. For gamma and radium data that cannot be acquired until after cover completion, Umetco should provide an addendum to the FSSR as soon as all the data is available.	Section 2 comment response; FSSR summary and supplementary data are provided in remainder of document
2	Verification of status and ultimate disposition of laboratory buildings within the restricted area.	Umetco should justify this change in disposition of the laboratory in the FSSR and provide the data in the FSSR addendum.	Section 2 comment response
3	Citation and figure references: pp. 5, 6, and 45.	Include the NRC 1999 reference in the revised report and consider correcting in text references.	Section 2 and Attachment 1
4	DW-6 process water pipeline trench cleanup basis and final status survey approach	Justify procedures used for the pipeline trench cleanup verification that are not in accordance with approved methods.	Section 2 and Section 4 (DW-6 Pipeline Supplemental Eval.)
5	Demonstration of attainment of 10 CFR 40, Appendix A, Criterion 6(6), given final status survey areas not meeting the concentration limits set forth in that rule	Considering the related information in the FSSR, Umetco should consider proposing an alternative to Criterion 6(6), as described in the introduction to Appendix A.	Section 3: Alternative Criteria for Gas Hills Site Soil Cleanup, dose assessment & ALARA analysis
6	Cleanup of petroleum affected soils in the northern portion of GHP-1	Indicate what criteria were used for cleanup of the petroleum and why.	Section 5 (GHP-1 Supplemental Eval.)
7	Final Status Survey results for GHP-1	Umetco should provide reasonable assurance that all 11e.(2) byproduct material impacts have been adequately addressed for Pond 1.	Section 2 comment response; Section 3 is also germane
8	Final Status Survey verification data for Carbide Draw and the excavated trash pits.	Indicate why the portion of Carbide Draw south of the county road and the trash pits meet cleanup standards.	Section 2 comment response
9	Correlation data for non-windblown areas of the site and radium-226 (Ra-226) to thorium-230 (Th-230) and Ra-226 to natural uranium (U-nat) ratios.	Provide the correlation graph of the final gamma and corresponding Ra-226 analytical data for areas other than the windblown area. Indicate how the final data support the original assumption concerning Th-230 and U-nat contamination.	Section 2 comment response

Detailed comments are provided in the corresponding sections.

2.0 NRC COMMENTS AND UMETCO COMMENT RESPONSES

This section documents NRC's comments (NRC 2003a) and the corresponding Umetco responses. Some comments requiring more detailed evaluation and backup are addressed in more detail in subsequent sections as referenced below.

Comment 1. *As mentioned in the electronic mail to you November 18, 2003, the staff's acceptance review determined that the Umetco Final Status Survey Report (FSSR) is not complete as data for several areas are missing. Page 2 of the FSSR mentions that the gamma survey for the A-9 and Pond 2 cell covers and C-18 Pit, and soil verification for the A-9 haul road have not been done. In addition, data for the three excavated trash pits was not found. A schedule for completing the report was requested (more detail than FSSR, bottom of page 52).*

> REQUEST: Umetco should provide all available final radiological data for this FSSR. For gamma and radium data that cannot be acquired until after cover completion, Umetco should provide an addendum to the FSSR as soon as all the data is available.

Response to Comment 1

With the exception of supplementary soil sampling data (see below), all radiological data available for the Gas Hills site have been submitted to the NRC. As indicated in the previous section, exposure surveys and verification data for the A-9 Pit and haul road, the C-18 Pit (upon completion of the C-18 backfill), and GHP No. 2 will be submitted in Addendums 2 and 3 upon completion of the survey and sampling tasks. Supplementary soils data for the DW-6 pipeline, GHP-1, and trash pits are discussed in the following comment responses and corresponding addendum sections. Byproduct cleanup for the North and South Evaporation Ponds is discussed in the following paragraphs.

The methodology and rationale for removal of byproduct material from the North and South Evaporation Ponds has been addressed in the report entitled "*Design Report Part I, Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository*" (SMI 1998). This design was submitted October 27, 1998 and approved by License Amendment No. 42 on December 9, 1999. Radiological data associated with cleanup of this area were provided in the October 1998 submittal and Umetco's subsequent responses to NRC comments (December 10, 1998 and March 29, 1999). These data will not be reiterated here; however, an overview of the evaporation pond cleanup rationale and approach is provided below.

The North and South Evaporation Ponds were constructed with a 3-foot thick clay soil liner on top of mine waste overburden piles, shown on Figure 1.1. These ponds were used to store and evaporate mill waste solutions and tailings liquor pumped from the A-9 Repository from 1983 to 1991. The mine waste overburden piles beneath the ponds have naturally elevated concentrations of Ra-226, U-Nat, and Th-230, attributable to sediments surrounding the uranium roll front deposit that were mined at the Gas Hills site. The October 1998 submittal referenced above provided results of the detailed field investigation and associated geochemical modeling conducted at the ponds, evaluated in the context of 10 CFR 40, Appendix A, Criterion 6(6).

Based on these results, this report concluded that the mine spoil material beneath the clay liner was not significantly impacted by mill byproduct material and that little or no further removal was required. NRC approval of this revised reclamation approach resulted in the requirement to remove and dispose of the remaining clay liner material (approximately 2 feet). Initial cleanup of the pond sludge and upper one foot of clay liner occurred prior to SMI's 1998 field and geochemical investigation. The remaining clay liner material was removed in June and July 2000 and was disposed of in the A-9 Repository. Figure 2.1 provides cross-sections based on field civil surveys which illustrate the extent of contaminated soil removal. Detailed radiological characterization data for the North and South Evaporation pond embankment, below the clay liner, is provided in Section 6 of the October 1998 design report (SMI 1998).

Comment 2. *Page 4 of the FSSR indicates that the laboratory will be surveyed and released for unrestricted use. However, the approved status survey plan (as part of the decommissioning plan) stated that the only building in the restricted area is a mobile soils laboratory and it will be disposed in the tailings disposal cell when site reclamation is complete.*

> **REQUEST:** Umetco should justify this change in disposition of the laboratory in the FSSR and provide the data in the FSSR addendum.

<u>Response to Comment 2</u>

Two laboratory trailers are presently on site: Soils Lab A and Soils Lab B, a semi-trailer. Umetco expects Soils Lab A to meet release criteria for unrestricted use. Soils Lab B, however, is not expected to meet release criteria and will be disposed of in GHP No. 2, where decontamination facilities will be in place.

Comment 3. *The top of page 6 refers to NRC 1999a but this document is not listed in the reference section. Also, there are incomplete references to figures on page 5, first paragraph (Figure 6.x) and page 45, Section 7.1.2, number 2 (Section 3.x).*

> **REQUEST:** Include the NRC 1999 reference in the revised report and consider correcting in text references.

<u>Response to Comment 3</u>

The NRC 1999a reference was cited on page 6 of the FSSR as follows: "These mining-disturbed lands meet the NRC's definition of naturally occurring unprocessed ore (NRC 1999a) — i.e., background radiation." This citation referred to a previous version of the NRC's Standard Review Plan[1] (herein referred to as the SRP), prior to its recent finalization in June 2003 (NRC 2003b). Although earlier versions of the SRP made more explicit references to mining-related

[1] The full title, shortened above, is *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 of 1978*. NUREG-1620, Revision 1, June 2003 (NRC 2003). As the NRC acknowledges, the References section of the FSSR did not list the 1999a reference because it had been updated to cite the then current, but interim, January 2002 version.

impacts and concomitant issues regarding naturally occurring radioactive material (NORM), the more recent finalized version addresses these issues much more broadly. Discussion is generally limited to Section 5.1.2.3 (Cover Radioactivity Content) and selected text in Appendix I (Regulatory Issue Summary).

Given that the finalized SRP does not explicitly discuss unprocessed ore, the FSSR text on page 6 has been revised slightly as follows: "These mining-disturbed lands meet the NRC's definition of naturally occurring radioactive material or NORM (NRC 2003b) — i.e., background radiation." Attachment 1 includes the FSSR replacement page (pg. 6), the corresponding corrected NRC reference (pg. 55), and corrections of figure and section references for FSSR pages 5, 15, and 45.

Comment 4. *Page 9 (Table 2.2) of the FSSR indicates that 10 pCi/g was used for the Ra-226 background for cleanup of the DW-6 process water pipeline trench. The technical evaluation for the Umetco decommissioning plan states that the 10 pCi/g Ra-226 value for soil surrounding the site was to be used to compare to the Ra-226 average value for tailings pile covers. The only approved soil cleanup Ra-226 background values are 2.2 and 6.1 pCi/g for the windblown areas. Also, apparently there were no soil samples taken and the gamma readings were not averaged over 100 square meters (m^2), although the 3-mile long pipeline was excavated, in part, because of 11e.(2) byproduct material.*

REQUEST: Provide justification for the procedures used for verification of the pipeline trench cleanup that are not in accord with required/approved methods.

Response to Comment 4

In the discussion of soil background radioactivity in the Technical Evaluation Report (TER), Amendment 44, the NRC states: "A radium value of 10 pCi/g (0.37 Bq/g) was proposed to represent the soil surrounding the site, to be used for meeting Criterion 6(5), i.e., the value to compare to the tailing pile cover Ra-226 content" (NRC 2001). As the NRC acknowledges, the 10 pCi/g background value was intended as a site-wide criterion. However, the interpretation that this value would apply only to the tailings pile cover is not consistent with the intent set forth in the Final Status Survey Plan (FSSP) and supporting Background Report (Umetco 2000a, 2000b).

Table 3.1 of the FSSP indicates that 6.1 pCi/g is intended as Ra-226 background for the northern windblown cleanup area only, and that 10 pCi/g would apply to remaining site-wide soils, including GHP-1. Because the DW-6 pipeline, GHP-1, and the trash pits are located directly adjacent to or within mining areas (see Figures 3.1 and 3.2), the conservative 6.1 pCi/g background value is not appropriate for these areas. As shown on Figure 3.1, the pipeline route intersects several mining disturbance areas, resulting in naturally elevated radiological conditions. If the conservative 6.1 pCi/g background windblown area background value were applied to the DW-6 pipeline, the appropriate cleanup standard would be 21.1 pCi/g, given that the pipeline was surveyed in a 4-5 ft deep trench and thus the background plus 15 pCi/g Ra-226 subsurface standard applies. As demonstrated in Section 4, analysis of 12 archived composite soil samples collected along segments of the pipeline trench indicates Ra-226 levels well below this standard (3.7 – 14 pCi/g Ra-226). Six of these samples were collected in Area 1, the area exhibiting the highest gamma survey readings likely stemming from the adjacent B-5 Pit.

In response to the NRC's comments regarding the methodology used in the DW-6 final status survey, survey procedures were in accordance with approved methods—i.e., the gamma survey was performed using a Global Positioning System (GPS) and 11e.(2) materials were excavated as described in the FSSP (Umetco 2000a). The FSSR data presentation, which consisted of discrete gamma readings and concomitant data summaries, differed from the standard assessment based on a 100-square-meter (100 m^2) grid because the linear pipeline/trench configuration was thought to preclude such an approach. Grids configured based on a traditional 10 x 10m grid block would have inadequate survey spatial coverage (i.e., a survey line bisecting the grid). Alternatively, grids configured on a 100 m x 1 m layout, although technically meeting the 100 m^2 criterion, were thought to average radium values over too large a horizontal distance, resulting in potentially biased (over- or, more likely, under-estimated) Ra-226.

To address the NRC's concerns, geospatial estimation tools in ArcView were used to estimate 10 x 10 m grid averages, thereby satisfying the 100 m^2 assessment criterion set forth in 10 CFR 40, Appendix A, Criterion 6(6). Additionally, archived samples collected along the pipeline were submitted for analysis of Ra-226, Thorium-230 (Th-230), and natural uranium (U-Nat). These results are presented and discussed in Section 4 (see Figures 4.1 and 4.2), the DW-6 Pipeline Supplemental Evaluation. As demonstrated in this section, the majority of the 233 100 m^2 grids are well below the appropriate 25 pCi/g Ra-226 subsurface standard. Only 10 grid estimates exceed 25 pCi/g—all occurring adjacent to the B-5 Pit—and these exceedances are slight. In light of the soil sample results, the kriged estimates are likely overestimated (see Section 4) and, as discussed in the FSSR and above, are considered reflective of NORM.

Comment 5. *Page 9 of the FSSR indicates that a windblown area Ra-226 background of 10-15 pCi/g is more representative than the approved value of 6.1 pCi/g. Page 39 states that "...although residual windblown impacts are still apparent in some areas, Ra-226 is within the 10-15 pCi/g non-outlier range of background/NORM, and as such, the requirements of 10 CFR 40, Appendix A, Criterion 6(6) are satisfied." Since the NRC staff did not approve 10-15 pCi/g Ra-226 as background for this area, Criterion 6(6) is not satisfied.*

In addition, the revised gamma-radium correlation (page 18 and Appendix C-3) was not submitted for NRC approval per Umetco's commitment on page 13 of the status survey plan. The correlation graph (C-3, Attachment 2) indicates that Umetco could not reliably distinguish soil of 8 to 10 pCi/g (compliance) from soil with 12 to 14 pCi/g (non-compliance).

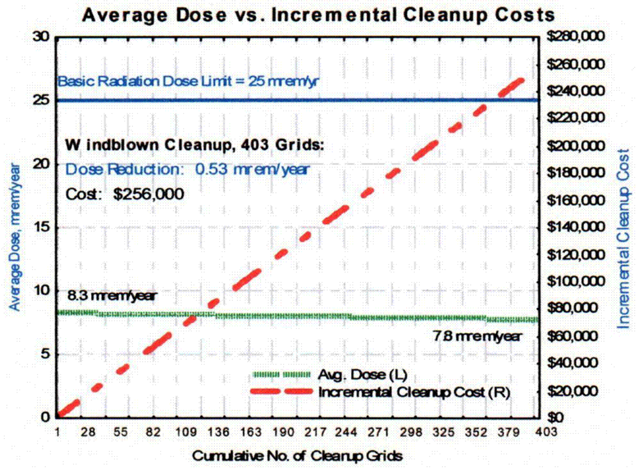
> **REQUEST:** Considering the related information in the FSSR, Umetco should consider proposing an alternative to Criterion 6(6), as described in the introduction to Appendix A.

<u>Response to Comment 5</u>

10 CFR Part 40, Appendix A, Criterion 6(6) requires that the soil radium concentration resulting from byproduct material, averaged over areas of 100 square meters, does not exceed the background levels by more than 1) 5 pCi/g of Ra-226 averaged over the first 15 cm [6 in.] below the surface, and 2) 15 pCi/g of Ra-226 averaged over 15-cm-thick layers, more than 15 cm below the surface (NRC 2003b). The common theme in this and NRC's comments is whether indeed the requirements of this criterion have been satisfied at the Gas Hills site. Implicit in this criterion is the determination of a representative background radium value or values. However, due to the heterogeneous radiological characteristics of the Gas Hills site, such a determination is not possible. For example, in the review of the background characterization report (Umetco 2000b), NRC staff corroborated what Umetco had previously identified, in determining that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001). As such, rather than pursue further statistical evaluations regarding background and corresponding cleanup criteria for which there may be no solution, Umetco developed an Alternate Criteria Evaluation as allowed by 10 CFR 40 Appendix A, which is documented in the following section.

Section 3 evaluates health and environmental impacts resulting from a no further action alternative, as well as costs and associated dose/risk reduction expected under various cleanup scenarios. This evaluation uses the same assumptions as that developed for East Canyon Creek (see SMI 1999, SMI 2000, Umetco 2000a, and the 2001 NRC TER), but applies these assumptions to the site as a whole. Although the ALARA analysis only applies to the windblown area, the resulting Derived Concentration Guideline Levels (DCGLs) are appropriate for all areas of the site, including GHP-1, the DW-6 pipeline, and the trash pits. This evaluation will demonstrate that the potential adverse environmental impacts and high cleanup costs are not justified by any benefit that would result from further soil remediation in the Gas Hills Site final status survey areas. This finding is demonstrated in the following graph, plotted based on results of a deterministic ALARA analysis which used the most conservative theoretical DCGL (26.9 pCi/g Ra-226 vs. 141 pCi/g, considered most representative) and lower bound cost estimates for the windblown cleanup scenario (see Section 3 for further information). As shown below, the calculated dose is well below the 25 mrem/year dose limit under the current (no cleanup) scenario, the dose reduction would be negligible if additional cleanup were undertaken, and as such the cleanup costs are not justified.

Exhibit 2.1 Cost-Benefit Graph for Windblown Cleanup Scenario 1



It is important to identify at the outset that the DCGLs calculated in support of the ALARA analysis, discussed above and documented in Section 3, are theoretical and do not negate or supersede the requirements set forth in 10 CFR Part 40, Appendix A, Criterion 6(6).

The ALARA analysis presented herein was conducted in accordance with NUREG-1727 guidance and used the same general approach as that applied in the November 2001 groundwater ACL. As such, cost-benefit calculations require the derivation of a radionuclide-specific activity concentration corresponding to a release criterion or dose limit. Twenty-five (25) mrem/year, although not typically applied to soil cleanup at mill sites, was chosen because it is conservative (relative to 100 mrem/year, cited in Appendix H of NUREG-1620), and it is consistent with the criterion applied in the approved groundwater ACL. In summary, although the DCGLs referred to above and discussed in Section 3 are considered representative of Ra-226 levels that would not pose a health risk to potentially exposed populations, this does not imply that Umetco will leave mill-impacted material of this magnitude (e.g., 141 pCi/g). Rather, the ALARA analysis and corresponding DCGLs support the conclusion that the Gas Hills site is suitable for release, pending completion of the remaining Final Status Survey components outlined in Section 1.1 of this addendum.

In response to the second paragraph of NRC Comment 5—regarding the windblown area gamma-radium correlation—this issue is discussed in Section 6.4 and Appendix C-3 of the FSSR. In these sections, Umetco evaluated the factors potentially accounting for the low strength of the correlation, but no definitive conclusions could be drawn. As discussed in the FSSR, the heterogeneity of the site, with significant NORM presence—both laterally and vertically—likely accounts for those cases where larger residuals were found. To account for this factor, the ALARA analysis provided in Section 3 includes a conservative scenario that attempts to address the implications of the NRC's comment that "*...Umetco could not reliably distinguish soil of 8 to 10 pCi/g (compliance) from soil with 12 to 14 pCi/g (non-compliance)*." This scenario was evaluated by adding 1.8 pCi/g to all Ra-226 values estimated using the FSSR

C16

gamma-radium correlation, wherein the new cutoff for compliance vs. non-compliance would be 9.3 pCi/g (vs. 11.1). The 1.8 pCi/g increment was derived based on a conservative calculation of residuals for the gamma-correlation data set (Section 3.5). The ALARA analysis did not justify further cleanup even under this conservative scenario.

Comment 6. *Page 19 (May 2002 entry) states that petroleum affected soils were identified in the northern portion of Pond 1. There is no mention of a report or data for the petroleum cleanup.*

REQUEST: Indicate what criteria were used for cleanup of the petroleum and why, and include a summary of the data in the FSSR.

Response to Comment 6

As discussed in Section 5 of the FSSR, petroleum affected soils were identified in the northern GHP-1 pond section, coinciding with the location of the former mill solvent catch basin (see FSSR Figure 5.1). The petroleum-affected soils were identified primarily by odor and were subsequently excavated an additional 6 feet (below the previous excavation) until the odor was no longer apparent. Upon completion of Final Status Survey activities, the total excavation depth within GHP-1—from the original ground surface to the post-cleanup pond bottom—was between 15 and 20 ft. Also note that the current base elevation of GHP-1, approximately 6970 ft, is well above the water table (approx. 178 ft depth) in unsaturated soils, indicating that the potential for migration of any existing petroleum residuals to underlying groundwater is negligible.

In response to the NRC's comment regarding cleanup criteria, five soil samples were collected from the area corresponding to the former mill solvent catch basin, representing the area previously exhibiting the greatest petroleum impacts prior to excavation (see FSSR Section 5.1 and Section 5 herein). These samples were collected on January 26, 2004 and submitted to ACZ for Total Petroleum Hydrocarbon (TPH) analysis using EPA Method 8015B. This analytical method was chosen based on site records (Material Safety Data Sheets (MSDS)) indicating that a kerosene spill was the most likely source of the observed impacts.

Kerosene falls within the C_{10}-C_{32} carbon range, also referred to as Diesel Range Organics (DRO), which are quantified using the 8015B method. TPH results, documented in Section 5.1, ranged from 4 mg/kg to 10 mg/kg in three of the samples; the remaining two samples had non-detectable concentrations (< 3 mg/kg). These results are well below the 100 mg/kg DRO (TPH) Wyoming cleanup standard for hydrocarbon contaminated soil.

Umetco acknowledges the importance of considering non-radiological hazards, particularly in an ALARA demonstration. Based on the issues discussed above and in Section 5, potential risks to the public and the environment from any residual petroleum constituents are considered to be negligible. This conclusion is supported by the following five factors:

1) the extensiveness of the excavation in GHP-1 (15-20 ft), as evidenced by the exposure of the underlying ore body in some areas;

2) TPH results indicating negligible presence of DRO petroleum constituents, at levels well below the 100 mg/kg Wyoming DEQ standard;

3) the depth to groundwater in the pond area (178 ft), which would preclude any significant previous or future migration of petroleum residuals to underlying groundwater;

4) the final grading plan, entailing the placement of approximately 4 to 6 feet of backfill over the GHP-1 pond area, which will be sloped to drain—i.e., storm water will not pond and infiltrate in this area; and

5) this area is within the DOE transfer boundary discussed in Section 2.5 of the FSSR and as such will be controlled with restricted use for long-term surveillance and maintenance.

Comment 7. *Page 32, Section 5.4.2, states that after additional soil removal from Pond 1 to address apparent impacts, "... no final verification soil sampling was performed." Sampling was thought unnecessary given the extensive excavations and test pit sampling results. Section 5.5 states that the majority of grids are between 15 and 20 pCi/g Ra-226, within the range measured in the B-5 Pit.*

REQUEST: Given the imprecision of the gamma-radium correlation, the variation of test pit data (Table 5.2), and that the B-5 Pit was not approved as background for Pond 1, Umetco should provide reasonable assurance that all 11e.(2) byproduct material impacts have been adequately addressed for Pond 1.

Response to Comment 7

As documented in the FSSR report, approximately 30,000 cubic yards of material were excavated from GHP-1 to mitigate byproduct affected areas as well as the petroleum affected soils addressed in the previous comment. This excavation proceeded well below the original ground surface (see response to Comment 6 above). As documented in Section 5.3 and Appendix B-3 of the FSSR, an extensive geochemical investigation undertaken by Lidstone and Associates (LA) indicated that 11e.(2) byproduct material impacts from pond solutions were limited to the upper 3 to 4 feet of pond material, primarily in the northern-central pond area. This material was subsequently excavated, as well as an additional 2 feet below the impacted horizon to ensure that the cleanup met ALARA requirements.

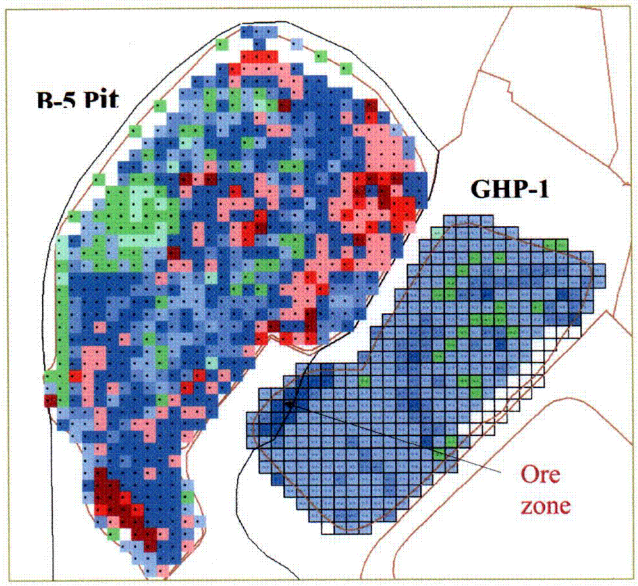
Comparison of the initial 2001 gamma survey results with the post-excavation 2002 gamma survey indicates that these cleanup efforts did not yield a concomitant reduction in Ra-226 concentrations because underlying ore zone areas were exposed (e.g., in the southwest pond section, an area observed by J. Lusher during the 2002 site audit). Pond-wide average Ra-226 concentrations increased slightly, and areas where the excavation was deepest corresponded to those grids exhibiting the greatest increases in average Ra-226 concentrations (see FSSR, Figures 5.16 and 5.17). The latter trend is not consistent with that typically exhibited in 11e.(2) impacted areas. As such, Ra-226 concentrations measured in GHP-1 based on the May 2002 gamma survey—the majority between 15-20 pCi/g—reflect NORM conditions, and are within or well below the range of concentrations measured in the nearby B5 Pit, an open-pit uranium mine. This conclusion is demonstrated in the following exhibit.

Exhibit 2.2
Gamma Survey Results for GHP-1 (2002) and the B-5 Pit (1995)

This inset reflects the magnitude of Ra-226 estimates.

Green: 0-15 pCi/g
Blue: >15-50 pCi/g
Red: > 50 pCi/g

Darker shading within each color group reflects greater Ra-226 magnitude within that range. Refer to Figure 3.5 for additional data comparisons.



Section 5.2.2 of NUREG-1620 (NRC 2003b) states that: "Several different background values may be required if contaminated areas have distinctly different soil types. For example, if a portion of the site has a natural uranium and/or radium mineralization zone in/near the surface, the cleanup criterion for that area would use a background (reference) U-238 or Ra-226 value from a similarly mineralized area."

In conclusion, any additional excavation of GHP No. 1 will likely increase radium concentrations as the excavation approaches the ore body and would also result in the disposal of large volumes of NORM. GHP-1 will be backfilled and reclaimed in accordance with WDEQ standards (SMI 1998) and the site transferred to DOE for long-term care. Given the latter, combined with the results of the Alternative Criteria Evaluation documented in Section 3, Umetco concludes that the criteria set forth in 10 CFR Part 40, Appendix A, Criterion 6(6) have been met at GHP-1.

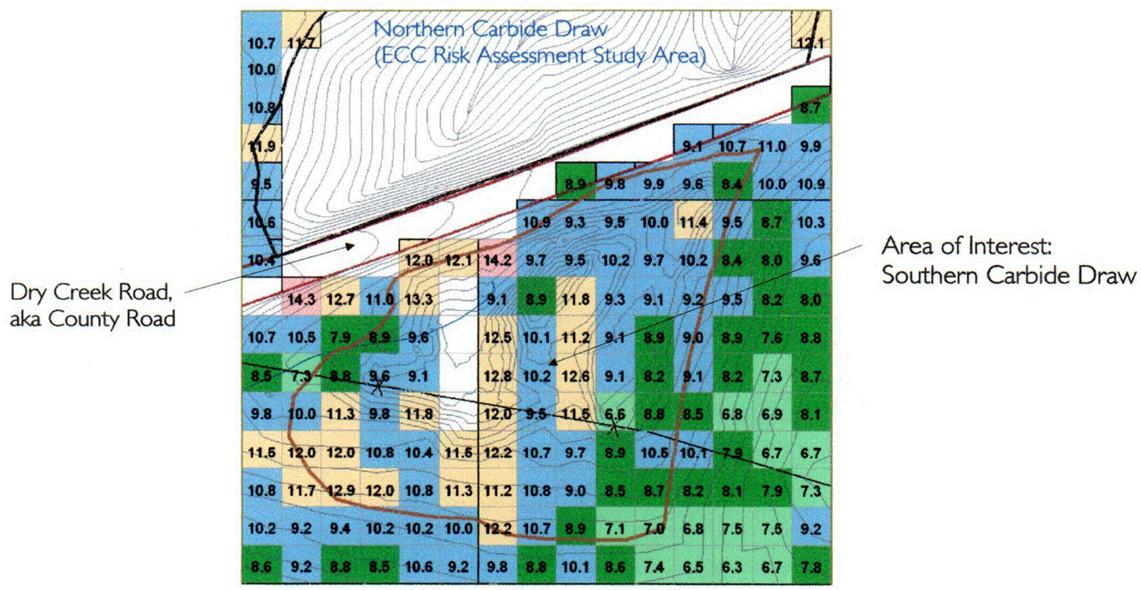
NRC Comment 8. *Neither Section 6 nor Section 7 of the FSSR summarize the data for the remediated portion of Carbide Draw. Table 2 of Appendix C-2 provides gamma-based estimates of Ra-226 and soil analysis Ra-226 results, but some grids exceed the approved criterion of 11.1 pCi/g (5 pCi/g plus 6.1 pCi/g if background influenced by ore). Also, page 49 indicates that Ra-226 results for the trash pits were below the 15 pCi/g site-wide criterion.*

REQUEST: Indicate why the portion of Carbide Draw south of the county road meets the cleanup standards. Given that the soil cleanup criterion is 11.1 pCi/g, indicate how the trash pits meet cleanup standards.

Umetco Response to NRC Comment 8, Part 1 (Re: Carbide Draw)

Figure 6.11 of the FSSR presents a detailed visual summary for the remediated potion of Carbide Draw and, as acknowledged by the NRC above, supporting documentation is provided in Appendix C-2, Table 2. The Carbide Draw excavation, entailing the removal of approximately 6,300 cubic yards of material, proceeded as far as feasible — i.e., down to bedrock. In most cases, the Carbide Draw area grids exceeding 11 pCi/g Ra-226 occur at bedrock . These grids are shown in the following exhibit, adapted from Figure 6.11 of the FSSR.

Exhibit 2.3
Final Status Survey Results for Carbide Draw Area



Adapted from FSSR Figure 6.11 (Umetco 2003).

Field observations made during the field characterization and excavation efforts are documented in Section 6.1 of the FSSR, but are reiterated and augmented here for completeness. But first, a reiteration of the conclusions drawn for the East Canyon Creek drainage, including the portion of Carbide Draw located north of the county road, is warranted.

As documented in the FSSP and East Canyon Creek risk assessment (Umetco 2000a, SMI 1999, 2000), process solutions were released to East Canyon Creek (ECC) through the drainage tributary Carbide Draw during the early operation of the mill (1960 to 1963). A breach of the above-grade tailings impoundment in 1972 resulted in another release of mill tailings which, although mitigated, contributed to the residual radioactivity within the drainage. Due to the sensitive ecological conditions within the ECC drainage, combined with other factors warranting

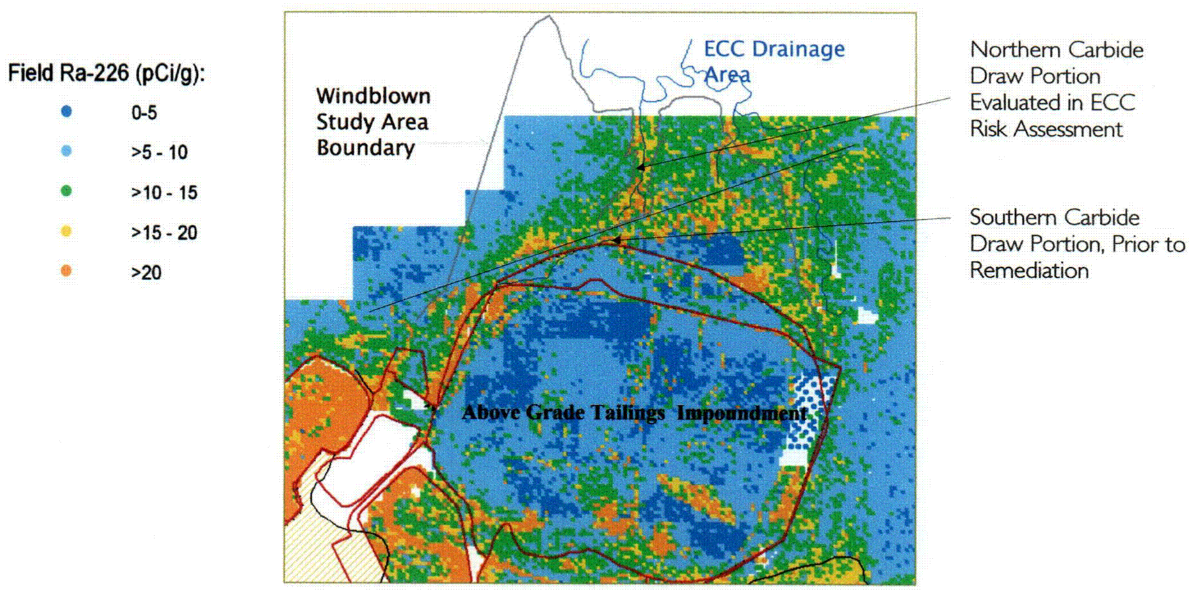
C18

special consideration (e.g., cultural resources and wetlands), Umetco proposed a no-action alternative for this area, which included Carbide Draw north of Dry Creek Road (Umetco 2000a). The NRC staff review of this alternative determined that:

> " ... *the proposed no-action alternative protects the sensitive ecological conditions in the creek and that the proposed alternative will achieve a level of protection for public health, safety, and the environment from the radiological and non-radiological hazards of byproduct material which is equivalent to, to the extent practicable, the requirements of Criterion 6(6).*" (NRC TER, 2001)

This determination was based on a cost-benefit analysis of the remedial action and on the results of the ECC risk assessment (SMI 1999, 2000). This report demonstrated the magnitude and heterogeneous distribution of radium within the ECC drainage, with some of the highest concentrations occurring in Carbide Draw just north of the county road (see exhibit below).

Exhibit 2.4. Subset of 1995 Gamma Survey Results Showing Ra-226 Distribution in East Canyon Creek Drainage



This exhibit was adapted from Figure 3.5 herein.

As discussed in the FSSR, early (2001-May 2002) gamma survey characterizations of Carbide Draw south of the county road indicated the need for only localized cleanup of windblown tailings. However, as the excavation proceeded, underlying sediments—apparently resulting from the 1972 tailings impoundment breach—were exposed. Because it was difficult for field staff to distinguish between the 11e.(2) material and NORM, which was prevalent in the area, Lidstone & Associates (LA) was retained to assess geological conditions within Carbide Draw. These investigations included a geological field evaluation of mineralogy, sedimentology, and stratigraphy of both native materials and tailings sands. As part of their review, LA determined that the pre-tailings disturbance elevation could be established on the downstream section of

C19

Carbide Draw north of the county road. Once this elevation was established, a hypothetical pre-disturbance slope was projected across the disturbance area.

Based on their initial evaluation in June 2002 (which preceded the bulk of the Carbide Draw excavation), LA concluded that the base of the southern Carbide Draw pits remained in tailings or 11e.(2) materials. However, there was evidence of a native Wind River Formation surface underlying the base of these pits. Based on the results of this investigation and the geomorphic interpretation of the historical channel grade, LA established a cleanup depth of approximately 5 to 10 feet below existing grade or a net elevation of 6870 feet (msl). Based on LA's recommendation and to ensure complete removal of potentially byproduct-affected sediments, the Carbide Draw excavation proceeded down to bedrock and 6,300 cubic yards of material were removed.[2]

LA returned to the site on July 31, 2002 for a field review of the mineralogy and sedimentology of the excavated land surface. Unlike the previous backhoe pit investigation, it was readily apparent that the floor of the excavation was firmly embedded on native Wind River Formation material and that all residual tailings had been removed from the southern Carbide Draw area.

Similar to observations made for GHP-1, whereby excavation of 11e.(2) material led to the exposure of underlying NORM, the Carbide Draw excavation proceeded to the extent feasible. In most areas, further excavation is not possible as bedrock has been encountered. Furthermore, Ra-226 concentrations measured in this area are well below the theoretical Derived Concentration Guideline Levels (DCGLs) established in Section 3.

Reiteration of NRC Comment 8 (see pg. 14 for entire comment). "*...page 49 indicates that Ra-226 results for the trash pits were below the 15 pCi/g site-wide criterion.*"

> REQUEST: Given that the soil cleanup criterion is 11.1 pCi/g, indicate how the trash pits meet cleanup standards.

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[2] The southern portion of Carbide Draw addressed in NRC's comment is technically part of the East Canyon Creek drainage in that it is contiguous with the northern portion of Carbide Draw (interrupted by the road culvert). Therefore, the conclusions drawn regarding ECC—which culminated in the NRC's approval of the no-action alternative—are germane to the southern portion of Carbide Draw as well. As such, the 6,300 cubic yard excavation undertaken as part of the Final Status Survey represents a conservative remedial effort.

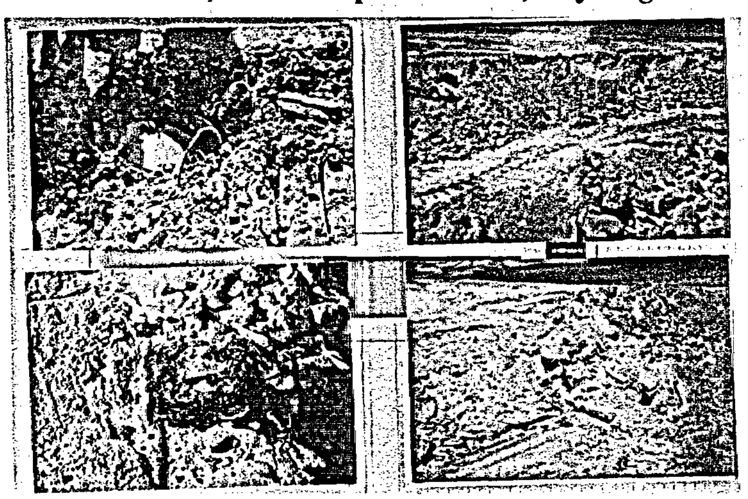
Umetco Response to NRC Comment 8, Part 2 (Re: Trash Pits)

Because the trash pits are located directly within mining areas (see Figures 1.1 and 2.1), the approved site background utilized is 10 pCi/g. The trash pits were acknowledged in the FSSR because recent discovery (i.e., during development of the plan), and the FSSP were considered the most efficient way to document their excavation and reclamation.

As discussed in the FSSP, during site reclamation activities conducted in July and August 2000, three small former trash pits were uncovered in mine spoil areas (see Figure 1.1 herein and Figure 4.1 of the FSSP). The first pit, Trash Pit #1, was located on the northern boundary of the north evaporation pond. The other two pits, Trash Pits #2 and #3, were found in the reclaimed portion of the B-Spoils mining area. These pits are described further as follows:

1. **Trash Pit #1**: This trash pit was encountered during the reshaping of the North Evaporation Pond, where mine spoils were utilized in associated construction. The pit was found within the mine spoils, which accounts for the Ra-226 levels measured in the associated soil sample (see Table 3.1 and discussion on the following page).

Trash Pit #1, North Evap. Pond Area, July-August 200



2. **Trash Pit #2**: This pit was encountered in the B-Spoils area near access Gate 5 during the excavation of the drainage channel for the Heap Gap to the A-8 mine pit area.

3. **Trash Pit #3**: This pit, also referred to as the B-Spoils Channel Trash Pit, was found during the construction of a drainage channel into the A-8 Pit area. Two samples were collected from this pit; results for both indicate low levels of radioactivity (see below).

The trash in these pits consisted largely of scrap metal and laboratory waste—e.g., rusted barrels, used gloves, protective Tyvek clothing (Umetco 2000a, 2003). The only exception was the uncovering of some old yellowcake filter press cloth, but otherwise the inventory reflected refuse of a general nature. No evidence was found of any significant byproduct material contamination, as indicated by the results of gamma scans, which were generally within background ranges (see FSSR Section 7.3). During excavation, no visual observations of soil stainage, standing water or spillage were observed by site radiological personnel assigned to observe excavation proceedings. All pits were excavated 1 to 3 feet laterally and verticall beyond the observed residual trash layer. The trash was removed and hauled to the A-9 pit, after which the trash pits were surveyed and soil samples were collected and analyzed for Ra-226, Th-230, and U-nat. Laboratory results reported for this limited sampling are documented in Table 2.1 (below).[3] The pits were then backfilled with mine spoils.

Table 2.1 Soil Sample Results for Mine Spoil Area Trash Pits, August 2000

Location Code	Location	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-nat (pCi/g)
Trash Pit #1	Evap. T- Pit	46 ±1.3	59 ±2.9	47.4
Trash Pit #2	Gate 5 T-Pit	7.8 ±0.53	6.8 ±1.4	31.8
Trash Pit #3	B Channel T-Pit	5.5 ±0.46	5.4 ±1.2	13.5
Trash Pit #3	Slope B Channel	4.1 ±0.41	4.1 ±1.1	9.5

Samples were collected in August 2000 after excavation and were analyzed by Barringer Labs. U-Nat, originally reported in mass units (mg/kg), was converted to activity (pCi/g) by multiplying the mass value by 0.677.

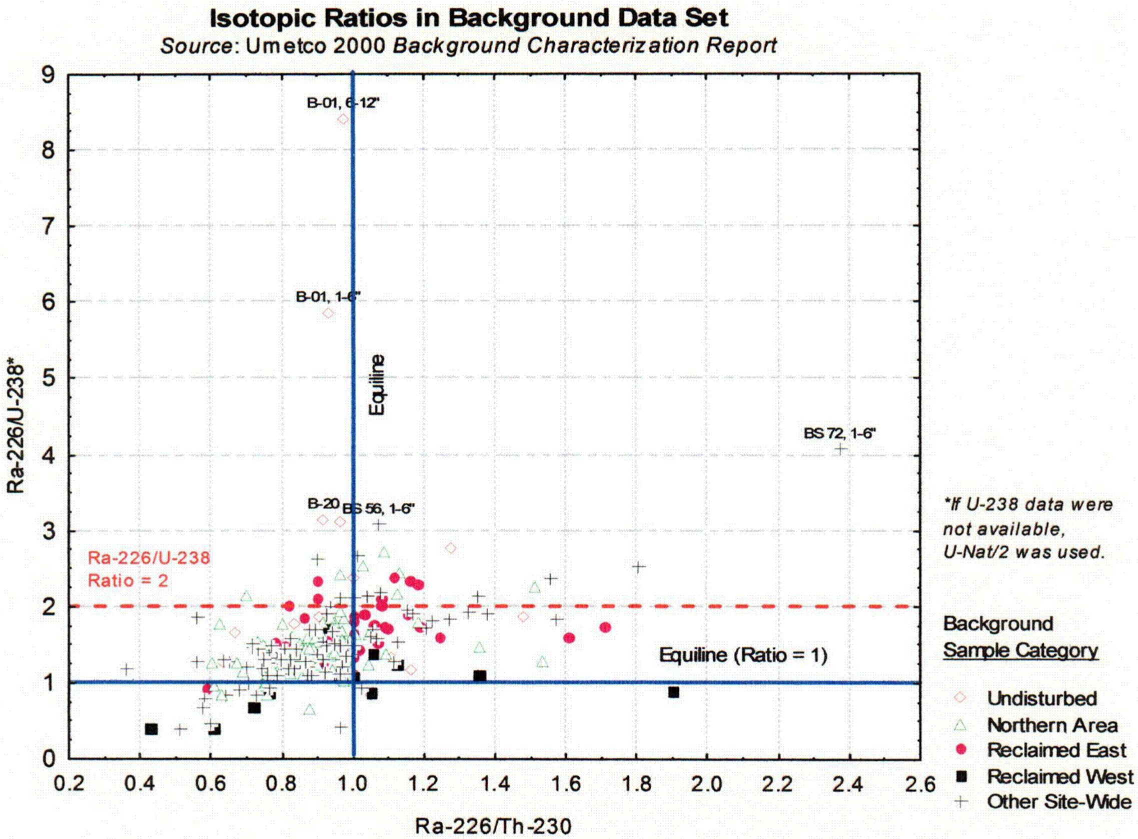
The results listed in Table 2.1 above indicate low levels of radioactivity within the B-Spoils area (Trash Pits #2 and #3). Soil sampling for all of the trash pits consisted of a composite sample collected from the pit floor and walls. Meter readings (alpha, beta/gamma and gamma) and visual observations were utilized to determine soil sample locations. Use of meter and visual driven soil sampling tends to give a worse case scenario of radiological conditions.

Trash Pit #1 was the largeset of the three trash pits and was excavated to approximately 7,200 square feet to remove discarded materials. Trash Pit #1 Ra-226 levels are above the NRC approved background level. The ratio of U-nat, Ra-226 and Th-230, however, indicate the material is in disequilibrium with a Ra-226/U-nat ratio of 1.94.

The disequilibrium apparent in Trash Pit Sample #1, where Ra-226/0.5*U-nat is 1.94 (see note below), is not considered indicative of mill-related impacts because this ratio is well within the range of ratios calculated for the approved background data set. As discussed in Section 3.1 of Umetco's *Background Characterization Report* (Umetco, 2000), although using Ra-226/U-238 ratios to identify milling-related impacts is recommended by the NRC and has been applied at other sites, such an evaluation has not yielded compelling results at the Gas Hills site. This

[3] Section 7.3 of the FSSR cited an Ra-226 result of 9.7 pCi/g. This value was based on results of on-site gamma spec analysis of soil samples and is not to be compared with the Barringer laboratory results listed in Table 2.1.

finding is demonstrated graphically in Figure 3.10 of the *Background Characterization Report* and in the plot below:



Note:
For samples analyzed for total U-nat and lacking isotopic data for U-238, the U-238 component was estimated by dividing the U-nat value by 2. This approach assumes that the U-nat source term is represented as percent activity by 49.2% U-238, 49.2% U-234, and 1.6% U-235.

If byproduct material were present, you would expect (from some of the materials excavated) elevated U-nat levels from the yellowcake filter press cloths or solvent extraction solutions. Inventory of materials excavated from the trash pits show no evidence that tailings or process waste materials were encountered so one would not expect to see elevated Ra-226 or Th-230 levels related to licensed materials. The higher radioactivity levels observed in Trash Pit #1 located at the edge of the north evaporation pond are expected, given that this pit was encountered within the mine spoils utilized to construct the evaporation pond. This conclusion is corroborated in Section 3.2 of Addendum 1, which discusses the radiological setting characterizing the mining background mining areas. The ratios observed from Trash Pit #1 are consistent with ratios observed from low-level ore (mine spoils) identified at the B-5 Pit and similar ratios discussed in the *Final Background Characterization Report* Section 3 and Tables 3.3 through 3.8. Cleanup of Trash Pit #1 is considered complete with the remaining soils being characteristic of low grade ore/mine spoils (i.e., NORM material).

Trash Pit #2 was excavated to approximately 1,500 square feet to ensure removal of disposed materials. The higher uranium content observed in soil samples from Trash Pit #2 likely eflects the presence of lower grade ore in this reclaimed mining area. Meter readings taken after excavation show radiological readings were at or near background levels for the area. Trash Pit #2 was backfilled with approximately 8 feet of mine spoils upon confirmation of soil sampling results. Soil sampling results show Ra-226 values meets the more conservative surface cleanup level of 15 pCi/g or the applicable subsurface cleanup level of 25 pCi/g for site mining areas at 7.8 pCi/g. As such, no additional cleanup is necessary.

Trash Pit #3 was excavated to approximately 450 square feet in size to remove disposed materials. Trash Pit #3 soil sampling shows U-nat, Ra-226 and Th-230 levels to be in equilibrium. Meter readings of levels after excavation show radiological readings were at or near background levels for the area. Trash Pit #3 was backfilled with approximately 5 feet of mine spoils. Soil sampling results show Ra-226 values will meet the surface and/or subsurface criterion from Trash Pit #3 at 5.5 pCi/g. Trash Pit #3 meets the Ra-226 regulatory standard for surface and subsurface as specified in 10 CFR 40 Appendix A, Criterion 6(6) and no further cleanup is necessary.

NRC Comment 9. *Page 7 of the final status survey plan indicated Umetco would provide a correlation of the final gamma and Ra-226 data, but only the windblown area correlation was provided (Appendix C-3, Figure 1). Pages 8 and 9 of that plan indicate that the Ra-226 to Th-230 ratio is about 1 and that elevated U-nat due to milling is not expected. Therefore, benchmark dose modeling was not performed to derive cleanup criteria for Th-230 and U-nat.*

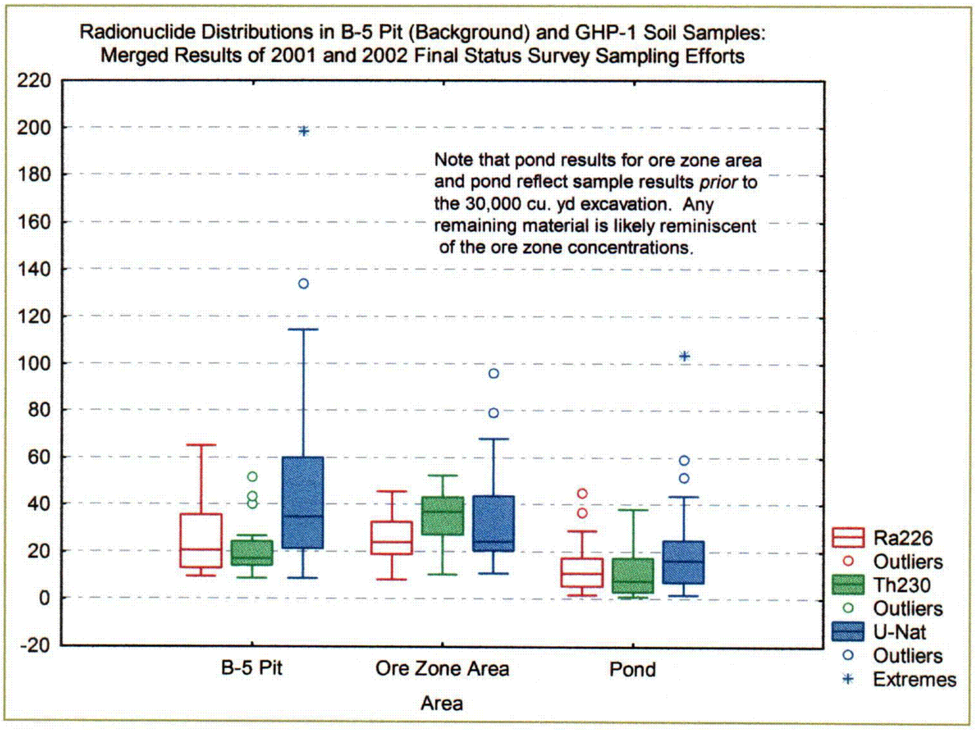
REQUEST: Provide the correlation graph of the final gamma and corresponding Ra-226 analytical data for areas other than the windblown area. Also, indicate how the final data support the original assumption concerning Th-230 and U-nat contamination.

Umetco Response to NRC Comment 9

The correlation equation and graph for non-windblown areas—i.e., GHP-1 and the DW-6 pipeline—are documented in detail in Appendix B-2 of the FSSR (Umetco 2003). The gamma-radium correlation developed for GHP-1 was also applied to the DW-6 pipeline due to the proximity of these two areas and because data were not available at the time to establish a pipeline-specific algorithm. The gamma-radium correlation for GHP-1 was developed based on the April 2001 soil sampling effort and corresponding gamma survey results (see FSSR Section 3.7). This equation tended to overestimate Ra-226 concentrations by approximately 4 pCi/g, the average residual calculated in Appendix B-2, Table 3.

Data plots supporting Umetco's original assumption regarding Ra-226/Th-230 and Ra-226/U-Nat ratios are provided in the following exhibit, which plots the radionuclide distributions in pond samples (merged results of 2001 – 2002 final status survey investigations) vs. B-5 Pit and GHP-1 ore zone samples (units in pCi/g).

Exhibit 2.5



C21

3.0 ALTERNATIVE CRITERIA EVALUATION FOR ADDITIONAL GAS HILLS SITE SOIL CLEANUP

Given the issues raised in the NRC's comments, in particular Comment 5, this section documents the evaluation supporting Umetco's proposal for a no-further-action alternative for the Gas Hills Site areas addressed in the 2003 Final Status Survey report. This proposed alternative for mill cleanup is allowed under 10 CFR 40, Appendix A, which states that:

> *"Licensees or applicants may propose alternatives to the specific requirements in this Appendix. The alternative proposals may take into account local or regional conditions, including geology, topography, hydrology, and meteorology. The Commission may find that the proposed alternatives meet the Commission's requirements if the alternatives will achieve a level of stabilization and containment of the sites concerned, and a level of protection for public health, safety, and the environment from radiological and nonradiological hazards associated with the sites, which is equivalent to, to the extent practicable..."* the soil radium standard..." *with due consideration to the economic costs involved..."*

The following pages document the evaluation of health and environmental impacts resulting from a no further action alternative, as well as the costs and the associated dose/risk reduction expected under various cleanup scenarios. In support of this analysis, theoretical derived concentration guideline levels for soils (DCGLs) were derived consistent with the assumptions employed in the ECC risk assessment. An ALARA analysis was then performed consistent with NRC guidance (NUREG-1727, NRC 2000). As discussed in the response to NRC Comment 5 Section 2, the DCGLs calculated in support of the ALARA analysis are theoretical and do not negate or supersede the requirements set forth in 10 CFR Part 40, Appendix A, Criterion 6(6). This evaluation begins with a discussion of pertinent background information (Section 3.1) and the regional geology and radiological setting (Section 3.2). Section 3.3 describes the underlying conceptual approach; Section 3.4 documents the equations and assumptions used in the ALARA calculations. Results are presented in Section 3.5. This evaluation will demonstrate that the potential adverse environmental impacts and high cleanup costs are not justified by any benefit that would result from further soil remediation in the Gas Hills Site final status survey areas.

3.0.1 Defined Areas of FSP Deviation

Umetco is requesting alternate criteria or deviation from the approved Final Status Survey Plan for the following areas:

1. GHP-1 – Excavation of byproduct material resulted in exposure of underlying low-level ore (NORM) exhibiting Ra-226 levels higher than those previously measured in GHP-1 affected soils. Ra-226 concentrations measured in GHP-1 are within the range of concentrations measured in the adjacent B5 pit. Umetco is proposing alternate criteria to demonstrate cleanup of this area using the B5 pit as a local reference area. In support of this request, a geochemical investigation has been completed to identify the extent and cleanup boundaries of byproduct contamination.

   The post-cleanup grading of GHP-1 will be performed in accordance with the site wide grading plan which requires approximately 5 feet of fill over the northern portion of the

GHP-1 pond bottom and 3 feet of excavation in the southern portion of the pond bottom. Excavated soils from post-cleanup grading of GHP-1 will be placed in the B5 pit backfill. Once the area has been graded, approximately 12 inches of topsoil will be placed and the area seeded to provide erosional stability.

2. DW-6 Process Water Pipeline – Removal of tailings and affected soils from the DW-6 pipeline trench resulted in exposure of underlying low-level ore (NORM) in some areas. Consequently Ra-226 measurements exceed the background criteria approved in the FSSP. Umetco is requesting approval of an alternate criteria to demonstrate cleanup in this area using the B5 pit Ra-226 levels as a specific local reference area. Also because the DW-6 pipeline cleanup was in a linear configuration, the verification was not performed on a $100m^2$ grid basis. However, Section 4.0 of this Addendum 1 provides a supplemental evaluation which includes use of the subsurface standard and evaluation of data on a $100m^2$ grid basis. Since this verification method deviates from the approved FSSP, Umetco is requesting approval of alternate criteria and methodology for the DW-6 pipeline.

3. Select Windblown Cleanup Areas Including Carbide Draw South of the County Road – Byproduct removal in some windblown locations and in Carbide Draw south of the County Road led to exposure of underlying low-level ore (NORM). As such, residual 11e.(2) material, if present, can not be identified. Accordingly, Umetco is requesting alternate criteria as allowed in the introduction of Appendix A, 10 CFR 40, to account for local geological conditions.

3.0.2 Submittal of Radium-Gamma Correlation

The radium-gamma correlation initially used for the final status survey was submitted to the NRC by letter dated August 6, 2001. The correlation study was approved by NRC letter dated August 30, 2001. This approval was conditional upon:

1. Conducting soil sampling of grids in the windblown tailings area with surface disturbances similar to the grids of concern, and

2. Confirm the acceptability of the gamma guideline value with additional radium-gamma correlation data during the final status survey.

Condition 1 required soil sampling of grids with surface disturbances such as tire tracks which may have an impact on the radium-gamma correlation. During windblown cleanup, areas in which meter readings indicated 11e.(2) byproduct material were excavated. Accordingly, surface disturbances were no longer present. Therefore, soil sampling was performed on the grids which exhibited the highest gamma values (upper 5%).

Preparation of the final status survey report included evaluating Condition 2 of the radium-gamma correlation. Based on soil samples collected in GHP-1 and the windblown area, it was determined that the conditionally approved correlation overestimated grid averages in GHP-1 and in the windblown area. The initial correlation underestimated grid averages by 2.3 pCi/g. As a result, the revised radium-gamma correlation was proposed in the FSSR, Volume I, submitted on October 27, 2003.

3.1 Background

3.1.1 Final Status Survey Findings

The 2002-2003 Gas Hills Site Final Status Survey investigations and cleanup efforts were extensive, entailing the removal of approximately 60,000 cubic yards of material and numerous surveys and characterization efforts—e.g., the GHP-1 geochemical investigation and the windblown area germanium detector evaluation (Umetco 2003). Despite these efforts, demonstration of cleanup was difficult, in that was confounded by the highly heterogeneous presence of NORM and mineralized areas which characterize the Gas Hills region.

Difficulties related to the derivation of representative background values for the highly heterogeneous and mineralized Gas Hills region are discussed at great length in the FSSR and, as discussed previously, were corroborated by the NRC.[4] As such, if it is not possible to derive a background statistic, it is not reasonable to derive a single cleanup level. Feasible cleanup criteria could be derived if the underlying background values adequately accounted for the wide variability in background values—e.g., if a 75th percentile value or several standard deviations above the mean were assumed, but these higher estimators (although suggested) were not approved by the NRC.

Furthermore, final status efforts indicated that additional cleanup may not result in a concomitant reduction in residual radioactivity. For example, cleanup of GHP-1—entailing the removal of over 30,000 cubic yards of material—resulted in a slight overall increase in average Ra-226 content because an underlying ore zone was encountered (Umetco 2003). In the case of the windblown area, cleanup of grids exceeding the approved 11.1 pCi/g Ra-226 cleanup level were found to result in a negligible (0.1 pCi/g) reduction in the average Ra-226 content.[5] The following evaluation will further corroborate this conclusion.

Given the factors cited above — 1) the difficulty in establishing representative, defensible background levels, and 2) the potential ineffectiveness of additional cleanup—an ALARA evaluation was undertaken, as documented in the following sections. Also germane to this discussion are the findings of the previous East Canyon Creek risk assessment and associated Alternative Criteria proposal, discussed below.

[4] See FSSR Sections 1.4 and 6.1 (Background Characterization Refinement), Umetco 2003; NRC 2001; and Umetco's response to NRC Comment 5.

[5] As discussed later in this section, the preliminary analysis of expected Ra-226 reduction presented in the FSSR (Umetco 2002) assumed a post-cleanup value of 11.1 pCi/g (i.e., the cleanup level) for all cleanup grids (Umetco 2003, Section 6.3). This assumption was modified in this analysis, however, to be more conservative (Section 3.4). Although the expected change in radium magnitude calculated herein is slightly higher than original estimates, the ALARA analysis still strongly supports the conclusion of negligible health benefit or risk reduction relative to the associated costs (Section 3.5).

3.1.2 Alternative Criteria for East Canyon Creek Streambed

This alternative criteria proposal was based on an assessment of potential risks to the public and the environment from the 11e.(2) byproduct material remaining in the ECC channel, including the portion of Carbide Draw north of the county road (SMI 1999, 2000). The proposal also included a cost-benefit analysis of the remedial action. In their review of Umetco's proposal, the NRC concluded that: "*The long-term ecological damage, potential harm to threatened and endangered species, and high costs of remediation are not justified by any benefit that would result from soil remediation in ECC*" (NRC 2001). As such, the no-action alternative for East Canyon Creek was approved.

Some of the cost issues assessed in the ECC assessment are not necessarily germane to the site areas evaluated herein. For example, the final status survey areas are not as ecologically sensitive as ECC, where disruption of wildlife habitat, wetlands impacts, and the preservation of cultural resources were key issues. However, the environmental impacts of increased erosion are still a factor for the windblown area and, most importantly, the conclusion that there would be no reduction in potential radiological dose to any likely area resident also still applies. This conclusion is supported by the results of the ALARA analysis, documented in Section 3.5.

3.2 Radiological Setting

Before presenting the ALARA analysis, it is important to reiterate that the Gas Hills site is located within a region characterized by uranium ore trends that has been heavily mined. This factor precluded the derivation of a statistically defensible Ra-226 background value and associated cleanup criterion. As demonstrated in the FSSR, it also impacted the feasibility and/or demonstration of cleanup (e.g., in ore-containing areas). This discussion focuses on the presence of NORM, as milling-related (i.e., 11e.(2) byproduct) impacts have been discussed at length in previous documents and were the subject of the preceding Final Status Survey Report.

3.2.1 Regional Geology

The Umetco Gas Hills facility is located in the Wind River Basin of Central Wyoming. The Wind River Basin is a large sediment filled, northwest-trending structural depression that was formed as a result of Late Cretaceous and Early Cenozoic tectonic activity. During the Eocene, continued uplift of the surrounding mountain ranges and subsequent erosion resulted in the deposition of the Wind River Formation. In the vicinity of Gas Hills, the Wind River Formation sediments were deposited in a series of coalescing alluvial fans and are characterized as a sequence of alternating and discontinuous layers of sandstone, siltstone, claystone, and conglomerate. This depositional environment resulted in the discontinuous occurrence of uranium deposits both vertically and laterally.[6]

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[6] The Wind River Formation and underlying ore zones are discussed at length in the *Application for Alternate Concentration Limits*, submitted by Umetco in November 2001 and approved by the NRC in March 2002 (Umetco 2001). This document discusses at length the mineralogical and geochemical characteristics exhibited in Gas Hills region NORM areas, as well as areas impacted by mining and reclamation activities.

Uranium occurs in rocks of nearly every age in the Wind River Basin, including crystalline rocks in the adjacent Precambrian uplifts (Hausel and Holden 1978). In the Gas Hills District, uranium typically occurs as roll-front deposits within the Wind River Formation, which is approximately 300 feet thick at the Umetco mill site. The uranium trend extends to the west of the Umetco facility as indicated by the mining operations of Pathfinder (see below), and also extends east and south of the site. The presence of this ore accounts for the historical prevalence of open pit uranium mining activities and resulting mining-related impacts both on and surrounding the Gas Hills site, discussed below.

3.2.2 Mining-Related Impacts and Regional Radiological Setting

The issue of mining-related impacts has been discussed at length in previous documents (Umetco 2000a, 2000b, 2001, 2003) and therefore is only briefly summarized here. From the late 1950s until 1984, uranium was mined from open pits in the Wind River Formation east, west, and south of the site by Pathfinder Mines Corporation, Umetco, the Tennessee Valley Authority (TVA) and a number of smaller mining companies. Figures 3.1 and 3.2 show the locations of these mined areas and demonstrate their spatial prevalence both on and adjacent to the Gas Hills site. Although most of these areas have been reclaimed—e.g., under the Wyoming Abandoned Mine Lands (AML) program—residual impacts are still apparent to the west, south, and east of the Gas Hills site. This elevated radioactivity in former mining areas is sometimes indistinguishable from that exhibited due to the underlying ore, also NORM, prevalent throughout the Gas Hills region.

To demonstrate some of the factors discussed above regarding the site geology, its regional heterogeneity, and the resulting mining- and milling related impacts, it is useful to compare the radiological characteristics exhibited in the early 1980s—coinciding with the later period of heavy mining and just prior to the termination of the Gas Hills milling operations—with those exhibited more recently. In 1981, the NRC commissioned EG&G to perform an aerial radiological survey of the Gas Hills Mining District (EG&G 1982). This 150 km^2 survey focused on the three uranium mills operating in the region at that time —Federal American Partners, Pathfinder Mines Corporation, and the Union Carbide (Umetco) facilities. This discussion is limited to the measurements made in the eastern survey portion, coinciding with the Gas Hills site.

Figures 3.3 and 3.4 show the isoradiation contours of excess Ra-226 and external exposure rates measured at and surrounding the Gas Hills site based on the NRC's survey (aerial photos taken in June 1981). Milling-related impacts attributable to the Gas Hills site are clearly evident, as are the mining-related impacts both on and adjacent to the site (also see Figures 3.1 and 3.2). However these figures also demonstrate the heterogeneity of the region, as indicated by the large variation in Ra-226 surrounding the site (Figure 3.3). According to the NRC, the large B-level north of the Gas Hills site—representing Ra-226 abundance in excess of the mean by 3 to 12 times the standard deviation—"appears to be a purely natural variation due to erosion of overburden from ore-bearing strata below" (EG&G 1982). Irrespective of Ra-226 magnitude (it was not determined by the survey), variations of 3 to 12 times the standard deviation of the mean

Ra-226 are noteworthy and likely reflect the ore trends that characterize(d) the Gas Hills region.[7] It is also important to recognize that the mined areas (which include the Gas Hills mill site) reflect those areas containing the highest-grade ore—i.e., similar maps reflecting pre-mining and pre-milling radiological characteristics would likely exhibit the same spatial trends, albeit lower in magnitude.

Similar variation is demonstrated in Figure 3.4, which shows the distribution of terrestrial exposure rates. Levels ranging from 30-45 μR/hr (acknowledged as possibly underestimated by EG&G) characterize the mining regions west and south of the Gas Hills site. Some of these areas have been reclaimed (again, refer to Figure 3.1), but not all. Also, as stated above, it is important to recognize that the mined areas correspond to those regions exhibiting the highest ore grades. For comparison, Figure 3.4 also shows the results of the recent final status survey exposure measurements made for the Above Grade Tailings Pile and Heap Leach areas (see Figure 3.4 inset, based on Plates 1 and 2 of the FSSR). This inset shows that current exposure rate measurements for the above grade and heap leach are consistent with background levels, with most measurements ranging between 20 and 30 μR/hr. As discussed in the FSSR, some of the higher regions (30-45 μR/hr) are likely attributable to "shine" from adjacent mining areas.

Figure 3.5 shows the Ra-226 distribution based on the initial gamma survey conducted in 1995. This figure, adapted from FSSP Figure 3.2 (Umetco 2000a), clearly demonstrates the elevated radioactivity in offsite mining areas, the majority of which had been reclaimed under the AML program.[8] This is particularly evident in the reclaimed area to the west of the site, as well as the B-5 Pit. Levels measured in onsite areas at that time were comparable to and, in many cases—e.g., the majority of the windblown area, heap leach, and above grade tailings pile—lower than levels observed offsite. Radioactivity in these onsite areas has decreased since then as a result of subsequent cleanup and reclamation efforts as demonstrated in the FSSR (Umetco 2003). For example, the inset reflecting the post-cleanup Ra-226 distribution in the windblown area demonstrates the effectiveness of remedial efforts and shows an even more marked difference relative to offsite mining areas. Alternatively, although no 1995 gamma survey data were collected for GHP-1, the insets in Figure 3.5 comparing pre- vs. post-excavation conditions illustrate the fact that excavation in this area resulted in increased Ra-226 concentrations, reminiscent of B-5 Pit background conditions, as underlying ore zones were exposed. These findings are germane to the following ALARA analysis because they underscore the fact that, with respect to off-site radiological trends, further cleanup of onsite areas will have a negligible impact on dose/radioactivity reduction in the site vicinity and, in some areas, could result in a dose increase (vs. reduction).

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[7] Hypothetically, even if the most conservative (unrepresentative) estimators were assumed—i.e., ignoring the natural variation and trimming the data set to remove all but the low-range Ra-226 values—e.g., a mean and standard deviation of 2 +/- 1 pCi/g Ra-226—a plausible background level for Ra-226 could be 14 pCi/g, even under the most conservative analysis.

[8] Figure 3.5 does not present data for the A-9 and C-18 pits, as no surveys were conducted in these areas; see Response to Comment 1 provided in Section 2 of this addendum. This comment response also discusses the results of previous evaluations of the North and South Evaporation Ponds.

3.3 Technical Approach

The ALARA evaluation documented in the following sections was conducted in general accordance with the procedures outlined in Appendix D (ALARA Analyses) of the NRC's NMSS Decommissioning Standard Review Plan, or NUREG-1727 (NRC 2000), as referenced in NUREG-1620, Section H2.2.3(4).[9] The analysis uses the same exposure assumptions as those developed for the East Canyon Creek Alternative Criteria Evaluation (SMI 1999, SMI 2000). These assumptions were used in RESRAD calculations to derive Single Radionuclide Soil Guidelines (SRSGs) or Derived Concentration Guideline Levels (DCGLs) for Ra-226, assuming a 25 mrem/year dose limit (see Comment 5 response and Table 3.1 rationales). Although the ALARA analysis was only undertaken for the windblown area, the Ra-226 DCGLs can be applied to other areas of the site, including GHP-1, the DW-6 pipeline, and the trash pits.

Two windblown cleanup scenarios were evaluated. The first was based on the number of 100 m^2 grids exceeding the previously approved 11.1 pCi/g Ra-226 cleanup level, determined based on the gamma survey results and supporting gamma-radium correlation provided in the FSSR (Umetco 2003). As such, this scenario assessed the costs and benefits resulting from the cleanup of an additional 403 grids. To address the possibility that the FSSR gamma-radium correlation underestimated soil Ra-226 (see NRC Comment 5), a more conservative scenario was assessed assuming that Ra-226 field estimates were approximately 2 pCi/g higher than those assumed in the first scenario (n = 1554 cleanup grids). Because of the uncertainty in some variables, both deterministic (i.e., using fixed parameter input) and probabilistic analyses were performed. The deterministic evaluation used fixed values for parameter input whereas the probabilistic analysis assigned distributions to certain parameters, reflecting the uncertainty in those estimates to better account for the potential variability in the data.

3.4 ALARA Analysis: Equations and Assumptions

As indicated above, the ALARA analysis was conducted in accordance with the procedures outlined in Appendix D (ALARA Analyses) of NUREG-1727 (NRC 2000), as referenced in Section H2.2.3(4) of NUREG-1620.

3.4.1 Calculation of Benefits: Collective Dose Averted

In the simplest form of the analysis, the only benefit estimated from a reduction in the level of residual radioactivity is the monetary value of the collective averted dose to future occupants of the site. This analysis uses the same critical group or exposed population as that assumed in the previous ECC risk assessment and the November 2001 groundwater ACL—i.e., a limited exposure occasional ranching scenario. Because the area in question is within the long-term care boundary, DOE contractors performing repairs on the site would also be a realistic assumption. The analysis presented assumes similar hours of exposure for both scenarios providing similar results. Table 3.1 documents the assumptions used in the following equations. The benefit from collective averted dose, B_{AD}, is calculated by determining the present worth of the future collective averted dose and multiplying it by a factor to convert the dose to monetary value:

[9] The NUREG-1727 guidance document supersedes the previous draft guide DG-4006 issued in August 1998.

Equation 3.1: Present Worth of the Future Collective Averted Dose *NUREG-1727, Eq. D2*

$$PW(AD_{collective}) = P_D * A * BRDL * F * \frac{Conc}{DCGL} * \frac{1 - e^{-(r+\lambda)N}}{r + \lambda}$$

When N = 1000 yrs, this portion of the equation is essentially = 0.

where:

P_D	=	population density for the critical group scenario in persons/m^2
A	=	area being evaluated in square meters (m^2); see Tables 3.1 and 3.2
BRDL	=	Basic Radiation Dose Limit, 0.025 rem/yr
F	=	fraction of the residual radioactivity removed by the remediation action
Conc	=	average concentration of residual radioactivity in the area being evaluated (pCi/g). In this analysis, F is assigned a value of 1, but is accounted for by substituting "Conc" with $C_1 - C_2$, representing the change in average Ra-226 magnitude expected as a result of the remedial action
DCGL	=	derived concentration guideline equivalent to the average concentration of residual radioactivity that would give a dose of 0.25 mSv/yr (25 mrem/yr) to the average member of the critical group (pCi/g). DCGLs are analogous to the Single Radionuclide Soil Guidelines (SRSG) values in Table 3.2
r	=	monetary discount rate in units of yr-1
λ	=	radiological decay constant for the radionuclide in units of yr^{-1}
N	=	number of years over which the collective dose will be calculated.

Table 3.1 Equation Terms and Assumptions Used in the ALARA Analysis

Parameter/ Equation Term	Definition	Assumed Value	Variable Type	Reference and Comments
$PW(AD_{collective})$	Present worth of future collective averted dose (units = person-rem)	See Equation 3.1	Calculated	NUREG-1727, Appendix D (ALARA Analyses), Eq. D2
B_{AD}	Benefit from averted dose for a remediation action ($ per person-rem)	$= PW(AD_{collective}) *$ $2000 See Equation 3.2	Calculated	NUREG-1727, Appendix D, Eq. D1. $2000 is the value in dollars of a person-rem averted (NUREG/BR-0058, as cited in NRC 2000)
$Cost_R$	Monetary cost of remediation	*Minimum:* $635.25 per 100 m^2 grid – most conservative, does not include disposal costs. *Most Likely:* $826, = $635 + 30%)	Variable See Tables 3.3 and 3.4 for additional information.	Note that, unlike the total cost, $Cost_T$ described in NUREG-1727 (NRC 2000), costs here are for remediation only and as such are very conservative.
Cost per person-rem	$= Cost/PW(AD_{collective})$	See Equation 3.3	Calculated	$20,000 per person-rem is considered "prohibitively expensive" (NRC 2000, App. D, Section 4.0)
P_D	Population density for the critical group scenario	0.0004 persons/m^2	Fixed	NUREG-1727 default, Appendix D, Table D.2
A	Area being evaluated in square meters	25,000 m^2	Fixed	This area is consistent with that implied in the Nov-01 ACL, where the number of potentially exposed persons was 10 (i.e., 0.0004 persons/m^2 * 25,000 m^2).
BRDL = Basic Radiation Dose Limit	Annual dose to an average member of the critical group from residual radioactivity at the DCGL (see below).	25 mrem/year or 0.025 rem/year	Fixed	NRC (2003) dose criterion & default assumption in RESRAD code. Also consistent with groundwater ACL dose limit and NUREG-1620, Section H2.2.3(8).
F	Fraction of the residual radioactivity removed by the remediation action	1	Fixed	This factor was retained to be consistent with NUREG-1727. It is accounted for by substituting Conc with $C_1 - C_2$ (see below).
Conc: $= C_1 - C_2$	Reduction in average Ra-226 expected as a result of the remediation, where C_1 is current average concentration and C_2 is the expected post- cleanup average (pCi/g)	Depends on cleanup scenario	Variable	C_2 is calculated by conservatively assuming all cleanup grids have Ra-226 = 6.5 pCi/g (see Table 3.3)

Table 3.1 Equation Terms and Assumptions Used in the ALARA Analysis, Cont.

Parameter/ Equation Term	Definition	Assumed Value	Variable Type	Reference and Comments
DCGL Derived Concentration Guideline Level	Average concentration of residual radioactivity that would give a dose of 25 mrem/yr to the average member of the critical group	Equivalent to the Single Radionuclide Soil Guideline (SRSG) derived using the RESRAD code (see below).	= DCGL (see below)	See Table 3.2. Again, DCGLs discussed herein are theoretical and do not correspond to release criteria for soil cleanup at the Gas Hills site.
SRSG	Single Radionuclide Soil Guideline (SRSG), derived using the RESRAD code	Ra-226 = 141 pCi/g, based on ECC assumptions (Table 3.2)	Variable (some calculations used very conservative DCGL of 26.9 pCi/g; see Table 3.2 note and Appendix B)	DCGL equivalent calculated using RESRAD. All assumptions consistent with ECC dose assessment except exposure time and contaminated zone area & depth Monte Carlo calculations used a lower bound (most conservative) value of 26.9 pCi/g to explore potential worst-case scenarios.
r	Monetary discount rate	0.03/yr	Fixed	NUREG-1727, Table D.2, value applied to soils
λ	Radiological decay constant for Ra-226	0.000247/yr	Fixed	NUREG-1727, Appendix D, Section 1.4
N	Number of years over which the collective dose will be calculated.	1000	Fixed	NRC default value (NUREG-1727, Appendix D, Table D.2). This value is very conservative, as the peak dose for Ra-226 occurs at time t = 0. After 100 years, the DCGLs become so high as to essentially become moot - i.e., no dose would be averted (see SRSGs in Appendix A).

Some slight modifications were made to the equations in NUREG-1727. In this analysis, the P_D and A terms were essentially combined to yield the number of potentially exposed persons. This area is consistent with that implicit in the November 2001 ACL, where the number of potentially exposed persons = 10 (i.e., 0.0004 persons/25,000 m^2 = 10 persons).

Equation 3.2: Benefit from Collected Averted Dose (B_{AD}) *Source: NUREG-1727, Eq. D1*

Using the PW($AD_{collective}$) value determined above, the benefit from the collective averted dose is calculated as follows:

$$B_{AD} = \$2000 * PW(AD_{collective})$$

where:

B_{AD}	=	benefit from averted dose for a remediation action, in $
$2000	=	value in dollars of a person-rem averted
PW($AD_{collective}$)	=	present worth of future collective averted dose

The value derived using this equation is evaluated in the following context: Any future corrective action that costs more than the calculated B_{AD} does not support a concomitant health benefit.

3.4.2 Calculation of Costs

The averted cost per person-rem is calculated by dividing the cost by the collective averted dose, as follows:

$$\text{Cost per person-rem} = \text{Cost} / PW(AD_{collective})$$

As documented in Appendix A, the baseline cost estimate used in this evaluation includes the costs of remediation only, resulting in an estimate of $256,000 for the windblown area (assuming cleanup of 403 grids; see Section 3.4.4), corresponding to an average cost of $635 per 100 m^2 grid. These costs are very conservative in that disposal costs aren't accounted for, nor are other factors such as accidents and environmental damage (erosion, topsoil shortages), possible grazing issues with ranchers, and the potential costs of exceeding disposal capacity in GHP-2, depending upon the additional cleanup volume. Given these factors that weren't accounted for in the baseline estimate, the ALARA calculations used two cost estimates for each scenario—the conservative baseline estimate of $635 per grid (documented in Appendix A), and a more representative estimate assuming a 30 percent increment above that to account for disposal and other costs factors addressed in NUREG-1727.

3.4.3 Derived Concentration Guideline Level Derivation

This section documents the derivation of Single Radionuclide Soil Guidelines (SRSGs) based on the NRC RESRAD code (Version 6.21, September 5, 2002). These SRSGs are analogous to the DCGLs used in the preceding ALARA calculations. As indicated in Table 3.2, the assumptions used to calculate the soil guideline values are generally consistent with those applied in the ECC

Table 3.2 Dose Assessment and DCGL Derivation: Assumptions and Results

Parameter	Original ECC Dose Assessment	FSS Addendum ALARA Analysis
ASSUMPTIONS:		
Pathways Evaluated	External gamma, inhalation (w/o radon), soil ingestion	same as original
BRDL	30 mrem/yr	25 mrem/yr*
Area of contaminated zone area	400 m^2	25,000 m^2 (see Table 3.1 basis)
Thickness of contaminated zone	2 m	0.15 m (6 inches)
Fraction of time spent outdoors (onsite)†	0.019 or 1.9%	0.019
All remaining assumptions:	NRC Default	NRC Default (see Appendix B)
RESULTS: SRSG or DCGL values		
Ra-226	**162 pCi/g**	**141 pCi/g**
Th-230	3.4E+04 (t = 10 yrs)	9.99E+03 (t=30 yrs)
U-234	8.81E+04	4.31E+04
U-235	2.75E+03	1.82E+03
U-238	1.17E+04	8.36E+03

* NRC RESRAD default assumption. See Appendix A for detailed summary reports.

Note:
The original East Canyon Creek (ECC) dose assessment was developed for a limited ranching exposure scenario (14 days/year, 12 hours/day) in support of the ECC Alternative Criteria Evaluation (SMI 1999, 2000). This evaluation was approved by the NRC in 2001 (see TER, NRC 2001). The corresponding assumptions and 162 pCi/g Ra-226 DCGL are presented for comparison purposes only, as the ECC assessment formed the basis for the ALARA analysis documented herein. The appropriate Ra-226 DCGL for this evaluation is 141 pCi/g.

As part of the standard RESRAD code output, SRSGs for Th-230 and U-nat were also calculated. These values are not presented here because they are not germane to this analysis (i.e., any elevated Th-230 and U-nat measured on site is attributable to the presence of native ore). However, for comparison purposes, it should be noted that these values are orders of magnitude greater than the 141 pCi/g DCGL calculated for Ra-226, and as such much greater than levels observed on site.

† Only the outdoor time fraction is listed above as the indoor time fraction does not apply—i.e., no one will live on site. In addition to the 141 pCi/g DCGLs listed above, a hypothetical worst-case scenario DCGLs was derived for Monte Carlo assessment calculations assuming an outdoor exposure fraction of 10 percent (vs. 1.9%). Using this assumption yielded a worse-case scenario DCGLs of 26.9 pCi/g. This value, comparable to the 25 pCi/g subsurface criterion (assuming a conservative site-background value of 10 pCi/g) was calculated primarily to provide a conservative upper bound on potential doses for Monte Carlo assessments and to demonstrate that the costs of remedial action are not justified by a concomitant health benefit, even under a worst-case exposure scenario. For all areas within the land transfer boundary shown on Figure 1.1, this hypothetical scenario can not occur at any present or future time because of mandated DOE long-term custodial care.

BRDL	Basic Radiation Dose Limit
DCGL	Derived Concentration Guideline Level, used in the ALARA cost-benefit calculations
SRSG	Single Radionuclide Soil Guideline, RESRAD code term, equivalent to the DCGL

risk assessment (SMI 1999, 2000). The only exceptions were modification of the Basic Radiation Dose Limit or BRDL (from 30 mrem/year to 25 mrem/year) and the contaminated zone area and depth. Using the assumptions documented in Table 3.1, a theoretical DCGL of 141 pCi/g was derived for Ra-226. This value was considered most representative and formed the basis for most of the ALARA analysis permutations presented herein (e.g., Table 3.4 results). As discussed in the notes accompanying Table 3.2, a worse-case theoretical DCGL of 26.9 pCi/g was calculated assuming amore conservative outdoor exposure fraction of 10%. This value was used as the basis for the conservative cost-benefit analysis plotted in Exhibit 3.3.

As mentioned several times in this document, the 141 pCi/g DCGL is theoretical and is derived herein for comparison purposes only – i.e., to demonstrate that residual Ra-226 levels in site areas are well below this dose-based guideline. Umetco does not intend to leave mill-impacted material of this magnitude. Rather, the ALARA analysis results documented in the remainder of this section support the conclusion that the Gas Hills site is suitable for release, pending completion of the remaining Final Status Survey components outlined in Section 1.1 of this addendum.

3.4.4 Cleanup Scenarios Evaluated

As discussed previously in Section 3.3, two windblown cleanup scenarios were evaluated. To supplement the base-case scenario, which uses the gamma survey Ra-226 estimates documented in the FSSR, a second scenario applied a 1.84 pCi/g residual to all Ra-226 estimates—i.e., all 100 m^2 grid average Ra-226 values were increased by 1.84 pCi/g. This value was the average residual for all *underestimated* Ra-226 averages based on the corresponding soil sample results (see FSSR, Appendix C-3, Table 3). Note that the average residual for all soil sample results—including under- and overestimated values—was 0.2 pCi/g. The number of cleanup grids corresponding to the two cleanup scenarios were 403 and 1554, as illustrated in Exhibits 3.1 and 3.2 below. Scenario 1 would involve cleanup of areas north of the county road, coinciding with the prevalent NORM areas discussed at length in the FSSR (Umetco 2003). Scenario 2 is extremely conservative, and likely incorporates many grids reflecting background conditions. Detailed assumptions used to evaluate these cleanup scenarios are summarized in Table 3.3.

Exhibit 3.1
Windblown Cleanup Scenario 1: 403 grids

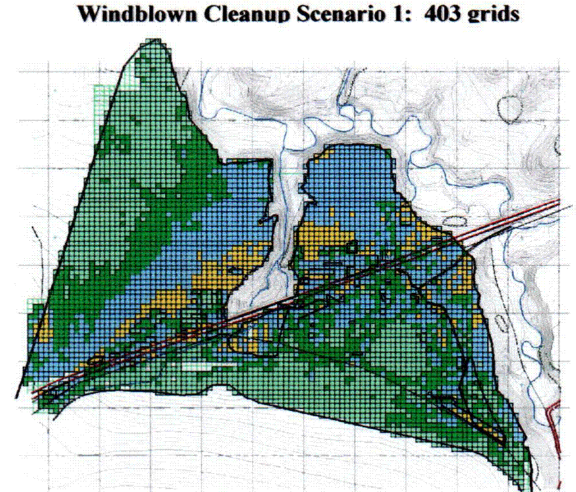
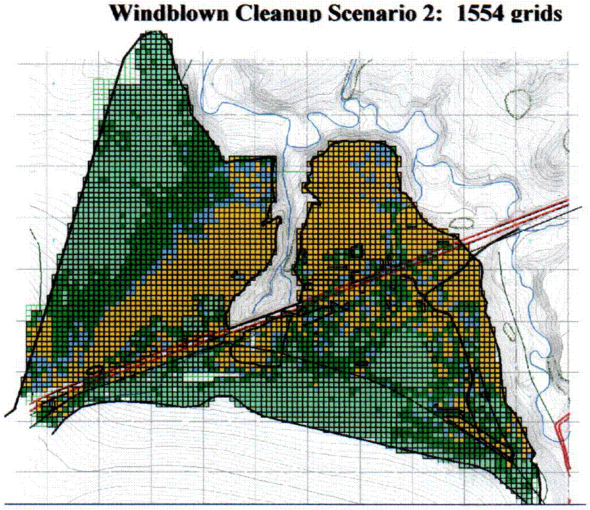


Exhibit 3.2
Windblown Cleanup Scenario 2: 1554 grids



In both exhibits, highlighted grids denote cleanup area.

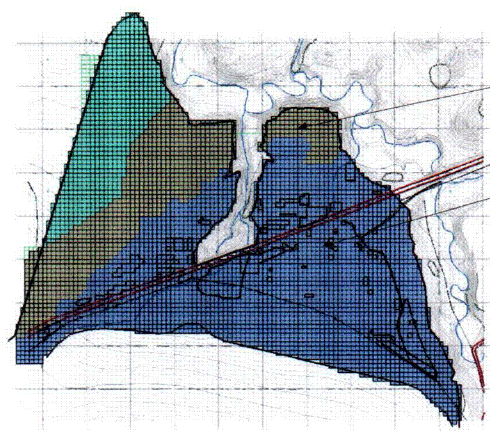
C22

Table 3.3 Summary of Windblown Cleanup Scenarios Evaluated

Cleanup Scenario	Description	No. of Grids	Mean 1 (C_1)	Post-Cleanup Mean (C_2)	$C_1 - C_2$ (pCi/g)	Cleanup Volume & Cost
Scenario 1: Grids with Ra-226 > 11.1 pCi/g	Based on field estimates exceeding the previously approved 11.1 pCi/g windblown area cleanup goal	403	9.0 pCi/g 11.8 pCi/g	8.4 pCi/g 6.5 pCi/g	0.6 5.3	5,279 cu. yds. min cost = $256,005
Scenario 2: Grids with Ra-226 > 9.3 pCi/g	Applies 1.84 pCi/g residual based on all soil sample vs. field estimate results (see FSSR, Appendix C-2, Table 2). This scenario was evaluated to account for the uncertainty in the gamma-radium correlation, acknowledged by the NRC in Comment 5.	1554	10.8 pCi/g 12.4 pCi/g	7.3 pCi/g 6.5 pCi/g	3.5 5.9	20,357 cu. yds. min cost = $987,179

Note:

All Ra-226 values are based on gamma survey estimates documented in the FSSR (Umetco 2003). Costs are $635.25 per 100 m^2 grid as documented in Appendix A. The upper bound of the assumed cost range reflects the minimum plus 30%. Two sets of mean values are presented for each scenario in the table above. The first represents the most likely estimate, assuming Ra-226 is averaged over the 3761 grids comprising the primary and secondary windblown area (see figure inset below). The second set of C_1 and C_2 values were averaged only over the area corresponding to exceedance grids, resulting in a more conservative (but less likely) estimate.



As documented in the FSSR, grid average Ra-226 concentrations did not vary significantly based on the number of grids over which results were averaged (see FSSR Section 6.3). To assess potential doses associated with hypothetical smaller averaging areas (e.g., on a grid-specific basis), refer to the Monte Carlo ALARA calculations (Appendix B, Section 3.5 summary), which reflect potential dose estimates on a grid-specific basis—all are still well below the 25 mrem/year criterion.

Regarding post cleanup Ra-226 assumptions, in the FSSR, all exceedance grids were converted to the 11.1 pCi/g cleanup level, but in fact this would overestimate the new average, as cleanup would likely be more effective. Therefore, for this analysis, the post-cleanup radium concentration was estimated based on FSSR results for cleanup grids. These results indicated a mean value of 9.3 pCi/g (+/- 1.7 pCi/g) and a range of 6.5 - 15.3 pCi/g, where the highest values reflect cleanup areas with underlying NORM. This analysis conservatively used the minimum of that range (6.5 pCi/g).

C23

3.5 ALARA Analysis Results

3.5.1 Deterministic Analysis Results

Table 3.4 (below) documents the results of the ALARA analysis using a deterministic (i.e., fixed parameter) approach.

Table 3.4 ALARA Results for Windblown Cleanup Scenarios

Scenario	Model Permutation	Scenario Description	$PW(AD_{collective})$, in person-rem	B_{AD}	Cost per person-rem
1a	$C_1 - C_2 = 5.3$ pCi/g Cost = $256,000	most conservative scenario	0.31	$621	$824,000
1b	$C_1 - C_2 = 5.3$ pCi/g Cost = $332,800	Same as above, but costs more likely	0.31	$621	$1,071,200
1c	$C_1 - C_2 = 0.6$ pCi/g Cost = $256,000	$C_1 - C_2$ term better reflects exposure area	0.04	$70	$7,278,800
1d	$C_1 - C_2 = 0.6$ pCi/g Cost = $332,800	Same as above, but costs more likely	0.04	$70	$9,462,400
2a	$C_1 - C_2 = 5.9$ pCi/g Cost = $987,200	most conservative scenario	0.35	$692	$2,854,400
2b	$C_1 - C_2 = 5.9$ pCi/g Cost = $1,283,300	Same as above, but costs more likely	0.35	$692	$3,710,600
2c	$C_1 - C_2 = 3.5$ pCi/g Cost = $987,200	$C_1 - C_2$ term better reflects exposure area	0.21	$410	$4,811,600
2d	$C_1 - C_2 = 3.5$ pCi/g Cost = $1,283,300	Same as above, but costs more likely	0.21	$410	$6,255,000

Windblown Area Cleanup Scenario Definitions

Cleanup Scenario 1: 403 Grids, Ra-226 > 11.1 pCi/g
Cleanup Scenario 2: 1554 Grids, Ra-226 + 1.84 pCi/g > 11.1 pCi/g

All calculations apply to Ra-226 only, assuming the most representative DCGL of 141 pCi/g (see Section 3.4.3).

All costs above were rounded to the nearest $100; BAD were not values were not rounded, however. The baseline (most conservative) cost assumption was $635.25 per grid (Appendix A), with the more likely estimate being $825.83 per cleanup grid (baseline plus 30%). Although some economies of scale may not be reflected for the 2nd cleanup scenario (cleanup of 1554 grids), the assumed costs are still considered conservative. $PW(AD_{collective})$ is the present worth of the future collective averted dose.

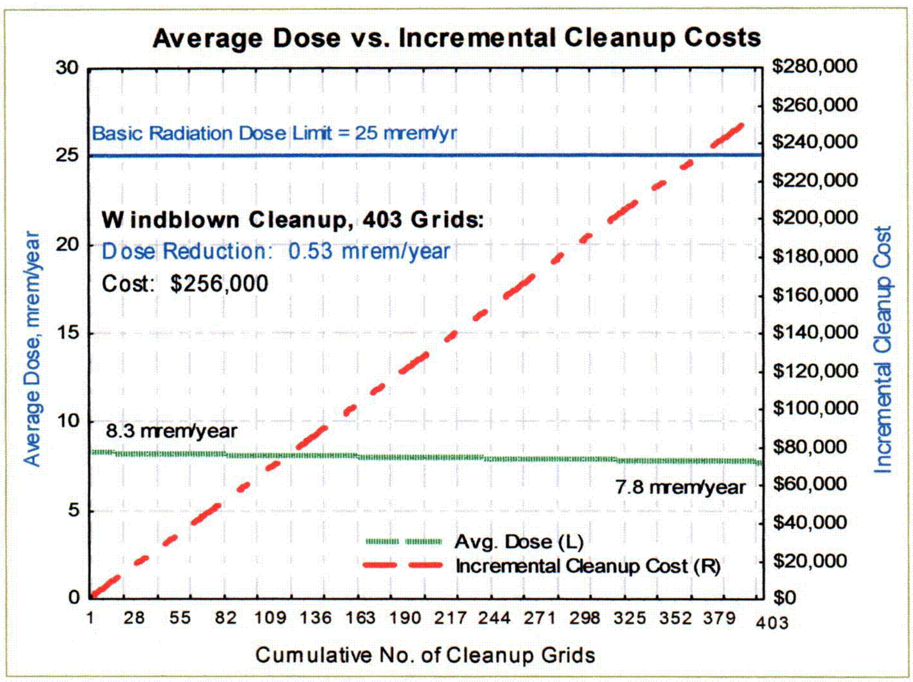
Interpretation of B_{AD} Values: B_{AD} represents the benefit from averted dose for a remediation action (in $ per person-rem). Any future corrective action that costs more the calculated value does not support a concomitant benefit.

Interpretation of cost per person-rem: The costs listed above are substantially higher than the $20,000 cost per person-rem considered "prohibitively expensive" (NUREG-1727, NRC 2000). As such, the costs of further remedial action are not justified by the ALARA analysis, even under the most conservative scenarios.

As indicated in the preceding table, costs per person-rem ranged from \$824,000 to \$9,462,400, reflecting both conservative and more representative scenarios. These costs are substantially higher than the \$20,000 cost per person-rem considered "prohibitively expensive" (NUREG-1727, NRC 2000). Underlying this guideline is the determination that a remediation would be prohibitively expensive if the cost to avert dose were an order of magnitude more than the cost recommended by the NRC for an ALARA analysis—i.e., the \$2,000 per person-rem used to calculated B_{AD}, or the benefit from averted dose (NRC 2000; also see NUREG/BR-0058, as cited in this document). Therefore, the costs of further remedial action are not justified by the ALARA analysis.

To present an alternative presentation of these findings, Exhibit 3.3 plots the incremental dose corresponding with iterative cleanup (whereby grids with highest Ra-226 magnitude are cleaned up first) vs. corresponding costs. This graph, developed using the most conservative DCGL (see Table 3.2 notes), clearly demonstrates the nominal dose reduction that would result from windblown area cleanup.

Exhibit 3.3

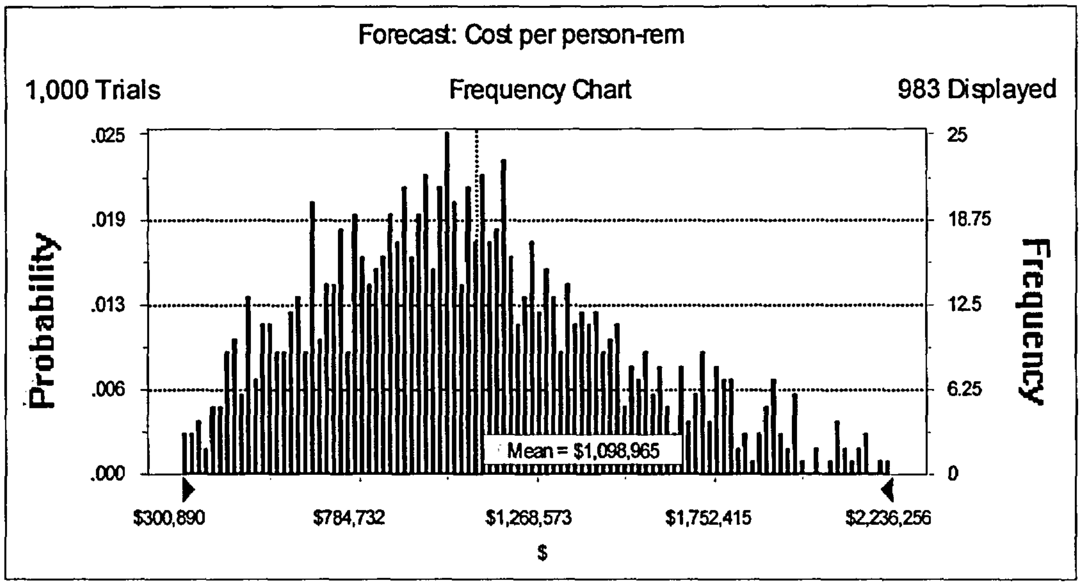


3.5.2 Probabilistic Analysis Results

To assess the ramifications of varying certain parameter values—e.g., the Ra-226 average concentration term (C_2 and C_1), costs and the assumed DCGL values—a probabilistic analysis was conducted using the assumptions documented in Appendix B. This analysis was conducted using Crystal Ball® using individual grid data for the C_1 term, thereby addressing any potential uncertainties associated with the average concentration reduction assumed in the deterministic analysis—i.e., depending on the area over which Ra-226 was averaged, the contaminant

C24

reduction could be over- or under-estimated and "hot-spots" would not be addressed. Additionally, a conservative lower bound DCGL of 26.9 pCi/g was included in the calculations to reflect a worst-case exposure scenario. Detailed assumptions and the corresponding distributional and forecast assumptions are documented in Appendix B. The following exhibit shows the results for the cost per person-rem, which corroborate the results of the previous deterministic analysis. This plot also demonstrates that even in the worst-case scenario (the lowest values on the chart), the costs per person-rem still exceed the costs of remediation.



3.6 Summary of ALARA Demonstration

Radiation protection regulations mandate that doses be ALARA, taking into account the state of technology, the economics of improvement in relation to benefits to public health and safety, other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest. License termination, or site decommissioning, requires that the licensee demonstrate that the applicable dose criteria have been met and that doses are ALARA.

The results of the ALARA analysis presented in Section 3.5 demonstrate that further windblown area cleanup is not justified. The ALARA analysis was not conducted for GHP-1 because the cleanup documented in the FSSR had proceeded to the point where cleanup efforts were counterproductive – i.e., underlying ore zones were encountered resulting in increased radionuclide concentrations making cleanup essentially technically unachievable.

4.0 DW-6 PIPELINE SUPPLEMENTAL EVALUATION

This section elaborates upon issues discussed in Umetco's response to NRC Comment 4 (Section 2); some of these issues are reiterated here for clarity. The reader should refer back to this comment for proper context and additional information.

4.1 Geospatial Estimation of 100 m^2 Ra-226 Grid Average Values

As discussed in the response to Comment 4 (Section 2), the FSSR data presentation, which consisted of discrete gamma readings and concomitant data summaries, differed from the standard assessment based on a 100 m^2 grid because the linear pipeline/trench configuration was thought to preclude such an approach. To address the NRC's concerns, geospatial estimation tools in ArcView were used to estimate 100 m^2 grid averages, thereby satisfying the assessment criterion set forth in 10 CFR 40, Appendix A, Criterion 6(6). The grid averages were estimated based on the gamma survey data provided in the FSSR, using the gamma-radium correlation derived based on GHP-1 pond data (FSSR, Appendix B-2). As discussed in the response to Comment 9, the GHP-1 gamma-radium correlation was applied to the pipeline survey data due to the proximity of these two areas and because data were not available at the time to establish a pipeline-specific algorithm. The soil sample results presented in Section 4.2 (below) could not be used for correlation purposes because their locations had not been surveyed (and as such are approximate) and because the samples had been composited over too large an interval (150 ft or 46 m) to allow valid comparison.[10]

The resulting kriged estimates are shown in Figures 4.1 and 4.2. These figures show the complete pipeline view relative to mining areas (Figure 4.1) and a larger-scale subarea view along with corresponding kriged estimate summaries (Figure 4.2). Based on kriging techniques, the majority of the 233 100 m^2 grids are well below the appropriate 25 pCi/g Ra-226 subsurface standard. Only 10 grid estimates exceed 25 pCi/g—all occurring in Area 1, adjacent to the B-5 Pit—and these exceedances are slight (maximum was 30 pCi/g; see Figure 4.2). These kriged estimates are likely overestimated (see below) and, as discussed in the FSSR and in the response to Comment 4, are considered reflective of NORM.

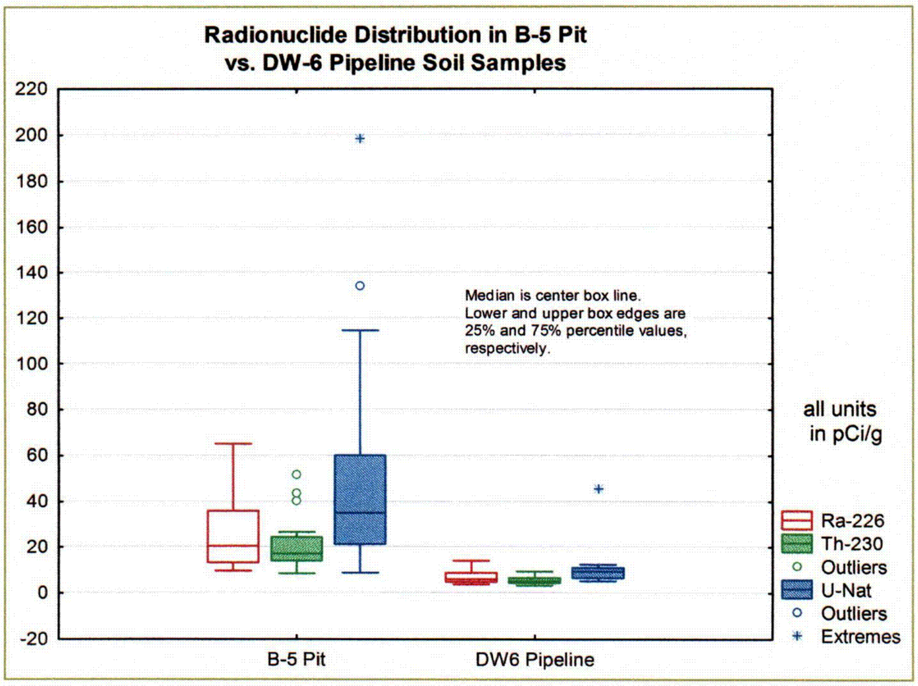
4.2 Soil Sample Analytical Results

Twelve archived composite samples collected along the pipeline were submitted for analysis of Ra-226, Th-230, and U-Nat. These samples were collected in February 2002 and were composited within 150 ft intervals; the archived samples were submitted for analysis in March 2004. Table 4.1 summarizes the results. Because soil sample locations were not surveyed, these results can not be directly compared with the kriged Ra-226 grid average estimates discussed above and shown in Figure 4.2. However, because the samples submitted for analysis were chosen to reflect the areas exhibiting the highest gamma survey readings, the results can be used to demonstrate the conservatism of these estimates.

[10] Another reason the meter Ra-226 readings do not correlate well with the soil sample results is that the readings were from the bottom of the trench excavation. The pipeline excavation was typically 3 to 4 feet wide and 3 to 4 feet in depth. This geometry resulted in augmented meter readings resulting from "shine" through the top of the collimator.

As shown in Table 4.1, Ra-226 levels ranged from 3.7 to 14 pCi/g Ra-226, well below the applicable 25 pCi/g subsurface criterion. Note that six of these samples were collected in Area 1, the area exhibiting the highest gamma survey readings likely stemming from the adjacent B-5 Pit. Exhibit 4.1 (below) plots the radionuclide distributions in pipeline soil samples (n = 12) vs. those measured in B-5 pit samples. The B-5 pit results represent the merged results of test pit sampling conducted in 2001 and 2002 for the final status survey (see FSSR Section 5). As shown in this exhibit, the magnitude of Ra-226, Th-230, and U-Nat in DW-6 samples is well below B-5 pit background levels and appear to be in equilibrium.

Exhibit 4.1



C25

Table 4.1 DW-6 Soil Sampling Pipeline Results

Sample ID	FSSP Area	Distance from B-5 Pit (ft)	Ra-226 (pCi/g)	+/-	Th-230 (pCi/g)	+/-	U-Nat, activity (pCi/g)	U-Nat, mass (mg/kg)	Percent Solids (%)	Ra-226/ Th-230	Ra-226/ 0.5*U-Nat	ACZ Lab ID
GH 000 A1	A1	0-150	10.20	1.0	7.27	1.0	45.36	67.0	93.9	1.40	0.45	L44515-01
GH 150 A1	A1	150-300	5.56	0.9	6.27	1.0	10.56	15.60	87.10	0.89	1.05	L44515-04
GH 450 A1	A1	300-450	3.74	0.7	4.00	0.7	9.41	13.90	87.30	0.94	0.79	L44515-02
GH 600 A1	A1	450-600	14.00	1.2	5.86	0.9	7.24	10.70	87.80	2.39	3.87	L44515-05
GH 750 A1	A1	600-750	4.89	0.8	3.90	0.7	8.87	13.10	89.10	1.25	1.10	L44515-03
GH 900 A1	A1	750-900	4.98	0.8	3.05	0.7	6.25	9.23	87.20	1.63	1.59	L44515-06
GH 2850 A2	A2	2850-3000	8.51	1.1	4.84	0.8	6.61	9.77	95.50	1.76	2.57	L44515-07
GH 3000 A2	A2	3000-3150	4.04	0.9	4.37	0.8	5.09	7.52	95.50	0.92	1.59	L44515-08
GH 11050 A4	A4	10900-11050	5.25	1.1	4.50	0.8	5.00	7.4	90.2	1.17	2.10	L44515-09
GH 13300 A4	A4	13150-13300	9.10	1.1	9.16	1.1	9.88	14.6	91.0	0.99	1.84	L44515-10
GH 15250 A4	A4	15100-15250	6.57	1.0	5.16	2.5	12.32	18.20	97.20	1.27	1.07	L44515-11
GH 15400 A4	A4	15250-15400	6.89	1.0	6.97	1.1	11.10	16.40	97.40	0.99	1.24	L44515-12
		Min:	3.7		3.0		5.0	7.4		0.9	0.4	
		Max:	14.0		9.2		45.4	67.0		2.4	3.9	
		Average:	7.0		5.4		11.5	17.0		1.3	1.6	
		Std. Dev.:	3.0		1.7		10.9	16.2		0.4	0.9	

Note:
Pipeline soil samples were collected in February 2002 and were composited within 150 ft intervals. Sample IDs listed above reflect the approximate distance from the adjacent B-5 pit. The areas listed above refer to the areas shown in Figures 4.1 and 4.2 of this addendum. No samples were collected for Area 3 as gamma survey readings were quite low in this area. Because soil sample locations were not surveyed, the above results can not be directly compared with the kriged Ra-226 grid average estimates shown in Figure 4.2. The archived composite samples were submitted for analysis on February 3, 2004 and analyzed on March 2, 2004 by ACZ.

5.0 GHP-1 SUPPLEMENTAL EVALUATION

This section provides supplementary data and information in response to NRC Comment 6 regarding the demonstration of the petroleum cleanup.

Total Petroleum Hydrocarbon (TPH) Sampling

In May 2002, petroleum affected soils were identified in the northern GHP-1 pond section, coinciding with the location of the former mill solvent catch basin (see FSSR Table 5.1 and Figure 5.1). The petroleum-affected soils were identified primarily by odor and were subsequently excavated an additional 6 feet until the odor was no longer apparent. In response to NRC Comment 6, five soil samples were collected from the area previously exhibiting the greatest petroleum impacts prior to excavation, corresponding to the former mill solvent catch basin shown in Exhibit 5.1 below. Samples were collected on January 26, 2004 and submitted to ACZ for Total Petroleum Hydrocarbon (TPH) analysis. Table 5.1 presents the analytical results.

Exhibit 5.1. January 2004 GHP-1 TPH Sampling Locations

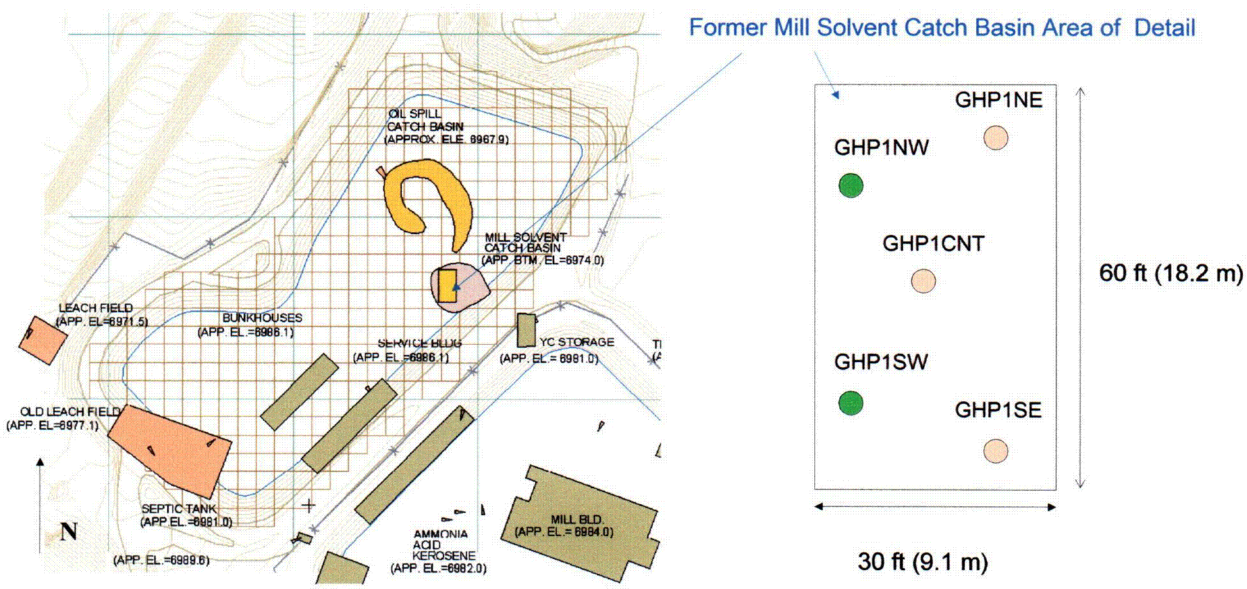


Table 5.1 GHP-1 TPH Soil Analytical Results

Laboratory ID	Sample ID	TPH (mg/kg)	% Solids
L44432-01	GHP1SE	6	79.5
L44432-02	GHP1SW	<3	82.9
L44432-03	GHP1CNT	4	87.1
L44432-04	GHP1NE	10	87.5
L44432-05	GHP1NW	<3	89.9

Samples were collected on 1/26/04 and analyzed on 2/5/04 by ACZ using EPA Method 8015B (GC/FID). Method detection limit = 3 mg/kg. See full data report in Volume II, Appendix B.

C26

Samples were analyzed for TPH content based on site (MSDS) records indicating that a kerosene spill was the most likely source of the observed impacts. Kerosene falls within the C_{10}-C_{32} carbon range, also referred to as Diesel Range Organics (DRO), which are quantified using EPA Method 8015B. As shown in Table 5.1, TPH results for the 3 samples exhibiting detectable concentrations are well below the 100 mg/kg DRO (TPH) Wyoming cleanup standard for hydrocarbon contaminated soil.[11] As such, no health or environmental risk is expected from residual TPH levels in soils. Additionally, based on the depth to groundwater measured in nearby well MWI64, approximately 178 ft, migration of petroleum residuals to underlying groundwater is not an endpoint of concern. [MWI 64 is located approximately 130 ft from the northwestern edge of GHP-1.] The latter findings, coupled with the ultimate disposition of the pond—reclamation and eventual transfer to DOE with perpetual restricted use—suggest that non-radiological hazards associated with the pond have been adequately addressed.

[11] Wyoming Water Quality Rules and Regulations, Chapter XVII, Underground Storage Tanks, Appendix A. Procedures for Establishing Environmental Restoration Standards for Leaking Underground Storage Tank Remediation Actions. This model is similar to ASTM's Risk-Based Closure Assessment (RBCA) methodology. Note that the Gasoline Range Organics (GRO, C10-C32) analysis, addressing the more hazardous and typically more mobile volatile organic constituents (benzene, ethylbenzene, toluene) is not required for kerosene spills.

6.0 REFERENCES

EG&G 1982. An Aerial Radiological Survey of the Federal-American Partners, Pathfinder, and Union Carbide Mill Sites and Surrounding Area. Gas Hills Mining District, Wyoming. Date of Survey: October 1981. Work performed by the EG&G measurements group for the U.S. NRC, EG&G Survey Report, NRC-8206. July 1982.

Hausel, D.W., and G.S. Holden. 1978. *Minerals Resources of the Wind River Basin and Adjacent Precambrian Uplifts*. In Resources of the Wind River Basin, Wyoming Geological Association, 30th Annual Field Conference 1978.

Shepherd Miller, Inc. (SMI). 1998. *Design Report Part I, Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository.* October 1998.

Shepherd Miller, Inc. (SMI). 1999. *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed, Gas Hills, Wyoming.* May 1999.

Shepherd Miller, Inc. (SMI). 2000. *Addendum to East Canyon Creek Dose Assessment in Response to NRC Comments.* September 2000.

Umetco Minerals Corporation. 2000a. *Final Status Survey Plan, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000b. *Final Background Characterization Report, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000c. Letter to P. Ting (U.S. Nuclear Regulatory Commission, Chief, Fuel Cycle Licensing Branch) from T. Gieck, Umetco. RE: "Gas Hills, License Number SUA-648; Docket #40-0299; Final Background Characterization Report and Final Status Survey Plan. Letter dated November 17, 2000.

Umetco Minerals Corporation. 2001. *Final Application for Alternate Concentration Limits for Gas Hills, Wyoming.* November 2001.

Umetco Minerals Corporation. 2003. *Final Status Survey Report, Gas Hills Wyoming Site.* October 2003.

U. S. Environmental Protection Agency (EPA). 1994. *Title 40, Code of Federal Regulations, Environment.* January 1, 1994.

U. S. Nuclear Regulatory Commission (NRC). 1999. NRC letter approving revisions to License Condition No. 58 re: *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository for Material License SUA-648, Amendment 42.* December 9, 1999.

U.S. Nuclear Regulatory Commission (NRC). 2000. NMSS Decommissioning Standard Review Plan. NUREG-1727. Division of Waste Management, Office of Nuclear Material Safety and Safeguards. September 2000. [*Note: This document supersedes the previous draft guide DG-4006 issued in August 1998.*]

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

U. S. Nuclear Regulatory Commission (NRC). 2003a. Letter from E. Brummett to C. Sealy (Umetco) re: "Request for Additional Information Concerning the Umetco Minerals Corporation's Final Status Survey Report for the Gas Hills Uranium Mill Tailings Site, SUA-648 (TAC No. LU0013)." Letter dated December 31, 2003.

U. S. Nuclear Regulatory Commission (NRC). 2003b. *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 of 1978.* NUREG-1620, Revision 1. June 2003.

FINAL STATUS SURVEY REPORT

Addendum 1

Gas Hills, Wyoming Site

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

April 2004
Revised August 2004

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Contents

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Deleted: 29
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Attachments and Appendices

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Contents

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Page Break

Tables

Exhibits

Contents

Figures

Contents

Definition of Terms

Acronym	Definition
11e.(2)	11e.(2) byproduct material, defined under 10 CFR 40 Appendix A
ALARA	As Low As Reasonably Achievable
AML	State of Wyoming Abandoned Mine Lands (program)
BRDL	Basic Radiation Dose Limit (25 mrem/year)
DCGL	Derived Concentration Guideline Level, analogous to SRSG (below)
DOE	Department of Energy
EA	Environmental Assessment
ECC	East Canyon Creek
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
GHP	Gas Hills Pond (e.g., GHP-1)
GIS	Geographic Information System
GPS	Global Positioning System
LC	License Condition
NORM	Naturally Occurring Radioactive Minerals
NRC	U. S. Nuclear Regulatory Commission
pCi/g	picoCuries per gram
PRI	Power Resources, Inc.
Ra-226	Radium-226
SMI	Shepherd Miller, Inc.
SRSG	Single Radionuclide Soil Guideline (as derived by the NRC RESRAD code)
SRP	Standard Review Plan
TER	Technical Evaluation Report (NRC 2001)
Th-230	Thorium-230
TVA	Tennessee Valley Authority
UCC	Union Carbide Corporation

1.0 INTRODUCTION

1.1 Background and Scope

This report constitutes the first addendum to the report entitled *Final Status Survey Report* (FSSR), submitted to the U.S. Nuclear Regulatory Commission (NRC) by Umetco Minerals Corporation (Umetco) on October 27, 2003 (Umetco 2003). The NRC responded to this submittal by requesting additional information as outlined in nine specific comments documented in a letter dated December 31, 2003 (NRC 2003a). Some of the information requested by the NRC can not be provided at this time—due to either ongoing reclamation efforts within some areas of the site (e.g., GHP No. 2) and/or the fact that further data collection is precluded until weather permits completion of the survey and sampling tasks. Given the additional time required to address these issues, Umetco will submit three addendums:

- This report, Addendum 1, consists of Umetco's comment responses and additional data and information elicited by those comments. This addendum also includes an Alternative Criteria evaluation, evaluating health and environmental impacts resulting from a no further action alternative, as well as costs and associated dose/risk reduction expected under various cleanup scenarios.

- Addendum 2, scheduled to be submitted in June 2004, will document the A-9 Repository gamma survey and A-9 haul road verification data.

- Addendum 3 will document the GHP No. 2 gamma survey, to be completed upon completion of the GHP No. 2 Reclamation Cover.

Figure 1.1 shows the site plan and location map reflecting the status of Final Status Survey efforts for all areas of the site.

1.2 Organization and Contents

Following this section, Section 2 documents the NRC's comments (NRC 2003a) and Umetco's corresponding responses. Table 1 summarizes the general issues and site areas addressed in each comment. Section 3—Alternative Criteria For Gas Hills Site Soil Cleanup—provides a summary characterization of the site radiological setting, followed by dose assessment and cost-benefit analysis in support of the Alternative Criteria Evaluation. Sections 4, 5, and 6 provide supplemental data and information for the DW-6 pipeline, GHP-1, and Carbide Draw, respectively. References are provided in Section 7.

This report should be reviewed referencing the preceding Final Status Survey Report (Umetco 2003), which documents much of the supporting background information and radiological data.

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Table 1.1. Summary of NRC Comments on Final Status Survey Report

NRC Comment	Primary Issue	NRC Request	Addendum Section(s) Containing Response
1	Completeness of Final Status Survey Report (FSSR) radiological data—e.g., the A-9 and C-18 pits, GHP-2, soil verification for the A-9 haul road, and the excavated trash pits.	Umetco should provide all available final radiological data for this FSSR. For gamma and radium data that cannot be acquired until after cover completion, Umetco should provide an addendum to the FSSR as soon as all the data is available.	Section 2 comment response; FSSR summary and supplementary data are provided in remainder of document
2	Verification of status and ultimate disposition of laboratory buildings within the restricted area.	Umetco should justify this change in disposition of the laboratory in the FSSR and provide the data in the FSSR addendum.	Section 2 comment response
3	Citation and figure references: pp. 5, 6, and 45.	Include the NRC 1999 reference in the revised report and consider correcting in text references.	Section 2 and Attachment 1
4	DW-6 process water pipeline trench cleanup basis and final status survey approach	Justify procedures used for the pipeline trench cleanup verification that are not in accordance with approved methods.	Section 2 and Section 4 (DW-6 Pipeline Supplemental Eval.)
5	Demonstration of attainment of 10 CFR 40, Appendix A, Criterion 6(6), given final status survey areas not meeting the concentration limits set forth in that rule	Considering the related information in the FSSR, Umetco should consider proposing an alternative to Criterion 6(6), as described in the introduction to Appendix A.	Section 3: Alternative Criteria for Gas Hills Site Soil Cleanup, dose assessment & ALARA analysis
6	Cleanup of petroleum affected soils in the northern portion of GHP-1	Indicate what criteria were used for cleanup of the petroleum and why.	Section 5 (GHP-1 Supplemental Eval.)
7	Final Status Survey results for GHP-1	Umetco should provide reasonable assurance that all 11e.(2) byproduct material impacts have been adequately addressed for Pond 1.	Section 2 comment response; Section 3 is also germane
8	Final Status Survey verification data for Carbide Draw and the excavated trash pits.	Indicate why the portion of Carbide Draw south of the county road and the trash pits meet cleanup standards.	Section 2 comment response
9	Correlation data for non-windblown areas of the site and radium-226 (Ra-226) to thorium-230 (Th-230) and Ra-226 to natural uranium (U-nat) ratios.	Provide the correlation graph of the final gamma and corresponding Ra-226 analytical data for areas other than the windblown area. Indicate how the final data support the original assumption concerning Th-230 and U-nat contamination.	Section 2 comment response

Detailed comments are provided in the corresponding sections.

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2.0 NRC COMMENTS AND UMETCO COMMENT RESPONSES

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This section documents NRC's comments (NRC 2003a) and the corresponding Umetco responses. Some comments requiring more detailed evaluation and backup are addressed in more detail in subsequent sections as referenced below.

Comment 1. *As mentioned in the electronic mail to you November 18, 2003, the staff's acceptance review determined that the Umetco Final Status Survey Report (FSSR) is not complete as data for several areas are missing. Page 2 of the FSSR mentions that the gamma survey for the A-9 and Pond 2 cell covers and C-18 Pit, and soil verification for the A-9 haul road have not been done. In addition, data for the three excavated trash pits was not found. A schedule for completing the report was requested (more detail than FSSR, bottom of page 52).*

> REQUEST: Umetco should provide all available final radiological data for this FSSR. For gamma and radium data that cannot be acquired until after cover completion, Umetco should provide an addendum to the FSSR as soon as all the data is available.

Response to Comment 1

With the exception of supplementary soil sampling data (see below), all radiological data available for the Gas Hills site have been submitted to the NRC. As indicated in the previous section, exposure surveys and verification data for the A-9 Pit and haul road, the C-18 Pit (upon completion of the C-18 backfill), and GHP No. 2 will be submitted in Addendums 2 and 3 upon completion of the survey and sampling tasks. Supplementary soils data for the DW-6 pipeline, GHP-1, and trash pits are discussed in the following comment responses and corresponding addendum sections. Byproduct cleanup for the North and South Evaporation Ponds is discussed in the following paragraphs.

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The methodology and rationale for removal of byproduct material from the North and South Evaporation Ponds has been addressed in the report entitled "*Design Report Part I, Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository*" (SMI 1998). This design was submitted October 27, 1998 and approved by License Amendment No. 42 on December 9, 1999. Radiological data associated with cleanup of this area were provided in the October 1998 submittal and Umetco's subsequent responses to NRC comments (December 10, 1998 and March 29, 1999). These data will not be reiterated here; however, an overview of the evaporation pond cleanup rationale and approach is provided below.

The North and South Evaporation Ponds were constructed with a 3-foot thick clay soil liner on top of mine waste overburden piles, shown on Figure 1.1. These ponds were used to store and evaporate mill waste solutions and tailings liquor pumped from the A-9 Repository from 1983 to 1991. The mine waste overburden piles beneath the ponds have naturally elevated concentrations of Ra-226, U-Nat, and Th-230, attributable to sediments surrounding the uranium roll front deposit that were mined at the Gas Hills site. The October 1998 submittal referenced above provided results of the detailed field investigation and associated geochemical modeling conducted at the ponds, evaluated in the context of 10 CFR 40, Appendix A, Criterion 6(6).

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Based on these results, this report concluded that the mine spoil material beneath the clay liner was not significantly impacted by mill byproduct material and that little or no further removal was required. NRC approval of this revised reclamation approach resulted in the requirement to remove and dispose of the remaining clay liner material (approximately 2 feet). Initial cleanup of the pond sludge and upper one foot of clay liner occurred prior to SMI's 1998 field and geochemical investigation. The remaining clay liner material was removed in June and July 2000 and was disposed of in the A-9 Repository. Figure 2.1 provides cross-sections based on field civil surveys which illustrate the extent of contaminated soil removal. Detailed radiological characterization data for the North and South Evaporation pond embankment, below the clay liner, is provided in Section 6 of the October 1998 design report (SMI 1998).

Comment 2. *Page 4 of the FSSR indicates that the laboratory will be surveyed and released for unrestricted use. However, the approved status survey plan (as part of the decommissioning plan) stated that the only building in the restricted area is a mobile soils laboratory and it will be disposed in the tailings disposal cell when site reclamation is complete.*

> REQUEST: Umetco should justify this change in disposition of the laboratory in the FSSR and provide the data in the FSSR addendum.

Response to Comment 2

Two laboratory trailers are presently on site: Soils Lab A and Soils Lab B, a semi-trailer. Umetco expects Soils Lab A to meet release criteria for unrestricted use. Soils Lab B, however, is not expected to meet release criteria and will be disposed of in GHP No. 2, where decontamination facilities will be in place.

Comment 3. *The top of page 6 refers to NRC 1999a but this document is not listed in the reference section. Also, there are incomplete references to figures on page 5, first paragraph (Figure 6.x) and page 45, Section 7.1.2, number 2 (Section 3.x).*

> REQUEST: Include the NRC 1999 reference in the revised report and consider correcting in text references.

Response to Comment 3

The NRC 1999a reference was cited on page 6 of the FSSR as follows: "These mining-disturbed lands meet the NRC's definition of naturally occurring unprocessed ore (NRC 1999a) — i.e., background radiation." This citation referred to a previous version of the NRC's Standard Review Plan[1] (herein referred to as the SRP), prior to its recent finalization in June 2003 (NRC 2003b). Although earlier versions of the SRP made more explicit references to mining-related

[1] The full title, shortened above, is *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 of 1978.* NUREG-1620, Revision 1, June 2003 (NRC 2003). As the NRC acknowledges, the References section of the FSSR did not list the 1999a reference because it had been updated to cite the then current, but interim, January 2002 version.

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impacts and concomitant issues regarding naturally occurring radioactive material (NORM), the more recent finalized version addresses these issues much more broadly. Discussion is generally limited to Section 5.1.2.3 (Cover Radioactivity Content) and selected text in Appendix I (Regulatory Issue Summary).

Given that the finalized SRP does not explicitly discuss unprocessed ore, the FSSR text on page 6 has been revised slightly as follows: "These mining-disturbed lands meet the NRC's definition of naturally occurring radioactive material or NORM (NRC 2003b) — i.e., background radiation." Attachment 1 includes the FSSR replacement page (pg. 6), the corresponding corrected NRC reference (pg. 55), and corrections of figure and section references for FSSR pages 5, 15, and 45.

Comment 4. *Page 9 (Table 2.2) of the FSSR indicates that 10 pCi/g was used for the Ra-226 background for cleanup of the DW-6 process water pipeline trench. The technical evaluation for the Umetco decommissioning plan states that the 10 pCi/g Ra-226 value for soil surrounding the site was to be used to compare to the Ra-226 average value for tailings pile covers. The only approved soil cleanup Ra-226 background values are 2.2 and 6.1 pCi/g for the windblown areas. Also, apparently there were no soil samples taken and the gamma readings were not averaged over 100 square meters (m^2), although the 3-mile long pipeline was excavated, in part, because of 11e.(2) byproduct material.*

REQUEST: Provide justification for the procedures used for verification of the pipeline trench cleanup that are not in accord with required/approved methods.

Response to Comment 4

In the discussion of soil background radioactivity in the Technical Evaluation Report (TER), Amendment 44, the NRC states: "A radium value of 10 pCi/g (0.37 Bq/g) was proposed to represent the soil surrounding the site, to be used for meeting Criterion 6(5), i.e., the value to compare to the tailing pile cover Ra-226 content" (NRC 2001). As the NRC acknowledges, the 10 pCi/g background value was intended as a site-wide criterion. However, the interpretation that this value would apply only to the tailings pile cover is not consistent with the intent set forth in the Final Status Survey Plan (FSSP) and supporting Background Report (Umetco 2000a, 2000b).

Table 3.1 of the FSSP indicates that 6.1 pCi/g is intended as Ra-226 background for the northern windblown cleanup area only, and that 10 pCi/g would apply to remaining site-wide soils, including GHP-1. Because the DW-6 pipeline, GHP-1, and the trash pits are located directly adjacent to or within mining areas (see Figures 3.1 and 3.2), the conservative 6.1 pCi/g background value is not appropriate for these areas. As shown on Figure 3.1, the pipeline route intersects several mining disturbance areas, resulting in naturally elevated radiological conditions. If the conservative 6.1 pCi/g background windblown area background value were applied to the DW-6 pipeline, the appropriate cleanup standard would be 21.1 pCi/g, given that the pipeline was surveyed in a 4-5 ft deep trench and thus the background plus 15 pCi/g Ra-226 subsurface standard applies. As demonstrated in Section 4, analysis of 12 archived composite

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soil samples collected along segments of the pipeline trench indicates Ra-226 levels well below this standard (3.7 – 14 pCi/g Ra-226). Six of these samples were collected in Area 1, the area exhibiting the highest gamma survey readings likely stemming from the adjacent B-5 Pit.

In response to the NRC's comments regarding the methodology used in the DW-6 final status survey, survey procedures were in accordance with approved methods—i.e., the gamma survey was performed using a Global Positioning System (GPS) and 11e.(2) materials were excavated as described in the FSSP (Umetco 2000a). The FSSR data presentation, which consisted of discrete gamma readings and concomitant data summaries, differed from the standard assessment based on a 100-square-meter (100 m^2) grid because the linear pipeline/trench configuration was thought to preclude such an approach. Grids configured based on a traditional 10 x 10m grid block would have inadequate survey spatial coverage (i.e., a survey line bisecting the grid). Alternatively, grids configured on a 100 m x 1 m layout, although technically meeting the 100 m^2 criterion, were thought to average radium values over too large a horizontal distance, resulting in potentially biased (over- or, more likely, under-estimated) Ra-226.

To address the NRC's concerns, geospatial estimation tools in ArcView were used to estimate 10 x 10 m grid averages, thereby satisfying the 100 m^2 assessment criterion set forth in 10 CFR 40, Appendix A, Criterion 6(6). Additionally, archived samples collected along the pipeline were submitted for analysis of Ra-226, Thorium-230 (Th-230), and natural uranium (U-Nat). These results are presented and discussed in Section 4 (see Figures 4.1 and 4.2), the DW-6 Pipeline Supplemental Evaluation. As demonstrated in this section, the majority of the 233 100 m^2 grids are well below the appropriate 25 pCi/g Ra-226 subsurface standard. Only 10 grid estimates exceed 25 pCi/g—all occurring adjacent to the B-5 Pit—and these exceedances are slight. In light of the soil sample results, the kriged estimates are likely overestimated (see Section 4) and, as discussed in the FSSR and above, are considered reflective of NORM.

Comment 5. *Page 9 of the FSSR indicates that a windblown area Ra-226 background of 10-15 pCi/g is more representative than the approved value of 6.1 pCi/g. Page 39 states that "...although residual windblown impacts are still apparent in some areas, Ra-226 is within the 10-15 pCi/g non-outlier range of background/NORM, and as such, the requirements of 10 CFR 40, Appendix A, Criterion 6(6) are satisfied." Since the NRC staff did not approve 10-15 pCi/g Ra-226 as background for this area, Criterion 6(6) is not satisfied.*

In addition, the revised gamma-radium correlation (page 18 and Appendix C-3) was not submitted for NRC approval per Umetco's commitment on page 13 of the status survey plan. The correlation graph (C-3, Attachment 2) indicates that Umetco could not reliably distinguish soil of 8 to 10 pCi/g (compliance) from soil with 12 to 14 pCi/g (non-compliance).

REQUEST: Considering the related information in the FSSR, Umetco should consider proposing an alternative to Criterion 6(6), as described in the introduction to Appendix A.

Response to Comment 5

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10 CFR Part 40, Appendix A, Criterion 6(6) requires that the soil radium concentration resulting from byproduct material, averaged over areas of 100 square meters, does not exceed the background levels by more than 1) 5 pCi/g of Ra-226 averaged over the first 15 cm [6 in.] below the surface, and 2) 15 pCi/g of Ra-226 averaged over 15-cm-thick layers, more than 15 cm below the surface (NRC 2003b). The common theme in this and NRC's comments is whether indeed the requirements of this criterion have been satisfied at the Gas Hills site. Implicit in this criterion is the determination of a representative background radium value or values. However, due to the heterogeneous radiological characteristics of the Gas Hills site, such a determination is not possible. For example, in the review of the background characterization report (Umetco 2000b), NRC staff corroborated what Umetco had previously identified, in determining that "there is no statistical answer to the question of what is the most appropriate background value for this area" (NRC 2001). As such, rather than pursue further statistical evaluations regarding background and corresponding cleanup criteria for which there may be no solution, Umetco developed an Alternate Criteria Evaluation as allowed by 10 CFR 40 Appendix A, which is documented in the following section.

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Section 3 evaluates health and environmental impacts resulting from a no further action alternative, as well as costs and associated dose/risk reduction expected under various cleanup scenarios. This evaluation uses the same assumptions as that developed for East Canyon Creek (see SMI 1999, SMI 2000, Umetco 2000a, and the 2001 NRC TER), but applies these assumptions to the site as a whole. Although the ALARA analysis only applies to the windblown area, the resulting Derived Concentration Guideline Levels (DCGLs) are appropriate for all areas of the site, including GHP-1, the DW-6 pipeline, and the trash pits. This evaluation will demonstrate that the potential adverse environmental impacts and high cleanup costs are not justified by any benefit that would result from further soil remediation in the Gas Hills Site final status survey areas. This finding is demonstrated in the following graph, plotted based on results of a deterministic ALARA analysis which used the most conservative theoretical DCGL (26.9 pCi/g Ra-226 vs. 141 pCi/g, considered most representative) and lower bound cost estimates for the windblown cleanup scenario (see Section 3 for further information). As shown below, the calculated dose is well below the 25 mrem/year dose limit under the current (no cleanup) scenario, the dose reduction would be negligible if additional cleanup were undertaken, and as such the cleanup costs are not justified.

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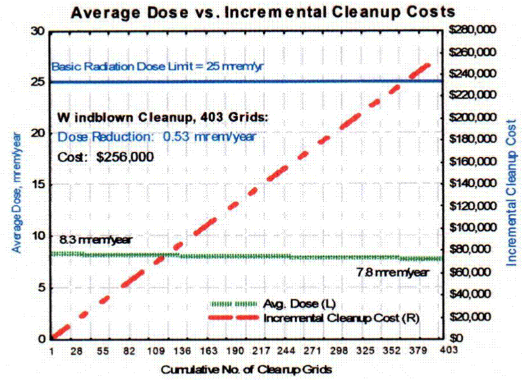
Exhibit 2.1 Cost-Benefit Graph for Windblown Cleanup Scenario 1



It is important to identify at the outset that the DCGLs calculated in support of the ALARA analysis, discussed above and documented in Section 3, are theoretical and do not negate or supersede the requirements set forth in 10 CFR Part 40, Appendix A, Criterion 6(6).

The ALARA analysis presented herein was conducted in accordance with NUREG-1727 guidance and used the same general approach as that applied in the November 2001 groundwater ACL. As such, cost-benefit calculations require the derivation of a radionuclide-specific activity concentration corresponding to a release criterion or dose limit. Twenty-five (25) mrem/year, although not typically applied to soil cleanup at mill sites, was chosen because it is conservative (relative to 100 mrem/year, cited in Appendix H of NUREG-1620), and it is consistent with the criterion applied in the approved groundwater ACL. In summary, although the DCGLs referred to above and discussed in Section 3 are considered representative of Ra-226 levels that would not pose a health risk to potentially exposed populations, this does not imply that Umetco will leave mill-impacted material of this magnitude (e.g., 141 pCi/g). Rather, the ALARA analysis and corresponding DCGLs support the conclusion that the Gas Hills site is suitable for release, pending completion of the remaining Final Status Survey components outlined in Section 1.1 of this addendum.

In response to the second paragraph of NRC Comment 5—regarding the windblown area gamma-radium correlation—this issue is discussed in Section 6.4 and Appendix C-3 of the FSSR. In these sections, Umetco evaluated the factors potentially accounting for the low strength of the correlation, but no definitive conclusions could be drawn. As discussed in the FSSR, the heterogeneity of the site, with significant NORM presence—both laterally and vertically—likely accounts for those cases where larger residuals were found. To account for this factor, the ALARA analysis provided in Section 3 includes a conservative scenario that attempts to address the implications of the NRC's comment that "...*Umetco could not reliably distinguish soil of 8 to 10 pCi/g (compliance) from soil with 12 to 14 pCi/g (non-compliance)*." This scenario was evaluated by adding 1.8 pCi/g to all Ra-226 values estimated using the FSSR

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gamma-radium correlation, wherein the new cutoff for compliance vs. non-compliance would be 9.3 pCi/g (vs. 11.1). The 1.8 pCi/g increment was derived based on a conservative calculation of residuals for the gamma-correlation data set (Section 3.5). The ALARA analysis did not justify further cleanup even under this conservative scenario.

Comment 6. *Page 19 (May 2002 entry) states that petroleum affected soils were identified in the northern portion of Pond 1. There is no mention of a report or data for the petroleum cleanup.*

REQUEST: Indicate what criteria were used for cleanup of the petroleum and why, and include a summary of the data in the FSSR.

<u>Response to Comment 6</u>

As discussed in Section 5 of the FSSR, petroleum affected soils were identified in the northern GHP-1 pond section, coinciding with the location of the former mill solvent catch basin (see FSSR Figure 5.1). The petroleum-affected soils were identified primarily by odor and were subsequently excavated an additional 6 feet (below the previous excavation) until the odor was no longer apparent. Upon completion of Final Status Survey activities, the total excavation depth within GHP-1—from the original ground surface to the post-cleanup pond bottom—was between 15 and 20 ft. Also note that the current base elevation of GHP-1, approximately 6970 ft, is well above the water table (approx. 178 ft depth) in unsaturated soils, indicating that the potential for migration of any existing petroleum residuals to underlying groundwater is negligible.

In response to the NRC's comment regarding cleanup criteria, five soil samples were collected from the area corresponding to the former mill solvent catch basin, representing the area previously exhibiting the greatest petroleum impacts prior to excavation (see FSSR Section 5.1 and Section 5 herein). These samples were collected on January 26, 2004 and submitted to ACZ for Total Petroleum Hydrocarbon (TPH) analysis using EPA Method 8015B. This analytical method was chosen based on site records (Material Safety Data Sheets (MSDS)) indicating that a kerosene spill was the most likely source of the observed impacts.

Kerosene falls within the C_{10}-C_{32} carbon range, also referred to as Diesel Range Organics (DRO), which are quantified using the 8015B method. TPH results, documented in Section 5.1, ranged from 4 mg/kg to 10 mg/kg in three of the samples; the remaining two samples had non-detectable concentrations (< 3 mg/kg). These results are well below the 100 mg/kg DRO (TPH) Wyoming cleanup standard for hydrocarbon contaminated soil.

Umetco acknowledges the importance of considering non-radiological hazards, particularly in an ALARA demonstration. Based on the issues discussed above and in Section 5, potential risks to the public and the environment from any residual petroleum constituents are considered to be negligible. This conclusion is supported by the following five factors:

1) the extensiveness of the excavation in GHP-1 (15-20 ft), as evidenced by the exposure of the underlying ore body in some areas;

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2) TPH results indicating negligible presence of DRO petroleum constituents, at levels well below the 100 mg/kg Wyoming DEQ standard;

3) the depth to groundwater in the pond area (178 ft), which would preclude any significant previous or future migration of petroleum residuals to underlying groundwater;

4) the final grading plan, entailing the placement of approximately 4 to 6 feet of backfill over the GHP-1 pond area, which will be sloped to drain—i.e., storm water will not pond and infiltrate in this area; and

5) this area is within the DOE transfer boundary discussed in Section 2.5 of the FSSR and as such will be controlled with restricted use for long-term surveillance and maintenance.

Comment 7. *Page 32, Section 5.4.2, states that after additional soil removal from Pond 1 to address apparent impacts, "... no final verification soil sampling was performed." Sampling was thought unnecessary given the extensive excavations and test pit sampling results. Section 5.5 states that the majority of grids are between 15 and 20 pCi/g Ra-226, within the range measured in the B-5 Pit.*

REQUEST: Given the imprecision of the gamma-radium correlation, the variation of test pit data (Table 5.2), and that the B-5 Pit was not approved as background for Pond 1, Umetco should provide reasonable assurance that all 11e.(2) byproduct material impacts have been adequately addressed for Pond 1.

Response to Comment 7

As documented in the FSSR report, approximately 30,000 cubic yards of material were excavated from GHP-1 to mitigate byproduct affected areas as well as the petroleum affected soils addressed in the previous comment. This excavation proceeded well below the original ground surface (see response to Comment 6 above). As documented in Section 5.3 and Appendix B-3 of the FSSR, an extensive geochemical investigation undertaken by Lidstone and Associates (LA) indicated that 11e.(2) byproduct material impacts from pond solutions were limited to the upper 3 to 4 feet of pond material, primarily in the northern-central pond area. This material was subsequently excavated, as well as an additional 2 feet below the impacted horizon to ensure that the cleanup met ALARA requirements.

Comparison of the initial 2001 gamma survey results with the post-excavation 2002 gamma survey indicates that these cleanup efforts did not yield a concomitant reduction in Ra-226 concentrations because underlying ore zone areas were exposed (e.g., in the southwest pond section, an area observed by J. Lusher during the 2002 site audit). Pond-wide average Ra-226 concentrations increased slightly, and areas where the excavation was deepest corresponded to those grids exhibiting the greatest increases in average Ra-226 concentrations (see FSSR, Figures 5.16 and 5.17). The latter trend is not consistent with that typically exhibited in 11e.(2) impacted areas. As such, Ra-226 concentrations measured in GHP-1 based on the May 2002 gamma survey—the majority between 15-20 pCi/g—reflect NORM conditions, and are within or well

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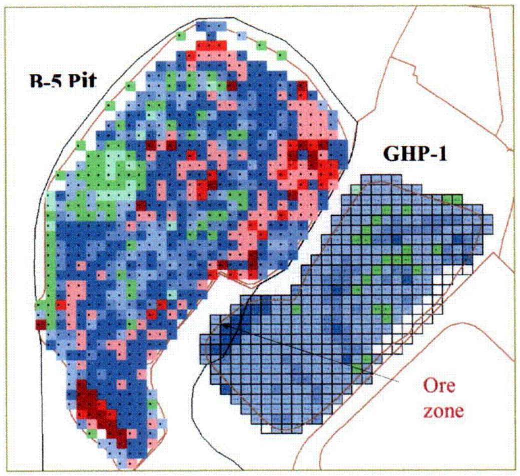
below the range of concentrations measured in the nearby B5 Pit, an open-pit uranium mine. This conclusion is demonstrated in the following exhibit.

Exhibit 2.2
Gamma Survey Results for GHP-1 (2002) and the B-5 Pit (1995)

This inset reflects the magnitude of Ra-226 estimates.
Green: 0-15 pCi/g
Blue: >15-50 pCi/g
Red: > 50 pCi/g
Darker shading within each color group reflects greater Ra-226 magnitude within that range. Refer to Figure 3.5 for additional data comparisons.



Section 5.2.2 of NUREG-1620 (NRC 2003b) states that: "Several different background values may be required if contaminated areas have distinctly different soil types. For example, if a portion of the site has a natural uranium and/or radium mineralization zone in/near the surface, the cleanup criterion for that area would use a background (reference) U-238 or Ra-226 value from a similarly mineralized area."

In conclusion, any additional excavation of GHP No. 1 will likely increase radium concentrations as the excavation approaches the ore body and would also result in the disposal of large volumes of NORM. GHP-1 will be backfilled and reclaimed in accordance with WDEQ standards (SMI 1998) and the site transferred to DOE for long-term care. Given the latter, combined with the results of the Alternative Criteria Evaluation documented in Section 3, Umetco concludes that the criteria set forth in 10 CFR Part 40, Appendix A, Criterion 6(6) have been met at GHP-1.

NRC Comment 8. *Neither Section 6 nor Section 7 of the FSSR summarize the data for the remediated portion of Carbide Draw. Table 2 of Appendix C-2 provides gamma-based estimates of Ra-226 and soil analysis Ra-226 results, but some grids exceed the approved criterion of 11.1 pCi/g (5 pCi/g plus 6.1 pCi/g if background influenced by ore). Also, page 49 indicates that Ra-226 results for the trash pits were below the 15 pCi/g site-wide criterion.*

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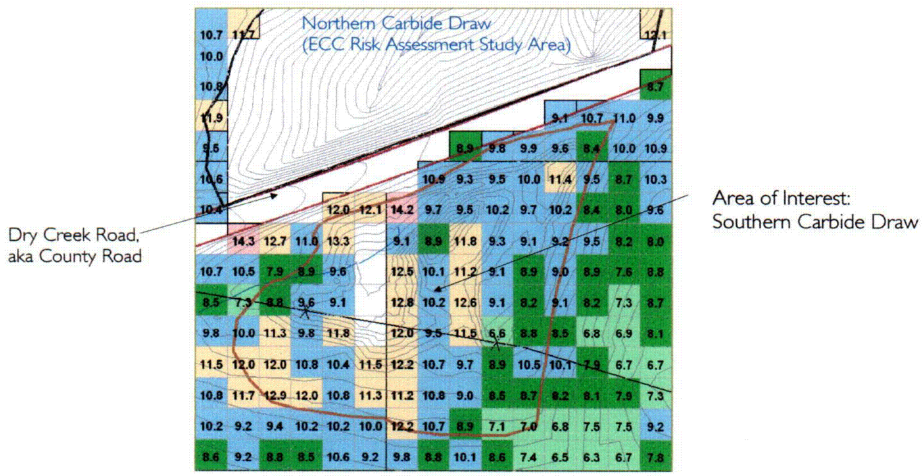
REQUEST: Indicate why the portion of Carbide Draw south of the county road meets the cleanup standards. Given that the soil cleanup criterion is 11.1 pCi/g, indicate how the trash pits meet cleanup standards.

Umetco Response to NRC Comment 8, Part 1 (Re: Carbide Draw)

Figure 6.11 of the FSSR presents a detailed visual summary for the remediated potion of Carbide Draw and, as acknowledged by the NRC above, supporting documentation is provided in Appendix C-2, Table 2. The Carbide Draw excavation, entailing the removal of approximately 6,300 cubic yards of material, proceeded as far as feasible — i.e., down to bedrock. In most cases, the Carbide Draw area grids exceeding 11 pCi/g Ra-226 occur at bedrock . These grids are shown in the following exhibit, adapted from Figure 6.11 of the FSSR.

Exhibit 2.3
Final Status Survey Results for Carbide Draw Area



Adapted from FSSR Figure 6.11 (Umetco 2003).

Field observations made during the field characterization and excavation efforts are documented in Section 6.1 of the FSSR, but are reiterated and augmented here for completeness. But first, a reiteration of the conclusions drawn for the East Canyon Creek drainage, including the portion of Carbide Draw located north of the county road, is warranted.

As documented in the FSSP and East Canyon Creek risk assessment (Umetco 2000a, SMI 1999, 2000), process solutions were released to East Canyon Creek (ECC) through the drainage tributary Carbide Draw during the early operation of the mill (1960 to 1963). A breach of the above-grade tailings impoundment in 1972 resulted in another release of mill tailings which, although mitigated, contributed to the residual radioactivity within the drainage. Due to the sensitive ecological conditions within the ECC drainage, combined with other factors warranting

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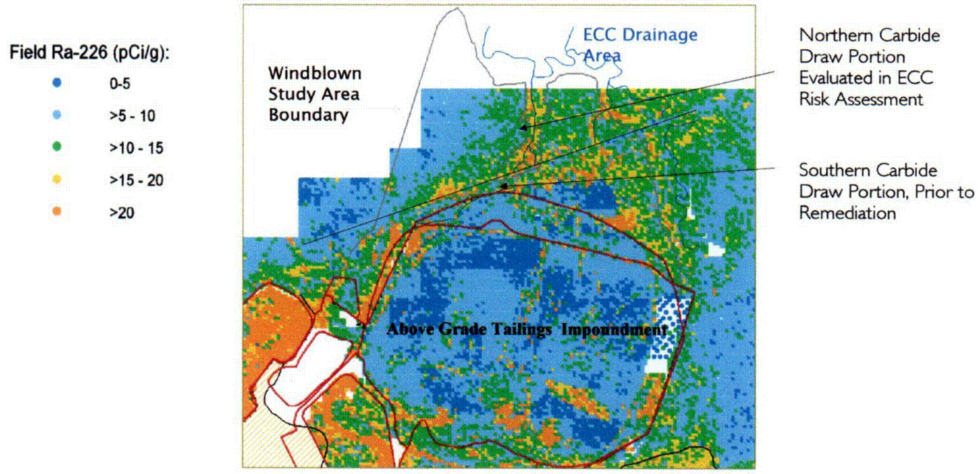
special consideration (e.g., cultural resources and wetlands), Umetco proposed a no-action alternative for this area, which included Carbide Draw north of Dry Creek Road (Umetco 2000a). The NRC staff review of this alternative determined that:

> " ... *the proposed no-action alternative protects the sensitive ecological conditions in the creek and that the proposed alternative will achieve a level of protection for public health, safety, and the environment from the radiological and non-radiological hazards of byproduct material which is equivalent to, to the extent practicable, the requirements of Criterion 6(6).*" (NRC TER, 2001)

This determination was based on a cost-benefit analysis of the remedial action and on the results of the ECC risk assessment (SMI 1999, 2000). This report demonstrated the magnitude and heterogeneous distribution of radium within the ECC drainage, with some of the highest concentrations occurring in Carbide Draw just north of the county road (see exhibit below).

Exhibit 2.4. Subset of 1995 Gamma Survey Results Showing Ra-226 Distribution in East Canyon Creek Drainage



This exhibit was adapted from Figure 3.5 herein.

As discussed in the FSSR, early (2001-May 2002) gamma survey characterizations of Carbide Draw south of the county road indicated the need for only localized cleanup of windblown tailings. However, as the excavation proceeded, underlying sediments—apparently resulting from the 1972 tailings impoundment breach—were exposed. Because it was difficult for field staff to distinguish between the 11e.(2) material and NORM, which was prevalent in the area, Lidstone & Associates (LA) was retained to assess geological conditions within Carbide Draw. These investigations included a geological field evaluation of mineralogy, sedimentology, and stratigraphy of both native materials and tailings sands. As part of their review, LA determined that the pre-tailings disturbance elevation could be established on the downstream section of

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Carbide Draw north of the county road. Once this elevation was established, a hypothetical pre-disturbance slope was projected across the disturbance area.

Based on their initial evaluation in June 2002 (which preceded the bulk of the Carbide Draw excavation), LA concluded that the base of the southern Carbide Draw pits remained in tailings or 11e.(2) materials. However, there was evidence of a native Wind River Formation surface underlying the base of these pits. Based on the results of this investigation and the geomorphic interpretation of the historical channel grade, LA established a cleanup depth of approximately 5 to 10 feet below existing grade or a net elevation of 6870 feet (msl). Based on LA's recommendation and to ensure complete removal of potentially byproduct-affected sediments, the Carbide Draw excavation proceeded down to bedrock and 6,300 cubic yards of material were removed.[2]

LA returned to the site on July 31, 2002 for a field review of the mineralogy and sedimentology of the excavated land surface. Unlike the previous backhoe pit investigation, it was readily apparent that the floor of the excavation was firmly embedded on native Wind River Formation material and that all residual tailings had been removed from the southern Carbide Draw area.

Similar to observations made for GHP-1, whereby excavation of 11e.(2) material led to the exposure of underlying NORM, the Carbide Draw excavation proceeded to the extent feasible. In most areas, further excavation is not possible as bedrock has been encountered. Furthermore, Ra-226 concentrations measured in this area are well below the theoretical Derived Concentration Guideline Levels (DCGLs) established in Section 3.

Reiteration of NRC Comment 8 (see pg. 14 for entire comment). "*...page 49 indicates that Ra-226 results for the trash pits were below the 15 pCi/g site-wide criterion.*"

> REQUEST: Given that the soil cleanup criterion is 11.1 pCi/g, indicate how the trash pits meet cleanup standards.

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[2] The southern portion of Carbide Draw addressed in NRC's comment is technically part of the East Canyon Creek drainage in that it is contiguous with the northern portion of Carbide Draw (interrupted by the road culvert). Therefore, the conclusions drawn regarding ECC—which culminated in the NRC's approval of the no-action alternative—are germane to the southern portion of Carbide Draw as well. As such, the 6,300 cubic yard excavation undertaken as part of the Final Status Survey represents a conservative remedial effort.

Umetco Response to NRC Comment 8, Part 2 (Re: Trash Pits)

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Because the trash pits are located directly within mining areas (see Figures 1.1 and 2.1), the approved site background utilized is 10 pCi/g. The trash pits were acknowledged in the FSSR because recent discovery (i.e., during development of the plan), and the FSSP were considered the most efficient way to document their excavation and reclamation.

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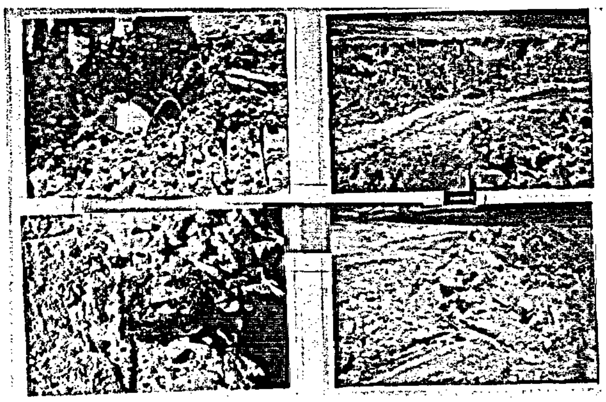
As discussed in the FSSP, during site reclamation activities conducted in July and August 2000, three small former trash pits were uncovered in mine spoil areas (see Figure 1.1 herein and Figure 4.1 of the FSSP). The first pit, Trash Pit #1, was located on the northern boundary of the north evaporation pond. The other two pits, Trash Pits #2 and #3, were found in the reclaimed portion of the B-Spoils mining area. These pits are described further as follows:

1. **Trash Pit #1:** This trash pit was encountered during the reshaping of the North Evaporation Pond, where mine spoils were utilized in associated construction. The pit was found within the mine spoils, which accounts for the Ra-226 levels measured in the associated soil sample (see Table 3.1 and discussion on the following page).

Trash Pit #1, North Evap. Pond Area, July-August 200



2. **Trash Pit #2:** This pit was encountered in the B-Spoils area near access Gate 5 during the excavation of the drainage channel for the Heap Gap to the A-8 mine pit area.

3. **Trash Pit #3:** This pit, also referred to as the B-Spoils Channel Trash Pit, was found during the construction of a drainage channel into the A-8 Pit area. Two samples were collected from this pit; results for both indicate low levels of radioactivity (see below).

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The trash in these pits consisted largely of scrap metal and laboratory waste—e.g., rusted barrels, used gloves, protective Tyvek clothing (Umetco 2000a, 2003). The only exception was the uncovering of some old yellowcake filter press cloth, but otherwise the inventory reflected refuse of a general nature. No evidence was found of any significant byproduct material contamination, as indicated by the results of gamma scans, which were generally within background ranges (see FSSR Section 7.3). During excavation, no visual observations of soil stainage, standing water or spillage were observed by site radiological personnel assigned to observe excavation proceedings. All pits were excavated 1 to 3 feet laterally and verticall beyond the observed residual trash layer. The trash was removed and hauled to the A-9 pit, after which the trash pits were surveyed and soil samples were collected and analyzed for Ra-226, Th-230, and U-nat. Laboratory results reported for this limited sampling are documented in Table 2.1 (below).[3] The pits were then backfilled with mine spoils.

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Table 2.1 Soil Sample Results for Mine Spoil Area Trash Pits, August 2000

Location Code	Location	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-nat (pCi/g)
Trash Pit #1	Evap. T- Pit	46 ±1.3	59 ±2.9	47.4
Trash Pit #2	Gate 5 T-Pit	7.8 ±0.53	6.8 ±1.4	31.8
Trash Pit #3	B Channel T-Pit	5.5 ±0.46	5.4 ±1.2	13.5
Trash Pit #3	Slope B Channel	4.1 ±0.41	4.1 ±1.1	9.5

Samples were collected in August 2000 after excavation and were analyzed by Barringer Labs. U-Nat, originally reported in mass units (mg/kg), was converted to activity (pCi/g) by multiplying the mass value by 0.677.

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The results listed in Table 2.1 above indicate low levels of radioactivity within the B-Spoils area (Trash Pits #2 and #3). Soil sampling for all of the trash pits consisted of a composite sample collected from the pit floor and walls. Meter readings (alpha, beta/gamma and gamma) and visual observations were utilized to determine soil sample locations. Use of meter and visual driven soil sampling tends to give a worse case scenario of radiological conditions.

Deleted: The higher uranium content in these samples likely reflects the presence of lower grade ore in this reclaimed mining area. The higher levels reported for Trash Pit #1, located near the north evaporation pond, are expected given that this pit was encountered within the mine spoils. This conclusion is corroborated in Section 3.2, which discusses the radiological setting characterizing the background mining areas. All analytical results are well below the applicable Derived Concentration Guideline Levels (DCGLs) for soils derived in the following section—141 pCi/g Ra-226 and substantially higher levels for Th-230 and U-Nat; see Table 3.2. Given the latter findings and the fact that potential residual contamination from the trash pits is indistinguishable from local mine spoils background, no further demonstration of cleanup standard attainment is considered necessary for the trash pit areas.

Trash Pit #1 was the largeset of the three trash pits and was excavated to approximately 7,200 square feet to remove discarded materials. Trash Pit #1 Ra-226 levels are above the NRC approved background level. The ratio of U-nat, Ra-226 and Th-230, however, indicate the material is in disequilibrium with a Ra-226/U-nat ratio of 1.94.

The disequilibrium apparent in Trash Pit Sample #1, where Ra-226/0.5*U-nat is 1.94 (see note below), is not considered indicative of mill-related impacts because this ratio is well within the range of ratios calculated for the approved background data set. As discussed in Section 3.1 of Umetco's *Background Characterization Report* (Umetco, 2000), although using Ra-226/U-238 ratios to identify milling-related impacts is recommended by the NRC and has been applied at other sites, such an evaluation has not yielded compelling results at the Gas Hills site. This

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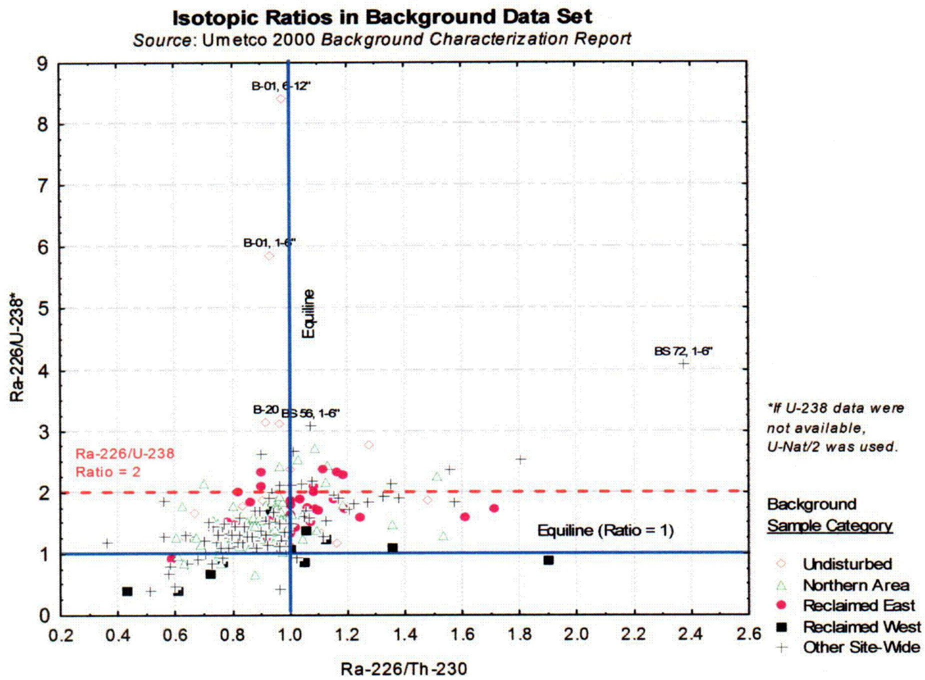
[3] Section 7.3 of the FSSR cited an Ra-226 result of 9.7 pCi/g. This value was based on results of on-site gamma spec analysis of soil samples and is not to be compared with the Barringer laboratory results listed in Table 2.1.

finding is demonstrated graphically in Figure 3.10 of the *Background Characterization Report* and in the plot below:



Note:
For samples analyzed for total U-nat and lacking isotopic data for U-238, the U-238 component was estimated by dividing the U-nat value by 2. This approach assumes that the U-nat source term is represented as percent activity by 49.2% U-238, 49.2% U-234, and 1.6% U-235.

If byproduct material were present, you would expect (from some of the materials excavated) elevated U-nat levels from the yellowcake filter press cloths or solvent extraction solutions. Inventory of materials excavated from the trash pits show no evidence that tailings or process waste materials were encountered so one would not expect to see elevated Ra-226 or Th-230 levels related to licensed materials. The higher radioactivity levels observed in Trash Pit #1 located at the edge of the north evaporation pond are expected, given that this pit was encountered within the mine spoils utilized to construct the evaporation pond. This conclusion is corroborated in Section 3.2 of Addendum 1, which discusses the radiological setting characterizing the mining background mining areas. The ratios observed from Trash Pit #1 are consistent with ratios observed from low-level ore (mine spoils) identified at the B-5 Pit and similar ratios discussed in the *Final Background Characterization Report* Section 3 and Tables 3.3 through 3.8. Cleanup of Trash Pit #1 is considered complete with the remaining soils being characteristic of low grade ore/mine spoils (i.e., NORM material).

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Trash Pit #2 was excavated to approximately 1,500 square feet to ensure removal of disposed materials. The higher uranium content observed in soil samples from Trash Pit #2 likely eflects the presence of lower grade ore in this reclaimed mining area. Meter readings taken after excavation show radiological readings were at or near background levels for the area. Trash Pit #2 was backfilled with approximately 8 feet of mine spoils upon confirmation of soil sampling results. Soil sampling results show Ra-226 values meets the more conservative surface cleanup level of 15 pCi/g or the applicable subsurface cleanup level of 25 pCi/g for site mining areas at 7.8 pCi/g. As such, no additional cleanup is necessary.

Trash Pit #3 was excavated to approximately 450 square feet in size to remove disposed materials. Trash Pit #3 soil sampling shows U-nat, Ra-226 and Th-230 levels to be in equilibrium. Meter readings of levels after excavation show radiological readings were at or near background levels for the area. Trash Pit #3 was backfilled with approximately 5 feet of mine spoils. Soil sampling results show Ra-226 values will meet the surface and/or subsurface criterion from Trash Pit #3 at 5.5 pCi/g. Trash Pit #3 meets the Ra-226 regulatory standard for surface and subsurface as specified in 10 CFR 40 Appendix A, Criterion 6(6) and no further cleanup is necessary.

NRC Comment 9. *Page 7 of the final status survey plan indicated Umetco would provide a correlation of the final gamma and Ra-226 data, but only the windblown area correlation was provided (Appendix C-3, Figure 1). Pages 8 and 9 of that plan indicate that the Ra-226 to Th-230 ratio is about 1 and that elevated U-nat due to milling is not expected. Therefore, benchmark dose modeling was not performed to derive cleanup criteria for Th-230 and U-nat.*

REQUEST: Provide the correlation graph of the final gamma and corresponding Ra-226 analytical data for areas other than the windblown area. Also, indicate how the final data support the original assumption concerning Th-230 and U-nat contamination.

Umetco Response to NRC Comment 9

The correlation equation and graph for non-windblown areas—i.e., GHP-1 and the DW-6 pipeline—are documented in detail in Appendix B-2 of the FSSR (Umetco 2003). The gamma-radium correlation developed for GHP-1 was also applied to the DW-6 pipeline due to the proximity of these two areas and because data were not available at the time to establish a pipeline-specific algorithm. The gamma-radium correlation for GHP-1 was developed based on the April 2001 soil sampling effort and corresponding gamma survey results (see FSSR Section 3.7). This equation tended to overestimate Ra-226 concentrations by approximately 4 pCi/g, the average residual calculated in Appendix B-2, Table 3.

Data plots supporting Umetco's original assumption regarding Ra-226/Th-230 and Ra-226/U-Nat ratios are provided in the following exhibit, which plots the radionuclide distributions in pond samples (merged results of 2001 – 2002 final status survey investigations) vs. B-5 Pit and GHP-1 ore zone samples (units in pCi/g).

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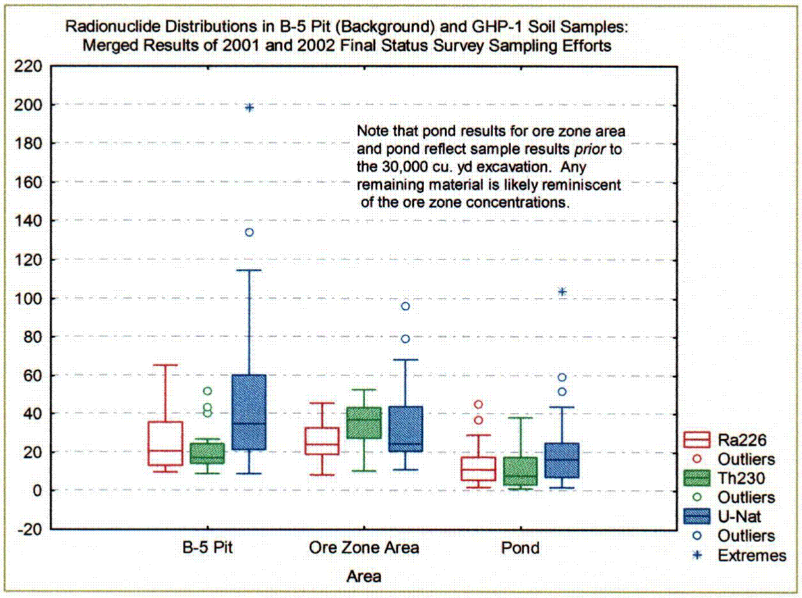
Exhibit 2.5



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3.0 ALTERNATIVE CRITERIA EVALUATION FOR ADDITIONAL GAS HILLS SITE SOIL CLEANUP

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Given the issues raised in the NRC's comments, in particular Comment 5, this section documents the evaluation supporting Umetco's proposal for a no-further-action alternative for the Gas Hills Site areas addressed in the 2003 Final Status Survey report. This proposed alternative for mill cleanup is allowed under 10 CFR 40, Appendix A, which states that:

> *"Licensees or applicants may propose alternatives to the specific requirements in this Appendix. The alternative proposals may take into account local or regional conditions, including geology, topography, hydrology, and meteorology. The Commission may find that the proposed alternatives meet the Commission's requirements if the alternatives will achieve a level of stabilization and containment of the sites concerned, and a level of protection for public health, safety, and the environment from radiological and nonradiological hazards associated with the sites, which is equivalent to, to the extent practicable..."* the soil radium standard..." *with due consideration to the economic costs involved..."*

The following pages document the evaluation of health and environmental impacts resulting from a no further action alternative, as well as the costs and the associated dose/risk reduction expected under various cleanup scenarios. In support of this analysis, theoretical derived concentration guideline levels for soils (DCGLs) were derived consistent with the assumptions employed in the ECC risk assessment. An ALARA analysis was then performed consistent with NRC guidance (NUREG-1727, NRC 2000). As discussed in the response to NRC Comment 5 Section 2, the DCGLs calculated in support of the ALARA analysis are theoretical and do not negate or supersede the requirements set forth in 10 CFR Part 40, Appendix A, Criterion 6(6). This evaluation begins with a discussion of pertinent background information (Section 3.1) and the regional geology and radiological setting (Section 3.2). Section 3.3 describes the underlying conceptual approach; Section 3.4 documents the equations and assumptions used in the ALARA calculations. Results are presented in Section 3.5. This evaluation will demonstrate that the potential adverse environmental impacts and high cleanup costs are not justified by any benefit that would result from further soil remediation in the Gas Hills Site final status survey areas.

3.0.1 Defined Areas of FSP Deviation

Umetco is requesting alternate criteria or deviation from the approved Final Status Survey Plan for the following areas:

1. GHP-1 – Excavation of byproduct material resulted in exposure of underlying low-level ore (NORM) exhibiting Ra-226 levels higher than those previously measured in GHP-1 affected soils. Ra-226 concentrations measured in GHP-1 are within the range of concentrations measured in the adjacent B5 pit. Umetco is proposing alternate criteria to demonstrate cleanup of this area using the B5 pit as a local reference area. In support of this request, a geochemical investigation has been completed to identify the extent and cleanup boundaries of byproduct contamination.

   The post-cleanup grading of GHP-1 will be performed in accordance with the site wide grading plan which requires approximately 5 feet of fill over the northern portion of the

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GHP-1 pond bottom and 3 feet of excavation in the southern portion of the pond bottom. Excavated soils from post-cleanup grading of GHP-1 will be placed in the B5 pit backfill. Once the area has been graded, approximately 12 inches of topsoil will be placed and the area seeded to provide erosional stability.

2. DW-6 Process Water Pipeline – Removal of tailings and affected soils from the DW-6 pipeline trench resulted in exposure of underlying low-level ore (NORM) in some areas. Consequently Ra-226 measurements exceed the background criteria approved in the FSSP. Umetco is requesting approval of an alternate criteria to demonstrate cleanup in this area using the B5 pit Ra-226 levels as a specific local reference area. Also because the DW-6 pipeline cleanup was in a linear configuration, the verification was not performed on a 100m^2 grid basis. However, Section 4.0 of this Addendum 1 provides a supplemental evaluation which includes use of the subsurface standard and evaluation of data on a 100m^2 grid basis. Since this verification method deviates from the approved FSSP, Umetco is requesting approval of alternate criteria and methodology for the DW-6 pipeline.

3. Select Windblown Cleanup Areas Including Carbide Draw South of the County Road – Byproduct removal in some windblown locations and in Carbide Draw south of the County Road led to exposure of underlying low-level ore (NORM). As such, residual 11e.(2) material, if present, can not be identified. Accordingly, Umetco is requesting alternate criteria as allowed in the introduction of Appendix A, 10 CFR 40, to account for local geological conditions.

3.0.2 Submittal of Radium-Gamma Correlation

The radium-gamma correlation initially used for the final status survey was submitted to the NRC by letter dated August 6, 2001. The correlation study was approved by NRC letter dated August 30, 2001. This approval was conditional upon:

1. Conducting soil sampling of grids in the windblown tailings area with surface disturbances similar to the grids of concern, and

2. Confirm the acceptability of the gamma guideline value with additional radium-gamma correlation data during the final status survey.

Condition 1 required soil sampling of grids with surface disturbances such as tire tracks which may have an impact on the radium-gamma correlation. During windblown cleanup, areas in which meter readings indicated 11e.(2) byproduct material were excavated. Accordingly, surface disturbances were no longer present. Therefore, soil sampling was performed on the grids which exhibited the highest gamma values (upper 5%).

Preparation of the final status survey report included evaluating Condition 2 of the radium-gamma correlation. Based on soil samples collected in GHP-1 and the windblown area, it was determined that the conditionally approved correlation overestimated grid averages in GHP-1 and

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in the windblown area. The initial correlation underestimated grid averages by 2.3 pCi/g. As a result, the revised radium-gamma correlation was proposed in the FSSR, Volume I, submitted on October 27, 2003.

3.1 Background

3.1.1 Final Status Survey Findings

The 2002-2003 Gas Hills Site Final Status Survey investigations and cleanup efforts were extensive, entailing the removal of approximately 60,000 cubic yards of material and numerous surveys and characterization efforts—e.g., the GHP-1 geochemical investigation and the windblown area germanium detector evaluation (Umetco 2003). Despite these efforts, demonstration of cleanup was difficult, in that was confounded by the highly heterogeneous presence of NORM and mineralized areas which characterize the Gas Hills region.

Difficulties related to the derivation of representative background values for the highly heterogeneous and mineralized Gas Hills region are discussed at great length in the FSSR and, as discussed previously, were corroborated by the NRC.[4] As such, if it is not possible to derive a background statistic, it is not reasonable to derive a single cleanup level. Feasible cleanup criteria could be derived if the underlying background values adequately accounted for the wide variability in background values—e.g., if a 75th percentile value or several standard deviations above the mean were assumed, but these higher estimators (although suggested) were not approved by the NRC.

Furthermore, final status efforts indicated that additional cleanup may not result in a concomitant reduction in residual radioactivity. For example, cleanup of GHP-1—entailing the removal of over 30,000 cubic yards of material—resulted in a slight overall increase in average Ra-226 content because an underlying ore zone was encountered (Umetco 2003). In the case of the windblown area, cleanup of grids exceeding the approved 11.1 pCi/g Ra-226 cleanup level were found to result in a negligible (0.1 pCi/g) reduction in the average Ra-226 content.[5] The following evaluation will further corroborate this conclusion.

Given the factors cited above — 1) the difficulty in establishing representative, defensible background levels, and 2) the potential ineffectiveness of additional cleanup—an ALARA evaluation was undertaken, as documented in the following sections. Also germane to this discussion are the findings of the previous East Canyon Creek risk assessment and associated Alternative Criteria proposal, discussed below.

[4] See FSSR Sections 1.4 and 6.1 (Background Characterization Refinement), Umetco 2003; NRC 2001; and Umetco's response to NRC Comment 5.

[5] As discussed later in this section, the preliminary analysis of expected Ra-226 reduction presented in the FSSR (Umetco 2002) assumed a post-cleanup value of 11.1 pCi/g (i.e., the cleanup level) for all cleanup grids (Umetco 2003, Section 6.3). This assumption was modified in this analysis, however, to be more conservative (Section 3.4). Although the expected change in radium magnitude calculated herein is slightly higher than original estimates, the ALARA analysis still strongly supports the conclusion of negligible health benefit or risk reduction relative to the associated costs (Section 3.5).

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3.1.2 Alternative Criteria for East Canyon Creek Streambed

This alternative criteria proposal was based on an assessment of potential risks to the public and the environment from the 11e.(2) byproduct material remaining in the ECC channel, including the portion of Carbide Draw north of the county road (SMI 1999, 2000). The proposal also included a cost-benefit analysis of the remedial action. In their review of Umetco's proposal, the NRC concluded that: "*The long-term ecological damage, potential harm to threatened and endangered species, and high costs of remediation are not justified by any benefit that would result from soil remediation in ECC*" (NRC 2001). As such, the no-action alternative for East Canyon Creek was approved.

Deleted: As discussed in Umetco's response to NRC Comment 8, the Final Status Survey Plan proposed a no-action alternative for the East Canyon Creek drainage (Umetco 2000a).

Some of the cost issues assessed in the ECC assessment are not necessarily germane to the site areas evaluated herein. For example, the final status survey areas are not as ecologically sensitive as ECC, where disruption of wildlife habitat, wetlands impacts, and the preservation of cultural resources were key issues. However, the environmental impacts of increased erosion are still a factor for the windblown area and, most importantly, the conclusion that there would be no reduction in potential radiological dose to any likely area resident also still applies. This conclusion is supported by the results of the ALARA analysis, documented in Section 3.5.

3.2 Radiological Setting

Before presenting the ALARA analysis, it is important to reiterate that the Gas Hills site is located within a region characterized by uranium ore trends that has been heavily mined. This factor precluded the derivation of a statistically defensible Ra-226 background value and associated cleanup criterion. As demonstrated in the FSSR, it also impacted the feasibility and/or demonstration of cleanup (e.g., in ore-containing areas). This discussion focuses on the presence of NORM, as milling-related (i.e., 11e.(2) byproduct) impacts have been discussed at length in previous documents and were the subject of the preceding Final Status Survey Report.

3.2.1 Regional Geology

The Umetco Gas Hills facility is located in the Wind River Basin of Central Wyoming. The Wind River Basin is a large sediment filled, northwest-trending structural depression that was formed as a result of Late Cretaceous and Early Cenozoic tectonic activity. During the Eocene, continued uplift of the surrounding mountain ranges and subsequent erosion resulted in the deposition of the Wind River Formation. In the vicinity of Gas Hills, the Wind River Formation sediments were deposited in a series of coalescing alluvial fans and are characterized as a sequence of alternating and discontinuous layers of sandstone, siltstone, claystone, and conglomerate. This depositional environment resulted in the discontinuous occurrence of uranium deposits both vertically and laterally.[6]

[6] The Wind River Formation and underlying ore zones are discussed at length in the *Application for Alternate Concentration Limits*, submitted by Umetco in November 2001 and approved by the NRC in March 2002 (Umetco 2001). This document discusses at length the mineralogical and geochemical characteristics exhibited in Gas Hills region NORM areas, as well as areas impacted by mining and reclamation activities.

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Uranium occurs in rocks of nearly every age in the Wind River Basin, including crystalline rocks in the adjacent Precambrian uplifts (Hausel and Holden 1978). In the Gas Hills District, uranium typically occurs as roll-front deposits within the Wind River Formation, which is approximately 300 feet thick at the Umetco mill site. The uranium trend extends to the west of the Umetco facility as indicated by the mining operations of Pathfinder (see below), and also extends east and south of the site. The presence of this ore accounts for the historical prevalence of open pit uranium mining activities and resulting mining-related impacts both on and surrounding the Gas Hills site, discussed below.

3.2.2 Mining-Related Impacts and Regional Radiological Setting

The issue of mining-related impacts has been discussed at length in previous documents (Umetco 2000a, 2000b, 2001, 2003) and therefore is only briefly summarized here. From the late 1950s until 1984, uranium was mined from open pits in the Wind River Formation east, west, and south of the site by Pathfinder Mines Corporation, Umetco, the Tennessee Valley Authority (TVA) and a number of smaller mining companies. Figures 3.1 and 3.2 show the locations of these mined areas and demonstrate their spatial prevalence both on and adjacent to the Gas Hills site. Although most of these areas have been reclaimed—e.g., under the Wyoming Abandoned Mine Lands (AML) program—residual impacts are still apparent to the west, south, and east of the Gas Hills site. This elevated radioactivity in former mining areas is sometimes indistinguishable from that exhibited due to the underlying ore, also NORM, prevalent throughout the Gas Hills region.

To demonstrate some of the factors discussed above regarding the site geology, its regional heterogeneity, and the resulting mining- and milling related impacts, it is useful to compare the radiological characteristics exhibited in the early 1980s—coinciding with the later period of heavy mining and just prior to the termination of the Gas Hills milling operations—with those exhibited more recently. In 1981, the NRC commissioned EG&G to perform an aerial radiological survey of the Gas Hills Mining District (EG&G 1982). This 150 km^2 survey focused on the three uranium mills operating in the region at that time —Federal American Partners, Pathfinder Mines Corporation, and the Union Carbide (Umetco) facilities. This discussion is limited to the measurements made in the eastern survey portion, coinciding with the Gas Hills site.

Figures 3.3 and 3.4 show the isoradiation contours of excess Ra-226 and external exposure rates measured at and surrounding the Gas Hills site based on the NRC's survey (aerial photos taken in June 1981). Milling-related impacts attributable to the Gas Hills site are clearly evident, as are the mining-related impacts both on and adjacent to the site (also see Figures 3.1 and 3.2). However these figures also demonstrate the heterogeneity of the region, as indicated by the large variation in Ra-226 surrounding the site (Figure 3.3). According to the NRC, the large B-level north of the Gas Hills site—representing Ra-226 abundance in excess of the mean by 3 to 12 times the standard deviation—"appears to be a purely natural variation due to erosion of overburden from ore-bearing strata below" (EG&G 1982). Irrespective of Ra-226 magnitude (it was not determined by the survey), variations of 3 to 12 times the standard deviation of the mean

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Ra-226 are noteworthy and likely reflect the ore trends that characterize(d) the Gas Hills region.[7] It is also important to recognize that the mined areas (which include the Gas Hills mill site) reflect those areas containing the highest-grade ore—i.e., similar maps reflecting pre-mining and pre-milling radiological characteristics would likely exhibit the same spatial trends, albeit lower in magnitude.

Similar variation is demonstrated in Figure 3.4, which shows the distribution of terrestrial exposure rates. Levels ranging from 30-45 μR/hr (acknowledged as possibly underestimated by EG&G) characterize the mining regions west and south of the Gas Hills site. Some of these areas have been reclaimed (again, refer to Figure 3.1), but not all. Also, as stated above, it is important to recognize that the mined areas correspond to those regions exhibiting the highest ore grades. For comparison, Figure 3.4 also shows the results of the recent final status survey exposure measurements made for the Above Grade Tailings Pile and Heap Leach areas (see Figure 3.4 inset, based on Plates 1 and 2 of the FSSR). This inset shows that current exposure rate measurements for the above grade and heap leach are consistent with background levels, with most measurements ranging between 20 and 30 μR/hr. As discussed in the FSSR, some of the higher regions (30-45 μR/hr) are likely attributable to "shine" from adjacent mining areas.

Figure 3.5 shows the Ra-226 distribution based on the initial gamma survey conducted in 1995. This figure, adapted from FSSP Figure 3.2 (Umetco 2000a), clearly demonstrates the elevated radioactivity in offsite mining areas, the majority of which had been reclaimed under the AML program.[8] This is particularly evident in the reclaimed area to the west of the site, as well as the B-5 Pit. Levels measured in onsite areas at that time were comparable to and, in many cases—e.g., the majority of the windblown area, heap leach, and above grade tailings pile—lower than levels observed offsite. Radioactivity in these onsite areas has decreased since then as a result of subsequent cleanup and reclamation efforts as demonstrated in the FSSR (Umetco 2003). For example, the inset reflecting the post-cleanup Ra-226 distribution in the windblown area demonstrates the effectiveness of remedial efforts and shows an even more marked difference relative to offsite mining areas. Alternatively, although no 1995 gamma survey data were collected for GHP-1, the insets in Figure 3.5 comparing pre- vs. post-excavation conditions illustrate the fact that excavation in this area resulted in increased Ra-226 concentrations, reminiscent of B-5 Pit background conditions, as underlying ore zones were exposed. These findings are germane to the following ALARA analysis because they underscore the fact that, with respect to off-site radiological trends, further cleanup of onsite areas will have a negligible impact on dose/radioactivity reduction in the site vicinity and, in some areas, could result in a dose increase (vs. reduction).

[7] Hypothetically, even if the most conservative (unrepresentative) estimators were assumed—i.e., ignoring the natural variation and trimming the data set to remove all but the low-range Ra-226 values—e.g., a mean and standard deviation of 2 +/- 1 pCi/g Ra-226—a plausible background level for Ra-226 could be 14 pCi/g, even under the most conservative analysis.

[8] Figure 3.5 does not present data for the A-9 and C-18 pits, as no surveys were conducted in these areas; see Response to Comment 1 provided in Section 2 of this addendum. This comment response also discusses the results of previous evaluations of the North and South Evaporation Ponds.

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3.3 Technical Approach

The ALARA evaluation documented in the following sections was conducted in general accordance with the procedures outlined in Appendix D (ALARA Analyses) of the NRC's NMSS Decommissioning Standard Review Plan, or NUREG-1727 (NRC 2000), as referenced in NUREG-1620, Section H2.2.3(4).[9] The analysis uses the same exposure assumptions as those developed for the East Canyon Creek Alternative Criteria Evaluation (SMI 1999, SMI 2000). These assumptions were used in RESRAD calculations to derive Single Radionuclide Soil Guidelines (SRSGs) or Derived Concentration Guideline Levels (DCGLs) for Ra-226, assuming a 25 mrem/year dose limit (see Comment 5 response and Table 3.1 rationales). Although the ALARA analysis was only undertaken for the windblown area, the Ra-226 DCGLs can be applied to other areas of the site, including GHP-1, the DW-6 pipeline, and the trash pits.

Deleted: These DCGLs were derived for Ra-226, Th-230, and U-Nat (U-234, U-235, and U-238) and represent the concentrations in soil corresponding to the 25 mrem/year dose limit established by the NRC. ALARA calculations used only the DCGL for Ra-226, as the DCGLs for Th-230 and U-Nat were orders of magnitude greater than levels observed onsite.

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Two windblown cleanup scenarios were evaluated. The first was based on the number of 100 m^2 grids exceeding the previously approved 11.1 pCi/g Ra-226 cleanup level, determined based on the gamma survey results and supporting gamma-radium correlation provided in the FSSR (Umetco 2003). As such, this scenario assessed the costs and benefits resulting from the cleanup of an additional 403 grids. To address the possibility that the FSSR gamma-radium correlation underestimated soil Ra-226 (see NRC Comment 5), a more conservative scenario was assessed assuming that Ra-226 field estimates were approximately 2 pCi/g higher than those assumed in the first scenario (n = 1554 cleanup grids). Because of the uncertainty in some variables, both deterministic (i.e., using fixed parameter input) and probabilistic analyses were performed. The deterministic evaluation used fixed values for parameter input whereas the probabilistic analysis assigned distributions to certain parameters, reflecting the uncertainty in those estimates to better account for the potential variability in the data.

3.4 ALARA Analysis: Equations and Assumptions

As indicated above, the ALARA analysis was conducted in accordance with the procedures outlined in Appendix D (ALARA Analyses) of NUREG-1727 (NRC 2000), as referenced in Section H2.2.3(4) of NUREG-1620.

3.4.1 Calculation of Benefits: Collective Dose Averted

In the simplest form of the analysis, the only benefit estimated from a reduction in the level of residual radioactivity is the monetary value of the collective averted dose to future occupants of the site. This analysis uses the same critical group or exposed population as that assumed in the previous ECC risk assessment and the November 2001 groundwater ACL—i.e., a limited exposure occasional ranching scenario. Because the area in question is within the long-term care boundary, DOE contractors performing repairs on the site would also be a realistic assumption. The analysis presented assumes similar hours of exposure for both scenarios providing similar results. Table 3.1 documents the assumptions used in the following equations. The benefit from collective averted dose, B_{AD}, is calculated by determining the present worth of the future collective averted dose and multiplying it by a factor to convert the dose to monetary value:

[9] The NUREG-1727 guidance document supersedes the previous draft guide DG-4006 issued in August 1998.

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Equation 3.1: Present Worth of the Future Collective Averted Dose *NUREG-1727, Eq. D2*

$$PW(AD_{collective}) = P_D * A * BRDL * F * \frac{Conc}{DCGL} * \frac{1 - e^{-(r+\lambda)N}}{r+\lambda}$$

When N = 1000 yrs, this portion of the equation is essentially = 0.

where:

P_D	=	population density for the critical group scenario in persons/m^2
A	=	area being evaluated in square meters (m^2); see Tables 3.1 and 3.2
BRDL	=	Basic Radiation Dose Limit, 0.025 rem/yr
F	=	fraction of the residual radioactivity removed by the remediation action
Conc	=	average concentration of residual radioactivity in the area being evaluated (pCi/g). In this analysis, F is assigned a value of 1, but is accounted for by substituting "Conc" with $C_1 - C_2$, representing the change in average Ra-226 magnitude expected as a result of the remedial action
DCGL	=	derived concentration guideline equivalent to the average concentration of residual radioactivity that would give a dose of 0.25 mSv/yr (25 mrem/yr) to the average member of the critical group (pCi/g). DCGLs are analogous to the Single Radionuclide Soil Guidelines (SRSG) values in Table 3.2
r	=	monetary discount rate in units of yr-1
λ	=	radiological decay constant for the radionuclide in units of yr^{-1}
N	=	number of years over which the collective dose will be calculated.

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Table 3.1 Equation Terms and Assumptions Used in the ALARA Analysis

Parameter/ Equation Term	Definition	Assumed Value	Variable Type	Reference and Comments
$PW(AD_{collective})$	Present worth of future collective averted dose (units = person-rem)	See Equation 3.1	Calculated	NUREG-1727, Appendix D (ALARA Analyses), Eq. D2
B_{AD}	Benefit from averted dose for a remediation action ($ per person-rem)	$= PW(AD_{collective}) *$ \$2000 See Equation 3.2	Calculated	NUREG-1727, Appendix D, Eq. D1. $2000 is the value in dollars of a person-rem averted (NUREG/BR-0058, as cited in NRC 2000)
$Cost_R$	Monetary cost of remediation	*Minimum:* $635.25 per 100 m^2 grid – most conservative, does not include disposal costs. *Most Likely:* $826, = $635 + 30%)	Variable See Tables 3.3 and 3.4 for additional information.	Note that, unlike the total cost, $Cost_T$ described in NUREG-1727 (NRC 2000), costs here are for remediation only and as such are very conservative.
Cost per person-rem	$= Cost/PW(AD_{collective})$	See Equation 3.3	Calculated	$20,000 per person-rem is considered "prohibitively expensive" (NRC 2000, App. D, Section 4.0)
P_D	Population density for the critical group scenario	0.0004 persons/m^2	Fixed	NUREG-1727 default, Appendix D, Table D.2
A	Area being evaluated in square meters	25,000 m^2	Fixed	This area is consistent with that implied in the Nov-01 ACL, where the number of potentially exposed persons was 10 (i.e., 0.0004 persons/m^2 * 25,000 m^2).
BRDL = Basic Radiation Dose Limit	Annual dose to an average member of the critical group from residual radioactivity at the DCGL (see below).	25 mrem/year or 0.025 rem/year	Fixed	NRC (2003) dose criterion & default assumption in RESRAD code. Also consistent with groundwater ACL dose limit and NUREG-1620, Section H2.2.3(8).
F	Fraction of the residual radioactivity removed by the remediation action	1	Fixed	This factor was retained to be consistent with NUREG-1727. It is accounted for by substituting Conc with $C_1 - C_2$ (see below).
Conc: $= C_1 - C_2$	Reduction in average Ra-226 expected as a result of the remediation, where C_1 is current average concentration and C_2 is the expected post- cleanup average (pCi/g)	Depends on cleanup scenario	Variable	C_2 is calculated by conservatively assuming all cleanup grids have Ra-226 = 6.5 pCi/g (see Table 3.3)

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Table 3.1 Equation Terms and Assumptions Used in the ALARA Analysis, Cont.

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Parameter/ Equation Term	Definition	Assumed Value	Variable Type	Reference and Comments
DCGL Derived Concentration Guideline Level	Average concentration of residual radioactivity that would give a dose of 25 mrem/yr to the average member of the critical group	Equivalent to the Single Radionuclide Soil Guideline (SRSG) derived using the RESRAD code (see below).	= DCGL (see below)	See Table 3.2. Again, DCGLs discussed herein are theoretical and do not correspond to release criteria for soil cleanup at the Gas Hills site.
SRSG	Single Radionuclide Soil Guideline (SRSG), derived using the RESRAD code	Ra-226 = 141 pCi/g, based on ECC assumptions (Table 3.2)	Variable (some calculations used very conservative DCGL of 26.9 pCi/g; see Table 3.2 note and Appendix B)	DCGL equivalent calculated using RESRAD. All assumptions consistent with ECC dose assessment except exposure time and contaminated zone area & depth Monte Carlo calculations used a lower bound (most conservative) value of 26.9 pCi/g to explore potential worst-case scenarios.
r	Monetary discount rate	0.03/yr	Fixed	NUREG-1727, Table D.2, value applied to soils
λ	Radiological decay constant for Ra-226	0.000247/yr	Fixed	NUREG-1727, Appendix D, Section 1.4
N	Number of years over which the collective dose will be calculated.	1000	Fixed	NRC default value (NUREG-1727, Appendix D, Table D.2). This value is very conservative, as the peak dose for Ra-226 occurs at time t = 0. After 100 years, the DCGLs become so high as to essentially become moot - i.e., no dose would be averted (see SRSGs in Appendix A).

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Some slight modifications were made to the equations in NUREG-1727. In this analysis, the P_D and A terms were essentially combined to yield the number of potentially exposed persons. This area is consistent with that implicit in the November 2001 ACL, where the number of potentially exposed persons = 10 (i.e., 0.0004 persons/25,000 m^2 = 10 persons).

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Equation 3.2: Benefit from Collected Averted Dose (B_{AD}) *Source: NUREG-1727, Eq. D1*

Using the PW($AD_{collective}$) value determined above, the benefit from the collective averted dose is calculated as follows:

$$B_{AD} = \$2000 * PW(AD_{collective})$$

where:

B_{AD}	=	benefit from averted dose for a remediation action, in $
$2000	=	value in dollars of a person-rem averted
PW($AD_{collective}$)	=	present worth of future collective averted dose

The value derived using this equation is evaluated in the following context: Any future corrective action that costs more than the calculated B_{AD} does not support a concomitant health benefit.

3.4.2 Calculation of Costs

The averted cost per person-rem is calculated by dividing the cost by the collective averted dose, as follows:

$$\text{Cost per person-rem} = \text{Cost} / PW(AD_{collective})$$

As documented in Appendix A, the baseline cost estimate used in this evaluation includes the costs of remediation only, resulting in an estimate of $256,000 for the windblown area (assuming cleanup of 403 grids; see Section 3.4.4), corresponding to an average cost of $635 per 100 m^2 grid. These costs are very conservative in that disposal costs aren't accounted for, nor are other factors such as accidents and environmental damage (erosion, topsoil shortages), possible grazing issues with ranchers, and the potential costs of exceeding disposal capacity in GHP-2, depending upon the additional cleanup volume. Given these factors that weren't accounted for in the baseline estimate, the ALARA calculations used two cost estimates for each scenario—the conservative baseline estimate of $635 per grid (documented in Appendix A), and a more representative estimate assuming a 30 percent increment above that to account for disposal and other costs factors addressed in NUREG-1727.

3.4.3 Derived Concentration Guideline Level Derivation

This section documents the derivation of Single Radionuclide Soil Guidelines (SRSGs) based on the NRC RESRAD code (Version 6.21, September 5, 2002). These SRSGs are analogous to the DCGLs used in the preceding ALARA calculations. As indicated in Table 3.2, the assumptions used to calculate the soil guideline values are generally consistent with those applied in the ECC

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Table 3.2 Dose Assessment and DCGL Derivation: Assumptions and Results

Parameter	Original ECC Dose Assessment	FSS Addendum ALARA Analysis
ASSUMPTIONS:		
Pathways Evaluated	External gamma, inhalation (w/o radon), soil ingestion	same as original
BRDL	30 mrem/yr	25 mrem/yr*
Area of contaminated zone area	400 m^2	25,000 m^2 (see Table 3.1 basis)
Thickness of contaminated zone	2 m	0.15 m (6 inches)
Fraction of time spent outdoors (onsite)†	0.019 or 1.9%	0.019
All remaining assumptions:	NRC Default	NRC Default (see Appendix B)
RESULTS: SRSG or DCGL values		
Ra-226	**162 pCi/g**	**141 pCi/g**
Th-230	3.4E+04 (t = 10 yrs)	9.99E+03 (t=30 yrs)
U-234	8.81E+04	4.31E+04
U-235	2.75E+03	1.82E+03
U-238	1.17E+04	8.36E+03

* NRC RESRAD default assumption. See Appendix A for detailed summary reports.

Note:

The original East Canyon Creek (ECC) dose assessment was developed for a limited ranching exposure scenario (14 days/year, 12 hours/day) in support of the ECC Alternative Criteria Evaluation (SMI 1999, 2000). This evaluation was approved by the NRC in 2001 (see TER, NRC 2001). The corresponding assumptions and 162 pCi/g Ra-226 DCGL are presented for comparison purposes only, as the ECC assessment formed the basis for the ALARA analysis documented herein. The appropriate Ra-226 DCGL for this evaluation is 141 pCi/g.

As part of the standard RESRAD code output, SRSGs for Th-230 and U-nat were also calculated. These values are not presented here because they are not germane to this analysis (i.e., any elevated Th-230 and U-nat measured on site is attributable to the presence of native ore). However, for comparison purposes, it should be noted that these values are orders of magnitude greater than the 141 pCi/g DCGL calculated for Ra-226, and as such much greater than levels observed on site.

† Only the outdoor time fraction is listed above as the indoor time fraction does not apply—i.e., no one will live on site. In addition to the 141 pCi/g DCGLs listed above, a hypothetical worst-case scenario DCGLs was derived for Monte Carlo assessment calculations assuming an outdoor exposure fraction of 10 percent (vs. 1.9%). Using this assumption yielded a worse-case scenario DCGLs of 26.9 pCi/g. This value, comparable to the 25 pCi/g subsurface criterion (assuming a conservative site-background value of 10 pCi/g) was calculated primarily to provide a conservative upper bound on potential doses for Monte Carlo assessments and to demonstrate that the costs of remedial action are not justified by a concomitant health benefit, even under a worst-case exposure scenario. For all areas within the land transfer boundary shown on Figure 1.1, this hypothetical scenario can not occur at any present or future time because of mandated DOE long-term custodial care.

BRDL Basic Radiation Dose Limit
DCGL Derived Concentration Guideline Level, used in the ALARA cost-benefit calculations
SRSG Single Radionuclide Soil Guideline, RESRAD code term, equivalent to the DCGL

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risk assessment (SMI 1999, 2000). The only exceptions were modification of the Basic Radiation Dose Limit or BRDL (from 30 mrem/year to 25 mrem/year) and the contaminated zone area and depth. Using the assumptions documented in Table 3.1, a theoretical DCGL of 141 pCi/g was derived for Ra-226. This value was considered most representative and formed the basis for most of the ALARA analysis permutations presented herein (e.g., Table 3.4 results). As discussed in the notes accompanying Table 3.2, a worse-case theoretical DCGL of 26.9 pCi/g was calculated assuming amore conservative outdoor exposure fraction of 10%. This value was used as the basis for the conservative cost-benefit analysis plotted in Exhibit 3.3.

Deleted: DCGLs calculated for the ALARA calculations are summarized as follows: ¶

As mentioned several times in this document, the 141 pCi/g DCGL is theoretical and is derived herein for comparison purposes only – i.e., to demonstrate that residual Ra-226 levels in site areas are well below this dose-based guideline. Umetco does not intend to leave mill-impacted material of this magnitude. Rather, the ALARA analysis results documented in the remainder of this section support the conclusion that the Gas Hills site is suitable for release, pending completion of the remaining Final Status Survey components outlined in Section 1.1 of this addendum.

3.4.4 Cleanup Scenarios Evaluated

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<#>Th-230 . 9,990 pCi/g (peak dose t=30 yrs)¶
<#>U-234 . 43,100 pCi/g¶
<#>U-235 . 1,820 pCi/g¶
<#>U-238 . 8,260 pCi/g¶
The time of peak dose is 0 years for all constituents except Th-230 as indicated above. Although the ALARA calculations used only the DCGL derived for Ra-226, simple comparison of the values listed above with the concentrations measured onsite indicates that the residual radioactivity measured in final status survey areas (Umetco 2003) is well below levels that would present a health risk (using 25 mrem/year dose limit as a standard). ¶

As discussed previously in Section 3.3, two windblown cleanup scenarios were evaluated. To supplement the base-case scenario, which uses the gamma survey Ra-226 estimates documented in the FSSR, a second scenario applied a 1.84 pCi/g residual to all Ra-226 estimates—i.e., all 100 m^2 grid average Ra-226 values were increased by 1.84 pCi/g. This value was the average residual for all *underestimated* Ra-226 averages based on the corresponding soil sample results (see FSSR, Appendix C-3, Table 3). Note that the average residual for all soil sample results—including under- and overestimated values—was 0.2 pCi/g. The number of cleanup grids corresponding to the two cleanup scenarios were 403 and 1554, as illustrated in Exhibits 3.1 and 3.2 below. Scenario 1 would involve cleanup of areas north of the county road, coinciding with the prevalent NORM areas discussed at length in the FSSR (Umetco 2003). Scenario 2 is extremely conservative, and likely incorporates many grids reflecting background conditions. Detailed assumptions used to evaluate these cleanup scenarios are summarized in Table 3.3.

Exhibit 3.1
Windblown Cleanup Scenario 1: 403 grids

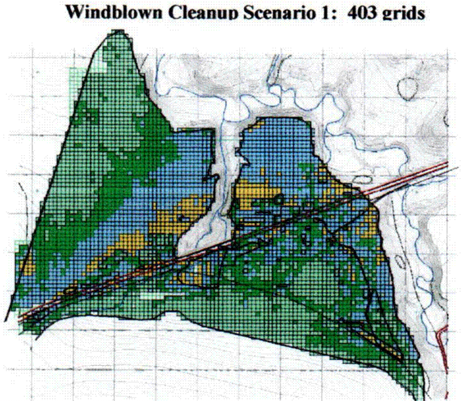
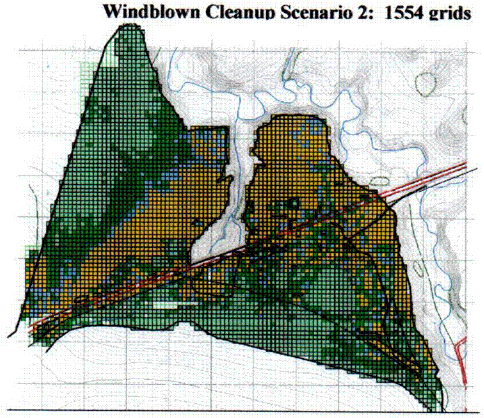


Exhibit 3.2
Windblown Cleanup Scenario 2: 1554 grids



In both exhibits, highlighted grids denote cleanup area.

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Table 3.3 Summary of Windblown Cleanup Scenarios Evaluated

Cleanup Scenario	Description	No. of Grids	Mean 1 (C_1)	Post-Cleanup Mean (C_2)	$C_1 - C_2$ (pCi/g)	Cleanup Volume & Cost
Scenario 1: Grids with Ra-226 > 11.1 pCi/g	Based on field estimates exceeding the previously approved 11.1 pCi/g windblown area cleanup goal	403	9.0 pCi/g 11.8 pCi/g	8.4 pCi/g 6.5 pCi/g	0.6 5.3	5,279 cu. yds. min cost = $256,005
Scenario 2: Grids with Ra-226 > 9.3 pCi/g	Applies 1.84 pCi/g residual based on all soil sample vs. field estimate results (see FSSR, Appendix C-2, Table 2). This scenario was evaluated to account for the uncertainty in the gamma-radium correlation, acknowledged by the NRC in Comment 5.	1554	10.8 pCi/g 12.4 pCi/g	7.3 pCi/g 6.5 pCi/g	3.5 5.9	20,357 cu. yds. min cost = $987,179

Note:

All Ra-226 values are based on gamma survey estimates documented in the FSSR (Umetco 2003). Costs are $635.25 per 100 m^2 grid as documented in Appendix A. The upper bound of the assumed cost range reflects the minimum plus 30%. Two sets of mean values are presented for each scenario in the table above. The first represents the most likely estimate, assuming Ra-226 is averaged over the 3761 grids comprising the primary and secondary windblown area (see figure inset below). The second set of C_1 and C_2 values were averaged only over the area corresponding to exceedance grids, resulting in a more conservative (but less likely) estimate.

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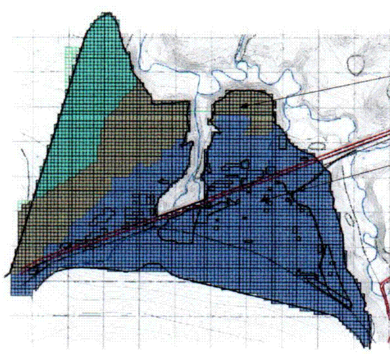

As documented in the FSSR, grid average Ra-226 concentrations did not vary significantly based on the number of grids over which results were averaged (see FSSR Section 6.3). To assess potential doses associated with hypothetical smaller averaging areas (e.g., on a grid-specific basis), refer to the Monte Carlo ALARA calculations (Appendix B, Section 3.5 summary), which reflect potential dose estimates on a grid-specific basis—all are still well below the 25 mrem/year criterion.

Regarding post cleanup Ra-226 assumptions, in the FSSR, all exceedance grids were converted to the 11.1 pCi/g cleanup level, but in fact this would overestimate the new average, as cleanup would likely be more effective. Therefore, for this analysis, the post-cleanup radium concentration was estimated based on FSSR results for cleanup grids. These results indicated a mean value of 9.3 pCi/g (+/- 1.7 pCi/g) and a range of 6.5 - 15.3 pCi/g, where the highest values reflect cleanup areas with underlying NORM. This analysis conservatively used the minimum of that range (6.5 pCi/g).

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3.5 ALARA Analysis Results

3.5.1 Deterministic Analysis Results

Table 3.4 (below) documents the results of the ALARA analysis using a deterministic (i.e., fixed parameter) approach.

Table 3.4 ALARA Results for Windblown Cleanup Scenarios

Scenario	Model Permutation	Scenario Description	$PW(AD_{collective})$, in person-rem	B_{AD}	Cost per person-rem
1a	$C_1 - C_2 = 5.3$ pCi/g Cost = $256,000	most conservative scenario	0.31	$621	$824,000
1b	$C_1 - C_2 = 5.3$ pCi/g Cost = $332,800	Same as above, but costs more likely	0.31	$621	$1,071,200
1c	$C_1 - C_2 = 0.6$ pCi/g Cost = $256,000	$C_1 - C_2$ term better reflects exposure area	0.04	$70	$7,278,800
1d	$C_1 - C_2 = 0.6$ pCi/g Cost = $332,800	Same as above, but costs more likely	0.04	$70	$9,462,400
2a	$C_1 - C_2 = 5.9$ pCi/g Cost = $987,200	most conservative scenario	0.35	$692	$2,854,400
2b	$C_1 - C_2 = 5.9$ pCi/g Cost = $1,283,300	Same as above, but costs more likely	0.35	$692	$3,710,600
2c	$C_1 - C_2 = 3.5$ pCi/g Cost = $987,200	$C_1 - C_2$ term better reflects exposure area	0.21	$410	$4,811,600
2d	$C_1 - C_2 = 3.5$ pCi/g Cost = $1,283,300	Same as above, but costs more likely	0.21	$410	$6,255,000

Windblown Area Cleanup Scenario Definitions

Cleanup Scenario 1: 403 Grids, Ra-226 > 11.1 pCi/g
Cleanup Scenario 2: 1554 Grids, Ra-226 + 1.84 pCi/g > 11.1 pCi/g

All calculations apply to Ra-226 only, assuming the most representative DCGL of 141 pCi/g (see Section 3.4.3).

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All costs above were rounded to the nearest $100; BAD were not values were not rounded, however. The baseline (most conservative) cost assumption was $635.25 per grid (Appendix A), with the more likely estimate being $825.83 per cleanup grid (baseline plus 30%). Although some economies of scale may not be reflected for the 2nd cleanup scenario (cleanup of 1554 grids), the assumed costs are still considered conservative. $PW(AD_{collective})$ is the present worth of the future collective averted dose.

Interpretation of B_{AD} Values: B_{AD} represents the benefit from averted dose for a remediation action (in $ per person-rem). Any future corrective action that costs more the calculated value does not support a concomitant benefit.

Interpretation of cost per person-rem: The costs listed above are substantially higher than the $20,000 cost per person-rem considered "prohibitively expensive" (NUREG-1727, NRC 2000). As such, the costs of further remedial action are not justified by the ALARA analysis, even under the most conservative scenarios.

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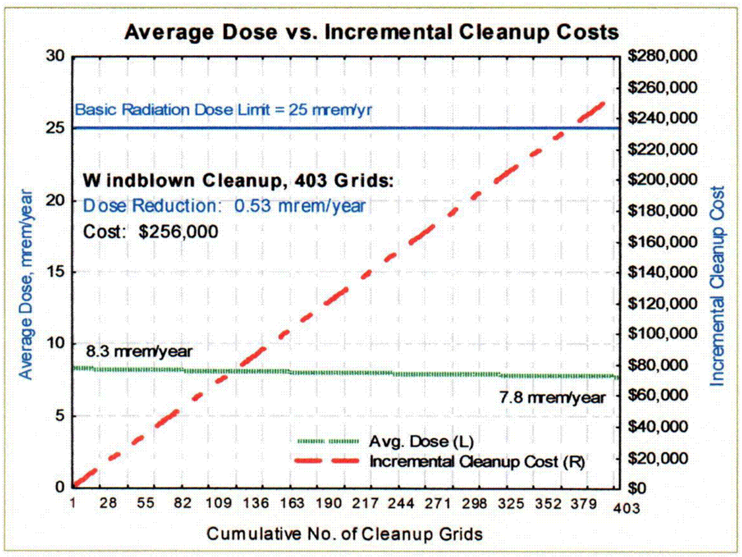
As indicated in the preceding table, costs per person-rem ranged from \$824,000 to \$9,462,400, reflecting both conservative and more representative scenarios. These costs are substantially higher than the \$20,000 cost per person-rem considered "prohibitively expensive" (NUREG-1727, NRC 2000). Underlying this guideline is the determination that a remediation would be prohibitively expensive if the cost to avert dose were an order of magnitude more than the cost recommended by the NRC for an ALARA analysis—i.e., the \$2,000 per person-rem used to calculated B_{AD}, or the benefit from averted dose (NRC 2000; also see NUREG/BR-0058, as cited in this document). Therefore, the costs of further remedial action are not justified by the ALARA analysis.

To present an alternative presentation of these findings, Exhibit 3.3 plots the incremental dose corresponding with iterative cleanup (whereby grids with highest Ra-226 magnitude are cleaned up first) vs. corresponding costs. This graph, developed using the most conservative DCGL (see Table 3.2 notes), clearly demonstrates the nominal dose reduction that would result from windblown area cleanup.

Exhibit 3.3



3.5.2 Probabilistic Analysis Results

To assess the ramifications of varying certain parameter values—e.g., the Ra-226 average concentration term (C_2 and C_1), costs and the assumed DCGL values—a probabilistic analysis was conducted using the assumptions documented in Appendix B. This analysis was conducted using Crystal Ball® using individual grid data for the C_1 term, thereby addressing any potential uncertainties associated with the average concentration reduction assumed in the deterministic analysis—i.e., depending on the area over which Ra-226 was averaged, the contaminant

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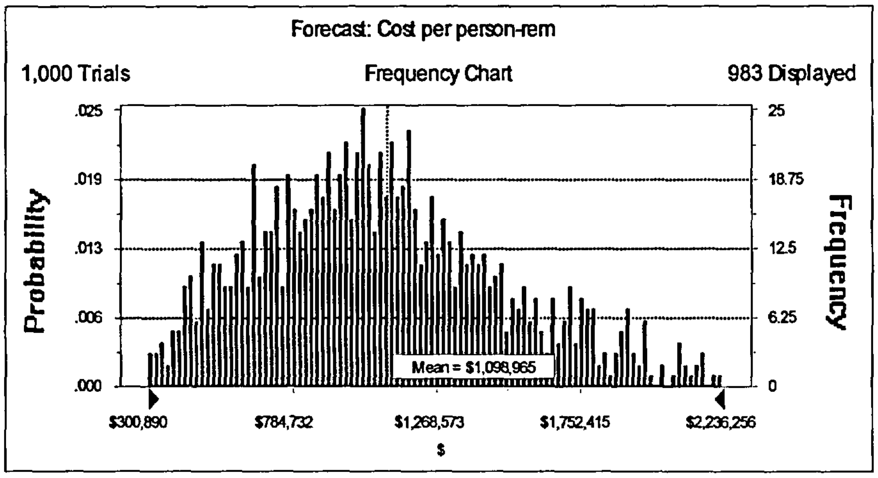
reduction could be over- or under-estimated and "hot-spots" would not be addressed. Additionally, a conservative lower bound DCGL of 26.9 pCi/g was included in the calculations to reflect a worst-case exposure scenario. Detailed assumptions and the corresponding distributional and forecast assumptions are documented in Appendix B. The following exhibit shows the results for the cost per person-rem, which corroborate the results of the previous deterministic analysis. This plot also demonstrates that even in the worst-case scenario (the lowest values on the chart), the costs per person-rem still exceed the costs of remediation.



3.6 Summary of ALARA Demonstration

Radiation protection regulations mandate that doses be ALARA, taking into account the state of technology, the economics of improvement in relation to benefits to public health and safety, other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest. License termination, or site decommissioning, requires that the licensee demonstrate that the applicable dose criteria have been met and that doses are ALARA.

The results of the ALARA analysis presented in Section 3.5 demonstrate that further windblown area cleanup is not justified. The ALARA analysis was not conducted for GHP-1 because the cleanup documented in the FSSR had proceeded to the point where cleanup efforts were counterproductive – i.e., underlying ore zones were encountered resulting in increased radionuclide concentrations making cleanup essentially technically unachievable.

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Deleted: Despite the latter, residual radioactivity in GHP-1 and other site areas can simply be compared with the DCGLs derived for soils in Section 3.4. These comparisons indicate that levels are well below levels that would be protective.

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4.0 DW-6 PIPELINE SUPPLEMENTAL EVALUATION

This section elaborates upon issues discussed in Umetco's response to NRC Comment 4 (Section 2); some of these issues are reiterated here for clarity. The reader should refer back to this comment for proper context and additional information.

4.1 Geospatial Estimation of 100 m^2 Ra-226 Grid Average Values

As discussed in the response to Comment 4 (Section 2), the FSSR data presentation, which consisted of discrete gamma readings and concomitant data summaries, differed from the standard assessment based on a 100 m^2 grid because the linear pipeline/trench configuration was thought to preclude such an approach. To address the NRC's concerns, geospatial estimation tools in ArcView were used to estimate 100 m^2 grid averages, thereby satisfying the assessment criterion set forth in 10 CFR 40, Appendix A, Criterion 6(6). The grid averages were estimated based on the gamma survey data provided in the FSSR, using the gamma-radium correlation derived based on GHP-1 pond data (FSSR, Appendix B-2). As discussed in the response to Comment 9, the GHP-1 gamma-radium correlation was applied to the pipeline survey data due to the proximity of these two areas and because data were not available at the time to establish a pipeline-specific algorithm. The soil sample results presented in Section 4.2 (below) could not be used for correlation purposes because their locations had not been surveyed (and as such are approximate) and because the samples had been composited over too large an interval (150 ft or 46 m) to allow valid comparison.[10]

The resulting kriged estimates are shown in Figures 4.1 and 4.2. These figures show the complete pipeline view relative to mining areas (Figure 4.1) and a larger-scale subarea view along with corresponding kriged estimate summaries (Figure 4.2). Based on kriging techniques, the majority of the 233 100 m^2 grids are well below the appropriate 25 pCi/g Ra-226 subsurface standard. Only 10 grid estimates exceed 25 pCi/g—all occurring in Area 1, adjacent to the B-5 Pit—and these exceedances are slight (maximum was 30 pCi/g; see Figure 4.2). These kriged estimates are likely overestimated (see below) and, as discussed in the FSSR and in the response to Comment 4, are considered reflective of NORM.

4.2 Soil Sample Analytical Results

Twelve archived composite samples collected along the pipeline were submitted for analysis of Ra-226, Th-230, and U-Nat. These samples were collected in February 2002 and were composited within 150 ft intervals; the archived samples were submitted for analysis in March 2004. Table 4.1 summarizes the results. Because soil sample locations were not surveyed, these results can not be directly compared with the kriged Ra-226 grid average estimates discussed above and shown in Figure 4.2. However, because the samples submitted for analysis were chosen to reflect the areas exhibiting the highest gamma survey readings, the results can be used to demonstrate the conservatism of these estimates.

[10]Another reason the meter Ra-226 readings do not correlate well with the soil sample results is that the readings were from the bottom of the trench excavation. The pipeline excavation was typically 3 to 4 feet wide and 3 to 4 feet in depth. This geometry resulted in augmented meter readings resulting from "shine" through the top of the collimator.

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As shown in Table 4.1, Ra-226 levels ranged from 3.7 to 14 pCi/g Ra-226, well below the applicable 25 pCi/g subsurface criterion. Note that six of these samples were collected in Area 1, the area exhibiting the highest gamma survey readings likely stemming from the adjacent B-5 Pit. Exhibit 4.1 (below) plots the radionuclide distributions in pipeline soil samples (n = 12) vs. those measured in B-5 pit samples. The B-5 pit results represent the merged results of test pit sampling conducted in 2001 and 2002 for the final status survey (see FSSR Section 5). As shown in this exhibit, the magnitude of Ra-226, Th-230, and U-Nat in DW-6 samples is well below B-5 pit background levels and appear to be in equilibrium.

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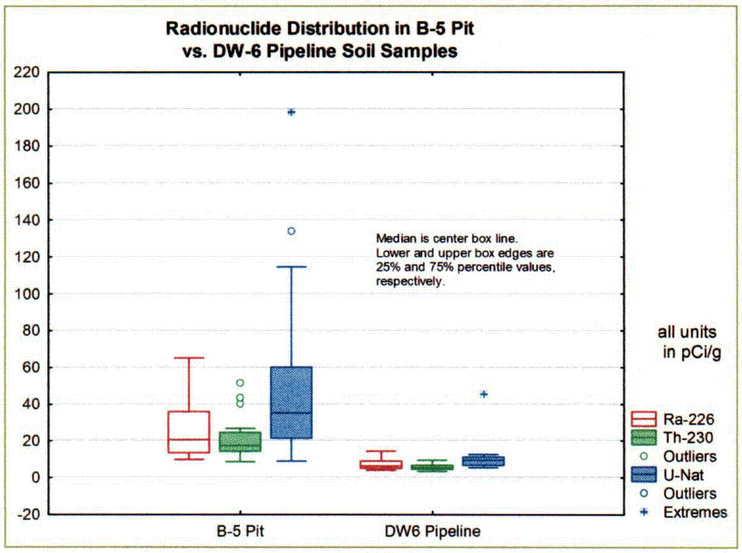
Exhibit 4.1



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5.0 GHP-1 SUPPLEMENTAL EVALUATION

This section provides supplementary data and information in response to NRC Comment 6 regarding the demonstration of the petroleum cleanup.

Total Petroleum Hydrocarbon (TPH) Sampling

In May 2002, petroleum affected soils were identified in the northern GHP-1 pond section, coinciding with the location of the former mill solvent catch basin (see FSSR Table 5.1 and Figure 5.1). The petroleum-affected soils were identified primarily by odor and were subsequently excavated an additional 6 feet until the odor was no longer apparent. In response to NRC Comment 6, five soil samples were collected from the area previously exhibiting the greatest petroleum impacts prior to excavation, corresponding to the former mill solvent catch basin shown in Exhibit 5.1 below. Samples were collected on January 26, 2004 and submitted to ACZ for Total Petroleum Hydrocarbon (TPH) analysis. Table 5.1 presents the analytical results.

Exhibit 5.1. January 2004 GHP-1 TPH Sampling Locations

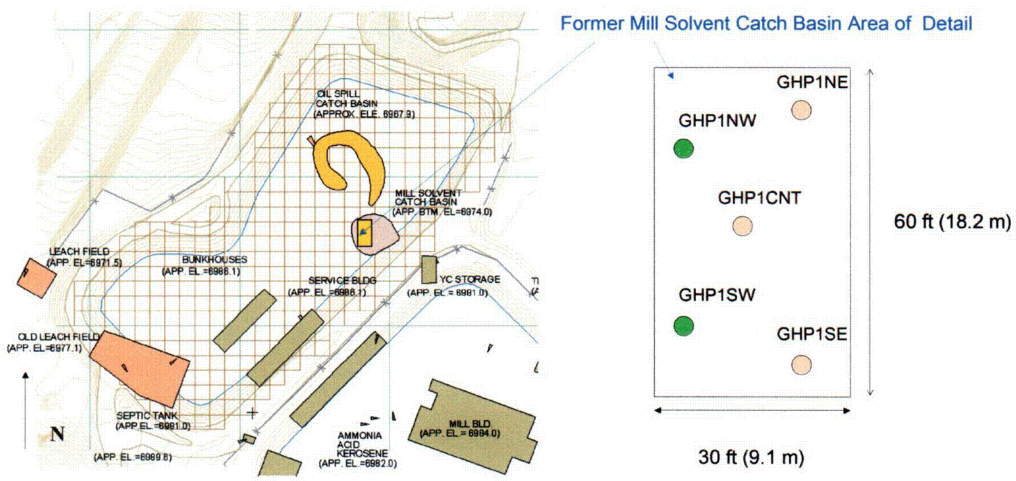

Table 5.1 GHP-1 TPH Soil Analytical Results

Laboratory ID	Sample ID	TPH (mg/kg)	% Solids
L44432-01	GHP1SE	6	79.5
L44432-02	GHP1SW	<3	82.9
L44432-03	GHP1CNT	4	87.1
L44432-04	GHP1NE	10	87.5
L44432-05	GHP1NW	<3	89.9

Samples were collected on 1/26/04 and analyzed on 2/5/04 by ACZ using EPA Method 8015B (GC/FID). Method detection limit = 3 mg/kg. See full data report in Volume II, Appendix B.

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Samples were analyzed for TPH content based on site (MSDS) records indicating that a kerosene spill was the most likely source of the observed impacts. Kerosene falls within the C_{10}-C_{32} carbon range, also referred to as Diesel Range Organics (DRO), which are quantified using EPA Method 8015B. As shown in Table 5.1, TPH results for the 3 samples exhibiting detectable concentrations are well below the 100 mg/kg DRO (TPH) Wyoming cleanup standard for hydrocarbon contaminated soil.[11] As such, no health or environmental risk is expected from residual TPH levels in soils. Additionally, based on the depth to groundwater measured in nearby well MWI64, approximately 178 ft, migration of petroleum residuals to underlying groundwater is not an endpoint of concern. [MWI 64 is located approximately 130 ft from the northwestern edge of GHP-1.] The latter findings, coupled with the ultimate disposition of the pond—reclamation and eventual transfer to DOE with perpetual restricted use—suggest that non-radiological hazards associated with the pond have been adequately addressed.

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[11] Wyoming Water Quality Rules and Regulations, Chapter XVII, Underground Storage Tanks, Appendix A. Procedures for Establishing Environmental Restoration Standards for Leaking Underground Storage Tank Remediation Actions. This model is similar to ASTM's Risk-Based Closure Assessment (RBCA) methodology. Note that the Gasoline Range Organics (GRO, C10-C32) analysis, addressing the more hazardous and typically more mobile volatile organic constituents (benzene, ethylbenzene, toluene) is not required for kerosene spills.

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6.0 REFERENCES

EG&G 1982. An Aerial Radiological Survey of the Federal-American Partners, Pathfinder, and Union Carbide Mill Sites and Surrounding Area. Gas Hills Mining District, Wyoming. Date of Survey: October 1981. Work performed by the EG&G measurements group for the U.S. NRC, EG&G Survey Report, NRC-8206. July 1982.

Hausel, D.W., and G.S. Holden. 1978. *Minerals Resources of the Wind River Basin and Adjacent Precambrian Uplifts.* In Resources of the Wind River Basin, Wyoming Geological Association, 30th Annual Field Conference 1978.

Shepherd Miller, Inc. (SMI). 1998. *Design Report Part I, Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository.* October 1998.

Shepherd Miller, Inc. (SMI). 1999. *Human Health and Ecological Risk Assessment, East Canyon Creek Streambed, Gas Hills, Wyoming.* May 1999.

Shepherd Miller, Inc. (SMI). 2000. *Addendum to East Canyon Creek Dose Assessment in Response to NRC Comments.* September 2000.

Umetco Minerals Corporation. 2000a. *Final Status Survey Plan, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000b. *Final Background Characterization Report, Gas Hills, Wyoming Site.* September 2000.

Umetco Minerals Corporation. 2000c. Letter to P. Ting (U.S. Nuclear Regulatory Commission, Chief, Fuel Cycle Licensing Branch) from T. Gieck, Umetco. RE: "Gas Hills, License Number SUA-648; Docket #40-0299; Final Background Characterization Report and Final Status Survey Plan. Letter dated November 17, 2000.

Umetco Minerals Corporation. 2001. *Final Application for Alternate Concentration Limits for Gas Hills, Wyoming.* November 2001.

Umetco Minerals Corporation. 2003. *Final Status Survey Report, Gas Hills Wyoming Site.* October 2003.

U. S. Environmental Protection Agency (EPA). 1994. *Title 40, Code of Federal Regulations, Environment.* January 1, 1994.

U. S. Nuclear Regulatory Commission (NRC). 1999. NRC letter approving revisions to License Condition No. 58 re: *Design for Enhancement of the Previously Approved Reclamation Plan for the A-9 Repository for Material License SUA-648, Amendment 42.* December 9, 1999.

U.S. Nuclear Regulatory Commission (NRC). 2000. NMSS Decommissioning Standard Review Plan. NUREG-1727. Division of Waste Management, Office of Nuclear Material Safety and Safeguards. September 2000. [*Note: This document supersedes the previous draft guide DG-4006 issued in August 1998.*]

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

U. S. Nuclear Regulatory Commission (NRC). 2003a. Letter from E. Brummett to C. Sealy (Umetco) re: "Request for Additional Information Concerning the Umetco Minerals Corporation's Final Status Survey Report for the Gas Hills Uranium Mill Tailings Site, SUA-648 (TAC No. LU0013)." Letter dated December 31, 2003.

U. S. Nuclear Regulatory Commission (NRC). 2003b. *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 of 1978.* NUREG-1620, Revision 1. June 2003.

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