Final Report:









INTERIM REMOVAL ACTION

FINAL REMOVAL SITE EVALUATION (RSE) REPORT FOR QUIVIRA SITE EVALUATION FOR CHURCH ROCK (CR-1) AND (CR-1E) MINE SITES

Prepared For:

Rio Algom Mining LLC

Prepared By:

SENES Consultants Limited

September 2011

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for

NORTHEAST CHURCH ROCK - QUIVIRA SITE EVALUATION for CHURCH ROCK (CR-1) and (CR-1E) MINE SITES

Prepared for:

Rio Algom Mining LLC

Prepared by:

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EXECUTIVE SUMMARY

Background

This Final Removal Site Evaluation (RSE) Report provides information on the "time-critical" mitigative work performed and characterization data collected at or near the former mines sites referred to as the Northeast Church Rock Quivira Mine Site under the United States Environmental Protection Agency (EPA) Administrative Order of Consent (AOC) dated 2010 (CERCLA Docket No.201-13). In accordance with the requirements of the AOC (EPA, 2010a), the work was planned and implemented as a two phase work program.

The Northeast Church Rock Quivira Mine Site consists of Church Rock 1 (CR-1) and Church Rock 1E (CR-1E) sites. The former mine sites are located in Section 35, T17N, R16W and Section 36, T17N, R16W, respectively of McKinley County. Mining related activities were carried out from the late 1960's and curtailed in early 1985 on Navajo Tribal Uranium Leases 14-20-0603-9987 and 14-20-0603-9988 respectively. Quivira Mining Company surrendered the lease properties to the Navajo Nation in February, 1987. Quivira Mining was subsequently sold to the predecessor company of Rio Algom Mining LLC (RAML) in 1988.

Program Overview

The Phase I program entailed the implementation of remedial measures including erosion control of site materials, perimeter fencing, and mitigation of actual or potential releases from Red Water Pond Road (RWPR), the mine entrance road and the shoulders, and sampling in accordance with the provisions of the AOC and the associated Phase I Scope of Work (SOW) (RAML, 2010a).

Phase II of the program entailed the characterization of surface and sub-surface soils and sediments from the mine sites via shallow surface and deeper subsurface sampling within prescribed areas of the lands associated with the respective mine sites including the waste rock piles, all former treatment ponds, discharge points into Unnamed Arroyo #2, any mixed waste disposal areas, and off site areas (Step-out) adjacent to the mine site boundary where wind and water transport may carry materials. The Phase II work was conducted in accordance with the provisions of the AOC and Phase Scope of Work (SOW) plan as amended and approved by EPA (RAML, 2010b).

The specific approved actions to be undertaken as part of the Phase I portion of the overall program were outlined in the document entitled "Church Rock Mine Sites #1 and 1E (Quivira) Mine Removal Site Phase 1, Interim Removal Action Work Plan", developed by SENES Consultants Limited (SENES) on behalf of RAML, August 2010 (RAML, 2010a) and approved by the US EPA.

The approved actions to be undertaken as part of the Phase II portion of the overall program were outlined in the document entitled “Removal Evaluation Work Plan Church Rock Sites #1 and 1E Phase II, developed by SENES on behalf of RAML, December 2010 (RAML, 2010b) and as amended by the 16 March 2011 technical memorandum on proposed drilling as amended through further discussions with the EPA (SENES 2011a,b,c).

Phase I Implementation Actions

Following approval of the work plan, logistics preparation and mobilization, the Phase I field work was initiated on 3 October 2010 and continued through 20 November 2010. US EPA and Navajo EPA representatives were present during the course of the work activities. The work was carried out in accordance with corporate health and safety guidelines without incident and included:

- inspection of approximately 7,000 feet of fencing with repairs and replacement of fencing as needed at CR-1;
- surface grading and shaping of approximately 2 acres prior to the placement of slope stabilization materials on the west side and partial south side of the CR-1 waste rock pile;
- chip seal placement on RWPR from intersection of route 566 to the south side of bridge over the Unnamed Arroyo #2, and placement of soil sealant on RWPR north of the bridge and 50 feet to the west of site access point as well as on the access ramp;
- erosion control works on the shoulder of the RWPR and along the west slope of CR-1 waste rock pile;
- soil sampling at 38 selected stations along RWPR and the toe and slope of the CR-1 waste rock pile; and
- static and scanning gamma survey measurement along the RWPR and Step-out areas and the slope and toe of the CR-1 waste rock area.

Phase II Implementation Actions

The Phase II program work plan was approved in a two stage process. Following the initial review of the Phase II work plan by the EPA, logistics preparation and mobilization, the initial portion of the Phase II field work commenced on 8 December 2010 and continued through 16 December 2010. Both U.S.EPA and Navajo representatives were present during the course of these work activities. The work was carried out in accordance with RAML corporate health and safety guidelines without incident and included:

- soil sampling at 39 selected stations at thirteen cross section in the Unnamed Arroyo #2;
- soil sampling at 15 selected stations at seven cross sections in the Pipeline Arroyo;
- static gamma measurements at sample locations within the respective arroyos;
- shallow soil sampling at 49 selected stations within the lease area of CR-1 and seven within the Step-out area of CR-1;

- surficial soil sampling at ten selected stations within the lease area of CR-1E and five within the Step-out area of CR-1E; and
- static and scanning gamma survey measurements across a portion of the CR-1 site.

Pursuant to the approval of the EPA, the second stage of the Phase II program, the deeper subsurface investigation, was initiated on 26 April 2011 and continued through 5 May 2011. A representative of the US EPA was on site during the course of this part of the work activities. As with Phase I, the work was carried out in accordance with RAML health and safety guidelines without incident and included:

- soil sampling at five selected stations across the waste rock area of CR-1;
- soil sampling at thirteen selected stations across the sediment pond area of CR-1;
- soil sampling at two selected stations across the industrial area of CR-1;
- soil sampling at two selected stations across the waste rock stockpiles of CR-1E;
- soil sampling within the limits of the single former pond at CR-1E;
- soil sampling at two selected stations within the industrial area of CR-1E;
- soil sampling at deeper intervals at twenty-four locations within the lease and Step-out areas of CR-1E; and
- completion of the static and scanning gamma survey measurements across CR-1 and CR-1E sites.

Characterization Results

Extensive data for the Church Rock sites have been collected through these programs as described within this report. In brief, the key observations can be summarized as follows:

The results of the non-radiological parameter analysis did not identify any contaminants of concern within the industrial areas of CR-1 or CR-1E; however, the results from one sample location within the sediment pond area of CR-1 did show the presence of diesel fuel at this location at a concentration above the New Mexico standard. The results of the TCLP and SPLP did not identify any parameters of concern.

The condition of the sites is as expected for remediated mine sites with generally low concentration material covering some higher activity material (waste rock). Surface and sub-surface measurements indicate that a number of locations exceed the AOC defined preliminary action level (PAL) of 2.24 pCi/g Ra-226.

Limitation

This report presents the analytical results obtained during the sampling conducted pursuant to the ordered removal action. No opinions are provided regarding the source(s) of any of the contaminants analyzed at any of the locations.

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ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
BLM	Bureau of Land Management
BMP	Best Management Practice
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	U.S. Code of Federal Regulations
CR	Church Rock
COC	contaminants of concern
cpm	counts per minute
DAC	derived air concentration
EPA	U.S. Environmental Protection Agency
GE/UNC	General Electric/United Nuclear Corporation
HSEC	Heath, Safety, Environment & Community
MARSSIM	Multi-Agency Radiation Site and Survey Investigation Manual
NaI	sodium iodide
NNEPA	Navajo Nation Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
OSC	On Scene Coordinator
PAL	Preliminary Action Level
pCi/g	picocuries per gram
pCi/L	picocuries per liter
QA/QC	quality assurance / quality control
QAPP	Quality Assurance Project Plan
Ra-226	radium 226
RAML	Rio Algom Mining LLC
RSE	Removal Site Evaluation
RSO	Radiation Safety Officer
RWPR	Red Water Pond Road
SAR	Sodium Absorption Ratio
SENES	SENES Consultants Limited
SOP	Standard Operating Procedure
SOW	Scope of Work
SWPPP	Storm Water Pollution Prevention Plan
Th-230	thorium 230
U	Uranium (total)
µg/L	microgram per liter
µCi/mL	micro curie per milliliter

1.0 BACKGROUND AND INTRODUCTION

This section provides a brief overview of the history of the Quivira Church Rock Mines sites, an overview of the Phase I and II programs, a project management, organizational and report structure.

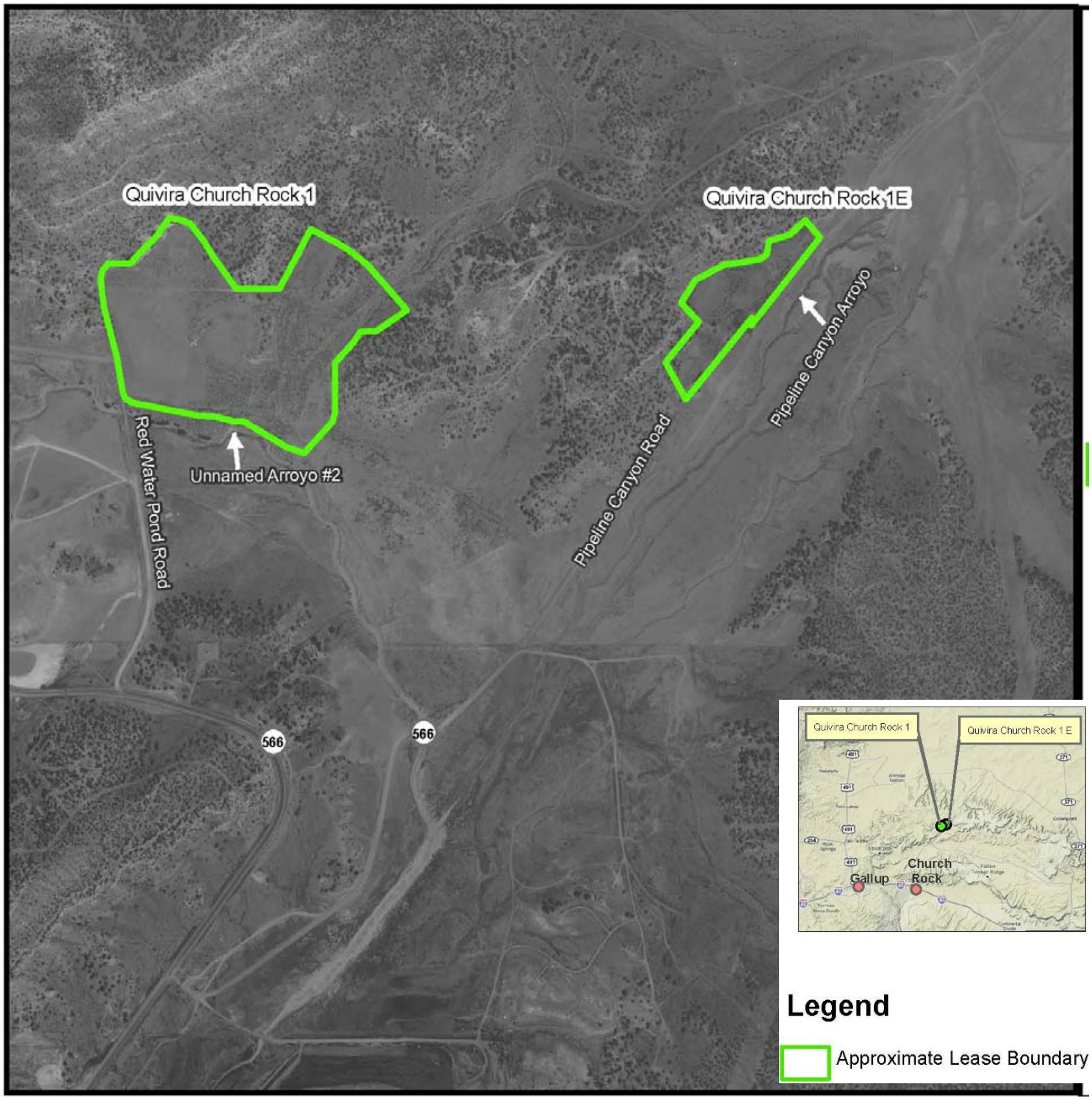
1.1 SITE HISTORY

The Northeast Church Rock Quivira Mine Site consists of Church Rock 1 (CR-1) and Church Rock 1E (CR-1E) sites. The former underground mine sites are located in Section 35, T17N, R16W and Section 36, T17N, R16W, respectively of McKinley County. Mining related activities were carried out from the late 1960's and curtailed in early 1985 under Navajo Tribal Uranium Leases 14-20-0603-9987 and 14-20-0603-9988 respectively. Ore from the underground deposits was trucked to Quivira's Ambrosia Lake property. Quivira Mining Company surrendered the lease properties in February, 1987. Quivira Mining was subsequently sold to the predecessor company of Rio Algom Mining LLC (RAML) in 1988. Plate 1.1-1 shows the locations and general outline of CR-1 and CR-1E.

Records indicate that the mine was placed in standby mode on January 31, 1985. Quivira Mining Company submitted an Abandonment and Reclamation Plan to U.S. Bureau of Land Management (BLM) in January 1987. The Abandonment and Reclamation Plan was reviewed by the BLM, Navajo Tribal Government and Bureau of Indian Affairs as part of the Department of Interiors trust responsibilities. On September 5, 1990, a "Finding of No Significant Impact" and a final Record of Decision by the BLM was issued that allowed for the reclamation of Church Rock I and IE in accordance with the stipulated conditions.

According to the plan and conditional approval, mine dewatering pumps were removed from Church Rock 1 in January 1986. Additional work outlined in the plan and approval included the removal of mine equipment including hoists, compressors, headframes, and generators from the site; buildings were removed and foundations destroyed; sediments from the mine water ponds were excavated and placed in shaft and ventilation raises and pond sediments and waste rock were deposited in these underground openings; grizzlies were placed over all shaft openings and monitored for 1 year for subsidence and backfilled as needed, prior to capping with a 4 foot concrete cap. Mine excavation waste rock piles and all disturbed areas were covered with a minimum of 1 foot of topsoil and reseeded. Bore hole foundations supporting the casing wall remained in place, but surface ventilation fans, transformers, switches, ductwork, electrical cables, and fences were removed from the bore hole area.

Plate 1.1-1 General Location & Site Plan



1.2 Program Overview

Work Plans were prepared for two phases of work in accordance with the AOC and SOW (EPA, 2010a). The AOC and SOW were previously provided as Exhibits A and B, respectively, of the Phase I Work Plan.

The Phase I Work Plan was provided to the EPA on 26 August 2010 (RAML, 2010a). Phase I work consisted primarily of characterization and chip sealing of portions of Red Water Pond Road and erosion control and fencing work at CR-1.

The Phase II Work Plan was provided to the EPA on 7 October 2010 (RAML, 2010b), conditional approval was provided by EPA on 5 November, a redline version of the revised work plan was provided 7 December 2010 (RAML, 2010c). The accepted copy was sent by RAML to US EPA on 10 December 2010. In keeping with EPA discussions, a technical memorandum amending the work plan was provided in a 16 March 2011 (RAML, 2011a) document that provided the work plan for collection of deeper subsurface soils at selected CR-1 and CR-1E sampling locations. Phase II work consists of characterization work at CR-1 and 1E as well as related arroyos located immediately adjacent these sites.

In association with the above works, an agronomic survey and cultural resource assessments were also carried out at CR-1 and CR-1E sites as part of the overall program.

The agronomic characterization study (Bamberg, 2010a) was advanced from the Phase II schedule and carried out in parallel to the Phase I work (see Appendix C). The studies included identification of the various plant species, their density and diversity of current vegetative cover at CR-1 and 1E. This study included physical and chemical soil characterization associated with each site.

Cultural resources studies were completed by Dinétahdóó Cultural Resources Management (DCRM, 2010a, 2011a) in conjunction with advice and guidance from the Navajo Preservation Office in Window Rock, Arizona. The studies initially investigated the area where the fencing would be disturbed and areas where additional intrusions would be made in previously undisturbed ground. The cultural resources studies also involved a review of alternate access routes to the mine disturbance areas and an assessment of the Red Water Pond Road (RWPR) and the planned remedial activities. The cultural resources studies were provided to EPA under separate cover.

The overriding objective of all these activities was to comply with AOC requirements and to implement the work in a safe manner that is protective of site personnel as well as nearby residents. Health and Safety Plans and Standard Operating Procedures (SOPs) were provided in the Phase I and II Work Plans.

1.3 MANAGEMENT AND ORGANIZATION

Management and organization of the project is described in detail in the Phase I and II Work Plans (RAML, 2010a,c). A brief synopsis is provided as follows. Site management was conducted by Rio Algom Mining LLC (RAML) who also provided oversight to SENES and Conestoga-Rovers & Associates (CRA). Specialized services were required in the final work plan and were subcontracted as necessary.

The Site Managers, Mr. Scott Johnsen and Mr. Tony Baus, managed activities of the Work Plan for the field work. Mr. Chuck Wentz acted as the Project Radiation Safety Officer. Mr. Frank Molina acted as the Health and Safety Officer and Mr. William McKay and Mr. Billy Ray acted as construction field supervisors.

During Phase I the SENES Project Manager was Dr. Douglas Chambers who along with the Senior Health Physicist, Ms. Krista Wenzel, were responsible for activities related to radiation and health physics. Dr. Chambers had overall responsibility for coordinating the sampling and surveys, defining areas of contamination, quality of the data collected and interpretation of the data that were presented in the interim investigation report. Mr. Gerd M. Wiatzka, P. Eng., a SENES principal was the alternate Project Manager at Phase I initiation, and became the full time Project Manager for the Phase II work and was actively involved in the development of the final Removal Site Evaluation (RSE) document. Mr. Charles Gravelle was the project lead for development and implementation of the Phase II borehole drilling program. Ms. Amanda Draine carried out Phase II remediation health physics and air monitoring activities. Mr. Ronald Stager, a Senior Environmental Scientist and Statistician, was a key technical contributor to this document. All responsible parties reported to the Project Director, Mr. Ken Black of RAML.

CRA was responsible for the construction activities associated with road chip sealing, dust control measures and erosion control measures during the fall 2010 and spring 2011 program. Tackifier placement was applied by Recon Inc. American Fencing was the primary fencing contractor repairing site fencing. Subsurface investigation boreholes were drilled by Yellow Jacket Drilling Services. Surface surveys of the sites were carried out by Elliot Land Surveying.

EPA Region 9 regulatory oversight and interaction with the work activities comprised:

- The Remedial Project Manager (RPM) Mr. Andrew Bain was the On-Scene EPA Coordinator;
- Consultant representatives for the EPA on site were: Ms. Robin Clemens of Ecology and Environment, Inc.; Mr. William Sass of Ecology and Environment, Inc.; and Mr. Brian Milton of E2 Consulting Engineers, Inc.;
- The NNEPA representative was Michele Dineyazhe.

1.4 REPORT STRUCTURE

The Report is structured as follows:

- Section 1 – provides a brief site history, and an overview of the program and management and organization structure;
- Section 2 – provides summary project description, and discusses work co-ordination and interactions, and project deliverables;
- Section 3 – describes the Phase I and II work elements as planned and undertaken;
- Section 4 – provides a discussions of results of the overall work program;
- Section 5 – provides summary comments on ongoing site monitoring and controls;
- Section 6 – provides a list of references used in the preparation of this report.

In addition, appended hereto are the raw data, field inspection logs, borehole logs and other information relevant to the preparation of this report as prescribed in the table of contents.

2.0 PROJECT DESCRIPTION

As described in the Phase I Work Plan (RAML, 2010a), the former Quivira Church Rock (CR) sites are located approximately 16 miles northeast of Gallup, McKinley County, New Mexico, as shown on Plate 1.1-1 of the General Location and Site Plan. After consultation with various government stakeholders and tribal stakeholders the CR-1 and 1E mine sites were reclaimed in accordance with the Bureau of Land Management requirements in 1990 (BLM, 1990).

In accordance with the US EPA Administrative Order of Consent dated August 2010 the Phase I work consisted primarily of soil characterization and chip seal stabilization work on Red Water Pond Road (RWPR). Work also included erosion control work along the shoulders of RWPR and on the west side of the work at CR-1, and fencing repairs and replacement work at CR-1 and CR-1E. The activities carried out in the Phase I work program are to address the time critical elements pertaining to Red Water Pond Road, site stabilization, and characterization as outlined in scope of work for Administrative Order of Consent dated August 2010. The efforts included excavation and grading of slopes, placement of stabilization materials, repairs and installation of fencing as planned or as approved in the field in keeping with the time of year and weather conditions. In April 2011 the final tackifier applications were made to the shoulders of RWPR thus completing the Phase I program.

The Phase II work consisted primarily of the following work elements; soil sampling, both shallow surface and deeper sub-surface, within the lease limits and step-out areas of CR-1 and CR-1E as well as the adjacent Unnamed Arroyo #2 and the Pipeline Arroyo, static gamma radiation surveys of both the CR-1 and CR-1E sites as well as the associated arroyos, and scanning gamma surveys of both the CR-1 and CR-1E sites.

The shallow soil sampling efforts included collection of shallow surface soil samples (up to 36 inches deep) by hand or by a power auger. The deeper soil sampling efforts included procurement of subsurface soil samples on either a continuous or selected stepped interval as a function of borehole location using a track mounted mobile auger. The static and scanning gamma measurements were collected as outlined in the Phase II Work Plan.

2.1 WORK COORDINATION

RAML was informed by the EPA that no licenses, permits or statutory approvals were required to execute the work described herein, since this work is defined by the EPA as a Time Critical Removal Action under an U.S. EPA Administrative Order on Consent dated August 2010 (EPA, 2010). RAML, however, coordinated with the State of New Mexico Department of Transportation and the Navajo Nation Department of Transportation for work conducted in the State highway right-of-way of route 566.

The approaches to the bridge over the Unnamed Arroyo #2 appeared to be unsafe for heavy equipment use. The conveyance of equipment was necessary for work on the section of RWPR road north of the bridge. EPA had an engineering consultant investigate the bridge on 20 October 2010. EPA then made a determination that the bridge was unsafe and requested RAML provide alternate means of stabilizing this segment of road. This determination resulted in a review of options to methods or means of access. Alternate routes were considered and none were adequate for heavy equipment use; the access from Pipeline Road from the SE was not appropriate due to identified cultural resources. Application of a chemical stabilizer that did not require use of heavy equipment was therefore approved by the EPA to seal this section of the road.

As approved by the EPA representative, a staging area was designated near the mine entrance area where contractors, regulators, and RAML personnel could place vehicles and materials during field activities. A roll off container (Conex) was leased and placed outside the fence in this area for secure storage of work materials. The staging area was in effect for both the Phase I and II portions of the site works.

Competitive bidding processes were employed by RAML for goods and services. Where possible, preference was given to qualified local suppliers or consultants for services and materials. Procurement was the responsibility of either the RAML project team, or SENES project team depending on the nature of the services.

2.2 DELIVERABLES

The AOC document outlines a series of deliverables for the overall program being undertaken at the Church Rock sites. A summary of the deliverables and the milestone dates associated with each is provided in Table 2.2-1.

Pursuant to the terms of the AOC an Interim Report was provided to the EPA as required under clause "Item 14 (d) of the AOC Time Critical SOW which states that RAML is to *"provide an Interim Report on the RWPR, Erosion Dust Control and Fencing Work no later than 90 days after field work is completed"*. Based on the completion of the field work on 20 November 2010 a deliverable date of 18 February 2011 would be appropriate. However, due to EPA request for provision of raw data with the Interim Report and timelines for receipt of the data, a revised submission date of 28 February 2011 was established during the January EPA/RAML conference call and the Phase I raw data were provided separately to EPA and its consultants on 5 February 2011.

In accordance with the provisions under clause 15 (d) of the AOC Scope of Work, there is a requirement to complete a Comprehensive Final Report no later than 90 days after the receipt of the all analytical results. This report is being submitted to EPA to fulfill this requirement.

Table 2.2-1 Deliverables

Action/Document	Deadline	Completion
Submit Proposed Phase I Overall Removal Action Work Plan, including: - Work Plan Outline - Construction Work Plan - Health and Safety Plan - Field Sampling Plan - Quality Assurance Project Plan	24 August 2010	24 August 2010
Project Initiation for Phase I field activities	28 September 2010	4 October 2010 (extended by agreement)
Completion of Phase I field activities	1 November 2010	20 November 2010 (extended by agreement)
Submit Phase II Overall Removal Action Work Plan	28 September 2010	7 October 2010 (extended by agreement)
Project Initiation for Phase II field activities	1 November 2010 (weather dependent)	8 December 2010 (extended by agreement)
Interim Report, including: - Phase I field activities - Sampling Report	90 days after field work is complete	Originally due Feb. 18, 2011; extended by agreement till February 28, 2011.
Completion of Phase II field activities	1 May 2011	8 May 2011
Comprehensive Final Report, including: - Phase I and II results - Proposed post-removal site control	90 days after analytical results from the RSE are received	Last analysis 1 July 2011 RSE no later than 29 September 2011

1. Monthly reports provided 1 February and 6 February

In addition to the hard copies and an electronic copy on a CD or DVD as specified in the AOC, an electronic copy of all deliverables created pursuant to the AOC was provided electronically to the following email addresses:

Andrew Bain: Ripperda.Mark@epamail.epa.gov
Michele Dineyazhe: dineyazhe.michele@epa.gov

3.0 DESCRIPTION OF WORK UNDERTAKEN

The following sections provide discussions of the work undertaken during both the Phase I and II portions of the program. The results of the program are provided in Section 4 of the report.

3.1 FENCE IMPROVEMENTS

3.1.1 Purpose

The fence is intended to restrict or prevent livestock and people from accessing designated portions of the Site. The fence is not intended to provide security against individuals and is not intended as a permanent structure, but was re-instated at the request of the EPA.

Under the provisions of the Phase I work plan, improvements were made to the fence lines at both the CR-1 and CR-1E sites. The limits of the existing fence, which comprise a mix of chain link and cattle fence, are presented in plan on Figures 3.1a and 3.1b for the CR-1 and CR-1E sites, respectively.

3.1.2 Locations/Description

The fencing around the CR-1 site covers about 7,000 feet. The primary fencing around the site was a 4 foot high hog wire fence. Approximately 500 feet of the northeast perimeter also included a chain link security fence. Fencing was for the most part intact prior to work start; however, sections of the fence had been breached or deteriorated thereby allowing for direct access to the site by grazing sheep, horses, and cattle.

The fence replacement plan was approved by the EPA in consultation with the EPA field representatives and NNEPA prior to commencement of the work. The contractor, American Fence, installed or repaired livestock fencing and signage around the CR-1 site and inspected and repaired fencing around CR-1E. Fencing was installed after the waste rock pile slope next to the road and other road areas were graded. The new perimeter fencing consists of metal t-posts (uninstalled length of 7 foot), 4 foot hog wire (4 feet from ground surface to top), and finished with two top strands of barbed wire. Top of posts were typically 5 foot 2 inches above ground surface after installation. The fence was installed on the approximate boundary of the former Mine Site lease. The different types of fences used on site and their location along the perimeter of the respective former mine sites are presented in plan on Figures 3.1a and 3.1b.

The gate structure located at the entrance of the Site at RWPR remains in place as a deterrent against vehicle traffic. An additional gate was constructed for ease of gaining access to the property for maintenance and construction of the sedimentation sumps at the toe of the waste rock pile. The location of the gates at the CR-1 and CR-1E sites are also shown on the above referenced figures.

3.1.3 Signs Posted, Security

In accordance with the AOC, signs were posted at regular intervals to notify people it is a restricted area and to not enter.

3.2 PHASE I CHARACTERIZATION OF SURFACE/SUB-SURFACE ROAD AND ROAD SHOULDER SOILS

The SOW requires that RAML characterize surface and subsurface road soils of the RWPR to include the former Mine Entrance Road leading to CR Site 1, including the shoulders (areas off the road but within approximately 50 feet of the center of the road) and 50 feet of RWPR to the west of the bend where the Mine Entrance Road begins. This includes static and scan surveys of these areas. Upon approval by EPA, after consultation of the NNEPA, the characterization plan was carried out by SENES (RAML, 2010a).

3.2.1 Soil Sampling

The primary radionuclide of concern at the site as identified by the USEPA is Ra-226. Surface and subsurface soil sampling primarily for Ra-226 and total uranium was conducted from 5-8 October 2010 in accordance with Phase I of the SOW. Soil samples were collected manually as grab samples and submitted to the laboratory and analyzed for Contaminants of Concern (COCs) as outlined in Appendix A of the Phase I Work Plan (RAML, 2010a).

A Quality Assurance Project Plan (QAPP) was developed for the project and is presented in Appendix B of the Work Plan (RAML, 2010a). The QAPP was prepared to describe the project requirements for all field and contract laboratory activities and data assessment activities associated with this Work Plan.

Figure 3.2 depicts the locations of 30 grid points where soil samples were taken for analysis of Ra-226 and total uranium along RWPR northward from the bridge over Unnamed Arroyo #2.

An additional eight (8) confirmatory soil samples were also taken south of the bridge along RWPR as shown in Figure 3.2 to assess potential affects from windblown materials from the nearby General Electric/United Nuclear Corporation (GE/UNC) mill site. In addition, seven (7) shallow soils samples collected from the 0-2 and 2-6 inch horizons were analyzed for thorium 230 (Th-230).

Surface soil samples were collected manually as grab samples at the surface (0-6 inches) and submitted to the laboratory and analyzed for Ra-226, uranium and in some cases Th-230. The surface soil samples were co-located with the static gamma radiation measurements. Both a portable hand auger, and a power auger mounted on a skid steer (Bobcat) were used, as appropriate, to sample subsurface soils at 18-24 inches and 30-36 inches.

Split samples (replicates) were taken but not required to be submitted to the EPA's laboratory per e-mail communication from the EPA on 6 October 2010 (EPA, 2010c). Split samples were collected and sent to the analytical laboratory to support RAML quality assurance.

Static and roving gamma readings were completed along the west slope of the waste rock pile, prior to re-grading the west slope and the movement of any eroded material off the road surface to the west slope. The original approved plan was to provide slope stabilization by means of grading the slopes, hydro-seed and then placement of a coconut mat over the slope to manage future stabilization of the slopes. Due to the timing of the start of construction, the slope stabilization plans were altered with the approval of the EPA. Soils that had eroded from the waste rock pile onto the side of the road and the road surface or from areas up gradient from the waste rock pile were moved back onto the west slope of the waste rock pile. This allowed for the construction of a temporary channel and placement of straw wattles along the west toe of the waste rock pile and a construction of a temporary sedimentation basin [Best Management Practice (BMP)] at the south toe of the waste rock pile in accordance with the Storm Water Pollution Prevention Plan (SWPPP) for the site.

3.2.2 Static Gamma Radiation Surveys

The field radiological stationary measurements and scans consisted of direct gamma radiation level measurements using a collimated scintillation detector coupled with a single-channel rate meter and a global positioning system (GPS). Use of GPS facilitated development of a site measurement map with radiological contours in various ranges of both uncorrected raw data and estimated Ra-226 concentrations in soil.

The sampling plan for the site was based on an 80-foot triangular grid as required by the AOC and SOW (EPA, 2010a). The sample locations and results are shown in Section 4. The grid pattern along with the results is also shown in Section 4 of this document. The triangular grid was cast on a random origin in accordance with MARSSIM guidance documents (EPA, 2001). A small number of locations were moved due to the presence of rock or difficult terrain (particularly) around the bridge. Static gamma radiation measurements were collected at these points located on the map.

A relationship between gamma radiation measurements and associated soil samples collected and analysed for Ra-226 concentration was developed to predict surface soil concentrations at locations without soil samples. In addition, scanning gamma radiation surveys were conducted of the site to provide data on the conditions between these stationary points. In carrying out the scanning surveys, field teams walked the site areas of interest and collected data gamma radiation measurements at 2-second increments along a serpentine path walked using a collimated detector linked to a GPS system which automatically recorded the positions and the measured gamma radiation level. Through this approach surface gamma radiation measurements were collected across much of the surface areas that are included in the Phase I SOW.

Static and scanning surveys were carried out using a Ludlum Model 2221 Ratemeter, S/N 97837, with Ludlum Model 44-10 Probe, S/N RN013814, both calibrated on 29 June 2010. The Ludlum Model 44-10 Probe contains a 2 inch by 2 inch sodium iodide (NaI), thallium-doped, crystal. A lead collimator was used to reduce the effects of radiation shine and geometry on the measurements.

3.2.3 Scanning (Roving) Gamma Radiation Surveys

Scanning surveys were done using the same instrumentation as for static surveys. Additional scanning surveys were carried out on the slopes of the waste rock pile in preparation for Phase II survey work. The location and results of the scanning surveys are presented in Section 4 of this report.

3.3 MITIGATION OF ACTUAL AND POTENTIAL RELEASES

Potential releases of contaminants were mitigated in accordance with the Phase I Work Plan (RAML, 2010a). Actual field work was carried out as planned or alternatively in accordance with EPA approved efforts consistent with the time of year and weather during which the work was being carried out. Water application using tank trucks was used for dust control. In addition, air monitoring was accomplished in community areas to demonstrate the absence of exposures caused by the work.

3.3.1 Mitigation of Surface and Subsurface Road Soils

The SOW required mitigation of potential and actual releases of Ra-226 from material located on RWPR, the Mine Entrance Road and their shoulders, including the 1,800 feet of RWPR sampled by General Electric/United Nuclear Corporation (GE/UNC), an additional 50 feet of RWPR west of the 90 degree bend and the Mine Entrance Road (EPA, 2010a). The SOW specified that a double layer of chip seal could be used to ensure mitigation of potential releases from the road for at least 5 years without reapplication or repair. RAML had indicated during various co-ordination meetings with EPA it was unlikely that the chip seal would last 5 years.

Areas of surface erosion control as carried out in accordance with EPA approval are shown on Figure 3.3.

Construction activities at the site were completed by CRA in a manner consistent with execution of a critical path, schedule driven, project. Chip sealing the road was the highest priority due to the freezing weather and the closing of the chip seal season. Chip seal and sub-grade preparation activities on south of the bridge on RWPR to the edge of the existing pavement were completed by Wednesday, 20 October, just ahead of the first snow and hail storm of the season.

All grading of the west slope of the waste rock pile and removal of sedimentation on the north side of the bridge had been completed prior to stabilizing the road surface. Hydro mulch was applied to the west side slope of the waste rock pile on Monday, 1 November.

A chemical stabilizer (Durasoil®) approved by the EPA was applied to the north side of the road and to the mine access road segment during the period of 1 to 8 November 2010 depending on polymer delivery. CRA sprayed Durasoil® and installed straw wattles on both sides of RWPR west of the waste rock pile.

In addition to the chip seal application, a natural fibre “tackifier” was applied approximately 35 ft out from the edges of the chip seal on the sections of the RWPR south of the bridge. The “tackifier” was applied during the second part of the Phase II program in April 2011.

Upon completion of the erosion control work a chemical stabilizer application approximately 100 ft wide, centred on the RWPR road allowance had been applied as part of the Phase I program to the limits shown in plan on Figure 3.3.

3.3.2 Mitigation of Potential Migration from the Quivira Mine Site Areas

The SOW requires mitigation of potential migration from the former Quivira Mine Areas which threaten to re-contaminate areas cleaned by EPA and/or GE/UNC (EPA, 2010a). Prior to mitigation activities, there was evidence of erosion channels in the slope and sediment at the toe of the waste rock pile (see Plate 3.3-1). Sampling of the Unnamed Arroyo #2 downstream of the pile showed elevated measurements of Ra-226.

The Phase I work plan called for the grading and removal of large plants to allow for direct application of the coconut matting on the soil so as to minimize short term erosion. However, on October 26th, due to the time of year, EPA (A. Bain’s email communication) directed RAML to stop grubbing and cutting vegetation. Efforts completed included grading of any large erosion rills with imported soil as needed; excavation of a small anchor trench at the top of the slope; placement and anchoring of the blanket in the trench; rolling the blanket down the slope; stapling the blanket at mid slope to assure good anchoring to the area; and stapling all joints and overlapping areas. The silt fence was attached to the existing perimeter fence or approved alternate locations to act as a secondary measure to control water borne sediment that may be present.

The west and south slope is about 1,200 ft long with an average slope length of about 100 ft. This area of the site is the only area which drains directly to the Unnamed Arroyo #2.

3.3.3 Storm Water Controls

A Storm Water Pollution Prevention Plan (SWPPP) for this project was prepared by Ajax Engineering (Ajax, 2011) and submitted to EPA in February 2011 for review and comments. This plan documented storm water management for CR Sites 1 and 1E and identified drainage patterns, controls, maintenance/inspection items and near-term improvements to the existing erosion and sediment controls. Temporary storm water control work included grading, the installation of silt fence and straw wattles and best management practices (BMPs). BMPs were developed to stabilize the waste rock pile for the winter in preparation of additional work next year. Grading was done to improve the drainage such that water would follow the toe of the slope parallel to the ramp and roadway and ultimately turn the corner and head east inside the berm at the toe of the south slope.

Plate 3.3-2 illustrates activities underway with respect to erosion control on the west slope of the CR-1 waste rock pile and chip seal of route 566. Plate 3.3-3 provides and illustrations of storm water management control efforts on the west side of the waste rock pile, and Plate 3.3-4 illustrates storm water management control efforts at the south toe of the waste rock pile.

Plate 3.3-1 West Slope of Waste Rock Pile Prior to Mitigation

Plate 3.3-2 View of Entrance Ramp Showing Road and Waste Rock Pile Mitigation

Plate 3.3-3 West Slope of Waste Rock Pile with Erosion Controls

Plate 3.3-4 Berm Storm Water Control at South End of Waste Rock Pile

Several thousand feet of earthen berms were repaired and extended to better direct "run-on" storm water safely around the facility and to direct potentially impacted "run-off" storm water to sediment traps and evaporation basins located onsite. One new trap was installed while others were deepened or enlarged to increase capacity. A 25-foot section of channel was excavated west of the mine entrance ramp that would allow storm water from the mountain ridge to be diverted off the ramp and to discharge as un-impacted water. Upon completion of the grading of the west slope of the waste rock pile, straw wattles were immediately installed at the toes of the slope.

Erosion rills in the soil cover were repaired on a portion of the reclaimed slope, which was further stabilized with straw wattles. To reduce the migration of sediment, straw wattles were installed in select locations along runoff channels, and silt fencing was installed in selected areas of potential sheet flow along the perimeter of the facility. RAML will continue to conduct inspection and maintenance activities, as required under the AOC.

SWPPP inspections were conducted monthly by RAML to assess the performance of storm water controls and the integrity of site fencing. The inspections are recorded in Appendix B.

3.4 CULTURAL SURVEYS

Cultural resource reviews were carried out by Dinétahdóó Cultural Resources Management LLC (DCRM). Cultural survey results were provided to RAML and the EPA prior to commencement of work; indicating that no culturally sensitive areas were identified along RWPR or within the property boundaries. Thus boundary limits were not constrained during this work by known cultural resource properties identified in the cultural resource assessment conducted for Phase I work (DCRM, 2010).

The cultural resource survey report has been submitted to the Navajo Cultural Preservation Office and will be provided to EPA under separate cover.

3.5 AGRONOMIC REVIEW

Characterization of existing soil and vegetative cover was completed from 10-15 October 2010 following Phase I work. The purpose of this work is to assess current conditions and an agronomical assessment of the density and diversity of the vegetative cover and soil analyses. The report provides comments on the existing vegetation types, soil agronomic characteristics, current conditions of reclaimed areas, and recommendations on cover seed mixtures. The full report is provided in Appendix C (Bamberg, 2010).

As stated in the Bamberg agronomy report, the Church Rock sites are in a semi-arid steppe climatic zone with precipitation concentrated in the summer rainy season of the year from July to early October, and with storms in late summer and snow in winter and spring. Annual precipitation is approximately 11.6 inches per year; however, periodic droughts of low precipitation occur of about 8 inches per year.

Vegetation on the slopes, ridges and mesas is pinyon/juniper woodland with an understory of sparse shrubs, grasses and forbs. Woodlands grade down slope into alluvial valleys and toe of slopes that are a mixed shrub/grass shrub land and then into grasslands in the flatter, lower alluvial bottomland and flats. Vegetation community types are closely tied to the soil properties of depth, texture, pH, salinity, water-holding capacity, and salt and mineral content. Microclimatic differences are related to aspect, water and air patterns along streams, draws and valleys, and changes brought about to the structure of the plant community as a result of domestic livestock grazing, trampling, and bedding.

Soils at the site and vicinity areas have developed on topographic surfaces of hillside toes of slopes, stream floodplains and valley fill terraces, coalescing alluvial fans, hill slopes, and peaks and ridges. These soils are derived from a complex of substrates including sedimentary sandstones and claystones are composed of weathered residuum, colluvium, and alluvium. Soil depth varies from shallow to non-existent on ridges and slopes to deep alluvium in valleys and along drainages. Soils within the woodlands are shallow, skeletal (i.e., little profile development) and rocky. Soils at the bases of slopes and into the alluvial valleys are deeper with finer textured sandy to silt loams.

The agronomic study included assessment of current conditions of the vegetative cover and mapping of the type, density and diversity of the cover material. Locations of the points surveyed for vegetation and soil sampling and specific area designations are provided on three aerial maps found in Section 2 of the Bamberg report.

The methods used to evaluate vegetation community included: i) a single plot technique using square 12 foot by 12 foot quadrats in which the plant species were recorded, and ii) a linear transect of 5 connected rectangular plots each 2 foot by 50 or 100 foot in which plant species were recorded. Four quadrats were sampled in the small areas with low cover on the waste rock pile and linear transects sampled in the shrub dominated vegetation communities. Diagnostic characteristics for each vegetation type were noted for topographic position, soils, disturbance, and other notable factors, such as erosion, fencing, and use by domestic livestock or other animals.

Soils were sampled at locations based on the soil type and amount of previous disturbance, and analyzed for typical agronomic parameters important for re-vegetation to include: pH, saturation percentage, texture, rock fragment percentage, organic matter, available nutrients, sodium adsorption ratio (SAR), cation exchange capacity (CEC) and electrical conductivity (EC). Vegetation was sampled for types and major species on the natural and re-vegetated portions of the site, and mapped at an appropriate scale. Approximately four - 1.5 kilogram samples were collected in each area at two depths, 0-6 inches and 6-12 inches for a total of 52 samples.

3.6 PHASE II CHARACTERIZATION OF CR-1, CR-1E AND ARROYO SOILS

The SOW requires that RAML characterize surface and subsurface soil conditions at both the CR-1 and CR-1E sites. This sampling work was to be augmented by static and scan surveys of these areas. The Unnamed Arroyo #2 and Pipeline Arroyo were hand sampled at selected transects. The scope and nature of the characterization work was amended through discussions with the EPA between November 2010 and March 2011, and consultation with the NNEPA. The agreed to characterization work was implemented by RAML between December 2010 and May 2011.

3.6.1 Radiological Soil Sampling

The Phase II portion of the overall site radiological assessment work, as prescribed in the Phase II SOW, was completed in a two stage program between December 2010 and May 2011.

A summary of the soil sampling completed to collect samples for radiological analysis during the two stages of the Phase II program is outlined under separate headers below.

First Stage of Phase II Program - December 2010

The initial program, completed between 7th and 16th December 2010, entailed the shallow surface sampling at 138 locations across the CR-1 and 1E sites as well as the arroyos adjacent to the respective sites. The distribution of sampling locations and numbers of samples collected is shown in Table 3.6-1 below.

Table 3.6-1 Distribution of Sampling Locations and Numbers of Samples Collected

Location	Hand Dug Sample Locations (# of samples)	Power Auger Sample Locations (# of samples)	Total Number of Locations (# of samples)
CR-1	2 (2)	54 (161)	56 (163)
CR-1E	28 (30)	NA	28 (30)
Unnamed Arroyo #2	39 (112)	NA	39 (112)
Pipeline Arroyo	15 (42)	NA	15 (42)

Shallow soil samples were collected manually, as grab samples, procured from either hand digging or power augering to the prescribed sample depth as outlined in the SOP-7. Samples were submitted for laboratory analysis for Contaminant of Concern (COCs) as outlined in Appendix A of the Phase II Work Plan (RAML 2010c).

A Quality Assurance Project Plan (QAPP) was developed for the project and is presented in Appendix B of the Work Plan (RAML, 2010c). The QAPP was prepared to describe the project requirements for all field and contract laboratory activities and data assessment activities associated with this Work Plan.

Figures 3.4 to 3.8 depict, in plan, the locations where soil samples were procured from the respective areas of investigation and submitted for analysis of Ra-226. Figure 3.4 details the shallow surface samples collected from the lease and Step-out areas of the CR-1 Site, Figure 3.5 details the shallow surface samples collected from the lease and Step-out areas of the CR-1E Site, Figures 3.6 and 3.7 detail the samples collected from within the Unnamed Arroyo#2 while Figure 3.8 depicts the sample locations within the Pipeline Arroyo.

In general soil samples collected during this part of the program were procured from three different depth intervals as a function of the sample locations. A summary of the sampling intervals is provided in the Table 3.6-2 below.

Table 3.6-2 Summary of Sampling Intervals

Location	Sampling Intervals (in inches)[1]
Church Rock Site 1/1E Hand Dug Samples	0-2, 2-6, 18-24 and 30-36
Church Rock Site 1E/1E Power Auger Samples	0-2, 2-6, 18-24 and 30-36
Unnamed Arroyo #2	0-2, 2-6 and 30-36
Pipeline Arroyo	0-2, 2-6 and 30-36

[1] Where refusal was encountered above a depth of 36 inch, a sample was taken at the base of the sample hole

As part of the soil sampling program the soil stratigraphy was recorded at each sample location and a log was recorded. An electronic copy of the soil logs are provided in Appendix E for all sample locations completed as part of the Phase II program. It is noted that CR-1E sampling was amended at instruction from RAML and agreement of EPA due to concerns with buried utilities in the area so that shallow sampling was limited to the upper 2 inches.

Second Stage of Phase II Program – April/May 2011

The second stage of the Phase II Program completed between 26th April and 6 May 2011 entailed both shallow surface sampling at 24 locations at the CR-1E site and deep subsurface sampling at a total of 25 locations across the CR-1 and CR-1E. The environmental sampling program, as completed during this period, is discussed in Section 3.3.4.

A summary of the sampling completed at the respective sites is presented in the Table 3.6-3 below.

Table 3.6-3 Summary of the Sampling Completed at Respective Sites

Location	Shallow Surface Sampling Locations		Deep Subsurface Sampling Locations (# of Samples)	Total Sample Locations (# of Samples)
	Hand Dug (# of Samples)	Power Auger (# of Samples)		
CR-1	NA	NA	20 (224)	20 (224)
CR-1E	9 (21)	15 (40)	5 (37)	29 (98)

Soil samples for the shallow surface part of the program were collected manually, as grab samples, from either hand digging or power augering equipment at the prescribed sample depths and using the methodology outlined in the SOP-7. Soil samples procured from the deep subsurface locations were collected from split spoon samples at the prescribed sample depth and using the methodologies outlined in SOP-9 as amended by the work plan amendments (RAML 2011a – 16th March document submission to USEPA).

All soil samples collected for the radiological assessment of the site submitted to the laboratory and analyzed for Contaminants of Concern (COCs) as outlined in Appendix A of the Phase II Work Plan (RAML 2010c) namely Ra-226.

A Quality Assurance Project Plan (QAPP) was developed for the project and is presented in Appendix B of the Work Plan (RAML, 2010c). The QAPP was prepared to describe the project requirements for all field and contract laboratory activities and data assessment activities associated with this Work Plan.

Figures 3.4 and 3.5 depict, in plan, the locations where soil samples were procured on sites CR--1 and CR-1E and subsequently submitted for analysis of Ra-226. The boreholes advanced within the waste rock areas of the respective sites are labelled with the 300 series identifiers while the 400 and 700 series identifiers denote the sediment pond area boreholes at the respective sites. The 500 series boreholes were advanced within the industrial areas of the respective sites.

In general soil samples collected during this part of the program were procured from different depth intervals as a function of the sample locations. A summary of the sample intervals is provided in the Table 3.6-4 below.

Table 3.6-4 Summary of Sample Intervals

Location	Sampling Intervals
CR-1E Shallow Surface Soil Samples	2-6, 18-24 and 30-36[1] (inches)
CR-1 and CR-1E Waste Rock Deep Subsurface Samples	18 inch sample every 5 ft starting 5ft below grade and extending on full split spoon into the native soil
CR-1 and CR-1E Sediment Pond Deep Subsurface Samples	Continuous sample from surface to the depths prescribed in the March 2011 work plan amendment

[1] Where refusal was encountered above a depth of 36 inch, a sample was taken at the base of the sample hole

As part of the soil sampling program the soil stratigraphy was recorded at each sample location and a log was prepared. An electronic copy of the soil logs is provided in Appendix E for all sample locations completed as part of the Phase II program.

3.6.2 Gamma Radiation Surveys

Field radiological measurements of gamma radiation measurements consisted of stationary or static surveys as well as roving or scanning surveys. The surveys were performed by taking gamma radiation measurements using a collimated scintillation detector coupled with a single-channel rate meter and a global positioning system (GPS) equipped with an automated data logger. The detector was a 2 inch sodium iodide (NaI) detector as commonly used for field measurement at environmental Measurements.

The collimated detector was used to prevent potential "shine" caused by remote gamma radiation sources being detected and thereby providing a more precise gamma radiation measurement The detector was at a height of 18 inches above the ground surface. The data logger allowed for largely automated recording of the geographic position and gamma radiation count rate. Additional information of the system is provided in Appendix A4 and information on the data management is provided in Appendix A5.

Daily instrument checks were performed to ensure appropriate performance of the detector systems and these are described in Appendix A4.

3.6.2.1 Static Gamma Radiation Surveys

The sampling plan for the static gamma radiation measurements was based on an 80-foot triangular grid as required by the AOC and SOW (EPA, 2010a). The triangular grid is cast on a random origin in accordance with MARSSIM guidance documents (EPA, 2001). A small number of static measurement locations were moved due to the presence of rock or difficult terrain. The sample locations for CR-1 and CR-1E are shown in Figures 3.9 and 3.10 respectively.

The GPS system was used to identify the field locations of the static survey points. Static gamma radiation readings were either taken at the time the survey point was located or the point was flagged and read at a later time. Static gamma radiation readings were only collected when the area being surveyed was dry to reduce the potential impact of moisture in the soil on the accuracy of the readings.

The equipment required to take a static gamma reading included a survey meter with a 2 inch NaI scintillation detector, a GPS receiver unit for receiving the satellite positioning, a data logger to automatically record geographic coordinates and gamma detector readings, and a remote satellite antennae.

A static reading consisted of taking a 1-minute count of gamma radiation disintegrations observed in the detector, the counts per minute (cpm) were stored in the GPS data logger and recorded on the field sheet with the coordinates of the selected field location. During the 1-minute count time the gamma detector was positioned 18-inches above the ground at the selected grid location. A pole or walking stick was used at times to secure the detector at the desired height above ground. At other times the detector was attached to a metering wheel to maintain the desired height above the ground.

Static gamma radiation measurements and coordinates were collected and located on the site figures and for report plates. Soil samples collected at predetermined static locations were analyzed at an approved laboratory for Ra-226 concentrations. The static gamma radiation measurements were used with the 0-6 inch soil concentration measurements to develop a relationship to predict surface soil concentrations at locations based only on the gamma radiation measurements.

3.6.2.2 Scanning (Roving) Gamma Radiation Surveys

In addition, scanning gamma radiation surveys were conducted to provide data on the gamma radiation measurements between the static points. In carrying out the scanning surveys, field teams walked the site in the areas of interest and the instrumentation collected data gamma radiation measurements at 2-second increments along the path. The count rates from the collimated detector were linked to the GPS data logger which automatically recorded the geographic positions and the measured gamma radiation Measurements. The roving gamma radiation surveys followed a serpentine pattern with an approximately 30 foot distance between transects. Through this approach, surface gamma radiation measurements were collected across much of the surface areas that were discussed within the work scopes. Due to terrain restrictions, some locations were not surveyed due to accessibility or safety considerations.

The scanning gamma radiation surveys were also conducted using an all terrain vehicle (ATV). This was mainly done in areas without rocks, large vegetation, or steep slopes. Environmental concerns regarding the surface land integrity and safety factors had to be considered before using the ATV. When using the ATV the antennae and gamma radiation detector were attached to a rod on the front bumper of the ATV, the receiver was placed in a box under the hood, and the hand held data logger was mounted on the dash inside the ATV.

3.6.3 Non-Radiological Soil Sampling

As part of the second stage of the Phase II Program completed between 26th April and 6th May 2011 non-radiological soil sampling was completed to address USEPA concerns as outlined in the AOC. The non-radiological soil sampling program entailed the collection of soil samples from four locations, two from each site within the limits of the Church Rock Site 1 and 1E industrial areas respectively. A summary of the number of sample locations and the number of soil samples collected is outlined in Table 3.6-5 below.

Table 3.6-5 Summary of Number of Sample Locations and Number of Soil Samples Collected

Location	Total Number of Locations (# of samples)
Church Rock Site 1	2 (15)
Church Rock Site 1E	2 (12)

Soil samples procured from the deep subsurface locations were collected from split spoon samples at the prescribed sample depth and using the methodologies outlined in SOP-9 as amended by the work plan amendments (RAML 2011a – 16th March Technical Memorandum submission to USEPA). The soil sampling for the semi-volatile and volatile organic compound analysis was completed as per the protocol outlined in SOP-8.

A Quality Assurance Project Plan (QAPP) was developed for the project and is presented in Appendix B of the Work Plan (RAML, 2010c). The QAPP was prepared to describe the project requirements for all field and contract laboratory activities and data assessment activities associated with this Work Plan.

Figures 3.4 and 3.5 depict, in plan, the locations where soil samples were procured and submitted for analysis of metals, volatile and semi-volatile compounds, polychlorinated biphenyls (PCBs) and petroleum hydrocarbon compounds. The industrial area boreholes are identified as the 500 series boreholes on the respective site figures.

Soil samples collected during this part of the program were procured on a continuous basis from the split spoons which were advanced to refusal or to a minimum of ten feet into the overburden. Given that 18 inches split spoons were used a soil sample was collected from each 18 inch interval to the end of the respective boreholes. As part of the soil sampling program the soil stratigraphy was recorded at each sample location and a log was prepared. An electronic copy of the soil logs is provided in Appendix E for all sample locations completed as part of the Phase II program.

During the course of the soil sampling for the radiological program there was one borehole location C1LP-401, within the sediment area of CR-1 site, were petroleum hydrocarbon odours were reported. Two soil samples were collected from this borehole location, one within the zone of olfactory impact and one 3 feet below the impacted zone. The two samples from this location were submitted for gas and diesel range hydrocarbon analysis.

3.7 SAFETY, ENVIRONMENT AND HEALTH

This section provides a discussion of the safety, environment and health considerations and activities undertaken in association with development and implementation of the AOC work program.

3.7.1 Safety

The specific Health, Safety, and Environment (HSE) management plans were provided in the Phase I Work Plan and RAML's Response Letter to EPA's Comments dated September 10, 2010 (RAML 2010a, RAML 2010b).

As part of the qualification process, contractors provided RAML with evidence of a HSE program that considers the normal hazards. The contractor must also be made familiar with the special nature of the site conditions. These special conditions include the potential for incidental contact with residual materials from the site operations as well as natural hazards such as wildlife. The site's severe topographic relief imposed the need for experienced contractor personnel and the use of appropriate fall protection measures. The fence is readily accessible along the entire perimeter with safe access possible in all areas reviewed to date.

Prior to the initiation of work, RAML provided contractor employees with an induction on Health, Safety, Environment & Community (HSEC) and particularly regarding the site background issues and current conditions. The topics included potential exposure to radiation, management of hazardous or dangerous substances, and sharp or jagged metal debris. This briefing identified areas at the site to avoid. The Radiation Safety Officer (RSO) also provided a briefing on radiation hazards, controls and monitoring.

RAML and the contractor established a communication system (satellite phone, cell phones or radios) so that emergency medical help could be summoned, if necessary. Work was conducted in teams of at least two persons. Prior to field work being initiated RAML reviewed the Emergency Response Plan (ERP) as part of induction for contractors and subcontractors.

Detailed tailgate work assignment and safety meetings were held daily prior to work start. These tailgates included various safety topics, such as those listed below:

- weather conditions including use of sunscreen and drinking water on breaks after surveying hands and stopping work if there is any lightning;
- awareness of animals on and around the site such as cattle horses, sheep, stray dogs, insects, snakes;
- scanning out personnel each time they come off site (hands at a minimum before eating, drinking, smoking) or using the restroom and feet and other body areas as necessary prior to leaving site at the end of the day);

- random smears of workers on site, noting that all vehicles will be smeared and cleared prior to being allowed to drive off site;
- use of OSL dosimeters all day,
- working in pairs of two, and ensuring a six foot rule from the tops and bottoms of the arroyos; and
- personal protective equipment (PPE) required to be worn by personnel during work on site included hardhats, safety glasses, safety vest, plug and muff ear protection (during drill rig use), and steel-toed shoes.

Traffic control to include signage and warning cones was provided by the contractor, CRA. Temporary barriers, signs, warning lights, flaggers, and other protections were used as required to assure the safety of persons and vehicles around and within the construction area and to organize the smooth flow of traffic.

During construction work on the Red Water Pond Road, RAML notified the local community of its activities and advised NNEPA or EPA of the planned work. Safety plans, briefings, traffic control, and coordination of activities through NNEPA occurred without incident.

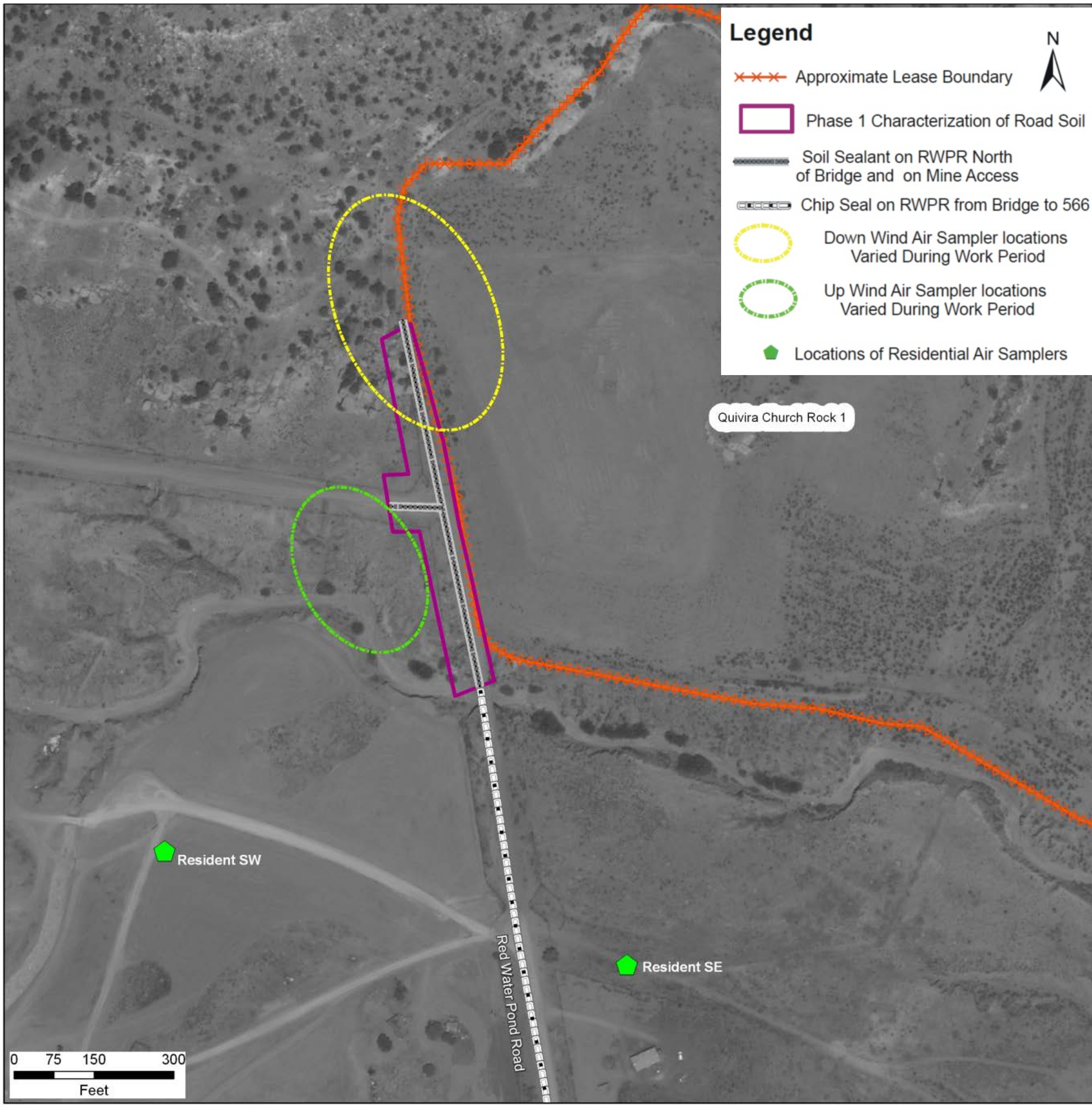
Prior to the commencement of each stage of the Phase II program (December 2010 and April/May 2011) a HSEC briefing was provided by RAML staff with input from the RSO. In December 2010, the briefing was attended by employees of RAML, SENES and private contractors retained to assist with the soil sampling work. Similarly, in April 2011, another HSEC briefing was held with employees from RAML, SENES, the drilling company (Yellow Jacket Drilling Services Limited) and the surveyor (Elliot Land Surveyors) in attendance. The topics discussed were similar to those noted above, with the addition of discussions regarding safe work practices when working around drilling equipment.

3.7.2 Air Monitoring

Ambient air sampling was done during Phase I Work at various dates from 5 October to 15 November 2010 and again during Phase II Work on various dates from 28 April to 3 May 2011. The purpose was to assess the potential risk to community members near CR-1 during radionuclide characterization, erosion control, and fencing activities. Of primary interest is Ra-226 based on discussions with EPA, per the SOW, and based on previous assessment documents done under the EPA purview in this area.

Plate 3.7-1 depicts the locations of the high volume air monitoring stations. Staplex air samplers were used in aluminum housings at approximate flow rates of 40 cubic feet per minute (cfm). Air filters were glass fiber, 8 inch x 10 inch, and were analyzed for radium-226 (Ra-226) and total uranium (U). Ra-226 was analyzed by EPA Analytical Method 903.1 (radon emanation) (EPA, 2007). Total U was analyzed using SW-846, 3rd Edition, Method 6020A (inductively couple plasma - mass spectroscopy, ICP-MS) (EPA, 2008).

Plate 3.7-1 Air Monitoring Stations



3.7.3 Storm Water Management

A Storm Water Pollution Prevention Plan (SWPPP) for the duration of the project was prepared and provided to EPA under separate cover as discussed in Section 3.4.3 of this report. An electronic copy of the SWPPP is included in Appendix D. Monitoring to date has shown that erosion control efforts have been successful to date in mitigating further erosion.

3.7.4 Occupational Health Surveys

Worker breathing zone (BZ) air sampling was performed during a variety of work activities on five days during Phase I and six days during Phase II program activities. During phase I, the BZ pumps used were AirLite Sampler Model 110-100 by SKC Inc. and were calibrated using a 1,000 ml bubbler calibration tube. During phase II, new SKC AirChek 52 pumps were used and were calibrated with a new Mini-Buck Model M-5 Calibrator.

Worker lapel air sample results were consistent with environmental air sampling results. All breathing zone results indicated measured Ra-226 and Natural Uranium were both less than 1% of the applicable occupational DACs from 10 CFR 20, Appendix B, Table 1.

In addition, Optically Stimulated Luminescent (OSL) dosimeters were worn by workers involved in both the Phase I and II work activities to document potential for external radiation exposure above background. The highest result reported in 2010 and 2011 work program was 3 mrem above the background control dosimeter. This can be compared to the typical annual background in New Mexico of 300 – 400 mrem and the 5,000 mrem limit for trained radiation workers.

3.7.5 Contamination Control Methods

A contamination control station was set up near the southwest corner of the Church Rock 1 site, and when necessary in the northeast corner of the Church Rock 1E site. Surveys of personnel were performed using Ludlum Model 4 detector with a Ludlum Model 43-5 or equivalent probe. Smears were also taken of drilling tools (augers, split spoons) to control or monitor the contamination within a borehole and between borehole locations and of personnel hands, feet, or other areas (knee, etc.) at random and when warranted based on the work performed. Smears were taken of all equipment after each trip on site, and prior to release offsite. Smears were counted using Ludlum Model 2000 Scaler detector with a Ludlum Model 43-1 probe or equivalent. Results were written in a log book in units of total counts and counts per minute (cpm) in accordance with the Standard Operating Procedure (SOP) 10 (RAML 2010d).

Representative smear samples were taken of equipment and personnel leaving the site to ensure release limits were not exceeded. A sub set of smear samples was sent for analysis to the off-site laboratory for confirmation of on-site results and which were confirmed.

The analytical results showed levels of Ra-226 and U were far below allowable release limits established by RAML which are equivalent to or less than the limits for uranium and daughters as specified in Table 2 of NRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities,* 2002.

Investigation Derived Waste (IDW) was initially stored within the Conex trailer on site until the end of the Phase II program this past May 2011. During the course of the Phase I and II program soil residual and wash water was collected in a 45 gal drum lined with a plastic bag. Upon the conclusion of the program the drum was left within the limits of the CR-1 site so as to allow the water to evaporate. Further to consultation with representatives of the EPA the residual soil was consolidated and placed below surface in a shallow pit excavated within the limits of the waste rock area and subsequently covered with soil from the existing waste rock area cap.

No IDW material was removed from site during any portion of the Phase I and II work activities.

3.8 STAKEHOLDER ACTIVITIES

3.8.1 Community Activities

Two representatives of RAML met with the seven (7) members of the Navajo Community Coyote Canyon Chapter, representatives from EPA, and a member of non-government organization on 28 September 2010 to discuss planned work activity relating to sampling, fencing slope erosion and chip sealing the road.

Access was approved by EPA in coordination with Navajo EPA for logistical arrangements that could directly affect the local residents, these arrangements were defined in consultation with the Navajo EPA representative and, if required, a local representative of the residents.

RAML values the communities in which we work and made every effort to complete the works without disturbing the local residents.

3.8.2 US EPA Activities

Routine and regular meetings were held with EPA during the course of the planning the work program and during its implementation. When required, meetings were held more frequently. Meetings invitations were circulated in advance of meetings to EPA, RAML and their respective consultants. Monthly reports were provided during the field work program.

Field changes required by the EPA and NNEPA were documented in field change logs and are included in Appendix B.1

3.9 GENERAL CONSIDERATIONS FOR THE ANALYSES OF DATA

3.9.1 A Characterization Study

The field investigation and reporting of the results are conducted as a characterization study rather than a final verification survey. The CR-1 and CR-1E sites were previously remediated to a standard considered protective of human health and the environment at the time. Since that time, as part of the AOC for the site, the EPA has introduced a more restrictive preliminary action level (PAL).

MARSSIM guidance provides useful aspects that have been included. This has supported random sampling, development of SOPs and quality assurance aspects.

The general approach is to illustrate the location and magnitude of the results, tabulation and summary statistics of the measurements.

3.9.2 Precision of Measurements

A QAPP program was developed to review the laboratory measurements and this indicates suitable quality for use. Ra-226 soil measurement data were specifically reviewed relative to the precision estimates provided from the laboratory in Appendix A1 and are summarized as follows.

The absolute precision for Ra-226 concentrations from 2 to 3 pCi/g ranged from 0.33 to 0.54 pCi/g. Relative precisions were calculated by dividing the reported precision by the reported concentration and these were also summarized. For concentrations from 2 to 3 pCi/g, the relative precision ranges from 15 to 23%. The precision is acknowledged to be suitable for the assessment, in particular relative to the PAL comparisons.

Gamma radiation measurements were collected using an integrating rate meter and GPS that provides assurances that geographic coordinates and gamma radiation measurements were recorded. Static gamma radiation measurements were collected for 60 seconds so that the counting uncertainty for a low level of 5,000 cpm would be +/- 3%. Daily QA/QC performance checks of the gamma radiation detector system showed little variation over the measurement period. There is little evidence that changing meteorological conditions had a substantive effect on the gamma radiation measurement program.

The scanning gamma radiation measurements were measured and automatically recorded. There is limited averaging, so the counting statistics are estimated to be for a 2 second count. The counting uncertainty at 5,000 cpm is +/- 775 cpm (2 standard deviations) or +/- 15% from a 2 second count. The average of multiple scanning measurements will have more precision and less uncertainty. Averaging of gamma radiation measurements is used in this report.

3.9.3 Comparison of Soil Concentrations to the PAL

The AOC requires a comparison of soil concentrations to a PAL provided by AOC for this area of 2.24 pCi/g based on a local background soil concentration of 1.0 pCi/g in the 0-6 inch soil horizon from one small area plus a incremental risk assessment of 1.24 pCi/g. The averaging area for these concentrations has not been specifically identified.

As part of the characterization program soil concentrations have been measured at many areas and various depths and comparison of the PAL may not be relevant for many of the samples. For example, it is unlikely that exposures on the arroyo bottom or at depths substantially below the surface are addressed by the PAL, since it would be unlikely to receive doses from those locations.

In this regard, it must be borne in mind that exceedance of the PAL may not constitute an unacceptable dose for many of the locations and likely uses.

For illustrative purposes only, soil concentrations have been categorized into four color ranges in the plates and figures provided in this report:

- soil concentrations ranging from 0 to 2.24 pCi/g are illustrated in green – these concentrations that are below the AOC PAL;
- soil concentrations greater than 2.24 to 5 pCi/g are shown in yellow.: This a relatively narrow range that includes the 5 pCi/g limit often used for Ra-226 clean-up and is about a factor of two larger than the PAL. New Mexico background Ra-226 concentrations can be in this range;
- soil concentrations greater than 5 pCi/g to 25 pCi/g are shown in orange. This range extends to about 10 times the AOC PAL. The IAEA states that it is *"usually unnecessary to regulate ... material containing radionuclides of natural origin at activity concentrations below 1 Bq/g*" IAEA RS-G-1.7 (2004). The value 1 Bq/g is equal to 27 pCi/g and is approximately equal to approximately 10 times the PAL;
- soil concentrations greater 25 pCi/g are illustrated in mauve and represent the top range of concentrations found during characterization.

The categorization of gamma *radiat*ion measurements has been established to have break points consistent with the Ra-226 soil concentration break points described above.

It is noted that at some locations soil concentrations were measured in the 0-2 inch and 2-6 inch soil horizons at many locations. Since the Ra-226 concentration in the 0-6 inch horizon was the basis for the PAL, the 0-6 inch concentration was calculated for these locations cases using a weighted estimate as determined by multiplying the 0-2 inch concentration by 2/6 and adding the 2-6 inches concentration multiplied by 4/6.

4.0 DISCUSSION OF RESULTS

This report presents the analytical results obtained during the sampling conducted pursuant to the ordered removal action. No opinions are provided regarding the source(s) of any of the contaminants analyzed at any of the locations.

4.1 FENCE IMPROVEMENTS

Fence improvements were conducted in accordance with the work plan. As discussed in further detail in Section 5.0 the integrity of the fence is monitored in accordance with the requirement of the AOC.

4.2 CHARACTERIZATION OF SURFACE AND SUB-SURFACE RED WATER POND ROAD SOILS

This section discusses the physical aspects of the site access road and shoulder relative to the characterization of potential contamination of surficial and subsurface soils along the Red Water Pond Road (RWPR) access route to Church Rock 1(CR-1).

4.2.1 Physical Aspects

Locations surveyed during the field investigations include gamma radiation measurements and soil sampling of the road surface and shoulder areas. The AOC requires that concentrations be compared to the Preliminary Action Level (PAL) of 2.24 pCi/g Ra-226 in the surface 0-6 inch soil horizon from previous UNC work (MWH 2010).

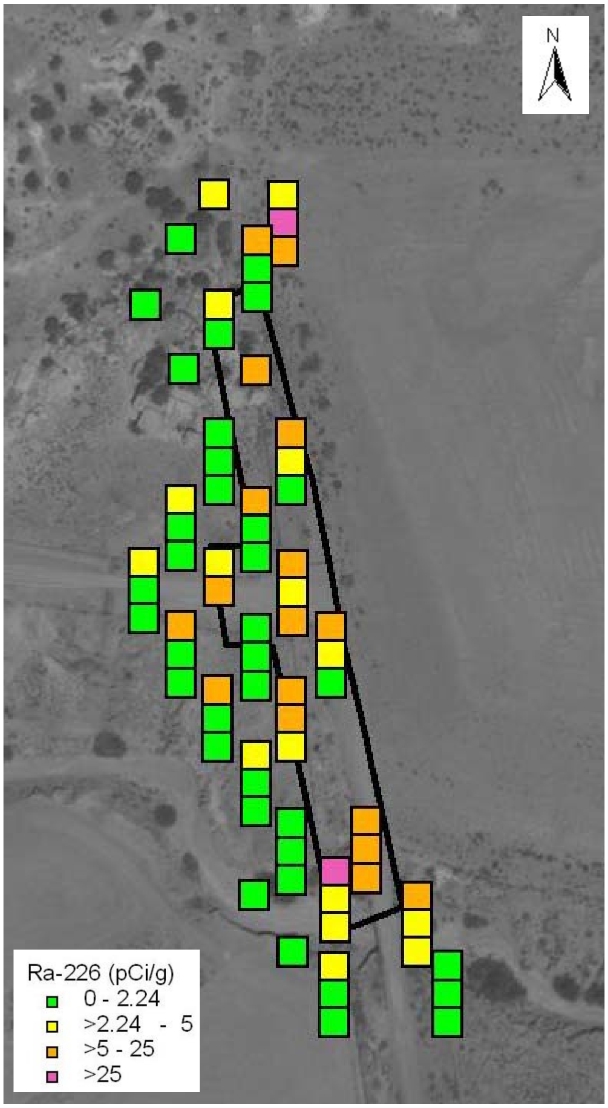
4.2.2 Soil Sampling

Figure 4.1 presents in plan view the location and results of Ra-226 for the sampling north and south of the bridge on the RWPR. The soil sampling data, data analysis and laboratory sheets are provided in Appendix A.

Plate 4.2-1 provides a graphic illustration of the Ra-226 concentrations measured on the RWPR area and Table 4.2-1 summarizes the data.

The surface measurements indicate that most locations have 0-6 inch Ra-226 concentration greater than the PAL. The soil concentrations generally decrease towards the west of the RWPR. Overall, concentrations in the 0-6 inch soil horizon are usually higher than from the deeper soil horizons.

Plate 4.2-1 RWPR Ra-226 Soil Concentrations (pCi/g)



RWPR South of Bridge

RWPR South of Bridge

Notes:

Top block is 0-6 inch; second block is 18-24 inch; third block is 30 to 36 inch soil horizon.
In some cases, a target zone was only partially measured due to refusal during sample collection

Sampling of the area north of the bridge at Arroyo #2 found higher concentrations generally along the road and near shoulders of the road.

Soil Ra-226 concentrations in the vicinity of the Unnamed Arroyo #2 Bridge and surroundings indicate a different pattern. Measurements collected near the base of the Unnamed Arroyo #2 show Ra-226 concentrations below the PAL as did the measurement program for the Unnamed Arroyo #2 described in following sections. Concentrations along the edge of the road to the north of Arroyo #2 show surface concentration above the PAL.

Table 4.2-1 Summary of Ra-226 Soil Concentrations (pCi/g) on the RWPR Site

	Depth in Inches	Number of Samples	Minimum	Median	Mean	Maximum
RWPR Road						
Shallow	0 to 6	13	1.02	12.2	16.3	43.2
Shallow	18 to 24	10	1.28	4.09	4.74	8.9
Shallow	30 to 36	9	0.66	3.05	3.12	6.7
RWPR South						
Shallow	0 to6 (est.)	8	1.42	5.4	14.9	84
Shallow	18to24	8	1.06	1.52	5.25	31.7
Shallow	30to36	7	1.07	1.72	6.05	33
Step-out						
Shallow	0 to 6 (est.)	17	0.79	2.9	4.31	21
Shallow	18 to 24	12	0.56	1.38	5.35	48.5
Shallow	30 to 36	12	0.63	1.27	2.78	17.3

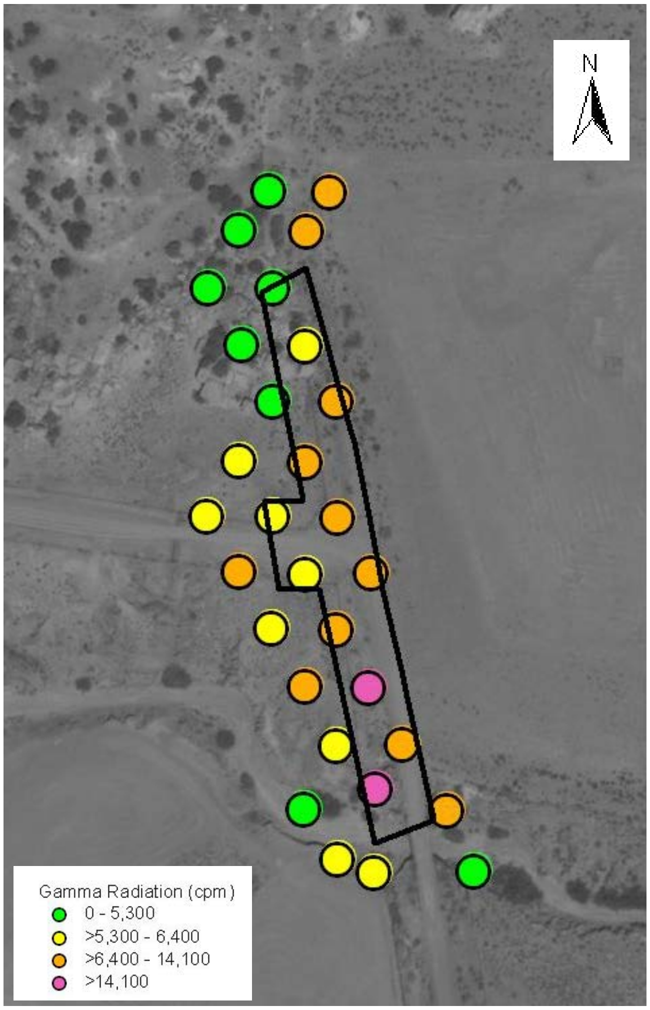
Note: Estimated values are results of combining two horizons

The samples from the RWPR south of the Bridge show that the Ra-226 concentrations in surface soils in most locations exceeding the PAL. Shallow subsurface soils generally exhibit lower concentrations than surface soils. The notable exception is RWPR-031, located at the east side of the road near the Unnamed Arroyo #2 Bridge where concentrations increased at depth. Initial assessment of sampling results shows results similar to those reported by UNC (MWH, 2010).

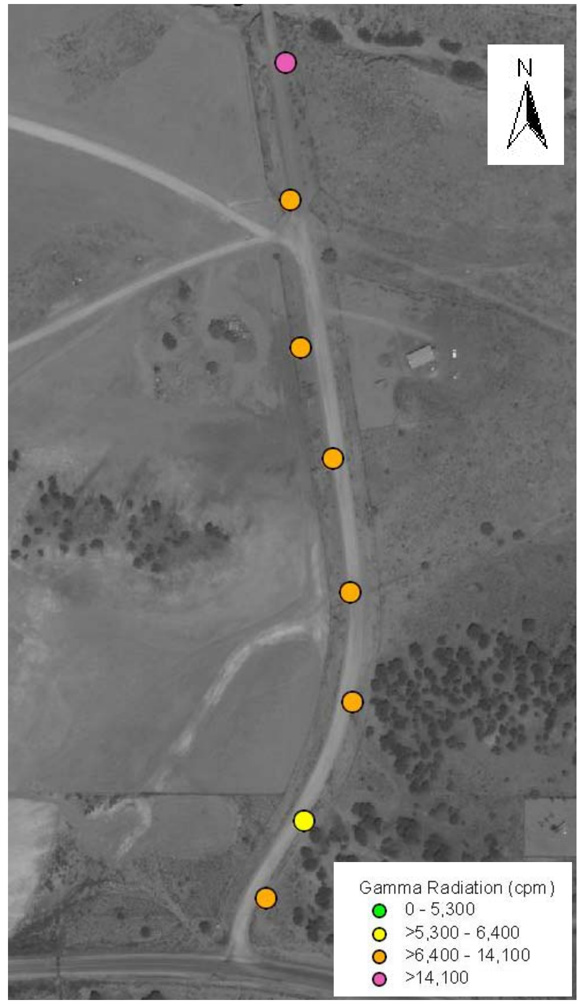
4.2.3 Gamma Radiation Survey

Gamma radiation levels were measured with both static one-minute counts at soil sampling locations and using a scanning survey where measurements were recorded automatically. Plate 4.2-2 shows both the static and the scanning gamma radiation levels measured on the RWPR north end and the RWPR south of the bridge. The PAL equivalent counts per minute (CPM) would be about 5,300 cpm as discussed in Section 4.5 and provides the basis for the binning of the gamma data in subsequent figures. Gamma radiation levels on RWPR north of the bridge show variability with a decrease to the west to levels consistent with being lower than the PAL but higher gamma radiation levels along the road and where sedimentation likely from overland flow was apparent as was also found in the soil concentration data. The pattern of radiation measurements for the area RWPR south of the bridge demonstrates variable gamma radiation levels both along the road but also in the shoulder locations. Table 4.2-2 summarizes the range of static gamma radiation levels for the three RWPR sub-areas.

Plate 4.2-2 RWPR Collimated Gamma Radiation Measurements (cpm) at Static Locations



RWPR North of Bridge



RWPR South of Bridge

Table 4.2-2 Summary of Static Gamma Radiation Levels (cpm) in RWPR

Sub Area	Number	Minimum	Median	Mean	Maximum
RWPR Road	12	5264	9924	9746	17057
RWPR South	8	5660	8619	11221	29602
Step-out	18	3927	5523	6045	10950

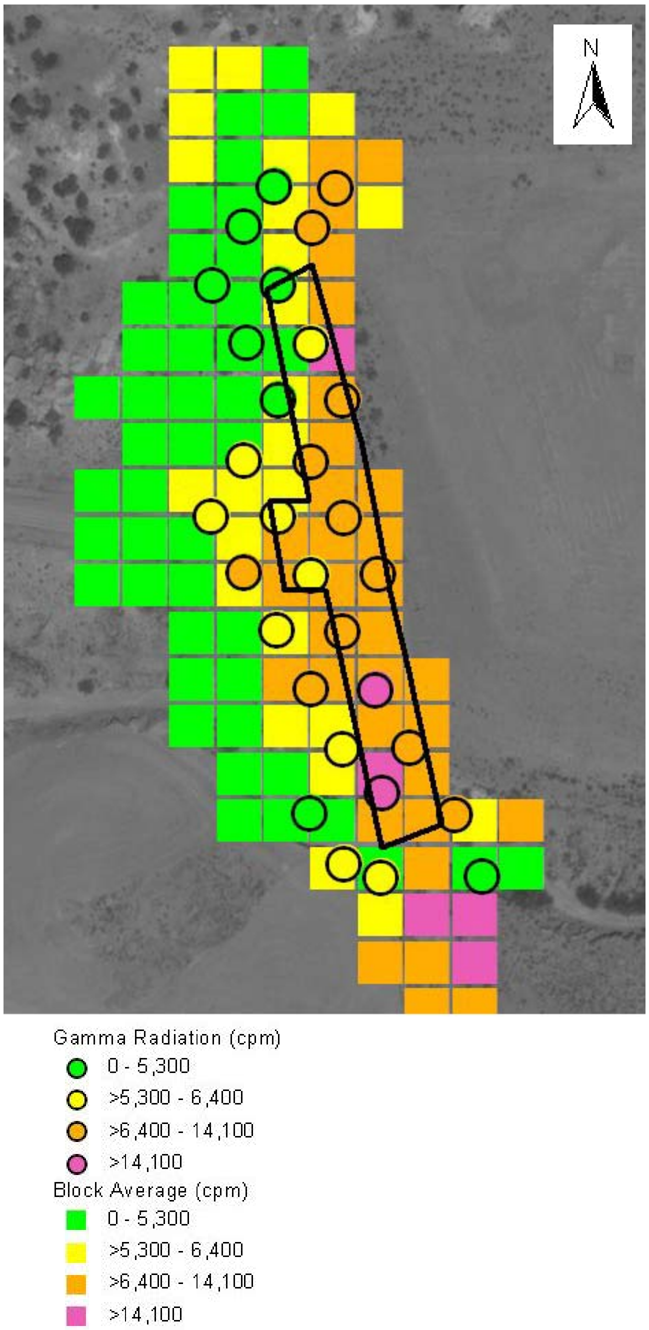
4.2.4 Scanning Gamma Radiation Measurements

The scanning gamma radiation measurements were automatically recorded to the GPS data logger and were measured at 18 inch height at transects within the static grid. These measurements were averaged to a grid area corresponding to the area represented by the 80 ft triangular grid used for static measurements. These averages are illustrated in Plate 4.2-3 along with the static point measurements as the measurements since both were measured with the same instrumentation type. The averaged scanning gamma radiation measurements are similar to the static gamma radiation measurements; however, the averaged scanning measurements provide a better representation of gamma radiation for each area. The static measurements are uncertain measurements for the representative area due to small scale variability in the gamma radiation measurements.

The plate indicates that gamma radiation measurements decrease towards to the west to locations indicative of below PAL soil concentrations in the 0-6 inch soil horizon and this indicates that appropriate Step-out has been reached for the RWPR north. Higher gamma radiation measurements are located on and near the RWPR road. Gamma radiation measurements on the RWPR South are generally indicative of soil concentrations exceeding the PAL: the higher concentrations in this area are generally found along the sides of the road.

The averaged gamma radiation measurements are summarized in Table 4.2-3. The scanning measurements were collected prior to any of the remediation activities required under the AOC (e.g. minor excavation and sealing the road). The RWPR north of the bridge was surveyed following grading and work on slope stabilization of the CR-1 Waste Rock area. The differences in averaged gamma radiation measurement between the pre-remediation and subsequent surveys are included in Table 4.2-3. The gamma radiation measurements typically decreased on these blocks and this is consistent with the re-profiling of west slope of the waste pile with a dozer.

Plate 4.2-3 RWPR Static and Scanning Gamma Radiation Measurements



RWPR North of Bridge

RWPR South of Bridge

Table 4.2-3 Block Averages of Scanning Gamma Radiation Measurements

Sub-Area	Number of Blocks	Minimum	Median	Mean	Maximum
Block Averages					
North	18	4750	10700	10600	18700
South of Bridge	93	5450	8980	9800	19500
Step-out	79	4060	5170	5920	13900
Difference from Pre-Remediation					
North	11	-4380	-1110	-1130	4120
Step-out	12	-6520	-2800	-2460	1970

Note:
Comparison is based on the difference between block averages before October 2010 remediation and the block averages following the October 2010 remediation. A negative value indicates that remediation resulted in lower gamma radiation measurements.

4.3 CHARACTERIZATION OF CR-1

This section discusses the physical aspects of the site relative to the potential for contamination, presents the results of soil sampling and gamma radiation measurements at the CR-1 site. In addition, the Ra-226 results at depth are also presented along with the results of the non-radiological aspects of the Phase II Soil Sampling Program as they pertain to the CR-1 site.

4.3.1 Physical Aspects

The Phase II soil sampling program for CR-1 included the assessment of shallow surface and deeper subsurface soil sampling and gamma radiation measurements at discrete locations across the three primary areas used to define work areas within the lease area on site namely the waste rock area, sediment pond area, and the industrial area plus the 100 ft step-out area adjacent the perimeter of the lease area. For presentation purposes, the west and east side lateral limits of these areas are presented in plan on Figures 4.2a and 4.2b respectively.

As part of the initial Phase II program in the CR-1 area, an assessment of the shallow surface soils and gamma radiation measurements at thirteen discrete cross-section locations along the Unnamed Arroyo #2 was undertaken. The sampling locations within the western and eastern limits of the Unnamed Arroyo#2 area are presented in plan on Figures 4.3a and 4.3b respectively.

Waste Rock Area

The waste rock area is defined by the limits of the soil covered waste rock stockpile at the western limits of lease area. The majority of the waste rock material within the stockpile is fine grained with most of the material defined as a fine to medium sand with little to no coarse sand or gravel.

Sediment Pond Area

The sediment pond area is defined by the area of the site where historic aerial photographs depict sediment ponds constructed and used for treatment and settling of water pumped from underground during the mining operations. A total of nine ponds where identified; however, information on their construction and subsequent decommissioning has not been made available if it exists at all. From a review of the site plans from the time when the mine was in operation, discussions with former employees, and the existing site conditions it is apparent that the ponds have been removed, the area graded and the soils underlying these former ponds removed and relocated on or off site.

Industrial Area

The industrial area of the site is defined by the portion of the site where industrial buildings and ancillary structures were located including a power transformer station. The buildings were decommissioned at the close out of operations and the majority of the area appears to have been graded over with overburden from the area likely as part of the waste rock stockpile capping program.

Unnamed Arroyo #2 Area

The CR-1 site is physically separated from the UNC lands to the south by the Unnamed Arroyo #2 that runs from west to east at or near the southern limit to the CR-1 lands. The Unnamed Arroyo #2 Area of the site is located immediately south of the CR-1 site and is a moderately wide and deep arroyo that drains west to east and flows periodically. The width of the arroyo typically ranges from 15 to 35 feet with sidewalls 10 to 15 feet high which flatten out to a flood plain near the junction with the Pipeline Arroyo location west and south of site CR-1E. In general the soil stratigraphy at the base of the arroyo is consistent with the fine to medium grained soils encountered at lease area and Step-out area of CR-1.

4.3.2 Radiological Soil (Ra-226) Sampling & Gamma Radiation Survey - Results

The analytical results for this portion of the site are tabulated in Appendix A1 and raw laboratory data sheets are provided in Appendix A2. Figures 4.2a and 4.2b shows graphically the Ra-226 concentrations measured across the CR-1 site from both the shallow surface sample locations and the deeper subsurface sample locations. Figure 4.3a and 4.3b show the location of the Ra-226 concentrations measured across the transects along the Unnamed Arroyo #2. The following sub-sections provide more details on the analytical results as a function of area.

4.3.2.1 Waste Rock Area

Ra-226 Soil Concentrations

Figure 4.2a presents the results of both the shallow and the deeper soil sampling across the waste rock area. The soil sampling data, data analysis and laboratory sheets are provided in Appendix A.

Plate 4.3-1 graphically illustrates the Ra-226 concentrations measured at the three target depths for the shallow surface program. In summary, the data indicate that concentrations are lower on the surface and often below the PAL, but concentrations at depths immediately below are higher than surface concentrations. Details on all individual soil concentrations are tabulated in Appendices A1 and A2 and are also shown in plan on Figure 4.2a. Additional comments are provided below.

Plate 4.3-1 CR-1 Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program-Site Wide

Notes:

Top block is 0-6 inches; second block is 18-24 inches; third block is 30 to 36 inches soil horizon.
In some cases, a target zone was only partially measured due to refusal during sample collection.

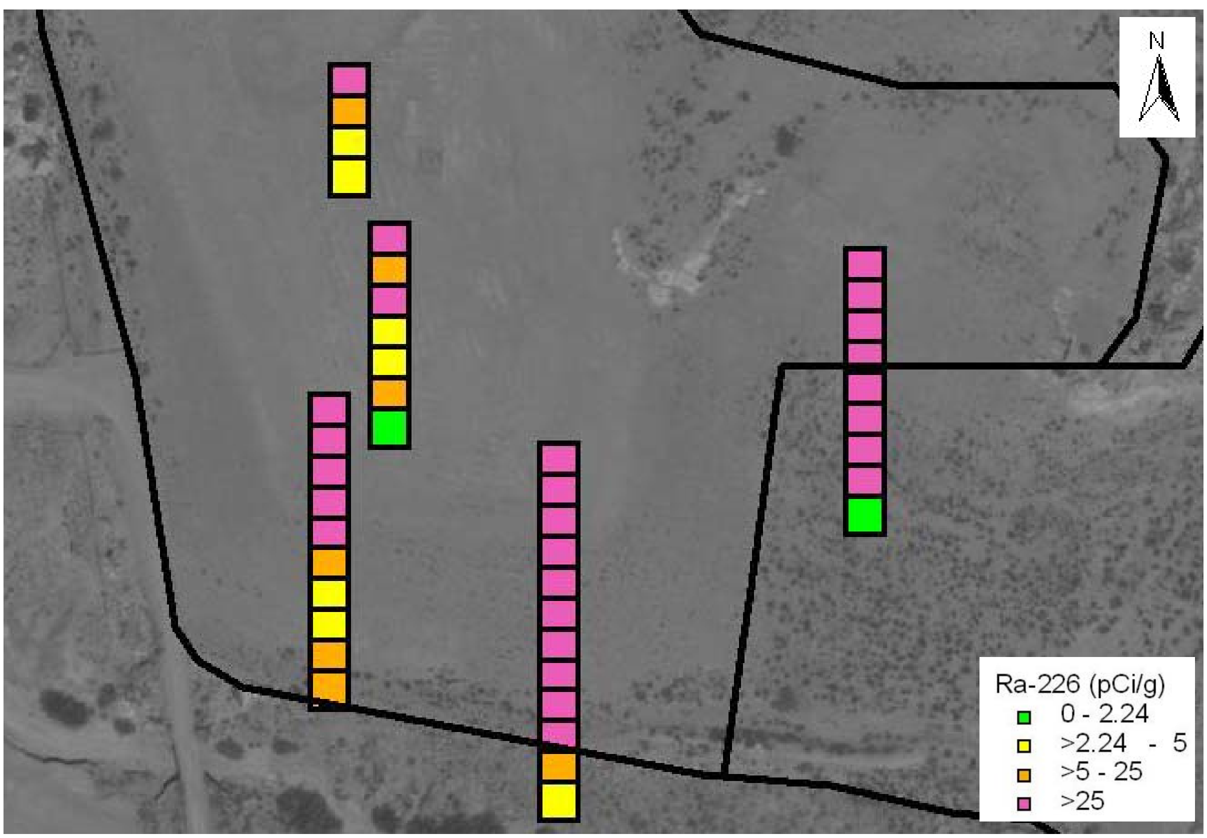
A summary of shallow surface concentrations is provided in Table 4.3-1. As illustrated in Plate 4.3-1, the profile of Ra-226 concentrations is as expected with lower concentrations, typically below the PAL, associated with the waste rock cover measured in the 0-6 inches soil horizon but with higher concentrations at depth where the waste rock is present. The median concentration of 1.86 pCi/g in the 0-6 inches soil horizon is below the PAL. The medians for both the 18 to 24 inches and 30 to 36 inches are about 60 pCi/g.

Table 4.3-1 Summary of Ra-226 Concentrations (pCi/g) for Shallow Sub-surface Samples from the Waste Rock Area

Sample Type	Depth	Number Of Samples	Minimum	Median	Mean	Maximum
Shallow	0to6	16	1.24	1.86	2.15	7.02
Shallow	18to24	10	1.82	65.2	67.2	154
Shallow	30to36	10	2.25	58.8	69	189

The deep drilling program collected composite samples over a 1.5 foot horizon at every five feet of depth and these are illustrated in Plate 4.3-2 and summarized in Table 4.3-2.

Plate 4.3-2 CR-1 Ra-226 Soil Concentrations Measured with Deep Drilling Program on Waste Rock Area



Notes:

Sampling conducted by 5 foot increments with a composite over 1.5 foot.
Top block begins at a 5 foot depth

Table 4.3-2 Summary of Ra-226 Concentrations (pCi/g) for Shallow Sub-surface Samples from the Waste Rock Area

Depth	Number Of Samples	Minimum	Median	Mean	Maximum
5	5	41.9	44	66.9	110
10	5	7.6	31.2	36.3	77.7
15	5	3.81	51.7	44	70.9
20	5	3.46	43.9	31.8	56.1
25	4	3.56	44.3	36.4	53.3
30	4	5.06	28.9	35	77
35	4	1.63	31.5	34	71.3
40	3	4.89	51.6	38.6	59.2
45	3	1.9	18.8	30	69.3
50	2	5.69	24.5	24.5	43.3
55	1	11.8	11.8	11.8	11.8
60	1	2.96	2.96	2.96	2.96

Table 4.3-2 indicates that the sample measurements are range from a low of 1.9 to a high of 110 pCi/g with means ranging from a low 11.8 to 66.9 pCi/g for all samples excluding the sample from the base of the pile which measured 2.96 pCi/g.

Gamma Radiation Results

Plate 4.3-3 shows the static gamma radiation levels measured on the waste rock area. These results are typically higher than would be indicative of the Ra-226 concentrations in the cover soils based on the data collected for the site which indicates that the PAL equivalent counts per minute (CPM) would be about 5,300 cpm as discussed in a later section. Table 4.3-3 summarizes the static gamma radiation measurements for the CR-1 site.

Plate 4.3-3 CR-1 Static Gamma Radiation Levels (cpm) Measured on Waste Rock Area

Table 4.3-3 Summary of Static Gamma Radiation Levels (cpm) at CR-1 Site

Sub Area	Number	Minimum	Median	Mean	Maximum
Former Industrial	102	3327	5028	5496	15935
Former Sediment Pond	134	3671	4883	5643	19577
Step-out	113	3158	5099	6123	22917
Unnamed #2	39	3592	4618	4652	5726
Waste Rock	105	3293	7276	8557	21021

4.3.2.2 Former Sediment Pond Areas

The boundary areas and sampling plan for the former sediment pond area was re-defined pursuant to preparation of the project plan submitted in October 2010 due to newly acquired information that identified the presence of sediment points in the north-east region of the lease area.

This resulted in a re-classification of the sample coding originally assigned to the pond area and the inclusion of samples in this area that were originally identified as being part of the former industrial area.

Shallow soil sampling locations are a combination of original random sample locations and judgemental sampling locations to ensure that the ponds and former discharge points are measured.

Soil Sampling

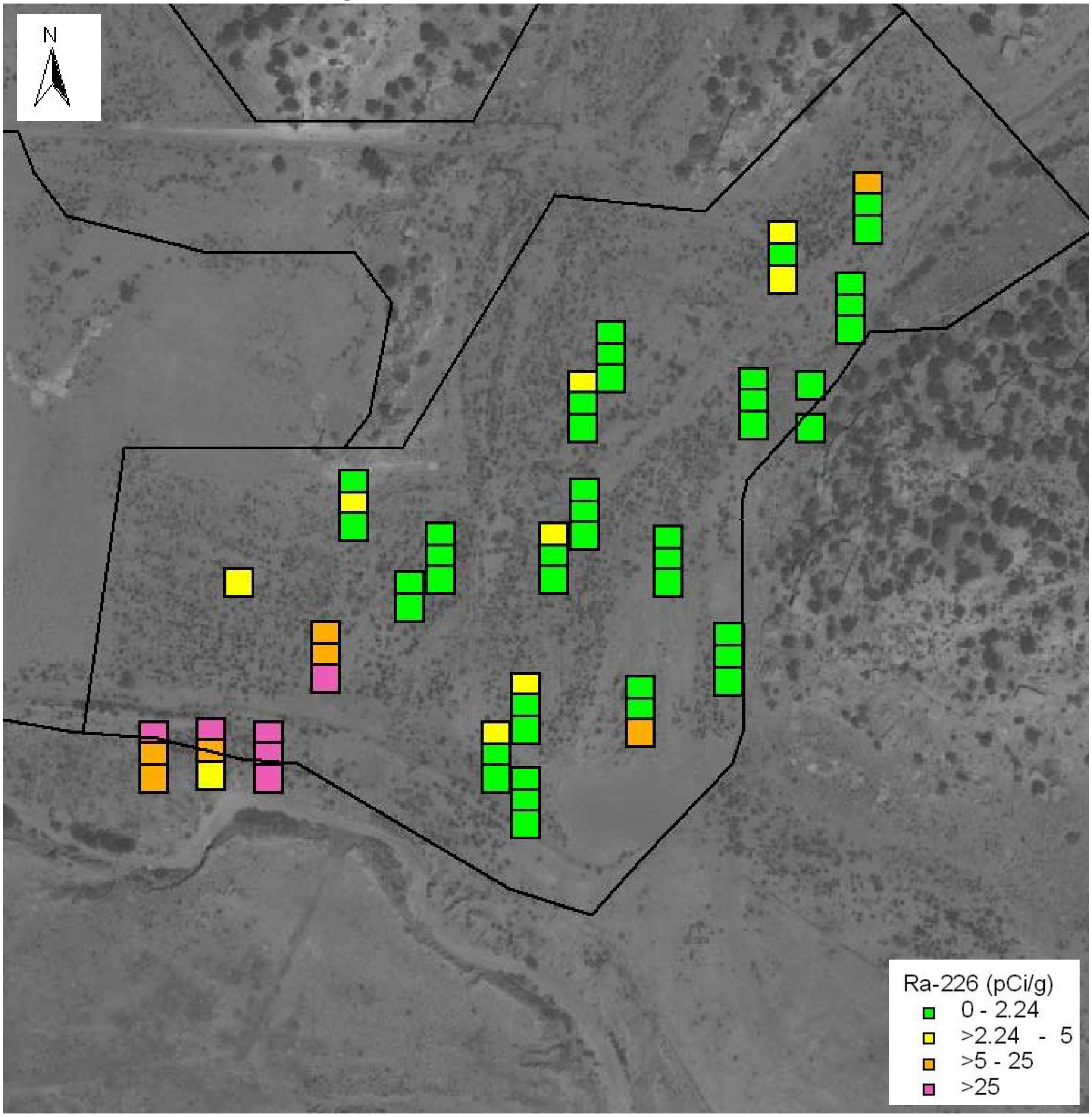
The sampling of the former sediment pond area included a random pattern plus targeted sampling near the historic discharge point. Figure 4.2b presents the results of both the shallow and the deeper soil sampling in the former pond area. The soil sampling data, data analysis and laboratory sheets are provided in Appendix A.

Plate 4.3-4 graphically illustrates the results for the 23 locations shallow soil surface sampling occurred. As illustrated, the majority of the surface soil concentrations from the shallow program were below the PAL. Surface and sub-surface soil concentrations tended to be higher near the discharge point.

Table 4.3-4 Summary of Ra-226 Concentrations (pCi/g)
for Shallow Surface Sampling in the Former Sediment Pond Area

Depth (inches)	Number of Samples	Minimum	Median	Mean	Maximum
0to6	23	1.05	2.23	7.43	47.1
18to24	20	1.17	1.88	5.09	29.9
30to36	21	0.89	1.65	4.76	29.2

Plate 4.3-4 CR-1 Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Former Sediment Pond Area



Notes: Top block is 0-6 inches; second block is 18-24 inches; third block is 30 to 36 inches soil horizon. In some cases, a target zone was only partially measured due to refusal during sample collection.

Plate 4.3-5 graphically illustrates the results of the deep drilling Ra-226 soil concentration data from the former sediment pond areas with summary statistics provided in Table 4.3-5. The majority of deep drilling occurred in this area with sampling from 13 locations. Consistent with the shallow sampling, results from the deeper sampling program found many of the surface concentrations to be below the PAL. The 16.5-18 foot sample interval at C1LP-402 had the highest Ra-226 concentration. These targeted samples are not intended to be statistically representative of the entire pond location and the resulting statistics may not be reliable indicators of concentrations at each depth. Ra-226 surface soil concentrations exceeded the PAL in the southwest and northeast part of the former sediment pond area.

Plate 4.3-5 CR-1 Ra-226 Soil Concentrations Measured with Deep Drilling Program on Former Sediment Pond Area

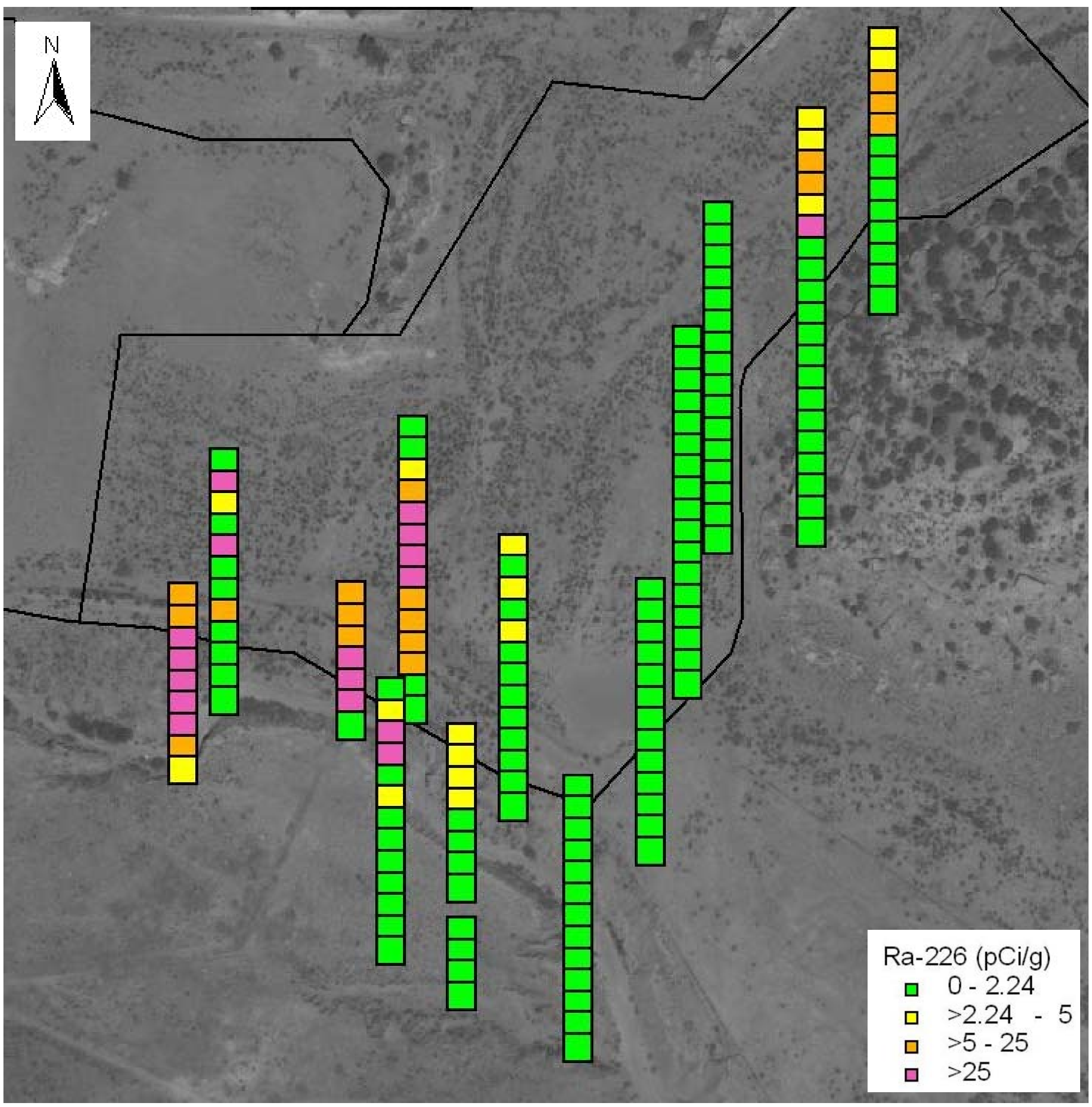


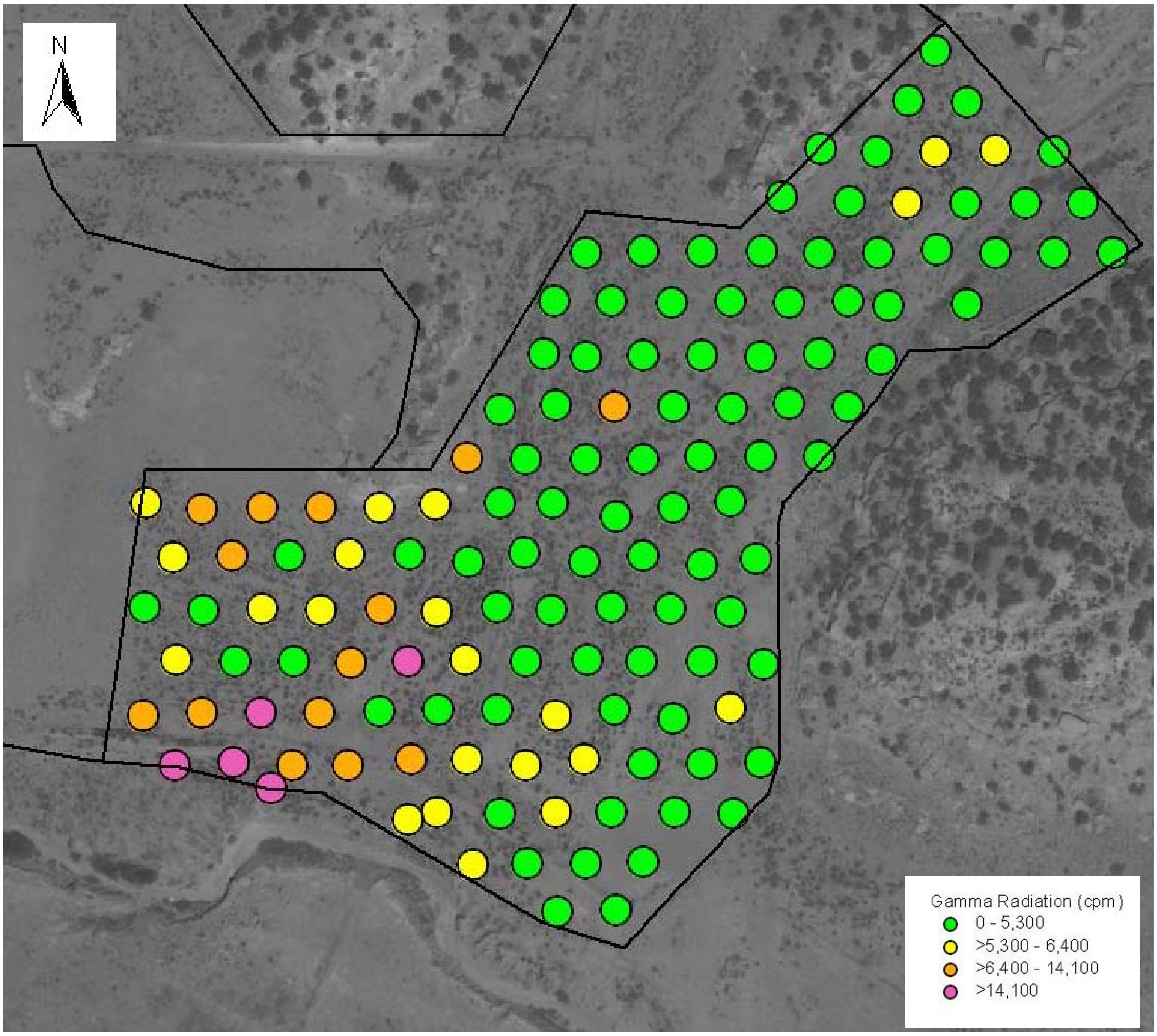
Table 4.3-5 Summary of Ra-226 Concentrations (pCi/g) for Deep Drilling in the Former Sediment Pond Area

Depth	Number Of Samples	Minimum	Median	Mean	Maximum
1.5	13	1.16	2.2	4.11	21.4
3	13	1.14	3.14	7.42	28.7
4.5	13	1.13	3.15	8.83	39.1
6	13	1.2	3.07	46.5	468
7.5	13	1.1	3.67	25.2	87.4
9	13	0.95	1.52	35.7	328
10.5	13	0.95	1.15	42.1	472
12	12	1.14	1.59	6.67	49.2
13.5	11	0.96	1.44	2.44	11.1
15	11	0.95	1.44	3.31	21.6
16.5	11	0.92	1.37	2.36	12.4
18	11	0.9	1.57	1.99	6.67
19.5	10	1.12	1.36	1.39	1.72
21	4	1.23	1.59	1.57	1.88
22.5	3	1.35	1.5	1.48	1.59
24	3	1.2	1.44	1.36	1.45
25.5	2	1.19	1.26	1.26	1.33
27	1		1.49		
28.5	1		1.62		
30	1		1.46		

Static Gamma Radiation

The static gamma radiation levels are illustrated in Plate 4.3-6. The summary of gamma radiation levels indicates that the surface gamma radiation across the former pond area is generally low with a limited area of higher concentrations near the original sediment pond, the early discharge area, and along the waste rock area.

Plate 4.3-6 CR-1 Static Gamma Radiation Levels (cpm) Measured on Former Sediment Pond Area

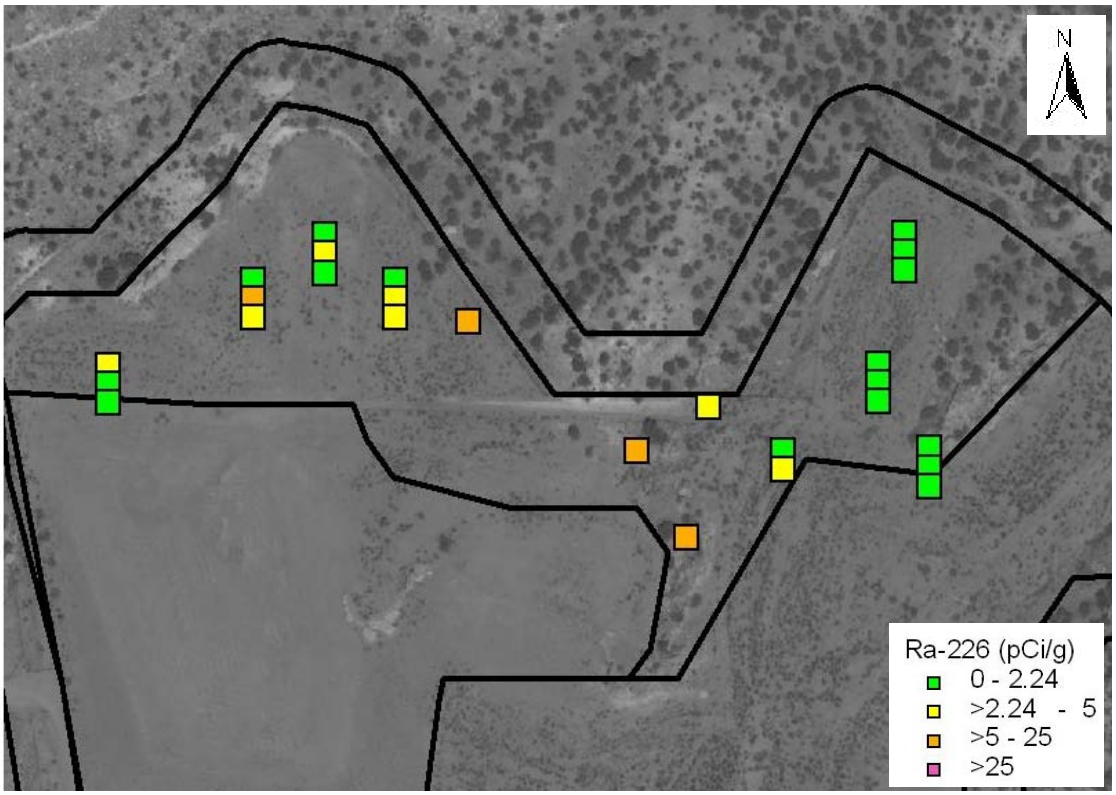


4.3.2.3 Former Industrial Area

Soil Concentrations

Shallow surface and deep-drilling sampling was conducted on the former industrial area. Plate 4.3-7 illustrates the shallow surface sampling results.

Plate 4.3-7 CR-1 Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Former Industrial Area



Notes:

Sampling conducted by 1.5 foot increments
Top block is from 0 to 1.5 foot depth

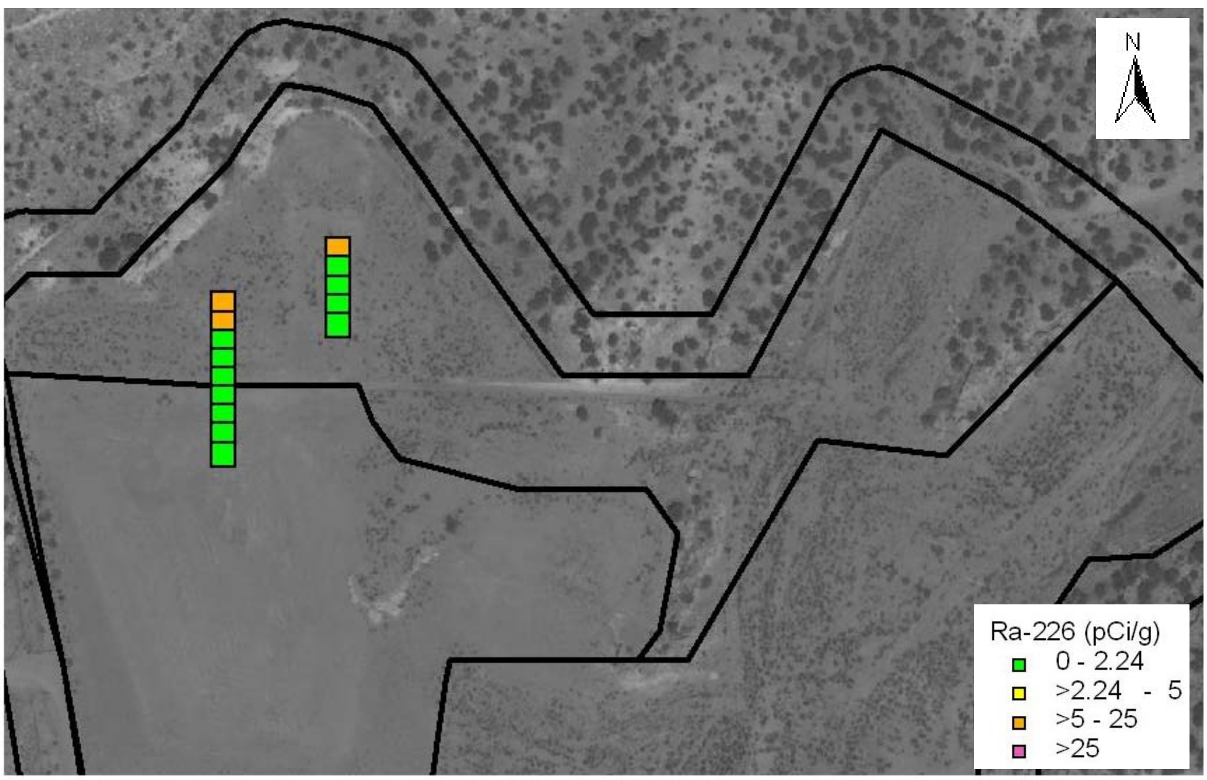
Table 4.3-6 shows the summary of concentrations measured in the three target sub-zones. A more complete table showing summary of all data is provided in Appendix A2. There were 11 locations with soil concentration measurements for the 0-6 inch soil horizon; however, a sample could only be recovered from the 0-2 inch soil horizon for the C1LI-047 location. The majority of samples had concentrations below the PAL.

Table 4.3-6 Summary of Shallow Sub-surface Soil Concentrations (pCi/g Ra-226) on Former Industrial Area

Depth (inches)	Number Of Samples	Minimum	Median	Mean	Maximum
0-6	11	0.98	1.85	2.84	7.37
18-24	7	1.17	1.9	2.79	5.23
30-36	7	0.84	1.63	2.04	4.71

Plate 4.3-8 illustrates and Table 4.3-7 summarizes the Ra-226 concentrations from the deep drilling program for this area. The two locations have samples that exceed the PAL.

Plate 4.3-8 CR-1 Ra-226 Soil Concentrations Measured with Deep Drilling Program on Former Industrial Area



Notes:

Sampling conducted by 5 foot increments with a composite over 1.5 foot.
Top block begins at a 5 foot depth

Table 4.3-7 Summary of Shallow Sub-surface Soil Concentrations (pCi/g Ra-226) on Former Industrial Area

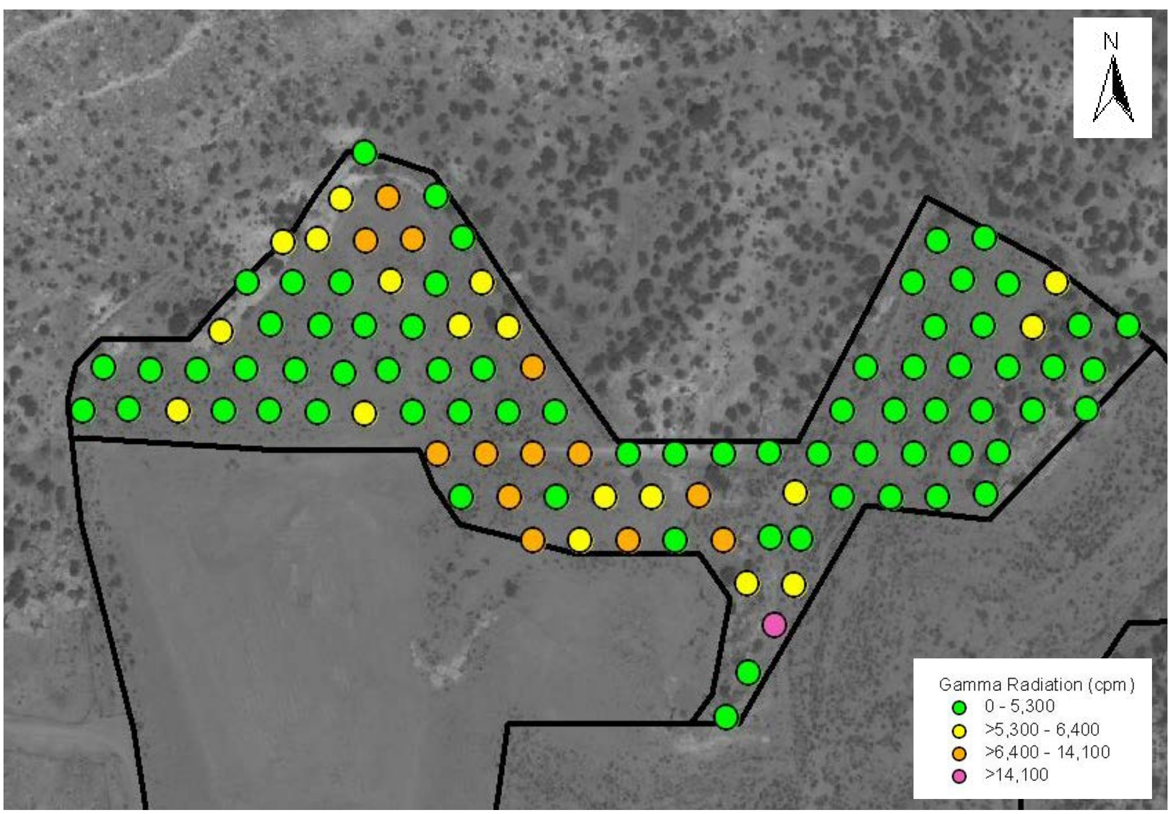
Depth (inches)	Number Of Samples	Minimum	Median	Mean	Maximum
1.5	2	5.51	7.86	7.86	10.2
3	2	1.03	7.67	7.67	14.3
4.5	2	1.07	1.35	1.35	1.62
6	2	0.67	1.38	1.38	2.09
7.5	2	1.16	1.31	1.31	1.45
9	1		0.86		
10.5	1		1.24		
12	1		1.23		
13.5	1		1.14		

As seen from the table soil concentrations generally became lower at depth in the boreholes.

Static Gamma Radiation

The static gamma radiation levels across the industrial area are illustrated in Plate 4.3-9. The measured gamma radiation levels indicate that the surface gamma radiation is generally low across the industrial area with some higher levels near the rock outcroppings in the central area and in the northeast corner.

Plate 4.3-9 Static Gamma Radiation Levels (cpm) in Former Industrial Area



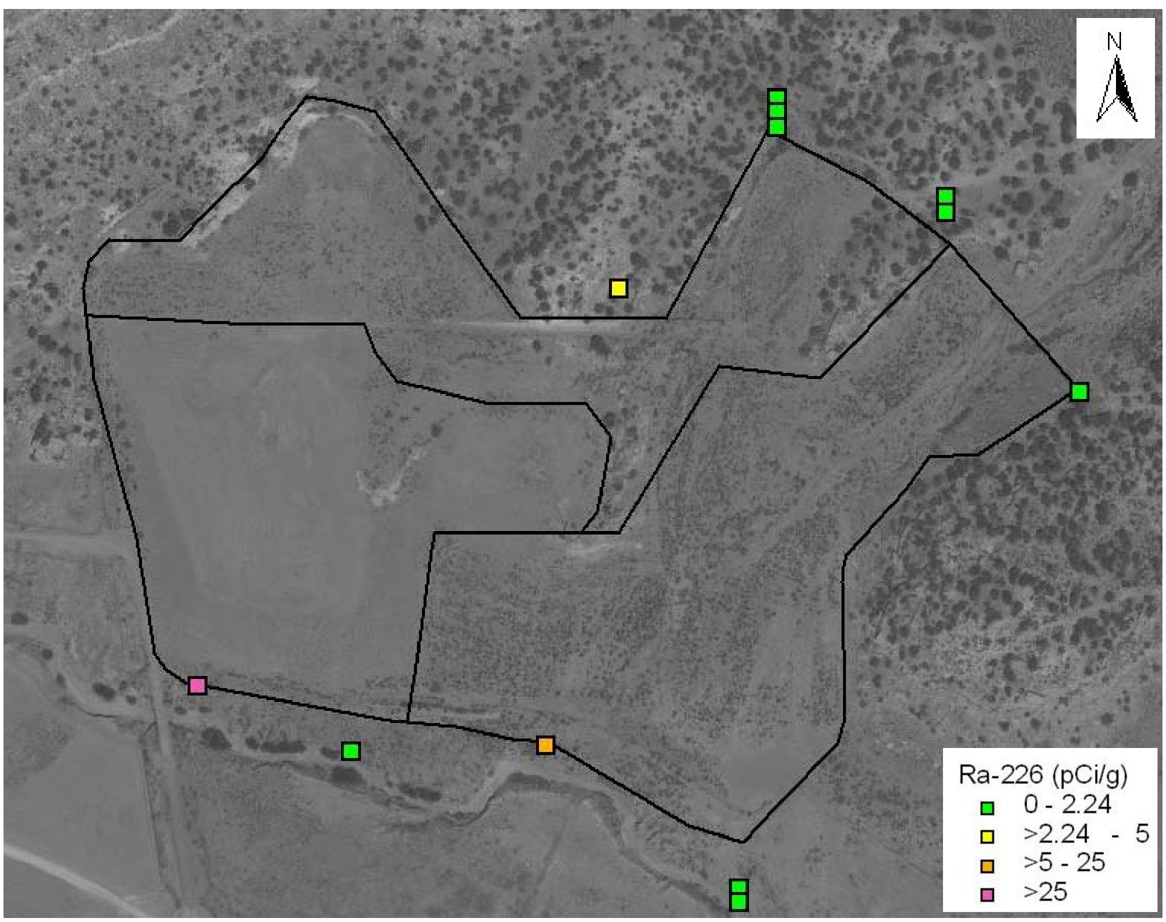
4.3.2.4 Step-out Areas

Soil Concentrations

Shallow soil sampling was carried out at selected and approved locations in the Step-out areas. Figures 4.2a and 4.2b show in plan the Ra-226 concentrations measured across the Step-out area.

Results of sampling are graphically illustrated in Plate 4.3-10 which show that soil concentrations exceeding the PAL were observed at two locations between the CR-1 and the Unnamed Arroyo #2. There was one location slightly exceeding the PAL to the north. Summary statistics on the data are provided in Table 4.3-8. Note that eight locations are shown in Plate 4.3-10, but the table reports only seven locations. One sampling location, C1SS-125, had refusal after the 0-2 inch horizon where a reported concentration of 1.29 pCi/g was measured.

Plate 4.3-10 CR-1 Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Step-out Area



Notes:

Top block is 0-6 inches; second block is 18-24 inches; third block is 30 to 36 inches soil horizon.
In some cases, a target zone was only partially measured due to refusal during sample collection.

Table 4.3-8 Summary of Ra-226 Soil Concentrations Measured in CR-1 Step-out Area with the Shallow Surface Program

Depth (inches)	Number Of Samples	Minimum	Median	Mean	Maximum
0to6 (est.)	7	1.26	1.84	8.33	30.2
18to24	3	0.93	1.04	1.19	1.61
30to36	1	1.25	1.25	1.25	1.25

Note: Estimated values are results of combining two horizons

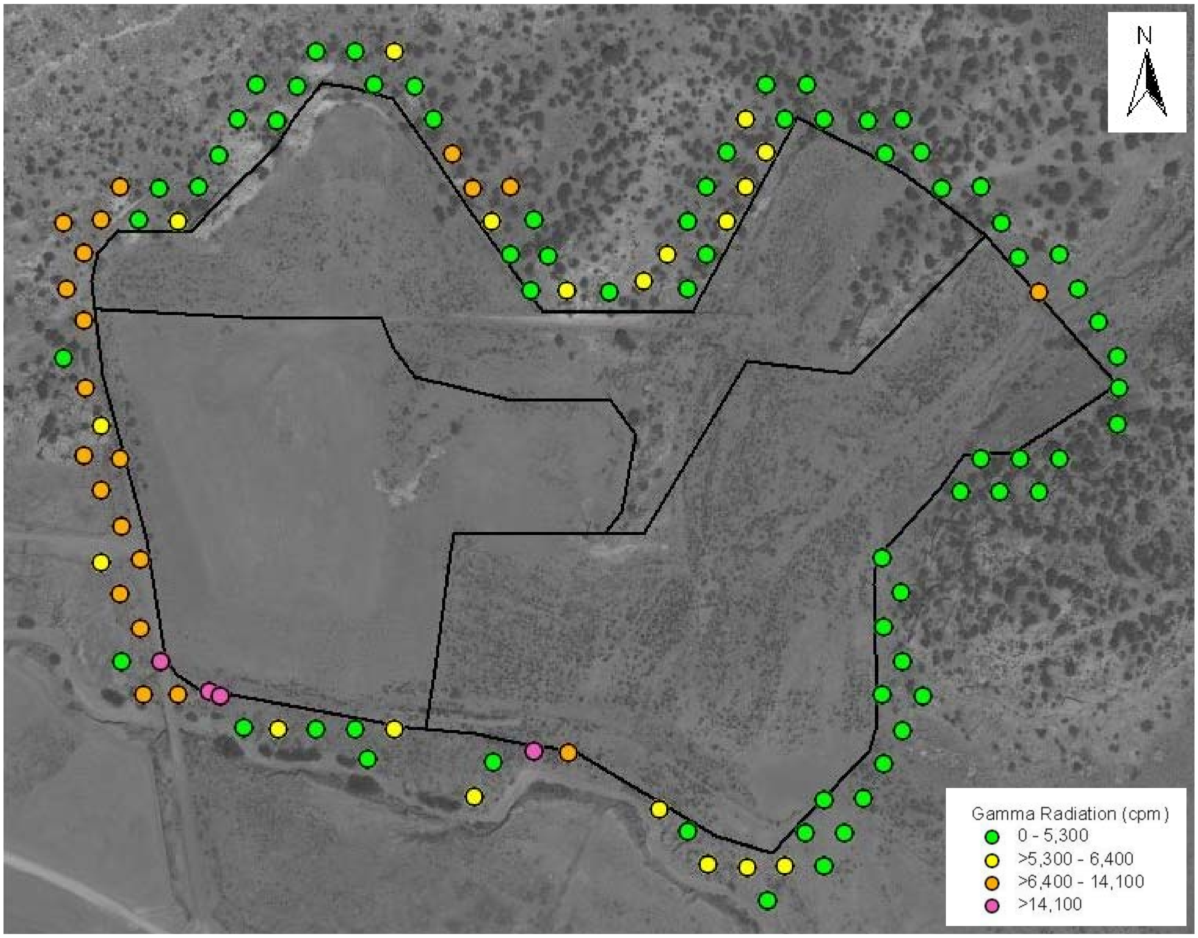
As part of the initial stage of the Phase II program, shallow surface soil samples were procured from seven locations at the CR-1 site not including those sample locations associated with the RWPR area near the site gate. No deeper sub-surface boreholes were advanced within this area.

In general, the soil stratigraphy from this area is similar to that noted above with coarser material observed near the site access road.

Gamma Radiation

Plate 4.3-11 illustrates the static gamma radiation levels measured in the CR-1 Step-out area. Higher gamma radiation levels are observed on the west side as previously measured on the RWPR. Higher gamma radiation levels are also observed between the CR-1 area and the Unnamed Arroyo #2 at the location of the previous discharge point and in the southwest corner near RPWR that may be due to erosion. The remaining area has limited number of locations above the PAL.

Plate 4.3-11 CR-1 Static Gamma Radiation Levels (cpm) Measured on Step-out Area

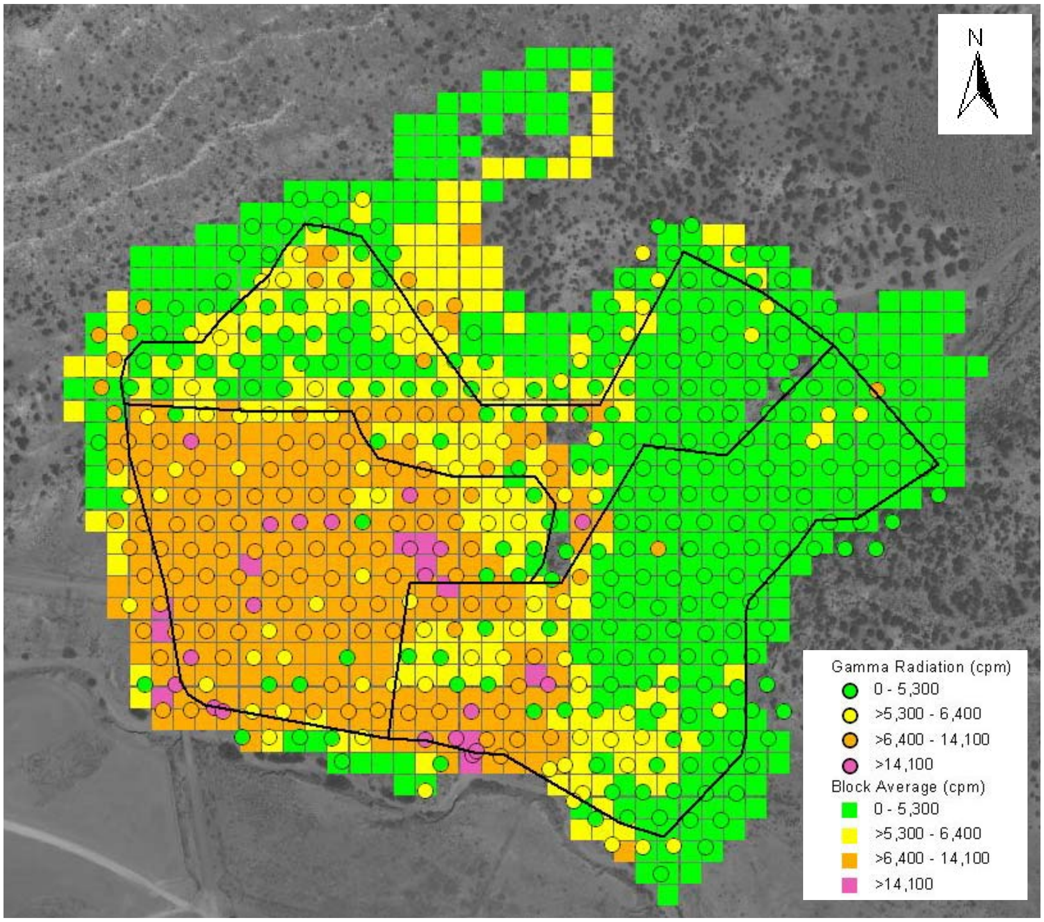


4.3.2.5 Scanning Gamma Radiation Measurements

The scanning gamma radiation measurements were averaged to a grid area corresponding to the area represented by the 80 ft triangular grid used for static measurements. These averages are shown in Plate 4.3-12 along with the static point measurements.

The average gamma radiation measurements are visually well correlated with the static gamma radiation measurements as low averages from the scan coincide with low static point measurements; however, the averages of scanning data are not as affected by short distance variability that can affect the representativeness of the static points. For example, there are a few static points with gamma radiation measurements >5,300 cpm in the northeast corner of the Former Sedimentation Pond subarea but the average gamma radiation measurements indicate that these are locations are quite isolated compared to the area averages.

Plate 4.3-12 CR-1 Scanning Gamma Radiation Measurements



Note:

- Circles are static gamma radiation results
- Squares indicate averages of scanning gamma radiation data
- No data in areas not colored.

Plate 4.3-12 indicates that gamma radiation measurements in the Step-out on north and east sides are consistent with little wind-blown or overland transport of Ra-226. There is some possibility of a higher background in some of these areas compared to 1.0 pCi/g assigned to the PAL. Gamma radiation levels tend to be higher in the northern step-out compared to other areas and this may be due to higher background than 1.0 pCi/g. In this area there is no consistent gradient in gamma radiation levels and field observations indicated that the higher gamma radiation levels were associated with naturally occurring gray shale and areas with evidence of oxidized rock. This suggests a higher local background in these areas than that used in the development of the PAL. The step-out on the west side corresponds with the higher measurements on the RWPR. Along the south side between the CR-1 and the Unnamed Arroyo #2, there is a mixture of background and elevated gamma radiation measurements. The higher gamma radiation measurements are present near the RWPR bridge and near the historic discharge point. Slightly higher gamma radiation measurements are apparent near the more recent discharge point at the south east corner.

Table 4.3-9 provides a summary of the averaged gamma radiation measurements by sub-area for the CR1 site. With the exception of the Waste Rock area, the typical (median) gamma radiation measurement is indicative of 0-6 inch soil concentrations below the PAL. Measurements along the west slope of the Waste Rock area and the west Step-out concurrent with the RWPR were collected prior to remediation activities in October 2010. Subsequent measurements found a slight decrease in concentrations was observed in the Step-out and a slight increase observed within the Waste Rock Area. This is consistent with placement of the scraped material from the RWPR being placed on the west slope of the Waste Rock pile.

Table 4.3-9 Block Averages of Scanning Gamma Radiation Measurements on CR-1 Site

Sub-Area	Number of Blocks	Minimum	Median	Mean	Maximum
Current					
Former Industrial	174	3690	5330	5460	9100
Former Sediment Pond	235	4080	5020	5710	15000
Step-out	309	3640	5080	5600	18100
Waste Rock	184	5230	8290	8780	19800
Compared to Pre-Remediation in October 2010					
Step-out	14	-7440	-225	-717	3320
Waste Rock	15	-6500	419	26.3	3730

Note:

Step-out contains some areas outside the established step-out zone in the SOW.

The comparison is based on the difference between block averages calculated after October 2010 and the block averages prior to October 2010 remediation. A positive value indicates that the gamma radiation measurements were higher following remediation.

4.3.2.6 Unnamed Arroyo #2

As part of the initial stage of the Phase II program in December of 2010, shallow surface soil samples were procured from thirty-nine selected location within thirteen transects of the Unnamed Arroyo #2. Figure 4.4 presents the results of the individual shallow surface samples at each location. No deep subsurface boreholes were advanced within this area due to concerns with the sidewall stability of the arroyo.

Plate 4.3-13 graphically illustrates the results of three locations per transect. All of the surface measured concentrations are below the PAL throughout the entire arroyo. There were five locations at the 30-36 inch soil horizon that were slightly higher than the surface concentrations. This type of variability could be due to natural variation in soil types.

Plate 4.3-13 CR-1 Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Unnamed Arroyo #2

Notes:

Top block is 0-2 inch, Second Block is 2-6 inch and Third Block is 30-36 inch
Some concentrations shown that only partially cover a depth increment of interest

Transect average concentrations were determined for each transect and are summarized in Table 4.3-10. There was no transect where the PAL was exceeded in the 0 to 6 inch soil horizon.

Table 4.3-10 Summary of Transect Ra-226 Concentration in Unnamed Arroyo #2

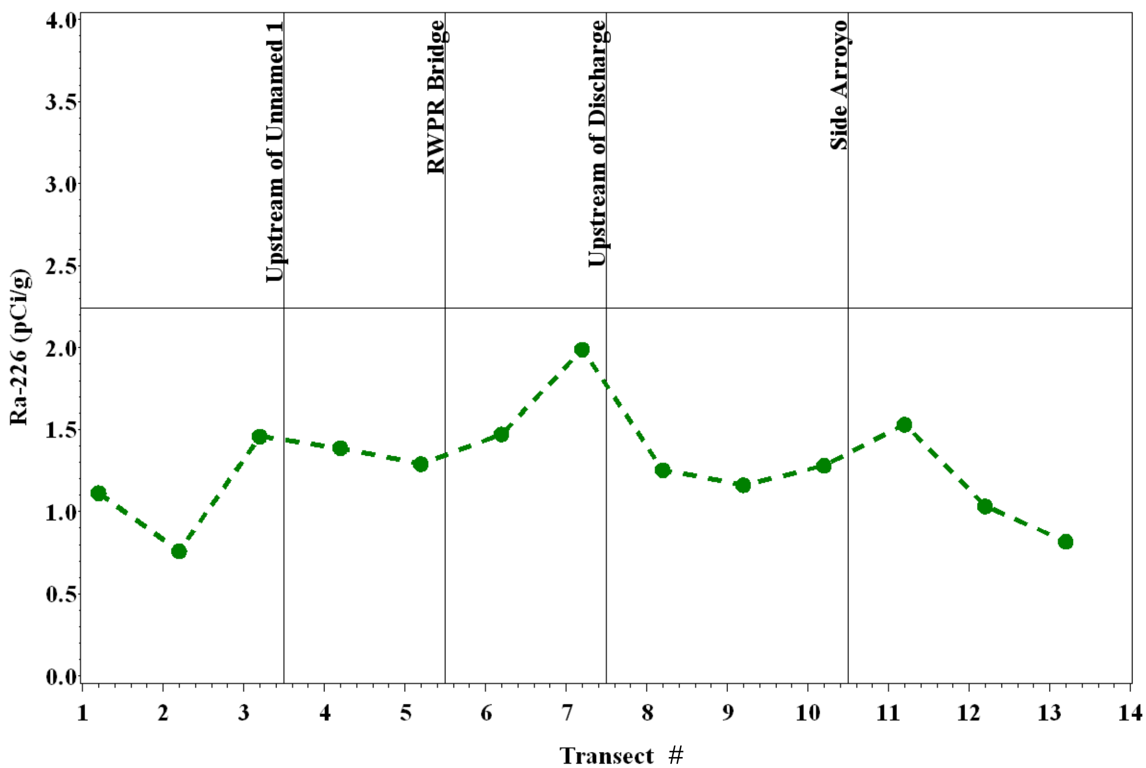
Depth (inches)	Number of Samples	Minimum	Median	Mean	Maximum
0-2	13	0.703	1	1.02	1.53
2-6	13	0.707	1.39	1.4	2.54
0-6 (est)	13	0.76	1.28	1.27	1.99
30-36	11	1.03	2.12	1.98	2.66

Note: Estimated values are results of combining two horizons

Plate 4.3-14 shows the profile of the Ra-226 concentrations for the Unnamed Arroyo #2. The 2 to 6 inches soil horizon has relatively consistently higher concentrations than the 0-2 inches soil horizon and the 30 to 36 inches soil horizon generally has the higher concentrations.

Plate 4.3-14 CR-1 Ra-226 Soil Concentration Profile Along Unnamed Arroyo #2

(0 to 6inch)



4.3.3 Non-radiological Soil Sampling

Under the terms of the AOC there is a requirement for four samples to be selected for metals, SVOC, VOC and PCB as well as petroleum hydrocarbon analysis. Further to the work plan amendments for the second stage of the Phase II program the EPA instructed RAML to have two boreholes advanced within the industrial areas of the respective sites for the purposes of procuring one sample from each borehole for the analysis of the aforementioned parameters. A blind duplicate of each sample was also submitted for the analysis of the environmental parameters noted above. In addition to the bulk analysis noted the EPA also requested in an amendment to the original work plan that TCLP and SPLP leachate analysis also be done on a composite waste rock sample from each site.

As part of this phase of the work headspace readings were recorded and the results incorporated into the borehole logs for each borehole advanced as part of the environmental program. A discussion of the analytical work completed for each set of parameters is provided below.

4.3.3.1 Metals

As part of the Phase II program four soil samples, two from each borehole advanced within the industrial area, were submitted the analysis of arsenic, molybdenum, selenium and vanadium. The sample locations are identified as C1LI- 500 and C1LI-501 and are presented on Figure 4.2a. The laboratory certificates for this analytical work are included in Appendix A2.

The results of the analytical work are presented in Table 4.3.11. The data show that the only the concentration of arsenic was above the industrial screening level standards as prescribed in the USEPA Region 9 guidelines. The concentrations of arsenic in the four samples (two original and two duplicate samples) ranged from 3.4 to 4.4 mg/kg as compared to the USEPA Region 9 standard of 1.6 mg/kg.

Table 4.3-11 Metals in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1							
		RDL	C1LI-500 SS5 6-7.5 ft	RDL	C1LI-500 SS7 Dup of SS5	RDL	C1LI-501 SS4 4.5-6 ft	RDL	C1LI-501 SS10 Dup of SS4
Arsenic	**1.6**	1	**4.4***	1.1	**3.8***	1.1	**3.4***	1.1	**3.6***
Molybdenum	**5100**	1	<	1.1	<	1.1	<	1.1	<
Selenium	**5100**	2.6	<	0.53	<	0.52	<	0.53	<
Vanadium	**72**	5.2	13	1.1	15	1.1	9.5	1.1	11

NOTES:

All parameter values in ug/g (ppm) unless otherwise indicated.
USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9
RDL Reportable Detection Limit.
< Not detected.

Comparison of these metal results to the local New Mexico Environment Department Screening Level standards reports that all metal parameters analysed were below criteria including arsenic which has a standard value of 17.7 mg/kg.

4.3.3.2 Organics [VOCs, SVOCs, TPHs, PCBs]

The list of organic compounds that were analysed as part of the Phase II program included volatile and semi-volatile compounds (VOC/SVOCs), total petroleum hydrocarbons and polychlorinated biphenyls (PCBs). During the course of the program two samples from each industrial area borehole were submitted for the analysis of these parameters. The results of the organic parameter analytical work are presented in Tables 4.3.-12 to 4.3-15 with the results compared to the EPA Region 9 screening level standards for an industrial site. In general, the analytical results for the respective parameters were reported being non-detect, or at a concentration well below the applicable standards. These results are consistent with field observations where olfactory or visual staining was observed in the soil samples recovered from the industrial area.

Further to the above noted analysis prescribed in the Phase II work plan the results of the deep subsurface investigation program within the sediment pond area identified the presence of olfactory contamination consistent with a diesel product at one borehole location. In borehole C1LP-401, located in what was formerly Pond 1A (see Figure 4.2b), at the depth interval 9 to 10.5 ft a sample of a soft clayey silt soil was procured for diesel and gasoline TPH analysis as the soil was noted to have olfactory impacts consistent with diesel fuel. In addition a deeper sample of what was believed to be non-impacted soil was procured from the depth internal 12 to 13.5 ft.

The results of the analytical work were compared to the NMED TPH Screening Guidelines (NMED 2006) as the EPA does not have screening levels for diesel or gasoline hydrocarbons (see Table 4.3-14). Comparison of the diesel results to the potable groundwater direct exposure screening level standard identified that the olfactory impacted soil has a diesel concentration above this standard of 1120 mg/kg at 1300 mg/kg. However given that the area is not a potable groundwater site it is conservative to compare the sub-surface result to this standard. Comparison of the result to the vapour migration and inhalation standard of 2200 mg/kg shows that the olfactory impacted soil meets this standards. Because of the low concentrations no further sampling was done. The diesel result for the deeper borehole was effectively non-detect and orders of magnitude below the screening level standard.

The gasoline results were effectively non-detect and as such the results report are consistent with a heavier fraction petroleum hydrocarbon.

Table 4.3-12 Volatile Organic Compounds in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1											
		RDL Depth	C1LP-401 SS7	RDL	C1LP-401 SS9 Dup of SS7	RDL	C1LI-500 SS5 6-7.5 ft	RDL	C1LI-500 SS7 Dup of SS5	RDL	C1LI-501 SS4 4.5-6 ft	RDL	C1LI-501 SS10 Dup of SS4
Dichlorodifluoromethane	**780000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Chloromethane	**500000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Vinyl Chloride	**1700**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Bromomethane	**32000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Chloroethane	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Trichlorofluoromethane	**3400000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1-Dichloroethylene (1,1-Dichloroethene)	**1100000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1,2-Trichloro-1,2,2-Trifluoroethane	**180000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Acetone	**630000000**	22	<	23	<	22	<	22	<	20	<	23	<
Iodomethane	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Carbon Disulfide	**3700000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Dichloromethane (Methylene Chloride)	**53000**	5.6	<	5.8	<	5.5	6	5.6	5.2	4.9	5.2	5.7	5.5
trans-1,2-Dichloroethylene	**9200000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Methyl Tert Butyl Ether (MTBE)	**220000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1-Dichloroethane	**17000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Vinyl Acetate	**4100000**	22	<	23	<	22	<	22	<	20	<	23	<
cis-1,2-Dichloroethylene	**2000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
2-Butanone	**200000000**	22	<	23	<	22	<	22	<	20	<	23	<
Bromochloromethane	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Chloroform	**1500**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1,1-Trichloroethane	**38000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
2,2-Dichloropropane	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Carbon Tetrachloride	**3000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1-Dichloropropene	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2-Dichloroethane	**2200**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Benzene	**5400**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Trichloroethylene (Trichloroethene)	**14000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2-Dichloropropane	**4500**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Dibromomethane	**110000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Bromodichloromethane	**1400**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
cis-1,3-Dichloropropene	**8100**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
4-Methyl-2-Pentanone	**-**	22	<	23	<	22	<	22	<	20	<	23	<
Toluene	**45000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
trans-1,3-Dichloropropene	**8100**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1,2-Trichloroethane	**5300**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
2-Hexanone	**1400000**	22	<	23	<	22	<	22	<	20	<	23	<
Tetrachloroethylene	**2600**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	9.7	5.7	7.8
1,3-Dichloropropane	**20000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Chlorodibromomethane (Dibromochloromethane)	**3300**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2-Dibromoethane (Ethylene Dibromide)	**170**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1-Chlorohexane	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Chlorobenzene	**1400000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1,1,2-Tetrachloroethane	**9300**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Ethylbenzene	**27000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Xylene (m,p)	**17000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Xylene (o)	**19000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Styrene	**36000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Bromoform	**220000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Isopropylbenzene	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2,3-Trichloropropane	**95**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,1,2,2-Tetrachloroethane	**2800**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Bromobenzene	**1800000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
n-Propylbenzene	**21000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
2-Chlorotoluene	**20000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,3,5-Trimethylbenzene	**10000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
4-Chlorotoluene	**72000000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Tert-butylbenzene	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2,4-Trimethylbenzene	**260000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Sec-butylbenzene	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,3-Dichlorobenzene (m-Dichlorobenzene)	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
p-Isopropyltoluene	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,4-Dichlorobenzene (p-Dichlorobenzene)	**12000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
n-Butylbenzene	**-**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2-Dichlorobenzene (o-Dichlorobenzene)	**9800000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2-Dibromo-3-chloropropane	**69**	11	<	12	<	11	<	11	<	9.9	<	11	<
1,2,4-Trichlorobenzene	**99000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Hexachlorobutadiene	**22000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
Naphtalene	**18000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<
1,2,3-Trichlorobenzene	**490000**	5.6	<	5.8	<	5.5	<	5.6	<	4.9	<	5.7	<

NOTES:

All parameter values in ug/kg (ppb) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

Table 4.3-13 Semi Volatile Organic Compounds in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1							
		RDL	C1LI-500 SS5 6-7.5 ft	RDL	C1LI-500 SS7 Dup of SS5	RDL	C1LI-501 SS4 4.5-6 ft	RDL	C1LI-501 SS10 Dup of SS4
Pyridine	**1000000**	330	<	350	<	360	<	350	<
n-Nitrosodimethylamine	**11**	330	<	350	<	360	<	350	<
Aniline	**300000**	330	<	350	<	360	<	350	<
Phenol	**180000000**	330	<	350	<	360	<	350	<
Bis(2-chloroethyl)ether	**1000**	330	<	350	<	360	<	350	<
2-Chlorophenol	**5100000**	330	<	350	<	360	<	350	<
1,3-Dichlorobenzene	**-**	330	<	350	<	360	<	350	<
1,4-Dichlorobenzene	**12000**	330	<	350	<	360	<	350	<
1,2-Dichlorobenzene	**9800000**	330	<	350	<	360	<	350	<
Benzyl Alcohol	**62000000**	330	<	350	<	360	<	350	<
Bis(2-chloroisopropyl)ether	**-**	330	<	350	<	360	<	350	<
2-Methylphenol	**-**	330	<	350	<	360	<	350	<
n-Nitroso-di-n-propylamine	**250**	330	<	350	<	360	<	350	<
3+4-Methylphenol	**-**	330	<	350	<	360	<	350	<
Hexachloroethane	**120000**	330	<	350	<	360	<	350	<
Nitrobenzene	**24000**	330	<	350	<	360	<	350	<
Isophorone	**1800000**	330	<	350	<	360	<	350	<
2-Nitrophenol	**-**	330	<	350	<	360	<	350	<
2,4-Dimethylphenol	**12000000**	330	<	350	<	360	<	350	<
Bis(2-chloroethoxy)methane	**1800000**	330	<	350	<	360	<	350	<
2,4-Dichlorophenol	**1800000**	330	<	350	<	360	<	350	<
Benzoic Acid	**2500000000**	1700	<	1800	<	1800	<	1700	<
1,2,4-Trichlorobenzene	**99000**	330	<	350	<	360	<	350	<
Naphthalene	**18000**	330	<	350	<	360	<	350	<
4-Chloroaniline	**8600**	330	<	350	<	360	<	350	<
Hexachlorobutadiene	**22000**	330	<	350	<	360	<	350	<
4-Chloro-3-methylphenol	**-**	330	<	350	<	360	<	350	<
2-Methylnaphthalene	**4100000**	330	<	350	<	360	<	350	<
1-Methylnaphthalene	**99000**	330	<	350	<	360	<	350	<
Hexachlorocyclopentadiene	**3700000**	330	<	350	<	360	<	350	<
2,4,6-Trichlorophenol	**160000**	330	<	350	<	360	<	350	<
2,4,5-Trichlorophenol	**62000000**	330	<	350	<	360	<	350	<
2-Chloronaphthalene	**82000000**	330	<	350	<	360	<	350	<
2-Nitroaniline	**6000000**	670	<	700	<	720	<	690	<
Dimethyl Phthalate	**-**	330	<	350	<	360	<	350	<
2,6-Dinitrotoluene	**620000**	330	<	350	<	360	<	350	<
Acenaphthylene	**-**	330	<	350	<	360	<	350	<
3-Nitroaniline	**-**	670	<	700	<	720	<	690	<
Acenaphthene	**33000000**	330	<	350	<	360	<	350	<
2,4-Dinitrophenol	**1200000**	670	<	700	<	720	<	690	<
4-Nitrophenol	**-**	670	<	700	<	720	<	690	<
Dibenzofuran	**-**	330	<	350	<	360	<	350	<
2,4-Dinitrotoluene	**5500**	330	<	350	<	360	<	350	<
Diethyl Phthalate	**490000000**	330	<	350	<	360	<	350	<
Fluorene	**22000000**	330	<	350	<	360	<	350	<
4-Chlorophenyl Phenyl Ether	**-**	330	<	350	<	360	<	350	<
4-Nitroaniline	**86000**	670	<	700	<	720	<	690	<
Azobenzene	**23000**	330	<	350	<	360	<	350	<
4,6-Dinitro-2-Methylphenol	**-**	670	<	700	<	720	<	690	<
n-Nitrosodiphenylamine	**350000**	330	<	350	<	360	<	350	<
4-Bromophenyl Phenyl Ether	**-**	330	<	350	<	360	<	350	<
Hexachlorobenzene	**1100**	330	<	350	<	360	<	350	<
2,3,4,6-Tetrachlorophenol		330	<	350	<	360	<	350	<
Pentachlorophenol	**2700**	670	<	700	<	720	<	690	<
Phenanthrene	**-**	330	<	350	<	360	<	350	<
Anthracene	**170000000**	330	<	350	<	360	<	350	<
Carbazole	**-**	330	<	350	<	360	<	350	<
Di-n-butyl Phthalate	**62000000**	330	<	350	<	360	<	350	<
Fluoranthene	**22000000**	330	<	350	<	360	<	350	<
Pyrene	**17000000**	330	<	350	<	360	<	350	<
Butyl Benzyl Phthalate	**910000**	330	<	350	<	360	<	350	<
Benzo(a)anthracene	**2100**	330	<	350	<	360	<	350	<
3,3'-Dichlorobenzidene	**3800**	330	<	350	<	360	<	350	<
Chrysene	**210000**	330	<	350	<	360	<	350	<
Bis(2-ethylhexyl)phthalate	**120000**	330	<	350	<	360	<	350	<
Di-n-octyl phthalate	**-**	330	<	350	<	360	<	350	<
Benzo(b)fluoranthene	**2100**	330	<	350	<	360	<	350	<
Benzo(k)fluoranthene	**21000**	330	<	350	<	360	<	350	<
Benzo(a)pyrene	**210**	330	<	350	<	360	<	350	<
Indeno(1,2,3-cd)pyrene	**2100**	330	<	350	<	360	<	350	<
Dibenzo(a,h)anthracene	**210**	330	<	350	<	360	<	350	<
Benzo(g,h,i)perylene	**-**	330	<	350	<	360	<	350	<

NOTES:

All parameter values in ug/kg (ppb) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

Table 4.3-14 Petroleum Hydrocarbons in Soil

PARAMETERS	NMED INDUSTRIAL '	Church Rock Site 1											
		RDL	C1LP-401 SS7	RDL	C1LP-401 SS9 Dup of SS7	RDL	C1LI-500 SS5 6-7.5 ft	RDL	C1LI-500 SS7 Dup of SS5	RDL	C1LI-501 SS4 4.5-6 ft	RDL	C1LI-501 SS10 Dup of SS4
Diesel Range Organics	**1120[(a)] ; 2200[(b)]**	6.2	**1300'**	5.9	3.6	5.2	2.6	5.3	2.8	5.2	4	5.3	7.2
Gasoline Range Organics	**-**	0.62	0.73	0.53	<	0.52	<	0.5	<	0.42	<	0.43	<

<u>NOTES</u>:

All parameter values in ug/g (ppm) unless otherwise indicated.

New Mexico Environment Department TPH Screening Guidelines (October 2006):
' Exceeds Industrial Standards - NMED TPH Screening Guidelines

(a) TPH Screening Guidelines for Potable Groundwater - Direct Exposure
(b) TPH Screening Guidelines for Vapor Migration and Inhalation of Groundwater - Direct Exposure

RDL Reportable Detection Limit.
- Standard not available.
< Not detected.

Table 4.3-15 Polychlorinated Biphenyls in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1							
		RDL	C1LI-500 SS5 6-7.5 ft	RDL	C1LI-500 SS7 Dup of SS5	RDL	C1LI-501 SS4 4.5-6 ft	RDL	C1LI-501 SS10 Dup of SS4
Aroclor-1016	**21000**	35	<	36	<	34	<	35	<
Aroclor-1221	**540**	71	<	71	<	69	<	71	<
Aroclor-1232	**540**	35	<	36	<	34	<	35	<
Aroclor-1242	**740**	35	<	36	<	34	<	35	<
Aroclor-1248	**740**	35	<	36	<	34	<	35	<
Aroclor-1254	**740**	35	<	36	<	34	<	35	<
Aroclor-1260	**740**	35	<	36	<	34	<	35	<

NOTES:

All parameter values in ug/kg (ppb) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

4.3.3.3 Soil Leachate [TCLP, SPLP]

Further to an amendment to the Phase II work plan, as requested by the USEPA, two composite soil samples, one from the waste rock area of the site and a second composite sample from a borehole location (C1LP-402 – See Figure 4.2b) where debris was encountered at depth, were submitted for Toxicity Characteristic Leaching Procedure (TCLP) and Synthetic Precipitation Leaching Procedure (SPLP) analysis. The results of this work are presented in Tables 4.3-16 and 4.3.17 respectively.

Table 4.3-16 TCLP Metals

PARAMETERS	US EPA LEACHATE *	Church Rock Site 1			
		RDL	C1LW-303 SS1-SS7 5-37 ft	RDL	C1LP-402 SS1-SS8 0-12 ft
Arsenic	**5**	0.1	<	0.1	<
Barium	**100**	1	2	1	<
Cadmium	**1**	0.05	<	0.05	<
Chromium	**5**	0.1	<	0.1	<
Lead	**5**	0.03	<	0.03	<
Selenium	**1**	0.05	0.081	0.05	<
Silver	**5**	0.1	<	0.1	<
Mercury	**0.2**	0.002	<	0.002	<

NOTES:

All parameter values in mg/L leachate unless otherwise indicated.

USEPA Identification and Listing of Hazardous Waste (current as of July 6 2011):
* Exceeds Maximum Concentration of Contaminants for the Toxicity Characteristic

RDL Reportable Detection Limit.
< Not detected.

Table 4.3-17 SPLP Metals

PARAMETERS	US EPA LEACHATE *	Church Rock Site 1			
		RDL	C1LW-303 SS1-SS7 5-37 ft	RDL	C1LP-402 SS1-SS8 0-12 ft
Arsenic	**5**	0.1	**<**	0.1	**<**
Molybdenum	**-**	0.1	<	0.1	<
Selenium	**1**	0.05	0.065	0.05	**<**
Vanadium	**-**	0.1	0.41	0.1	**<**

NOTES:

All parameter values in mg/L leachate unless otherwise indicated.

USEPA Identification and Listing of Hazardous Waste (current as of July 6 2011):
* Exceeds Maximum Concentration of Contaminants for the Toxicity Characteristic

RDL Reportable Detection Limit.
< Not detected.
- Standard not available.

The results for the two samples submitted for the respective leachate analysis (TCLP and SPLP) did not identify any parameters with concentrations above the USEPA toxicity characterization limits.

4.3.4 Air Monitoring During Field Investigations

Air monitoring was carried out during the program. Monitoring results presented in Table 4.3.18 show that the results for both Ra-226 and Total U are very low and essentially indistinguishable from background. The Derived Air Concentrations (DACs) for members of the public per NRC 10 CFR 20 Appendix B, Table 2, Column 1 are 9E-13 micro curie per milliliter (µCi/mL) for Ra-226 and 9E-14 µCi/mL for Class Y natural uranium, the most restrictive for inhalation.

For Ra-226, to examine the potential worst case result, the measured Ra-226 on the filters was added to the reported uncertainties in the Ra-226 value, and the concentrations were re-calculated. These upper estimates of Ra-226 air concentrations ranged from 2.4E-16 µCi/ml to 2.9E-15 µCi/ml. The largest value was therefore 300 times less than the Ra-226 DAC of 9E-13 µCi/mL for members of the public (10 CFR 20, Appendix B, Table 2, Column 1).

For uranium, the measured values ranged from 1.9E-16 µCi/mL to 7.7E-16 µCi/mL. The largest measured value was therefore more than 100 times less than the 10 CFR 20 DAC of 9E-14 µCi/mL for members of the public.

Based on both sets of results relative to the type of work being done and the known concentrations of Ra-226 and Total U in the soil, this sampling effort likely represents typical background for this area with little to no evidence of radiological impact from work activities at the site.

Table 4.3-18 Community Ambient Air Sampling Results

RAML Sample ID	Date of Sample	Sample Time (min)	Avg cfm	Volume of Air Sampled (ml)	Ra-226 Result (µCi/ml)	Ra TPU (2σ, µCi/ml)	Ra-226 result + TPU (µCi/ml)[1]	Total U Result (µCi/ml)[2]	Work Type During Sampling	Site Observed Weather
RWPR-AS-001	5-Oct-10	440	42	5.23E+08	5.73E-17	3.06E-16	3.63E-16	3.07E-16	Soil sampling by hand auger; gamma surveys.	AM calm then S wind 3-5 mph, PM from SW 5-10 mph.
RWPR-AS-005	5-Oct-10	470	42	5.59E+08	5.37E-17	4.47E-16	5.01E-16	2.88E-16	Soil sampling by hand auger; gamma surveys.	AM calm then S wind 3-5 mph, PM from SW 5-10 mph.
RWPR-AS-006	6-Oct-10	575	42	6.84E+08	2.05E-16	4.83E-16	6.87E-16	1.96E-16	Soil sampling by hand auger; gamma surveys.	AM calm then SW wind 5-10 mph, PM from SW 10-15 mph.
RWPR-AS-007	6-Oct-10	555	42	6.60E+08	5.15E-16	3.64E-16	8.79E-16	2.03E-16	Soil sampling by hand auger; gamma surveys.	AM calm then SW wind 5-10 mph, PM from SW 10-15 mph.
RWPR-AS-010	7-Oct-10	585	42	6.96E+08	4.31E-17	2.01E-16	2.44E-16	1.93E-16	Soil sampling by hand auger; gamma surveys.	AM calm then SW wind 10-15 mph, PM from SW 20-25 mph.
RWPR-AS-011	7-Oct-10	560	42	6.66E+08	1.65E-16	3.15E-16	4.80E-16	2.31E-16	Soil sampling by hand auger; gamma surveys.	AM calm then SW wind 10-15 mph, PM from SW 20-25 mph.
RWPR-AS-014	8-Oct-10	408	42	4.85E+08	3.50E-16	4.33E-16	7.83E-16	2.76E-16	Soil sampling by hand auger; gamma surveys.	AM calm then SW wind 5-10 mph, PM from SW 10-15 mph.
RWPR-AS-015	8-Oct-10	426	42	5.07E+08	5.92E-17	4.74E-16	5.33E-16	2.64E-16	Soil sampling by hand auger; gamma surveys.	AM calm then SW wind 5-10 mph, PM from SW 10-15 mph.
RWPR-AS-018	13-Oct-10	277	43	3.37E+08	5.93E-16	5.93E-16	1.19E-15	3.97E-16	Grading west slope	Calm, lite NW breeze.
RWPR-AS-019	13-Oct-10	285	42.5	3.43E+08	3.21E-16	7.00E-16	1.02E-15	4.49E-16	Grading west slope	Calm, lite NW breeze.
RWPR-AS-022	14-Oct-10	295	42	3.51E+08	3.14E-16	4.56E-16	7.70E-16	4.20E-16	Grading west slope	AM SW wind, PM NE breeze, warmer.
RWPR-AS-023	14-Oct-10	295	43	3.59E+08	2.23E-16	4.45E-16	6.68E-16	2.98E-16	Grading west slope	AM SW wind, PM NE breeze, warmer.
RWPR-AS-026	15-Oct-10	500	42	5.95E+08	2.02E-16	2.69E-16	4.71E-16	2.93E-16	Grading west slope	AM N wind, PM NW wind, calm, warm.
RWPR-AS-027	15-Oct-10	502	40	5.69E+08	5.28E-17	4.40E-16	4.92E-16	2.59E-16	Grading west slope	AM N wind, PM NW wind, calm, warm.

RAML Sample ID	Date of Sample	Sample Time (min)	Avg cfm	Volume of Air Sampled (ml)	Ra-226 Result (µCi/ml)	Ra TPU (2σ, µCi/ml)	Ra-226 result + TPU (µCi/ml)[1]	Total U Result (µCi/ml)[2]	Work Type During Sampling	Site Observed Weather
RWPR-AS-030	18-Oct-10	506	42	6.02E+08	0.00E+00	3.99E-16	3.99E-16	2.00E-16	Chip Seal Prep for RWPR	AM calm, partly cloudy and cool, PM warm.
RWPR-AS-031	18-Oct-10	500	41.5	5.88E+08	1.53E-16	2.38E-16	3.91E-16	4.33E-16	Chip Seal Prep for RWPR	AM calm, partly cloudy and cool, PM warm.
RWPR-AS-035	19-Oct-10	340	46	4.43E+08	6.77E-17	4.06E-16	4.74E-16	2.87E-16	Road oil and chip sealing from bridge to route 566; water truck used for dust suppression.	NE light wind, sunny.
RWPR-AS-050	3-Nov-10	487	44.5	6.14E+08	9.78E-17	3.91E-16	4.89E-16	2.62E-16	Grading slope	Calm, sunny.
RWPR-AS-051	3-Nov-10	490	42.5	5.90E+08	0.00E+00	3.73E-16	3.73E-16	2.95E-16	Grading slope	Calm, sunny.
RWPR-AS-055	28-Apr-11	224	42.5	2.70E+08	1.50E-15	1.40E-15	2.90E-15	7.70E-16	Drilling operations	Sunny, AM calm, PM 0-20 mph winds.
RWPR-AS-057	30-Apr-11	553	42	6.58E+08	1.40E-16	4.70E-16	6.10E-16	4.48E-16	Drilling operations	Sunny, light to moderate NE wind all day.
RWPR-AS-058	30-Apr-11	553	42	6.58E+08	5.60E-16	3.70E-16	9.30E-16	5.30E-16	Drilling operations	Sunny, light to moderate NE wind all day.
RWPR-AS-059	1-May-11	373	41.5	4.38E+08	1.80E-16	4.40E-16	6.20E-16	4.74E-16	Drilling operations	AM, cold, moderate 10 mph wind, PM sunny.
RWPR-AS-060	1-May-11	370	42	4.40E+08	7.10E-16	6.70E-16	1.38E-15	6.39E-16	Drilling operations	AM, cold, moderate 10 mph wind, PM sunny.
RWPR-AS-061	2-May-11	543	42.5	6.53E+08	4.00E-17	3.60E-16	4.00E-16	3.08E-16	Drilling operations	Sunny, 10-15 mph winds changing from WNW to E.
RWPR-AS-062	2-May-11	544	42.5	6.55E+08	3.30E-16	4.00E-16	7.30E-16	4.09E-16	Drilling operations	Sunny, 10-15 mph winds changing from WNW to E.
RWPR-AS-063	3-May-11	446	42.5	5.37E+08	3.80E-16	5.20E-16	9.00E-16	3.50E-16	Drilling operations	AM, sunny, light N NW 5-15 mph breeze, PM WNW 5-10 mph winds.
RWPR-AS-064	3-May-11	446	42	5.30E+08	2.00E-16	3.50E-16	5.50E-16	4.80E-16	Drilling operations	AM, sunny, light N NW 5-15 mph breeze, PM WNW 5-10 mph winds.

[1] Note: For comparison, Ra-226 DAC from 10 CFR 20, Appendix B, Table 2, Column 1 = 9 E-13 uCi/ml
[2] Note: For comparison, Natural Uranium DAC for Class Y from 10 CFR 20, Appendix B, Table 2, Column 1 = 9E-14 uCi/ml

4.4 CHARACTERIZATION OF CHURCH ROCK SITE 1E (CR-1E)

This section discusses the physical aspects of the site relative to the potential for contamination, presents the results of soil sampling and gamma radiation measurements and provides a preliminary relationship between surface soils and gamma radiation within the lease and Step-out limits of the CR-1E site. In addition, the results of radiation measurements at depth are also presented along with the results of the non-radiological aspects of the Phase II Soil Sampling Program. Figures 4.4 and 4.5 provide the results of shallow and deeper soil sampling at the CR-1E site and at the seven discrete transects along the Pipeline Arroyo, respectively.

A complete record of the analytical results for the CR-1E investigation program is provided in the appendix. Appendix A1 provides a detailed data analysis and a summary of the data. Appendix A2 provides the raw laboratory data sheets.

4.4.1 CR-1E Site Components

The lease area is defined by a perimeter fence and near vertical face bedrock outcropping along the western limit of the site. The lease area includes two former waste rock stockpiles, a former sediment pond and an industrial area at the northern end of the site as depicted in plan on Figure 4.4. The presence of covered waste rock stockpiles in the middle of the lease area could influence the static and scanning measurements on the cover of the waste area. It is noted that the waste rock material within the stockpile was similar to that encountered at the CR-1 namely a fine grained material.

The former sediment pond area is defined by a small area of the site where historic aerial photographs depict that a sediment pond had been constructed and used in the mining operations. Review of the aerial photos, site plans from the time of mine operation, review of historical records and discussions with former employees, and existing site conditions, suggest that pond sediment has been removed and relocated and the pond has been backfilled.

The former industrial area of the site is defined by the portion of the site where industrial buildings and ancillary structures were located including a power transformer station. The buildings were decommissioned at the close out of operations and the majority of the area appears to have been covered with overburden. There was no direct evidence of any environmental impacts on the ground surface within this area during the field program.

The Pipeline Arroyo is located immediately east of the CR-1E site and is a moderately wide and deep arroyo that drains north to south. The width of the arroyo typically ranges from 15 to 25 ft with sidewalls 10 to 15 feet high which flatten out to a flood plain near the junction with the Unnamed Arroyo #2 west and south of site CR-1E. In general, the soil stratigraphy at the base of the arroyo is consistent with the fine to medium grained soils encountered at lease and step-out areas of CR-1E.

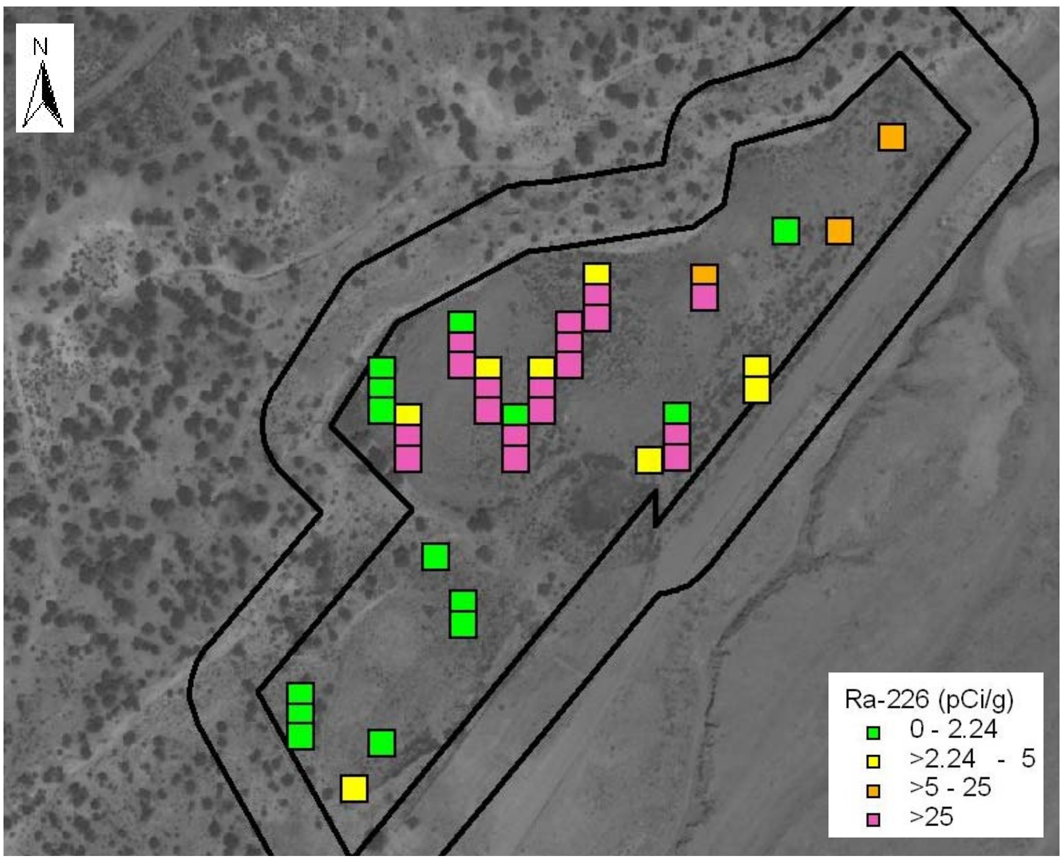
4.4.2 Radiological Soil Sampling& Gamma Radiation Survey

4.4.2.1 Lease Area

Soil Concentrations

Figure 4.4 provides the results of shallow soil sampling at the CR-1E site. The Ra-226 concentrations are graphically illustrated in Plate 4.4-1. Approximately half of the Ra-226 concentrations reported in the 0 to 6 inch horizon were below the PAL. Ra-226 concentrations at depth were generally higher than surface concentration for the central and northern portion of the CR-1E site. Although sampling to greater depths is limited on the remainder of the lease area, based on past activities at the site, expectations are that the concentrations are limited to the surface with the exception of the sediment pond area.

Plate 4.4-1 CR-1E Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Lease Area



Notes: Top block is 0-6 inch; second block is 18-24 inch; third block is 30 to 36 inch soil horizon. In some cases, a target zone was only partially measured due to refusal during sample collection.

The soil concentrations are summarized in Table 4.4-1. The summary statistics for the 18-24 inch and 30-36 inch are not representative averages for the Lease Area as the samples to these depths are typically from the waste rock pile and not the entire area.

Table 4.4-1 Ra-226 Concentrations (pCi/g) from Shallow Sampling on the Lease Area

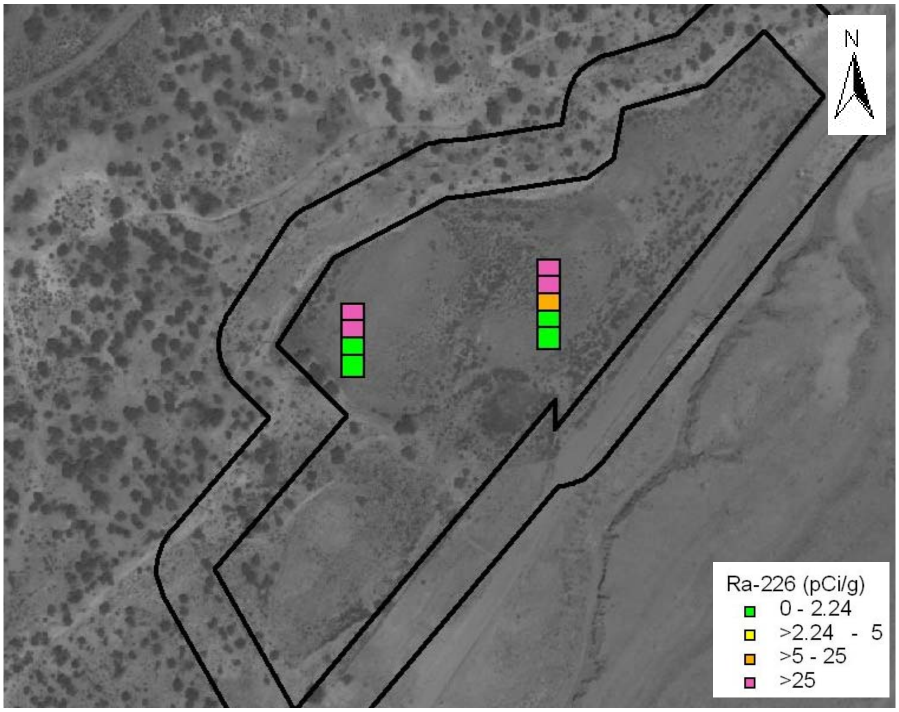
Soil Horizon (inches)	Number of Samples	Minimum	Median	Mean	Maximum
0 to 6 (est.)	20	1.46	2.6	6.16	52.1
18 to 24	11	1.18	96	145	363
30 to 36	9	1.13	74.2	70.7	151

Note: Estimated values are results of combining two horizons

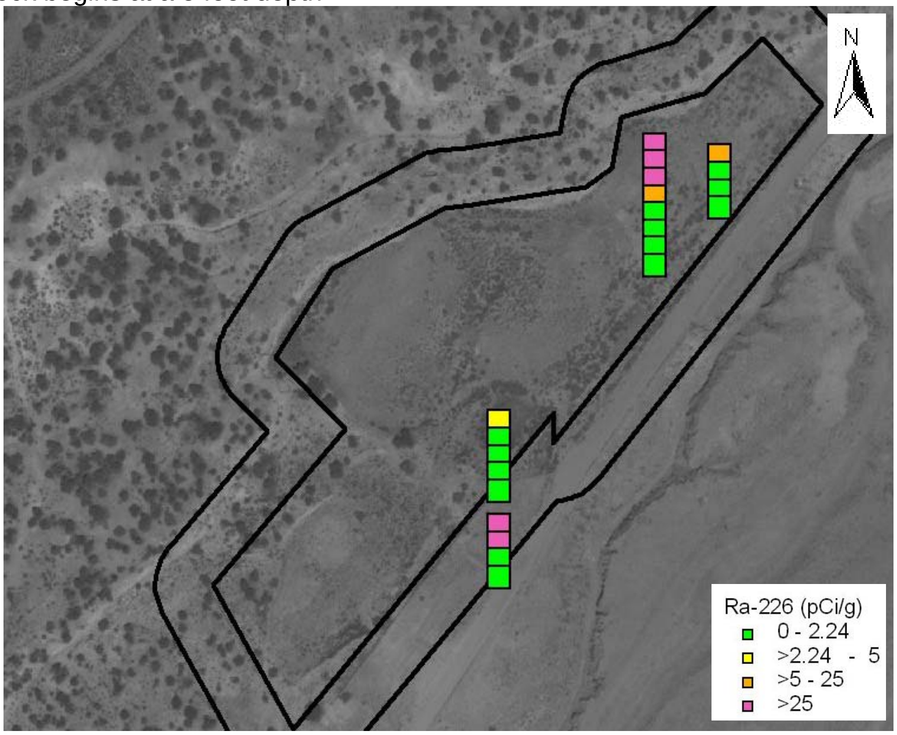
Deep drilling occurred at five locations on the CR-1E lease site. Results of deep drilling are shown in Figure 4.5. Soil concentrations are graphically illustrated in Plate 4.4-2 with the top image showing results in the waste rock area and the bottom image showing results in the industrial and former sediment pond locations. . Two separate images are presented as the waste rock samples were collected at 5 foot increments while the sediment pond and industrial samples were collected at 1.5 foot increments.

Consistent with the results of shallow sampling, the soil concentrations in the 0 to 6 inch horizon were reported at levels above the PAL for the locations sampled during the deeper drilling. Summary statistics on the soil horizons are provided in Table 4.4-2.

Plate 4.4-2 CR-1E Ra-226 Soil Concentrations Measured with Deep Drilling Program on Lease Area



Notes: Sampling conducted by 5 foot increments with a composite over 1.5 foot. Top block begins at a 5 foot depth



Notes: Sampling conducted by 1.5 foot increments. Top block represents 0-1.5 feet

Table 4.4-2 Summary of Deep Drilling Ra-226 Concentrations (pCi/g) on the Lease Area

Increment Bottom (feet)	Number of Samples	Minimum	Median	Mean	Maximum
Waste Rock					
5	2	78.4	89.7	89.7	101
10	2	75.9	141	141	206
15	3	1.09	1.42	9.17	25
20	2	1.01	1.37	1.37	1.72
25	1		0.98		
Former Industrial and Sediment Pond					
1.5	3	2.57	14.5	14.2	25.5
3	3	1.24	2.05	74.4	220
4.5	3	1.03	1.6	33.2	97
6	3	1.22	2.14	3.82	8.1
7.5	2	1.55	1.64	1.64	1.73
9	1		1.63		
10.5	2	1.58	239	239	476
12	2	2.07	51.5	51.5	101
13.5	1		1.29		

The soil concentrations are similar to those in previously remediated mine sites and in the CR-1 site. Surface soil concentrations tend to reflect the low concentrations in the clean cover with waste rock buried to depths below 3 feet under the cover. Ra-226 concentrations at other locations were generally low with the exception of a layer sampled at depth in the former sediment pond.

Gamma Radiation Measurements

Static gamma radiation measurements for the complete lease area of CR1-E are graphically illustrated in Plate 4.4-3 and statistics are provided in Table 4.4-3. There were eight locations within the Lease Area with static measurements that were not used in the analyses and these are further described in Appendix A1. Higher gamma radiation measurements were observed in the central area where the waste rock pile was located and in parts of the industrial area in the north-east.

Plate 4.4-3 CR-1E Static Gamma Radiation Measurement (cpm) on Lease Area

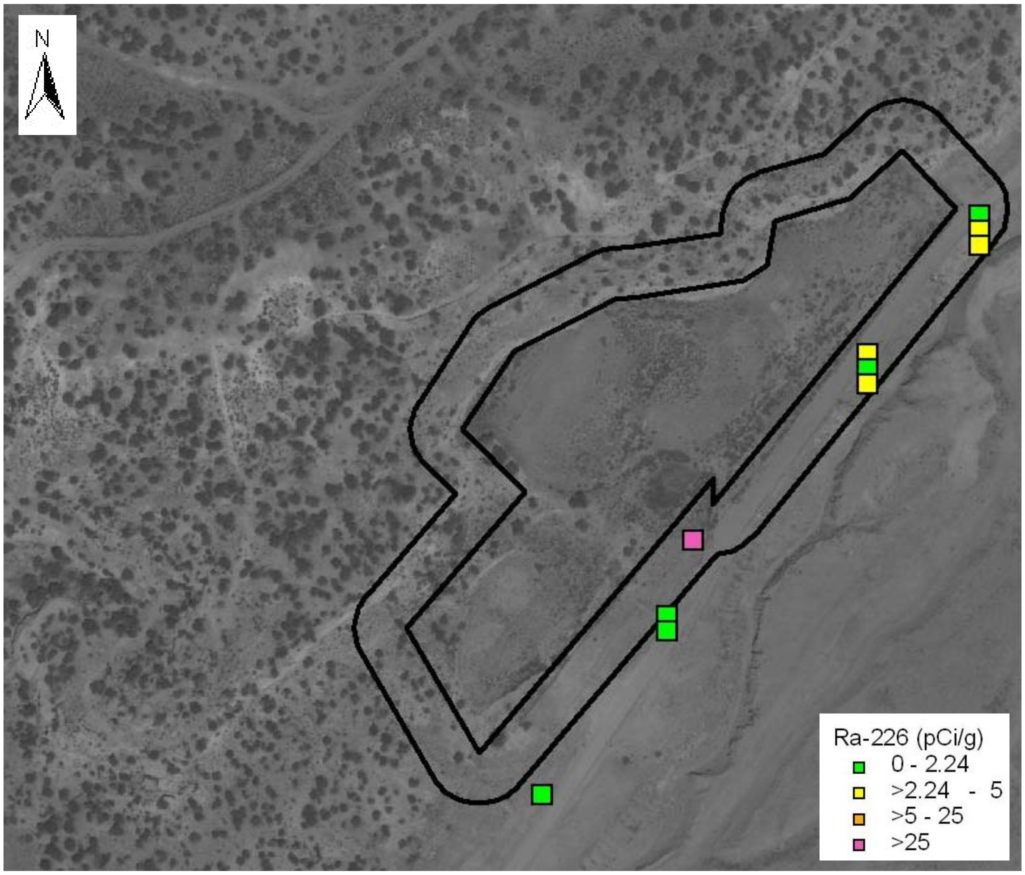
Table 4.4-3 Static Gamma Radiation Measurements on the CR-1E Site

Sub Area	Number of Static Points	Minimum	Median	Mean	Maximum
Lease	78	3968	5499	7509	25075
Pipeline Arroyo	15	4321	5197	5192	6449
Step-out	48	3878	4466	5659	18779

4.4.2.2 Step-out Areas

Figure 4.4 provides the results of shallow soil sampling at the CR-1E step out area. Plate 4.4-4 illustrates graphically the results of the shallow at five locations. Two of the five surface (0-6 inch) samples exceeded the PAL. The highest surface concentration found was at CESS-041 which is located outside the gate and near the sediment pond area. At CESS-041 the 2-6 inch soil horizon had a concentration of 86.3 pCi/g which led to the average in the 0-6 inch soil horizon of 60.4 pC/g. Refusal was reached at this location with a concentration of 16.9 pCi/g in the 6-12inch layer. The two north locations show soil concentrations at a depth of 30-36 inch with concentrations of 2.39 and 2.90 pCi/g. These may be naturally occurring concentrations.

Plate 4.4-4 CR-1E Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Step-out Area



Notes:

Top block is 0-6 inches, second block is 18-24 inches, third block is 30 to 36 inches soil horizon.
In some cases, a target zone was only partially measured due to refusal during sample collection.

The measured concentrations for the targeted depths are summarized in Table 4.4-4. There were four locations with samples for the 0-6 inch soil horizon; however, there was an additional location where the concentrations were only measured in the 0-2 inch soil horizon. The concentration in this increment at location CESS-070 located near the south end of the lease area was 1.60 pCi/g.

Table 4.4-4 Summary of Shallow Concentrations (pCi/g) on the Step-out Area

Depth Increment (inches)	Number of Samples	Minimum	Median	Mean	Maximum
0 to 6 (est.)	4	1.73	2.83	16.9	60.4
18 to 24	3	1.2	1.65	2.21	3.79
30 to 36	2	2.39	2.65	2.65	2.9

Note: Estimated values are results of combining two horizons

Gamma Radiation

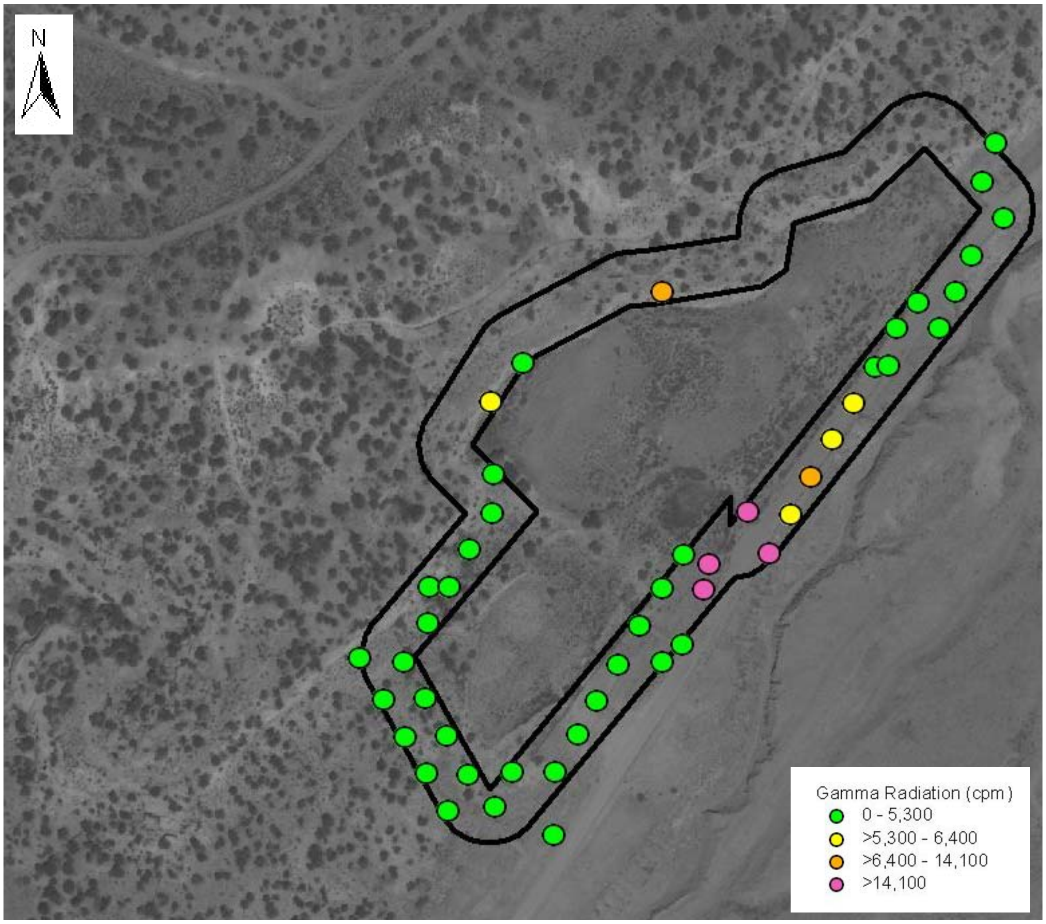
Plate 4.4-5 illustrates the static gamma radiation measurements measured on the CR-1E step-out which includes a few locations outside the planned step-out area. There are few locations to the northwest of the Lease Area due to obstruction by a cliff. The gamma radiation measurements in the Step-out area are generally low with an exception of along the Pipeline Arroyo Road near the centre of the site close to both the entrance to the site and the sediment ponds.

Summary statistics for static point measurements are provided in Table 4.4-5.

Table 4.4-5 Static Gamma Radiation Measurements on the CR-1E Site

Sub Area	Number of Static Points	Minimum	Median	Mean	Maximum
Step-out	48	3878	4466	5659	18779

Plate 4.4-5 CR-1E Static Gamma Radiation Measurements (cpm) on Step-out Area



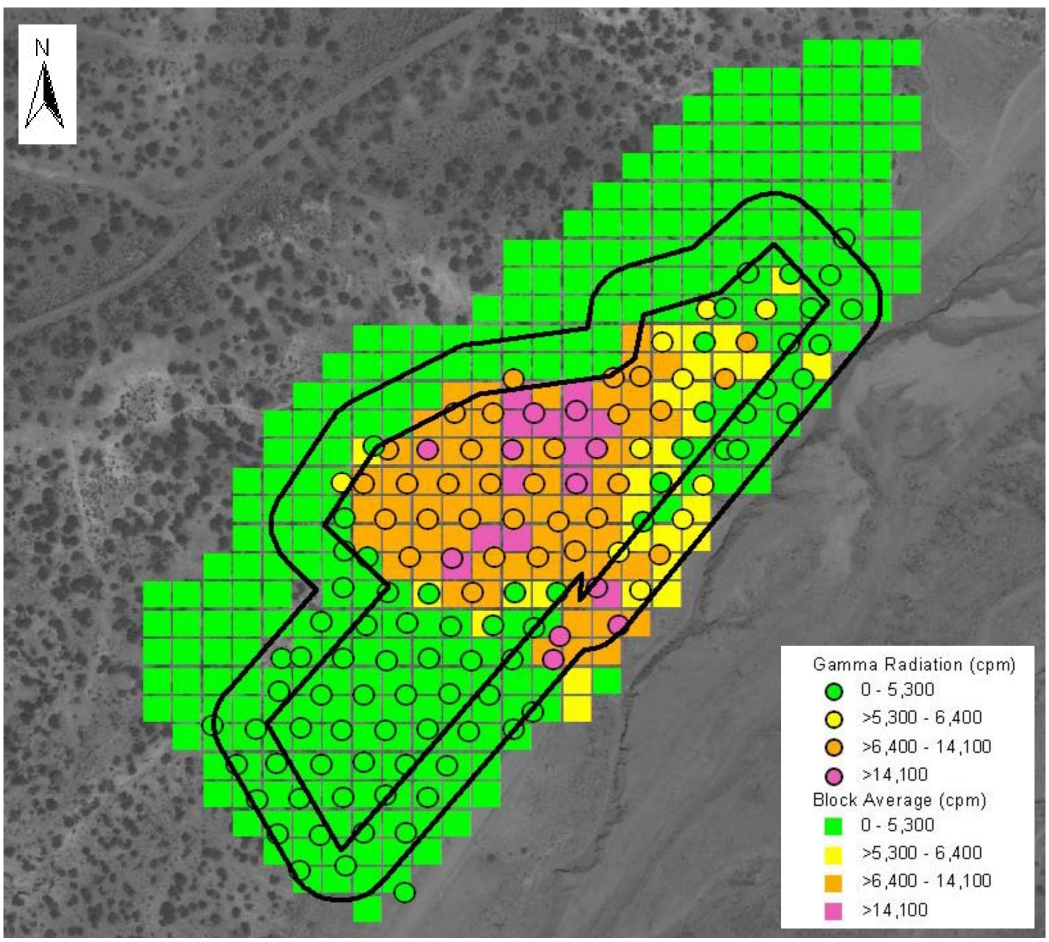
4.4.2.3 Scanning Gamma Radiation Measurements

Scanning gamma radiations were automatically recorded and averaged to areas considered representative by the 80 ft triangular grid and these are illustrated in Plate 4.4-6. The static gamma radiation measurements and the scan averages agree well. The Step-out areas generally indicate soil concentrations below the PAL with the exception of the area on the east central part of the CR-1E site. Summary statistics on the scan averages are provided in Table 4.4-6.

Table 4.4-6 Block Averages of Scanning Gamma Radiation Measurements

Sub-Area	Number of Blocks	Minimum	Median	Mean	Maximum
Lease	132	4040	6120	7810	17400
Step-out	252	2820	4350	4600	14700

Plate 4.4-6 CR-1E Scanning Gamma Radiation Measurements Site Wide



4.4.2.4 Pipeline Canyon Arroyo

Soil samples were collected from seven transects of the Pipeline Arroyo and the results are shown on Plate 4.4-7 for the three intended locations per transect. The measured concentrations were all below the PAL in the 0 to 6 inch horizon along the length of the arroyo. Only one sample at the 30 to 36 inches depth horizon in Transect 6 was slightly elevated.

Plate 4.4-7 CR-1E Ra-226 Soil Concentrations Measured with Shallow Sub-Surface Program on Pipeline Arroyo

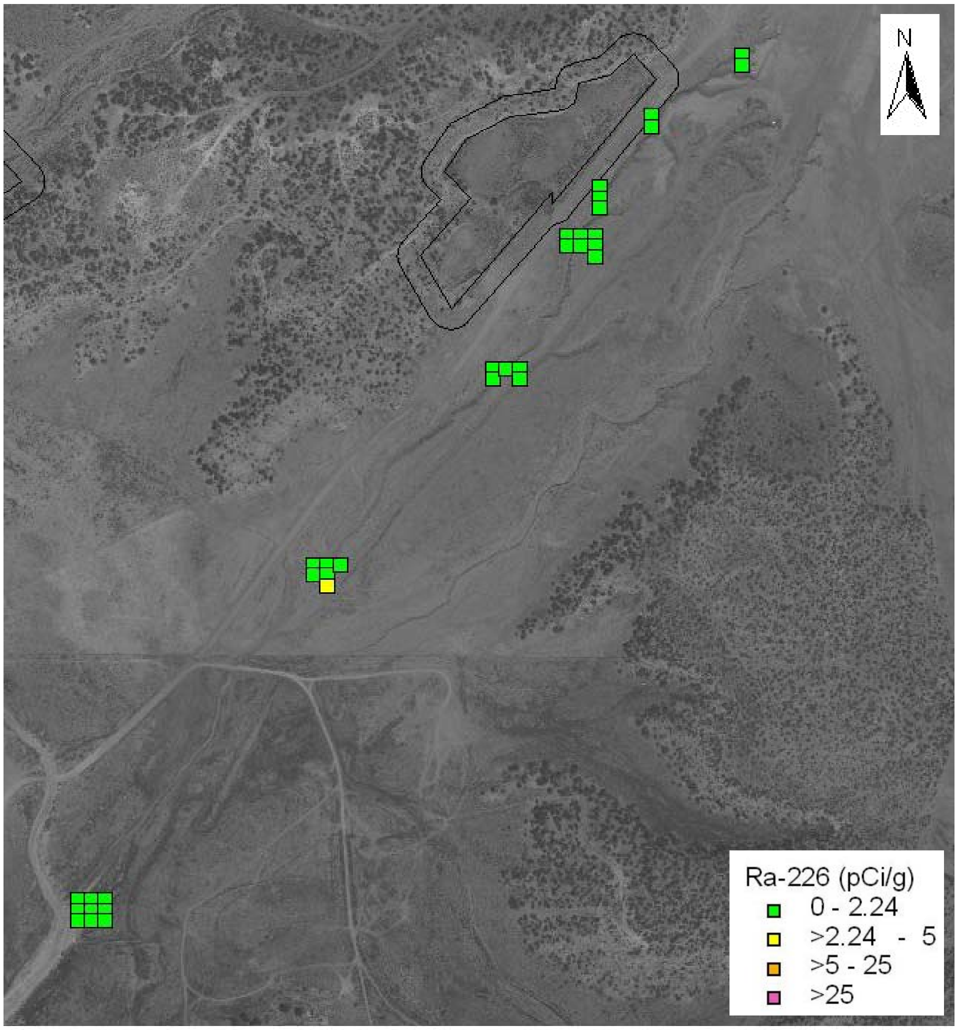


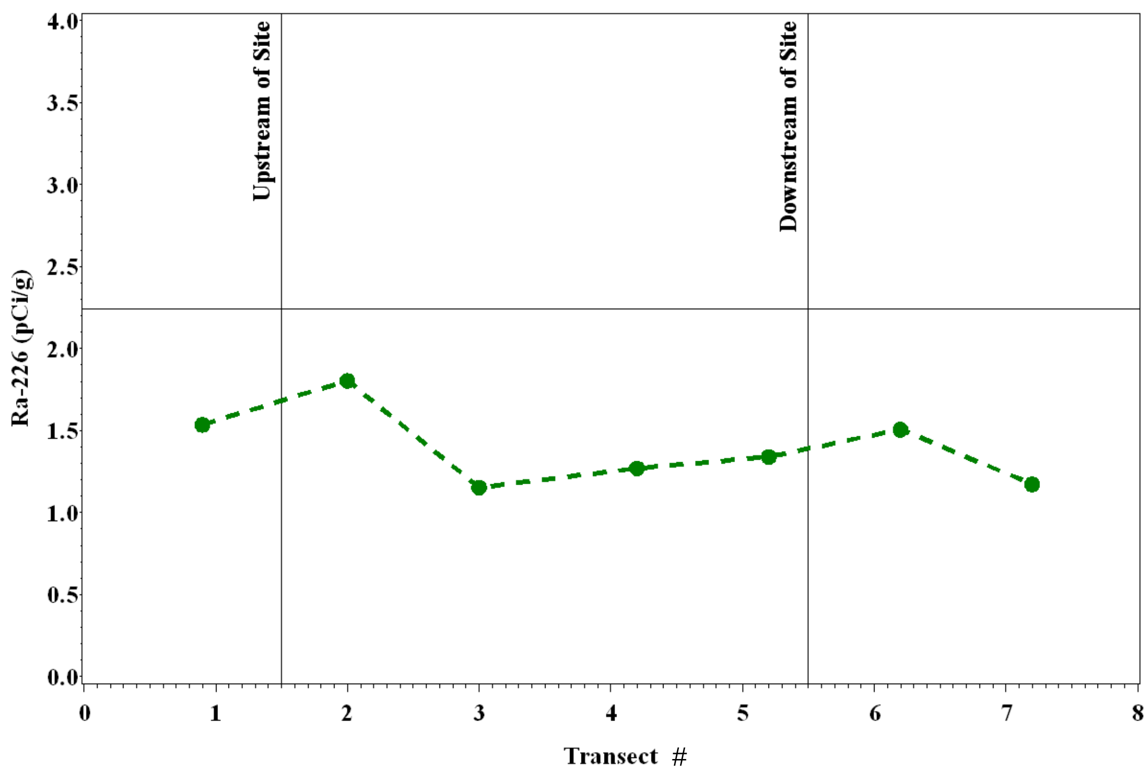
Table 4.4-7 Summary of Transect Ra-226 Concentration in Pipeline Arroyo

Depth Increment (inches)	Number of Samples	Minimum	Median	Mean	Maximum
0-2	7	0.9	1.25	1.34	1.79
2-6	7	1.12	1.43	1.43	1.81
0-6 (est.)	7	1.15	1.34	1.4	1.8
30-36	4	1.13	1.24	1.57	2.66

Note: Estimated values are results of combining two horizons

The profile of concentrations averaged by transect in the Pipeline Arroyo is illustrated in Plate 4.4-8. The figure shows little variation in Ra-226 concentrations along the pipeline or with the depth of sample. This differs from the profile for Unnamed Arroyo #2 which has the lower concentrations in the 0-2 inch soil horizon. The median concentration levels for the 2 to 6 inch depth soil horizon are 1.39 and 1.43 pCi/g for the Unnamed Arroyo #2 and the Pipeline Canyon Arroyo, respectively. These medians agree with the 1.35 pCi/g median for two deep drilling locations from an area that had been extensively excavated during prior remediation (locations C1LP-406 and C1LP-703 from the Former Sediment Pond area.)

Plate 4.4-8 CR-1E Ra-226 Concentrations Profile for Pipeline Arroyo



4.4.3 Non-radiological Soil Sampling

Under the terms of the AOC there is a requirement for four samples to be selected for metals, SVOC, VOC and PCB as well as petroleum hydrocarbon analysis. Further to the work plan amendments for the second stage of the Phase II program the USEPA instructed RAML to have two boreholes advanced within the industrial areas of the respective sites for the purposes of procuring one sample from each borehole for the analysis of the aforementioned parameters. As part of this program a blind duplicate of each sample was also procured and submitted for the analysis of the list of parameters noted above. Pursuant to an EPA request an amendment to the original work plan was implemented for TCLP and SPLP leachate analysis was done on a composite waste rock sample from each site.

As part of this phase of the work headspace readings were recorded and the results incorporated into the borehole logs for each borehole advanced as part of the environmental program.

A discussion of the analytical work completed for each set of parameters is provided below.

4.4.3.1 Metals

As part of the Phase II program four soil samples, two from each borehole advanced within the industrial area (CELI-502 and CELI-503), were submitted for the analysis of Arsenic, Molybdenum, Selenium and Vanadium. The results of the analytical work are presented in Table 4.4-8 and reported that the only the concentration of arsenic was above the industrial screening level standards as prescribed in the EPA Region 9 guidelines. The concentrations of arsenic in the four samples (two original and two blind duplicates) ranged from 2.0 to 7.2 mg/kg, as compared to the EPA Region 9 industrial land-use standard of 1.6 mg/kg. Comparison of these metal results to the local New Mexico Environment Department screening level standards reports that all metal parameters analysed were below criteria including arsenic which has an industrial land-use standard value of 17.7 mg/kg.

Table 4.4-8 Metals in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1E							
		RDL Depth	C1EI-502 SS3 3-4.5 ft	RDL	C1EI-502 SS9 Dup of SS3	RDL	C1EI-503 SS1 0-1.5 ft	RDL	C1EI-503 SS5 Dup of SS1
Arsenic	**1.6**	1.1	**2***	1.1	**2.8***	1.1	**6.2***	1.3	**7.2***
Molybdenum	**5100**	1.1	<	1.1	1.8	1.1	<	1.3	<
Selenium	**5100**	0.53	<	0.53	23	2.7	<	3.2	<
Vanadium	**72**	1.1	11	1.1	28	5.4	18	6.5	21

NOTES:

All parameter values in ug/g (ppm) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

The sample locations are presented in plan on Figure 4.4. The laboratory certificates for this analytical work are included in Appendix A2.

4.4.3.2 Organics [VOCs, SVOCs, TPHs, PCBs]

The list of organic compounds that were analysed as part of the Phase II program included volatile and semi-volatile compounds (VOC/SVOCs), total petroleum hydrocarbons and polychlorinated biphenyls (PCBs). During the course of the program one sample plus a blind duplicate sample were procured from each industrial area borehole (CELI-502 and CELI-503) and the samples submitted for the analysis of the listed parameters. The results of the organic parameter analytical work are presented in Tables 4.4.-9 to 4.4-12 with the results compared to the USEPA Region 9 screening level standards for an industrial land-use site. The analytical results for the respective parameters analysed were all reported as being either non-detect, or at a concentration well below the applicable standards. These results are consistent with field observations where olfactory or visual staining was observed in the soil samples recovered from the industrial area.

The sample locations are presented in plan on Figure 4.4. The laboratory certificates for this analytical work are included in Appendix A2.

Table 4.4-9 Volatile Organic Compounds in Soil

		Church Rock Site 1E							
PARAMETERS	**US EPA INDUSTRIAL ***	**RDL**	**C1EI-502 SS3 3-4.5 ft**	**RDL**	**C1EI-502 SS9 Dup of SS3**	**RDL**	**C1EI-503 SS1 0-1.5 ft**	**RDL**	**C1EI-503 SS5 Dup of SS1**
Dichlorodifluoromethane	**780000**	4.7	<	4.8	<	5	<	6.4	<
Chloromethane	**500000**	4.7	<	4.8	<	5	<	6.4	<
Vinyl Chloride	**1700**	4.7	<	4.8	<	5	<	6.4	<
Bromomethane	**32000**	4.7	<	4.8	<	5	<	6.4	<
Chloroethane	**-**	4.7	<	4.8	<	5	<	6.4	<
Trichlorofluoromethane	**3400000**	4.7	<	4.8	<	5	<	6.4	<
1,1-Dichloroethylene (1,1-Dichloroethene)	**1100000**	4.7	<	4.8	<	5	<	6.4	<
1,1,2-Trichloro-1,2,2-Trifluoroethane	**180000000**	4.7	<	4.8	<	5	<	6.4	<
Acetone	**630000000**	19	<	19	<	20	<	26	<
Iodomethane	**-**	4.7	<	4.8	<	5	<	6.4	<
Carbon Disulfide	**3700000**	4.7	<	4.8	<	5	<	6.4	<
Dichloromethane (Methylene Chloride)	**53000**	4.7	<	4.8	<	5	<	6.4	<
trans-1,2-Dichloroethylene	**9200000**	4.7	<	4.8	<	5	<	6.4	<
Methyl Tert Butyl Ether (MTBE)	**220000**	4.7	<	4.8	<	5	<	6.4	<
1,1-Dichloroethane	**17000**	4.7	<	4.8	<	5	<	6.4	<
Vinyl Acetate	**4100000**	19	<	19	<	20	<	26	<
cis-1,2-Dichloroethylene	**2000000**	4.7	<	4.8	<	5	<	6.4	<
2-Butanone	**200000000**	19	<	19	<	20	<	26	<
Bromochloromethane	**-**	4.7	<	4.8	<	5	<	6.4	<
Chloroform	**1500**	4.7	<	4.8	<	5	<	6.4	<
1,1,1-Trichloroethane	**38000000**	4.7	<	4.8	<	5	<	6.4	<
2,2-Dichloropropane	**-**	4.7	<	4.8	<	5	<	6.4	<
Carbon Tetrachloride	**3000**	4.7	<	4.8	<	5	<	6.4	<
1,1-Dichloropropene	**-**	4.7	<	4.8	<	5	<	6.4	<
1,2-Dichloroethane	**2200**	4.7	<	4.8	<	5	<	6.4	<
Benzene	**5400**	4.7	<	4.8	<	5	<	6.4	<
Trichloroethylene (Trichloroethene)	**14000**	4.7	<	4.8	<	5	<	6.4	<
1,2-Dichloropropane	**4500**	4.7	<	4.8	<	5	<	6.4	<
Dibromomethane	**110000**	4.7	<	4.8	<	5	<	6.4	<
Bromodichloromethane	**1400**	4.7	<	4.8	<	5	<	6.4	<
cis-1,3-Dichloropropene	**8100**	4.7	<	4.8	<	5	<	6.4	<
4-Methyl-2-Pentanone	**-**	19	<	19	<	20	<	26	<
Toluene	**45000000**	4.7	<	4.8	<	5	<	6.4	<
trans-1,3-Dichloropropene	**8100**	4.7	<	4.8	<	5	<	6.4	<
1,1,2-Trichloroethane	**5300**	4.7	<	4.8	<	5	<	6.4	<
2-Hexanone	**1400000**	19	<	19	<	20	<	26	<
Tetrachloroethylene	**2600**	4.7	<	4.8	<	5	<	6.4	<
1,3-Dichloropropane	**20000000**	4.7	<	4.8	<	5	<	6.4	<
Chlorodibromomethane (Dibromochloromethane)	**3300**	4.7	<	4.8	<	5	<	6.4	<
1,2-Dibromoethane (Ethylene Dibromide)	**170**	4.7	<	4.8	<	5	<	6.4	<
1-Chlorohexane	**-**	4.7	<	4.8	<	5	<	6.4	<
Chlorobenzene	**1400000**	4.7	<	4.8	<	5	<	6.4	<
1,1,1,2-Tetrachloroethane	**9300**	4.7	<	4.8	<	5	<	6.4	<
Ethylbenzene	**27000**	4.7	<	4.8	<	5	<	6.4	<
Xylene (m,p)	**17000000**	4.7	<	4.8	<	5	<	6.4	<
Xylene (o)	**19000000**	4.7	<	4.8	<	5	<	6.4	<
Styrene	**36000000**	4.7	<	4.8	<	5	<	6.4	<
Bromoform	**220000**	4.7	<	4.8	<	5	<	6.4	<
Isopropylbenzene	**-**	4.7	<	4.8	<	5	<	6.4	<
1,2,3-Trichloropropane	**95**	4.7	<	4.8	<	5	<	6.4	<
1,1,2,2-Tetrachloroethane	**2800**	4.7	<	4.8	<	5	<	6.4	<
Bromobenzene	**1800000**	4.7	<	4.8	<	5	<	6.4	<
n-Propylbenzene	**21000000**	4.7	<	4.8	<	5	<	6.4	<
2-Chlorotoluene	**20000000**	4.7	<	4.8	<	5	<	6.4	<
1,3,5-Trimethylbenzene	**10000000**	4.7	<	4.8	<	5	<	6.4	<
4-Chlorotoluene	**72000000**	4.7	<	4.8	<	5	<	6.4	<
Tert-butylbenzene	**-**	4.7	<	4.8	<	5	<	6.4	<
1,2,4-Trimethylbenzene	**260000**	4.7	<	4.8	<	5	<	6.4	<
Sec-butylbenzene	**-**	4.7	<	4.8	<	5	<	6.4	<
1,3-Dichlorobenzene (m-Dichlorobenzene)	**-**	4.7	<	4.8	<	5	<	6.4	<
p-Isopropyltoluene	**-**	4.7	<	4.8	<	5	<	6.4	<
1,4-Dichlorobenzene (p-Dichlorobenzene)	**12000**	4.7	<	4.8	<	5	<	6.4	<
n-Butylbenzene	**-**	4.7	<	4.8	<	5	<	6.4	<
1,2-Dichlorobenzene (o-Dichlorobenzene)	**9800000**	4.7	<	4.8	<	5	<	6.4	<
1,2-Dibromo-3-chloropropane	**69**	9.3	<	9.6	<	10	<	13	<
1,2,4-Trichlorobenzene	**99000**	4.7	<	4.8	<	5	<	6.4	<
Hexachlorobutadiene	**22000**	4.7	<	4.8	<	5	<	6.4	<
Naphtalene	**18000**	4.7	<	4.8	<	5	<	6.4	<
1,2,3-Trichlorobenzene	**490000**	4.7	<	4.8	<	5	<	6.4	<

NOTES:

All parameter values in ug/kg (ppb) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

Table 4.4-10 Semi Volatile Organic Compounds in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1E							
		RDL Depth	C1EI-502 SS3 3-4.5 ft	RDL	C1EI-502 SS9 Dup of SS3	RDL	C1EI-503 SS1 0-1.5 ft	RDL	C1EI-503 SS5 Dup of SS1
Pyridine	**1000000**	360	<	360	<	360	<	410	<
n-Nitrosodimethylamine	**11**	360	<	360	<	360	<	410	<
Aniline	**300000**	360	<	360	<	360	<	410	<
Phenol	**180000000**	360	<	360	<	360	<	410	<
Bis(2-chloroethyl)ether	**1000**	360	<	360	<	360	<	410	<
2-Chlorophenol	**5100000**	360	<	360	<	360	<	410	<
1,3-Dichlorobenzene	**-**	360	<	360	<	360	<	410	<
1,4-Dichlorobenzene	**12000**	360	<	360	<	360	<	410	<
1,2-Dichlorobenzene	**9800000**	360	<	360	<	360	<	410	<
Benzyl Alcohol	**62000000**	360	<	360	<	360	<	410	<
Bis(2-chloroisopropyl)ether	**-**	360	<	360	<	360	<	410	<
2-Methylphenol	**-**	360	<	360	<	360	<	410	<
n-Nitroso-di-n-propylamine	**250**	360	<	360	<	360	<	410	<
3+4-Methylphenol	**-**	360	<	360	<	360	<	410	<
Hexachloroethane	**120000**	360	<	360	<	360	<	410	<
Nitrobenzene	**24000**	360	<	360	<	360	<	410	<
Isophorone	**1800000**	360	<	360	<	360	<	410	<
2-Nitrophenol	**-**	360	<	360	<	360	<	410	<
2,4-Dimethylphenol	**12000000**	360	<	360	<	360	<	410	<
Bis(2-chloroethoxy)methane	**1800000**	360	<	360	<	360	<	410	<
2,4-Dichlorophenol	**1800000**	360	<	360	<	360	<	410	<
Benzoic Acid	**2500000000**	1800	<	1800	<	1800	<	2100	<
1,2,4-Trichlorobenzene	**99000**	360	<	360	<	360	<	410	<
Naphthalene	**18000**	360	<	360	<	360	<	410	<
4-Chloroaniline	**8600**	360	<	360	<	360	<	410	<
Hexachlorobutadiene	**22000**	360	<	360	<	360	<	410	<
4-Chloro-3-methylphenol	**-**	360	<	360	<	360	<	410	<
2-Methylnaphthalene	**4100000**	360	<	360	<	360	<	410	<
1-Methylnaphthalene	**99000**	360	<	360	<	360	<	410	<
Hexachlorocyclopentadiene	**3700000**	360	<	360	<	360	<	410	<
2,4,6-Trichlorophenol	**160000**	360	<	360	<	360	<	410	<
2,4,5-Trichlorophenol	**62000000**	360	<	360	<	360	<	410	<
2-Chloronaphthalene	**82000000**	360	<	360	<	360	<	410	<
2-Nitroaniline	**6000000**	720	<	720	<	730	<	830	<
Dimethyl Phthalate	**-**	360	<	360	<	360	<	410	<
2,6-Dinitrotoluene	**620000**	360	<	360	<	360	<	410	<
Acenaphthylene	**-**	360	<	360	<	360	<	410	<
3-Nitroaniline	**-**	720	<	720	<	730	<	830	<
Acenaphthene	**33000000**	360	<	360	<	360	<	410	<
2,4-Dinitrophenol	**1200000**	720	<	720	<	730	<	830	<
4-Nitrophenol	**-**	720	<	720	<	730	<	830	<
Dibenzofuran	**-**	360	<	360	<	360	<	410	<
2,4-Dinitrotoluene	**5500**	360	<	360	<	360	<	410	<
Diethyl Phthalate	**490000000**	360	<	360	<	360	<	410	<
Fluorene	**22000000**	360	<	360	<	360	<	410	<
4-Chlorophenyl Phenyl Ether	**-**	360	<	360	<	360	<	410	<
4-Nitroaniline	**86000**	720	<	720	<	730	<	830	<
Azobenzene	**23000**	360	<	360	<	360	<	410	<
4,6-Dinitro-2-Methylphenol	**-**	720	<	720	<	730	<	830	<
n-Nitrosodiphenylamine	**350000**	360	<	360	<	360	<	410	<
4-Bromophenyl Phenyl Ether	**-**	360	<	360	<	360	<	410	<
Hexachlorobenzene	**1100**	360	<	360	<	360	<	410	<
2,3,4,6-Tetrachlorophenol		360	<	360	<	360	<	410	<
Pentachlorophenol	**2700**	720	<	720	<	730	<	830	<
Phenanthrene	**-**	360	<	360	<	360	<	410	<
Anthracene	**170000000**	360	<	360	<	360	<	410	<
Carbazole	**-**	360	<	360	<	360	<	410	<
Di-n-butyl Phthalate	**62000000**	360	<	360	<	360	<	410	<
Fluoranthene	**22000000**	360	<	360	<	360	<	410	<
Pyrene	**17000000**	360	<	360	<	360	<	410	<
Butyl Benzyl Phthalate	**910000**	360	<	360	<	360	<	410	<
Benzo(a)anthracene	**2100**	360	<	360	<	360	<	410	<
3,3'-Dichlorobenzidene	**3800**	360	<	360	<	360	<	410	<
Chrysene	**210000**	360	<	360	<	360	<	410	<
Bis(2-ethylhexyl)phthalate	**120000**	360	<	360	<	360	<	410	<
Di-n-octyl phthalate	**-**	360	<	360	<	360	<	410	<
Benzo(b)fluoranthene	**2100**	360	<	360	<	360	<	410	<
Benzo(k)fluoranthene	**21000**	360	<	360	<	360	<	410	<
Benzo(a)pyrene	**210**	360	<	360	<	360	<	410	<
Indeno(1,2,3-cd)pyrene	**2100**	360	<	360	<	360	<	410	<
Dibenzo(a,h)anthracene	**210**	360	<	360	<	360	<	410	<
Benzo(g,h,i)perylene	**-**	360	<	360	<	360	<	410	<

NOTES:

All parameter values in ug/kg (ppb) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

Table 4.4-11 Petroleum Hydrocarbons in Soil

PARAMETERS	NMED INDUSTRIAL '	Church Rock Site 1E							
		RDL	C1EI-502 SS3 3-4.5 ft	RDL	C1EI-502 SS9 Dup of SS3	RDL	C1EI-503 SS1 0-1.5 ft	RDL	C1EI-503 SS5 Dup of SS1
Diesel Range Organics	**1120(a) ; 2200(b)**	5.4	11	5.4	14	5.5	13	6.2	7.4
Gasoline Range Organics	**-**	0.49	<	0.44	<	0.43	<	0.36	<

<u>NOTES</u>:

All parameter values in ug/g (ppm) unless otherwise indicated.

New Mexico Environment Department TPH Screening Guidelines (October 2006):
' Exceeds Industrial Standards - NMED TPH Screening Guidelines

(a) TPH Screening Guidelines for Potable Groundwater - Direct Exposure
(b) TPH Screening Guidelines for Vapor Migration and Inhalation of Groundwater - Direct Exposure

RDL Reportable Detection Limit.
- Standard not available.
< Not detected.

Table 4.4-12 Polychlorinated Biphenyls in Soil

PARAMETERS	US EPA INDUSTRIAL *	Church Rock Site 1E							
		RDL Depth	C1EI-502 SS3 3-4.5 ft	RDL	C1EI-502 SS9 Dup of SS3	RDL	C1EI-503 SS1 0-1.5 ft	RDL	C1EI-503 SS5 Dup of SS1
Aroclor-1016	**21000**	36	<	36	<	36	<	42	<
Aroclor-1221	**540**	71	<	72	<	73	<	84	<
Aroclor-1232	**540**	36	<	36	<	36	<	42	<
Aroclor-1242	**740**	36	<	36	<	36	<	42	<
Aroclor-1248	**740**	36	<	36	<	36	<	42	<
Aroclor-1254	**740**	36	<	36	<	36	<	42	<
Aroclor-1260	**740**	36	<	36	<	36	<	42	<

<u>NOTES</u>:

All parameter values in ug/kg (ppb) unless otherwise indicated.

USEPA Region 9 Screening Level (November 2010):
* Exceeds Industrial Standards - USEPA Region 9

RDL Reportable Detection Limit.
< Not detected.

4.4.3.3 Soil Leachate [TCLP, SPLP]

Further to an amendment to the Phase II work plan, as requested by the USEPA, a composite soil sample from the waste rock area of the CR-1E site was submitted for TCLP and SPLP analysis. The results of this work are presented in Tables 4.4-13 and 4.4-14 respectively and confirm that the toxicity characteristics are well below the EPA limits.

Table 4.4-13 TCLP Metals

PARAMETERS	US EPA LEACHATE *	Church Rock Site 1E	
		RDL	C1EW-305 SS1-SS4 5-21 ft
Arsenic	**5**	0.1	<
Barium	**100**	1	<
Cadmium	**1**	0.05	<
Chromium	**5**	0.1	<
Lead	**5**	0.03	<
Selenium	**1**	0.05	0.059
Silver	**5**	0.1	<
Mercury	**0.2**	0.002	<

<u>NOTES</u>:

All parameter values in mg/L leachate unless otherwise indicated.

USEPA Identification and Listing of Hazardous Waste (current as of July 6 2011):
* Exceeds Maximum Concentration of Contaminants for the Toxicity Characteristic

RDL Reportable Detection Limit.
< Not detected.

Table 4.4-14 SPLP Metals

PARAMETERS	US EPA LEACHATE *	Church Rock Site 1E	
		RDL	C1EW-305 SS1-SS4 5-21 ft
Arsenic	**5**	0.1	**<**
Molybdenum	**-**	0.1	<
Selenium	**1**	0.05	<
Vanadium	**-**	0.1	<

<u>NOTES</u>:

All parameter values in mg/L leachate unless otherwise indicated.

USEPA Identification and Listing of Hazardous Waste (current as of July 6 2011):
* Exceeds Maximum Concentration of Contaminants for the Toxicity Characteristic

RDL Reportable Detection Limit.
< Not detected.
- Standard not available.

4.5 CORRELATION BETWEEN RA-226 AND GAMMA RADIATION

Correlations between gamma radiation and soil surface Ra-226 concentrations in the 0-6 inch soil horizons have been used for estimate Ra-226 concentrations. The approach used by UNC for their site was adopted here. The relationship would not be used at locations where clean soil cover was placed over waste rock with substantively higher concentrations than observed on the surface. The relationship was then applied to averages of scanning gamma radiation.

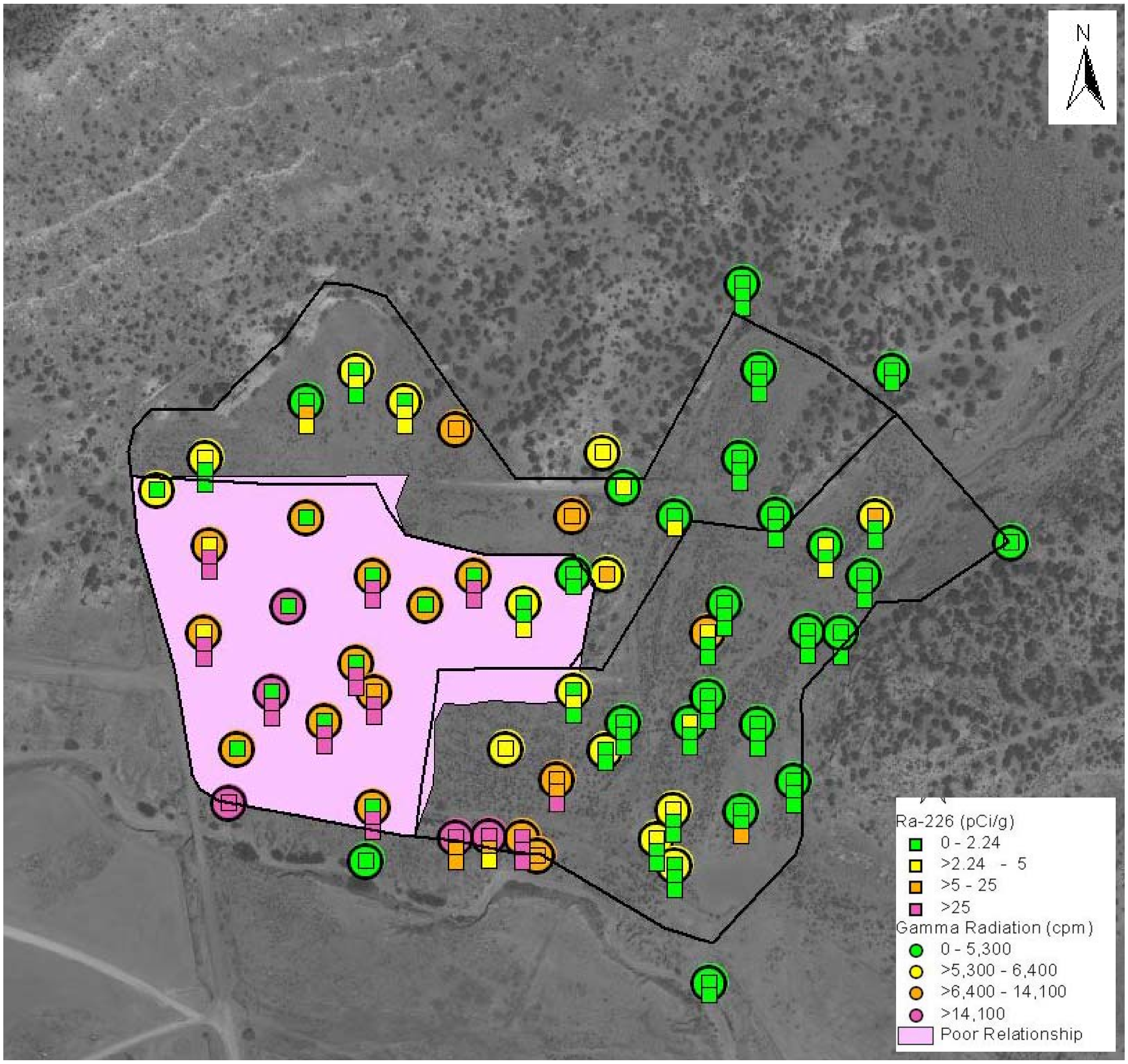
4.5.1 Data Used for Calibration Study

A comparison between gamma radiation and surface 0-6 inch Ra-226 concentrations was conducted to determine where these values are suitably correlated and where a prediction relationship can be applied. Plate 4.5-1 shows the spatial correlation between gamma radiation and the shallow surface soil concentrations. It is apparent that a poor relationship is present in the waste rock area as the gamma radiation concentrations appear to be higher than supported by the 0-6 inch soil concentrations. This arises because appreciable gamma radiation from the waste rock below the cover material is detected by the gamma radiation measurement; therefore, the gamma radiation measurement in these areas reflects the contribution not only from the 0-6 inch layer but also underlying layers and hence, these measurements incorrectly assign higher concentrations to the 0-6 inch layer than are actually present. To minimize this effect, data from the hatched area is not used in the calibration.

The static gamma radiation and surface soil concentrations on CR-1E show a pattern similar to that observed in CR-1. Plate 4.5-2 shows the paired measurements and the area that will be excluded from the calibration and prediction of Ra-226 soil concentration from measured gamma radiation. This occurs primarily on the water rock areas where higher concentration waste rock is present below the lower concentration surface material.

Additional exclusions for the calibration data set are discussed in Appendix A3 and include areas with high variability in radiological conditions that may mask the relationship between the soil sample and the gamma radiation reading.

Plate 4.5-1 CR-1 Surface Gamma Radiation Measurements (cpm) and 0-6 inch Soil Concentrations (pCi/g)



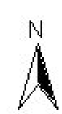
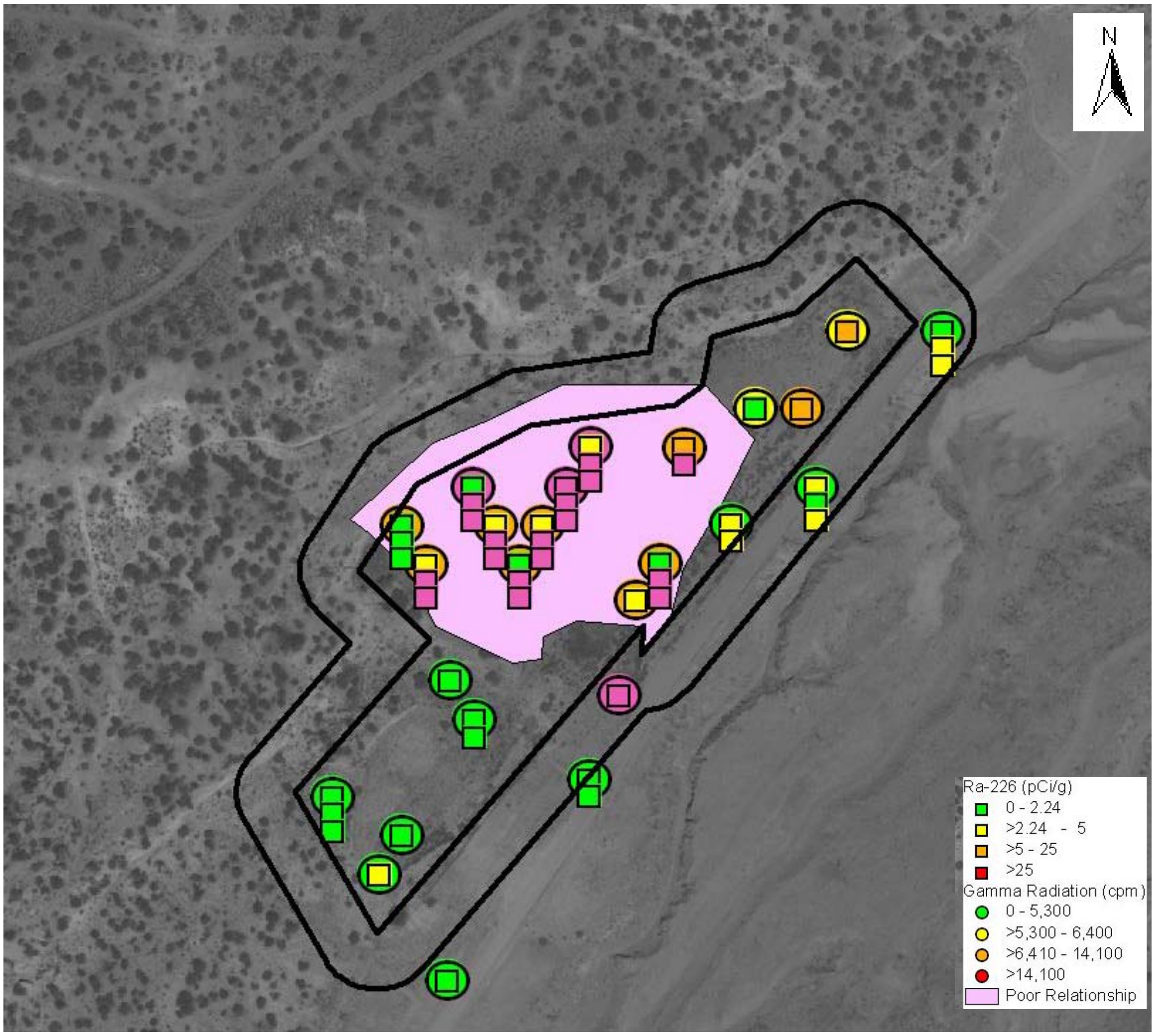


Plate 4.5-2 CR-1E Surface Gamma Radiation Measurements (cpm) and 0-6 inch Soil Concentrations (pCi/g)



4.5.2 Statistical Model Fitting and Performance

Gamma radiation measurements respond to radionuclides present in soil and see the effects of radionuclides from varying distances and depths; however, the soils closest to the detector and nearest the surface generally contribute the most to the gamma radiation level. Although not reading only the gamma radiation from a soil sample concurrently located at the 0-6 inch depth, the gamma radiation measurements are generally highly correlated with the soil Ra-226 concentration.

The relationship between gamma radiation and Ra-226 soil concentrations for areas at background or close to background can be affected by naturally varying mineralization of naturally occurring radionuclides. Changes in gamma radiation level in these areas can be due to changes in Ra-226 concentration, the thorium decay series and the potassium-40 (K-40) concentrations. The increase in Ra-226 per increase in gamma radiation will tend to be lower in this region since part of the increase will be due to other natural radionuclides than at locations where only the Ra-226 concentration is varying. The approach taken here is to develop a two part relationship. The first part is a relationship for low Ra-226 concentrations, i.e., below 5 pCi/g and includes the PAL, and is as shown below. The second part is a relationship for concentrations of Ra-226 above 5 pCi/g.

The statistical model relating gamma radiation level (cpm) to Ra-226 soil concentration (pCi/g) in the 0-6 inch soil horizon for this part is given by:

$$C_{Ra-226} = M_1 * \gamma + int$$

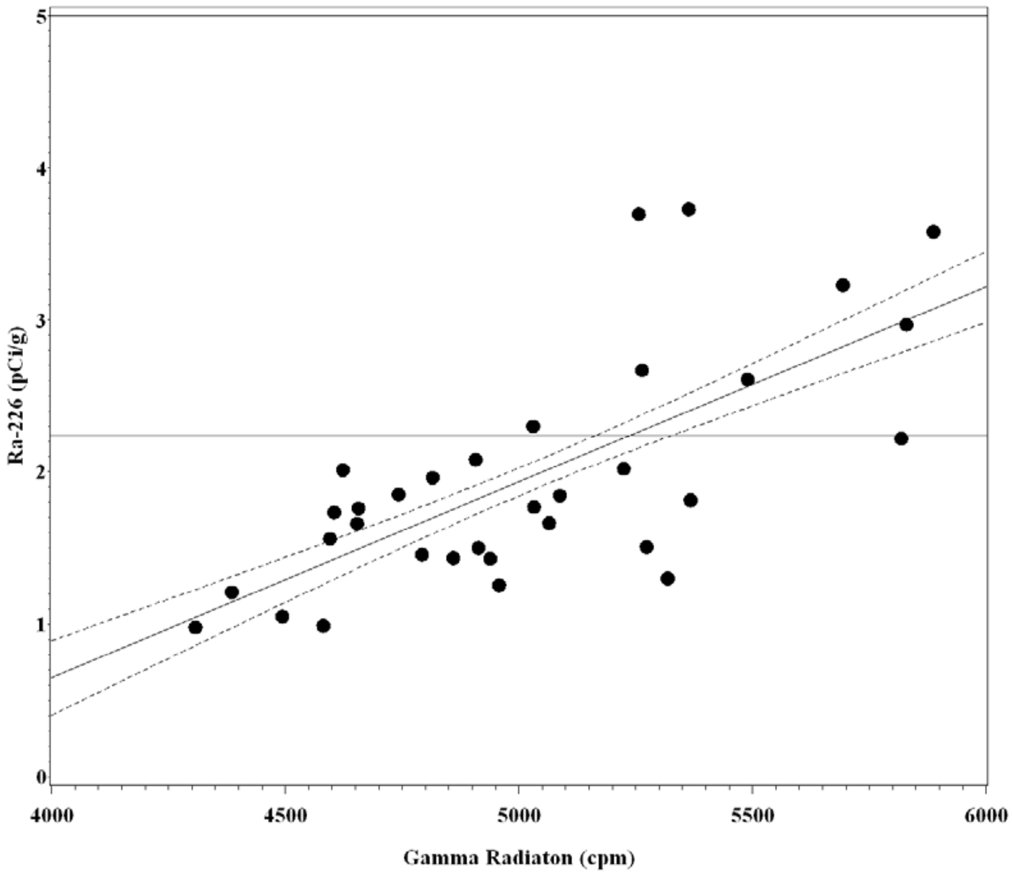
where:

- $C_{Ra\text{-}226}$ is the Ra-226 concentration in the 0-6 inch soil horizon;
- M_1 is the slope of the fitted line in (pCi/g per cpm);
- γ is the static gamma radiation count rate over 1 minute (cpm); and
- int is where the fitted line crosses the y axis (Ra-226 concentration).

This relationship performs well for soil profiles with homogeneous concentrations with depth or with a profile of higher concentrations at the surface. Also it is important that other gamma emitting radionuclides such as potassium-40 (K-40) or the natural thorium series are either constant across the samples or the gamma radiation level contribution from these are proportional to the gamma radiation level measured from the uranium (e.g. Ra-226) series.

Plate 4.5-3 shows the regression relationship for the calibration data set that has been fitted in Appendix A3. The confidence bounds of the mean prediction indicate that the mean predictions have low uncertainty at these gamma radiation levels. There are increasing Ra-226 concentrations with increasing gamma radiation and the prediction equation is $c_{Ra-226}(pCi/g) = 0.00126 * \gamma(cpm) - 4.5(pCi/g)$. The negative intercept accounts, in part, for the contribution from other naturally occurring radionuclides.

Plate 4.5-3 Regression Between Gamma Radiation Measurements (cpm) and Soil at Low Ra-226 Concentrations



The second part of the relationship recognizes that the increase Ra-226 with an increase in gamma radiation will be higher at larger gamma radiation levels as the Ra-226 will vary more than the other naturally occurring radionuclides. The complete two part relationship incorporating the range of concentrations has been developed using the following model:

$$C_{Ra\text{-}226} = M_1 * \gamma + M_2 * (maximum(\gamma - \gamma_O, 0)) + int$$

where:

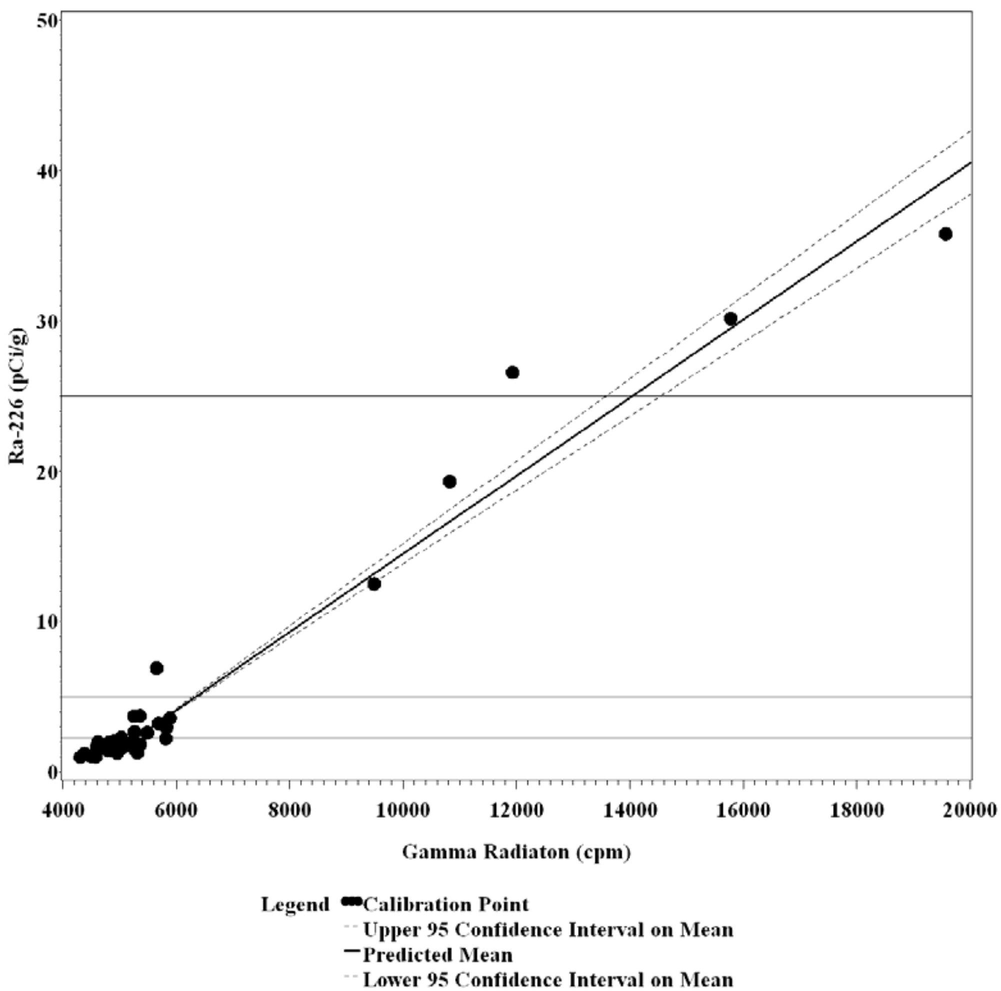
- $C_{Ra\text{-}226}$ = the predicted soil concentration with units pCi/g.
- γ = the gamma radiation level measured at the sampling location with units of cpm
- M_1 = the factor developed for the low concentrations and set to 0.00126 pCi/g per cpm
- M_2 = the additional factor relating soil concentration to gamma radiation levels for above background conditions. The units are pCi/g per cpm.
- γ_0 = the gamma radiation level at the PAL to ensure that estimation at the PAL is consistent with the low concentration relationship. This was estimated to be 5300 cpm.

int = the intercept and set equal to -4.5 from the earlier relationship

The term (maximum [γ -γO, 0]) in the equation allows for the increased slope to be only applied to gamma radiation increment above the gamma radiation break point. The increment is calculated if the total gamma radiation is above the break point, or set to zero, if the total gamma radiation is below the break point.

The model was fitted with the gamma radiation breakpoint constrained to be equal to the gamma radiation level developed for the PAL. The additional slope for gamma above 5,300 cpm was 0.00132 pCi/g per cpm. Plate 4.5-4 shows the two-part relationship relating gamma radiation levels to Ra-226 concentration in the 0-6 inch soil horizon.

Plate 4.5-4 Relationship Between Gamma Radiation and Soil Ra-226 Concentration over the Range of Calibration Samples



The performance has been assessed in Appendix A3 and it appears suitable for the range of interest and can be extended to higher gamma radiation measurements. The relationship can be used to estimate the gamma radiation measurements corresponding to the soil Ra-226 concentrations of interest. Table 4.5-1 shows the gamma radiation measurements corresponding to the soil Ra-226 concentrations in the 0-6 inch soil horizon. The gamma radiation measurements have been rounded to two significant figures for the table.

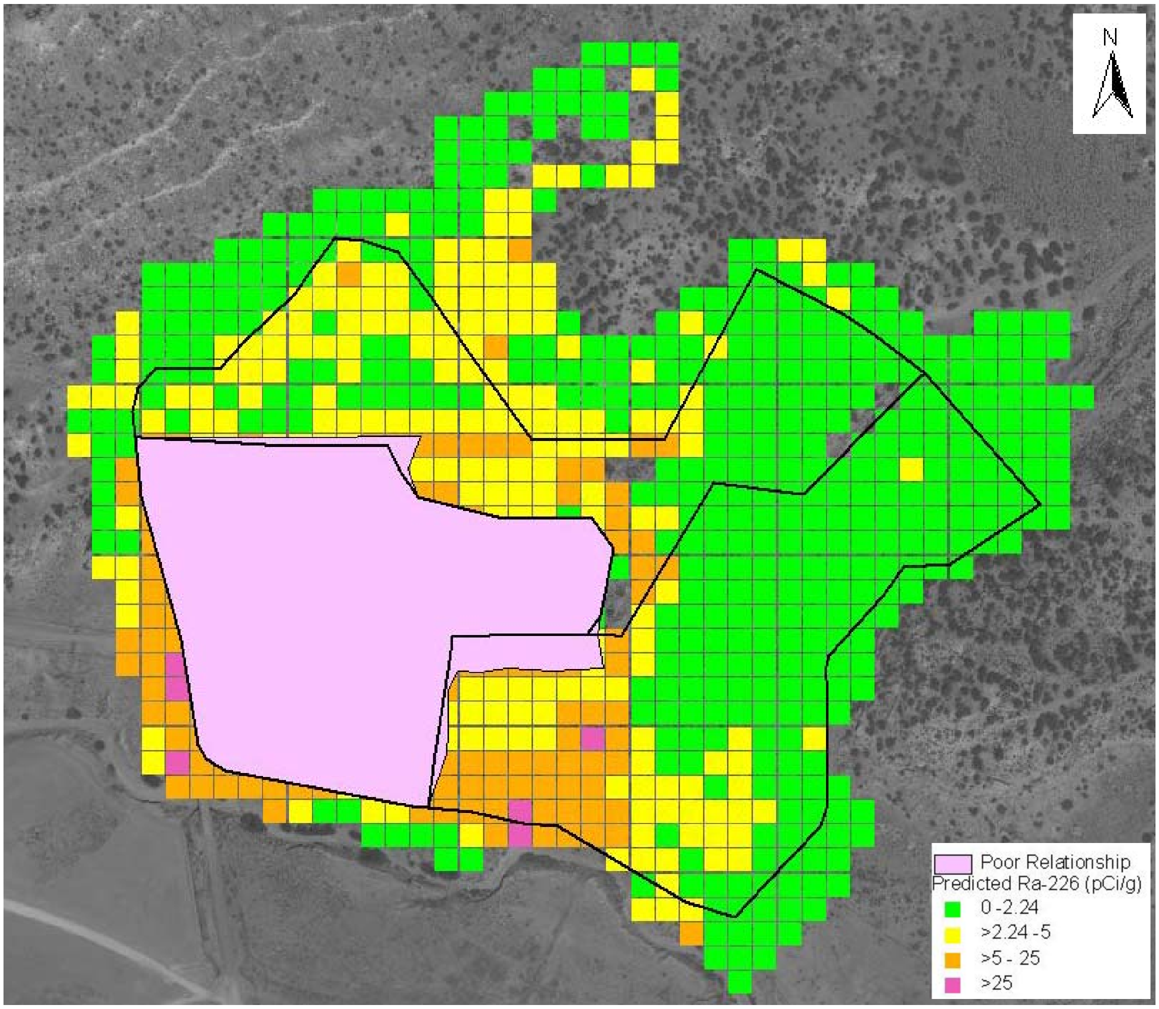
Table 4.5-1 Gamma Radiation Level Ranges (cpm) Corresponding with Ranges for Soil Ra-226 Concentration in 0-6 inch Soil Horizon

Classification Ranges	
Ra-226 Soil Concentration in the 0-6 inch Soil Horizon (pCi/g)	**Gamma Radiation Level (cpm)**
0-2.24	0-5,300
>2.24- 5.0	>5,300-6,400
>5.0 - 25.0	>6,400 -14,100
>25.0	>14,100

4.5.3 Predicting Ra-226 Soil Concentration from Gamma Radiation Measurements

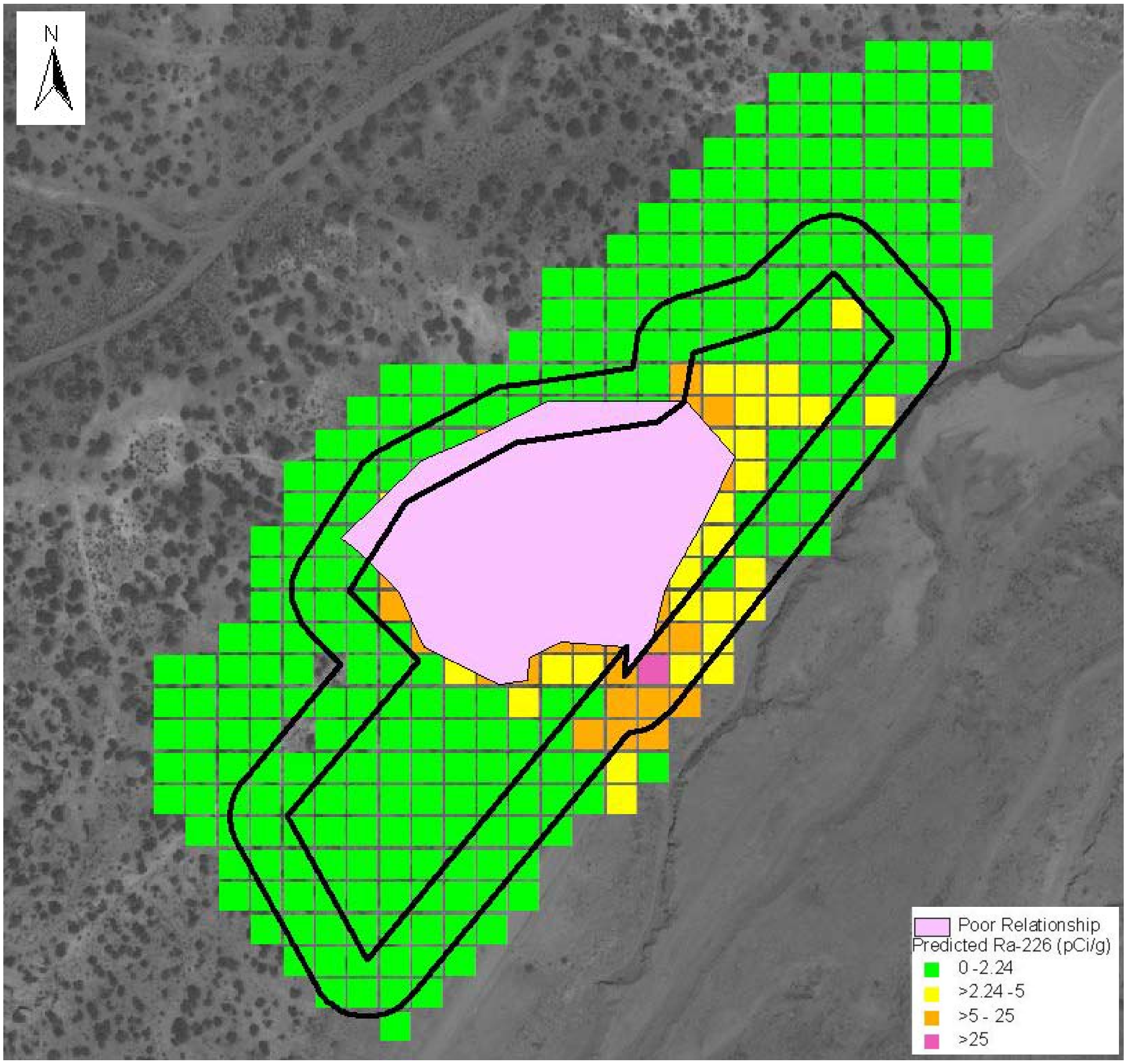
The relationship has been used to express the averaging of scanning gamma radiation measurements as corresponding 0-6 inch soil concentrations. Plates 4.5-5 and 4.5-6 show the 0-6 inch Ra-226 soil concentration predicted using the relationship and the scan averages for the CR-1 and CR-1E sites. Both sites have a fairly large area where the prediction relationship cannot be used; therefore data summaries of average concentration for the predefined areas are not possible by only using the relationship. The plots do show that locations with 0-6 inch soil concentrations above PAL concentrations are limited.

Plate 4.5-5 CR-1 Ra-226 Concentration from Scanning Gamma Radiation



Note: no data collected in open blocks

Plate 4.5-6 CR-1E Ra-226 Concentration Prediction from Scanning Gamma Radiation



4.6 CULTURAL SURVEY

Cultural surveys were provided to the EPA and NNEPA during work program under separate cover.

4.7 VEGETATION SURVEY AND SOIL SAMPLING RESULTS

4.7.1 Vegetation Conditions

Vegetation communities surveyed on the Sites were on re-vegetated portions of the previous mining disturbed surfaces that had been reclaimed during the early 1990's. Plant canopy cover was recorded as a measure of re-vegetation success. Although cover values were low on the portions of CR-1 that were grazed, there was good plant diversity with a good mixture of native shrubs, grasses, and forbs. A total of 41 native plant species were recorded on CR-1and 32 species recorded on the smaller CR-1E site. Due to the continual soil surface disturbance by trampling, Russian thistle was common on bare ground on this CR-1, but lacking on CR-1E. Most grasses were grazed to the ground and were not producing seed. In contrast to CR-1, CR-1E had been protected from livestock grazing since reclamation started, consequently had good plant cover with more diverse and productive vegetation communities. Shrubs and grasses had good vegetative growth and produced abundant seed. The two native grasses, blue grama and galleta, as well as other native grasses were abundant and had vigorous growth. The plant species that had good growth and presence on the two sites will help determine the recommended seed mix for any subsequent re-vegetation.

4.7.2 Soil Agronomy

Based on the results of the soils analyses, most of the soil tested can support re-vegetation using native plant species. There were no extreme values for soil characteristics or nutrients that would limit re-vegetation. In particular, the soil sandy loam textures were excellent for native vegetation establishment and growth. Soils were low in nitrogen and phosphorus, but these nutrients are not limiting for native vegetation that is not harvested or used to remove these nutrients. Addition of fertilizer high in nitrogen and phosphorus to native soils promotes weeds and suppresses native plant species, therefore is not recommended as an amendment. The high sulfur concentrations in two soil sample locations should not have an effect on the overall ability to re-vegetate soils on the sites. There is some variability in the soils parameters measured that is probably the result of soil sources and mixing during final reclamation grading, capping of mine waste rock pile, and subsequent erosion and deposition.

5.0 ONGOING SITE CONTROL

Work at the Church Rock Sites has been carried out as required by the provisions of the United States Environmental Protection Agency (EPA) Administrative Order on Consent (AOC) (CERCLA Docket No. 2010-13) and the associated Scope of Work (SOW) (EPA, 2010).

At the time of writing this report, the site continues to be monitoring by RAML in accordance with its obligations under the AOC and the approved scope of work. Periodic monitoring and control actions include:

- Inspection of the road sealing and related erosion control works work;
- Inspection of the graded slopes and associated erosion control measure; and
- Inspections of the fences and gates.

The inspections are ongoing on a monthly basis and repairs will be implemented in a timely manner when and where required.

A Storm Water Pollution Protection Plan provides specific guidance on the monitoring and management of surface flows across and around the site.

6.0 PROJECT COSTS

The Church Rock RSE was prepared in accordance with the requirements of the AOC to characterize existing site conditions.

Project efforts and costs are associated with the planning and implementation of the scope of work for the "time critical removal action" the AOC required. Summary project direct and in-direct costs associated with these efforts and activities are presented in Table 6.1.

Table 6.1 Cost Estimate

Quivira - Church Rock 1 and 1E Mines Closed Mines		
	Projects	**Cost to Date ($US000)**
1	**Technical** Development of Work Plans Technical Studies & Reviews Equipment Rentals Sub-Consultants/Contractors Laboratory Analysis, QA/QC, Shipping/Handling Reporting	**1,135**
2	**Construction** Mobilization / Demobilization Fencing Dust Control for Road and Shoulders Waste Rock Pile Re-Sloping Storm Water Pollution Protection	**183**
3	**Project Indirects**	**100**
	Total	**1,418**

In accordance with AOC requirements, the final RSE report is also required to report on the amount of material moved from the site. In this regard, it is noted that no materials were removed from the site during this program.

As noted in the Phase 1 Interim Report (RAML, 2011a) a small quantity of material was bladed from the RWPR road surface or from the southern toe of the waste pile and placed on the waste pile slopes during the Phase I work. This work was conducted at the request of EPA to allow for the construction of interim sedimentation ponds. In addition, in association with the Phase II work, a very small amount of decontaminated water and solids resulting from cleaning of the auger equipment, were temporarily stored in steel drum containers. After the water evaporated, the residual solids, with an estimated volume of less than 5 gallons, were taken to the top of the CR1 waste pile where they were placed under the waste rock cover in accordance with an approved disposal plan [email communication K. Black to A. Bain, Memo from G. Wiatzka, 23 May 2011).

LIST OF FIGURES

7.0 REFERENCES

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