APPENDIX C

TO

ADMINISTRATIVE ORDER ON CONSENT

NORTHEAST CHURCH ROCK INTERIM REMOVAL ACTION

CERCLA DOCKET NO. 2009-11

Prepared for:

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INTERIM REMOVAL ACTION WORK PLAN
NORTHEAST CHURCH ROCK MINE SITE

July 24, 2009

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1.0 INTRODUCTION

This Interim Removal Action (IRA) Work Plan (The Work Plan) describes the objectives, scope of work and methods for conducting an IRA at and adjacent to the Northeast Church Rock (NECR) Mine (the mine site). This Work Plan has been prepared in conjunction with and is consistent with the Removal Site Evaluation (RSE) Work Plan (MWH, 2006) and will be performed in accordance with the provisions of the United States Environmental Protection Agency (EPA) Administrative Order on Consent (CERCLA Docket No. 2009-11) ("AOC") into which it has been incorporated by reference. All submittals required by this Work Plan will be subject to EPA review and approval as provided in the AOC. To the extent that there is a conflict between this Work Plan and the terms of the AOC, the AOC will control.

A layout of the Site is presented in Figure 1, *Site Layout*. The Site is located approximately 16 miles northeast of Gallup, McKinley County, New Mexico. This Work Plan has been prepared on behalf of United Nuclear Corporation (UNC) and uses applicable aspects of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, EPA, 2000), as well as other applicable EPA guidance documents.

1.1 SITE BACKGROUND

The areas of concern for this IRA were investigated as part of the Removal Site Evaluation (RSE) and supplemental RSE investigations (SRSEs) conducted in 2006 through 2008. The results of the RSE are presented in the RSE Report (MWH, 2007) and the results of a supplemental surface soil RSE investigation are presented in the *Supplemental Removal Site Evaluation Report* (MWH, 2008). The results of these two investigations indicated that radium-226 (Ra-226) concentrations in soils exceed both the RSE Field Screening Level (FSL) of 2.24 pCi/g, as well as the UMTRCA Part 192 standard unrestricted use standards of 6.0 pCi/g (5.0 pCi/g + presumed 1.0 pCi/g background level) for shallow soils and 16 pCi/g for subsurface soils (15 cm or deeper) in areas of concern for the IRA. Additionally, a second supplemental RSE investigation was conducted in subsurface soils along the unnamed arroyo. The analytical results of these samples are shown on Figure 2, *Removal Site Evaluation Gamma Survey Results*, and Figure 3, *Removal Site Evaluation Soil Sampling Results*.

EPA Region 9 conducted a removal action in April through June 2007 of soils around three residences (designated for purposes of the RSE as Home Sites 4, 6, 7, 8, and 9) with exceedances of the FSL (E&E, 2007). The EPA removal action was initially limited to the 0.5-acre areas surrounding the home sites within which the RSE investigation was conducted; however the scope of the removal was expanded in the field. After the soils were removed, EPA conducted a final gamma survey and soil sampling of the excavated area, and then backfilled with clean soil and revegetated the areas (Ecology & Environment, 2007).

1.2 OBJECTIVES OF THE INTERIM REMOVAL ACTION

The objectives of the IRA will be to:

- Excavation: Remove soils containing Radium 226 (Ra-226) above 2.24 pCi/g (hereafter referred to as the IRA Action Level) from Navajo Reservation lands that are potentially attributable to historic activities at the NECR mine site.

- Regrading/Waste Deposition/Cover/Drainage: Reclaim the side-slopes of the NECR-1 pad to prevent transport of impacted materials via wind and storm water, place newly excavated soil and sediment on the waste pile, and regrading and covering with clean fill of the NECR-1 waste pile to reduce the chances of drainage of contaminants onto the side slopes and to convey surface drainage into the area designated as Pond 3.

- Erosion/Sediment Control: Install erosion and sedimentation controls on the periphery of the north portion of the NECR Mine site adjacent to the Navajo Reservation Boundary to prevent transport of potentially impacted material onto the reservation via stormwater (i.e., the unnamed arroyo and the drainage northeast of NECR-1). This will include installing sedimentation basins at the top of the unnamed arroyo on the mine site and within the drainage channel from the northeast portion of the site that drains towards the southern part of Red Water Pond Road. Regrading will be done to redirect runoff to the sediment basin The sedimentation basins will be shown on a figure in the Construction Plan

- Temporary Relocation and Services: provide temporary relocation and temporary relocation services for residents of the reservation lands in proximity to the Work,

- Investigation: investigate the Red Water Pond Road and the vicinity surrounding it to determine which portions of this area are in need of remediation,

- Revegetation: backfill with clean fill, as necessary and revegetate areas impacted by the Interim Remedial Action,

- Health & Safety: Implement the Work in a safe manner that is protective of site personnel as well as residents. UNC will offer temporary lodging to three households located in the immediate work area during implementation of the IRA.

The IRA excavation will be limited to those areas with exceedances of the IRA Action Level (see Figures 2 and 3) within the Navajo Reservation boundary, as shown on Figure 4 (*Interim Removal Action Areas*). As noted above, UNC is performing this IRA pursuant to the EPA Administrative Order on Consent into which it has been incorporated in order to advance removal activities on the reservation land adjacent to NECR. Additional response activities at the Site are anticipated in connection with an Engineering Evaluation/Cost Analysis (EE/CA) currently under development by EPA.

On May 15, 2009, Rena Martin, an Archaeologist with Dinetahdoo Cultural Resources Management performed a cultural resources inventory of the IRA work area. The survey identified one archaeological site (NM-Q-20-48), one traditional cultural property (TCP), seven isolated occurrences and two in-use sites and recommended clearance for the proposed work. On May 27, 2009 the Navajo Nation Historic Preservation Office issued a compliance form requiring that as a condition of compliance, "All Construction within 50 ft of the TCP must be flagged and monitored by a qualified archeologist prior to any activity." The TCP is not located within 50 feet of the proposed removal areas. If the pre-excavation radiation scanning discussed in Section 3.1.2 indicates that soils are impacted above the proposed action level within 50 feet of the TCP, UNC will retain a qualified archaeologist to flag and monitor the activities in this area.

2.0 SCOPE OF WORK

2.1 NECR-1 STEP-OUT AND VICINITY

The areas shown on Figure 4 north and northeast of NECR-1 on reservation land with surface soils containing Ra-226 in excess of the IRA Action Level will be excavated. Based on the RSE and SRSE work, the IRA Action Level is expected to be reached between 6 and 12 inches below ground surface (bgs). Ra-226 concentrations will be determined in the field using direct gamma radiation surveys correlated to Ra-226 concentrations based on site-specific conditions, consistent with the prior EPA removal action and as discussed in Section 3.0.

Excavation of surface soils within the step-out areas north and northeast of NECR-1 (see Figure 4) will be conducted westward until either the IRA Action Level or the edge of the unnamed arroyo are reached. To the east, excavation will be conducted to within 50 feet west of Red Water Pond Road. No removal action of the soils beneath or adjacent to Red Water Pond Road will be conducted. Respondents UNC and GE allege that impacts along the road appear to be associated with use of Red Water Pond Road as a haul road for other, unrelated mine sites. As discussed with EPA on July 11, 2009, additional soil sampling will be conducted along Red Water Pond Road to assess the extent of Ra-226 above the proposed action level. UNC and EPA will discuss potential approaches for conducting a removal action from Red Water Pond Road after the sampling results are received. To the south, excavation will extend up to the edge of the NECR-1 pile and the Navajo Reservation boundary in the southeast corner of the NECR-1 step-out area (see Figure 4). To the north, excavation will occur until the IRA Action Level is reached or until the arroyo that trends east-west is reached, as shown on Figure 4. The soils will be excavated and loaded into trucks, transported to NECR mine site, stockpiled, covered, and vegetated. The areas around the home sites where EPA previously conducted removal actions (see Figure 4) will not be included in the IRA, as soils above the FSL have already been removed from those areas.

The excavated areas will be regraded and backfilled, as necessary, to return the ground surface to approximately the original topographic configuration. All IRA areas will then be revegetated, as described in Section 2.4. Erosion and sedimentation controls to address potential transport of impacted soils onto the reservation, and to maintain stability of the excavated areas, will be in place during and after construction (see Section 2.5).

2.2 NECR-1 PILE

The IRA of the NECR-1 pile will consist of regrading the side slopes, regrading the top surface, covering with clean topsoil and revegetating. The side-slopes of NECR-1 (i.e., the northern and western slopes of the pile) will be regraded to no steeper than 2.5:1 (horizontal: vertical) for erosional and slope stability considerations. The top surface of the pile will be minimally graded to slope downward away from the side slopes and convey surface drainage into Pond 3 (see Figure 4).

The entire top surface of NECR-1 will be covered with six inches of clean topsoil and the regraded side slopes will be covered with one foot of clean topsoil. Once the topsoil has been placed on NECR-1, the entire area will be revegetated, as described in Section 2.4. Additional erosion and sedimentation controls to address potential transport of impacted soils onto the reservation will be utilized during and after construction (see Section 2.5).

The topsoil that will be used for backfill will come from thirty-five thousand cubic yards of topsoil previously obtained from the Pinedale chapter house property and stockpiled on UNC property. Prior to acquiring this material, UNC collected three soil samples from the stockpiled materials for analysis of Ra-226. The analytical results indicated Ra-226 from 0.6 to 0.7 pCi/g, within the range of concentrations detected in soil samples collected from the background reference area (MWH, 2006).

Appendix B provides calculations of the estimated soil loss from the NECR-1 pile and sideslopes due to erosion. Soil loss was estimated using the Revised Universal Soil Loss Equation 2 (RUSLE2) version 1.26.6.4. (Foster and Yoder, 2006) RUSLE2 software is the primary tool used in erosion modeling by federal agencies (e.g., Office of Surface Mines and U.S. Forest Service) to assess soil loss for mine reclamation applications. Based on RUSLE modeling, six inches of cover material on the top surface and 12 inches of material on the slopes will be sufficient to prevent exposure of underlying material due to sheet erosion.

2.3 UNNAMED ARROYO

Soils and sediment above the IRA Action Level are present in the unnamed arroyo, as discussed in the RSE report (MWH, 2006) and as confirmed in the supplemental subsurface soil investigation conducted in 2008 (see Figure 3). The RSE and SRSE results indicate that soils in excess of the IRA Action Level are present to approximately 6 feet bgs at the downstream end of the arroyo to approximately 16 feet bgs near NECR-1 (bgs referring to the bottom of the existing arroyo channel). Observations of the lithologies during drilling indicate that bedrock is present from approximately 25 feet bgs at the downstream end to approximately 45 feet bgs near NECR-1.

The IRA of the unnamed arroyo will consist of excavating soils within the confines of the unnamed arroyo until the IRA Action Level is reached (approximately 6 to 16 feet bgs). The excavation will extend laterally out to the edges of the existing arroyo banks. Upstream-downstream, excavation will extend from the reservation boundary (near NECR-1) to where the unnamed arroyo meets the next downstream arroyo (beyond the home sites). The excavated soils will then be hauled out of the arroyo and stockpiled at the NECR mine site and stabilized, covered and vegetated.

Following excavation of soil from the arroyo, clean soil will be placed in low reaches of the arroyo channel, and other reaches will be smoothed as needed to re-establish approximate pre-existing grade. Reclamation activities will avoid the existing banks of the arroyo to the extent feasible; however, it may be necessary in some areas to cut the banks back from the excavation to enhance stability of the slopes. Any slumping or caving of the side slopes that inadvertently occurs during excavation will be repaired to restore the topography so it remains similar to current conditions. Erosion and sedimentation controls to prevent transport of impacted soils into the arroyo will be in place during and after construction (see Section 2.5).

2.4 REVEGETATION

Areas impacted by the IRA activities will be revegetated. Revegetation is intended to reduce impacts to surface water by establishing a self-sustaining plant community that provides erosional stability. Inorganic fertilizer may be added to increase the nitrogen, phosphate, and potassium available to reseeded areas. Mulch will be applied after seeding is complete to conserve soil moisture and protect the soil from wind and water erosion. Revegetation will take place between June and September, if possible. Regraded areas will be seeded with a mixture containing native grasses and forbs that will not depend on external inputs of water or fertilizer. Specific species, composition percentages and seeding rates will be determined by a vegetation and wildlife survey and also will be selected to provide erosional stability.

To the extent practical, trees will be left in place and not disturbed during the IRA. MWH will conduct a vegetation survey to inventory the species and size and distribution of any native woody plants, including but not limited to trees. MWH will maintain an inventory of trees that are removed. This information will be used to develop a vegetation restoration plan that will be implemented as part of the final action.

2.5 REGULATORY COMPLIANCE

The construction activities work will be conducted consistent with CERCLA, requirements of Section 404 of the Clean Water Act (CWA) the requirements of the National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities (MSGP)(73 Federal Register 56572, 2008), the National Historic Preservation Act, and other ARARs identified by EPA. As provided by section 121(e) of CERCLA, permits will not be required for activities conducted entirely on-site. UNC/GE believe that all activities under the Work Plan are "on-site" as that term is defined in CERCLA, its implementing regulations, and USEPA guidance. As part of the MSGP requirements, UNC maintains a Stormwater Pollution Prevention Plan (SWPPP, MWH, 2005), which will be updated to incorporate the 2008 MSGP. Erosion control measures will be implemented, inspected, and maintained during construction and until the final removal action is implemented. Dust will be controlled during construction by watering haul roads and other dust-generating areas as necessary.

2.6 SITE ACCESS CONTROL

Primary access to the NECR mine site is from the end of Highway 566 and onto a dirt road that crosses the mine site. This dirt road crosses the area of NECR-1 that will be regraded and covered. This access road will be reconstructed at close to its current configuration to maintain access to the mine site. The current locked gate and fence will be maintained. The section of the fence that crosses the southeastern end of NECR-1 will be removed to facilitate the Work and then repaired and maintained after the IRA. Fences that are currently on-site will remain in place and/or will be repaired, as required. Temporary fencing will be installed at the end of each day to secure work areas where existing fencing is removed. UNC plans to retain security personnel for after-hours security.

3.0 RADIOLOGICAL SURVEYS

Radiological surveys conducted in a manner consistent with MARSSIM will be conducted for soil removal during the IRA. The radiological surveys will consist of excavation control surveys during construction, followed by a post-IRA status survey. The post-IRA status survey will be performed to confirm that the IRA met its objectives.

3.1 EXCAVATION CONTROL SURVEY

Excavation control surveys will be conducted to 1) support impacted soil excavation and removal; 2) determine when an area or a survey unit is ready for the post-IRA status survey; and 3) provide initial radiological data for planning the post-IRA status survey. The objective of the excavation control survey is to detect the presence of residual Ra-226 in soil at or below the IRA Action Level. This survey serves to monitor the effectiveness of soil excavation efforts that are intended to reduce residual Ra-226 in soil to the IRA Action Level. The excavation control survey is designed for expediency and cost effectiveness, as it needs to guide the IRA in real-time. In order to provide real-time excavation guidance, the excavation control survey will consist of in-situ direct gamma radiation level measurement in the field, as described in Section 5.4 of the MARSSIM for remedial action support surveys. The direct gamma radiation level survey for Ra-226 is a surrogate for gamma measurement of its decay product Bi-214. The EPA method 901.1 for laboratory analysis Ra-226 in soil also employs the Bi-214 surrogate gamma radiation measurement.

"In-situ" measurements consist of one-minute static measurements of gross gamma radiation level of the Ra-226 decay product Bi-214 using a 2x2" NaI detector. A site-specific calibration and correlation of the NaI detector between the gamma radiation levels, which includes gamma radiations from Bi-214 and Ra-226 content in soil, enables in-situ measurement of Ra-226 in the field. With adequate correlation, the in-situ measurement is a useful technique that provides real time measurement of Ra-226 in soil for cleanup and verification. Laboratory measurements consist of analysis of soil samples by a vendor laboratory for Ra-226 using gamma spectroscopy method 901.1. The laboratory gamma spectroscopy measurements are conducted under controlled conditions for distribution and decay product ingrowths which provide better accuracy. The laboratory results will be used for correlation soil sample analysis and confirmational soil sampling as discussed below.

A NaI gamma scintillation detector, similar to the one used for the RSE, will be used for direct gamma radiation level measurement during the excavation control surveys. The detector will be lead collimated for direct gamma radiation survey in order to minimize radiation shine interference from nearby radionuclide impacted areas (e.g., near the NECR-1 slope), and to focus on the localized area of interest under the detector. The direct radiation level will be measured by performing a scan gamma radiation survey and static gamma radiation measurements during the excavation control survey. The excavation control survey will be used as an interim step to guide soil removal. Areas that are determined to be clean on the basis of the excavation control survey will be surveyed in detail during the post-IRA status survey.

The direct gamma radiation level (in detector count rate) below which there is an acceptable level of assurance that the established IRA Action Level has been attained is equivalent to the level determined during the RSE, and will be used for immediate and in-field decisions. The gamma radiation level of 5,214 counts per minute (cpm) for the collimated detector equivalent to 2.24 pCi/g Ra-226 is based on the most recent site-specific correlation that was conducted for the supplemental RSE investigation in November 2007. This correlation was based on samples collected in the step-out areas north of NECR-1, and so is directly applicable to the IRA. The value of 5,214 cpm is consistent with the 5,272 cpm equivalent to 2.24 pCi/g Ra-226 determined for the unnamed arroyo sediments in August 2006. In order to consider the statistical uncertainty associated with radioactive decay, the direct gamma radiation level equivalent to the cleanup level will be reduced by 1.96σ (standard deviation) to provide assurance at a 95% confidence level that the measured direct gamma radiation level count is below the cleanup level count. Therefore, the direct gamma radiation cleanup level of 5,070 cpm for the collimated detector will be used initially in the field for the excavation control. It is expected that a direct gamma radiation survey will be performed using a collimated detector in most of the areas. If a bare 2x2 NaI detector is used during the survey, a 16,360 cpm level (the 16,619 cpm equivalent to 2.24 pCi/g reduced by 1.96σ) determined during the August 2006 RSE activities will be used initially.

The interim removal activities will result in changes to the concentration and distribution of Ra-226 in soil, which could change the site-specific correlation between direct gamma radiation levels and Ra-226 concentrations in soil. For most areas, the correlation will be updated as necessary as per Standard Operating Procedure #2 (SOP-2) during the construction activities and revised for the post-IRA status survey. A description of the IRA-specific correlation survey is included in Section 3.1.3.

3.1.1 Excavation Control Survey Instrumentation

As previously discussed, the Ra-226 concentration in soil will be estimated by direct gamma radiation level measurements. Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 KeV at about 4% intensity. Direct measurement of alpha radiation is not feasible. The low energy and intensity of the Ra-226 gamma radiation emission makes it impractical to determine Ra-226 in the field by direct gamma radiation measurement. However Bi-214, a Ra-226 decay product, emits high energy gamma radiations at a total of approximately 80% intensity. The gamma radiations of Bi-214 can be easily and accurately measured in the field utilizing a NaI scintillation detector, such as a 2x2 NaI Scintillation detector having high gamma radiation sensitivity. The Ra-226 concentrations in soil could be measured as a surrogate for gamma measurement of Bi-214 gamma radiation level. Bi-214 is a decay product of Ra-226 through radon-222 (Rn-222), a gaseous form, some of which emanates from soil. This phenomenon results in activity disequilibrium between Ra-226 and Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different geometric characteristics of a particular soil. Therefore, a site-specific calibration is necessary. Previous studies have shown that about 20% of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant (about 80%) portion of this would decay into Bi-214 in the soil matrix. If the soil geometry and other parameters, such as moisture, radon emanation fraction, constituent distribution profile, gamma ray shine from nearby sources, and land topography are consistent, the ratio of Bi-214 to Ra-226 would also be consistent. This means there would be a direct correlation between Bi-214 gamma radiation levels and Ra-226 concentrations in the soil.

Any gamma radiation detector, whether for in-situ or laboratory measurement, responds to all of the gamma radiations that interact with the detector. Registering and counting only output pulses from interaction of a specific energy radiation with a detector would depend on the counting system. At low Ra-226 concentrations in soil (2.24 pCi/gm cleanup level), the detector output pulse from the decay product Bi-214 gamma radiations recorded by a scaler/ratemeter are estimated at about 25-30% of the output pulse generated by all gamma radiations (including background radiations) that interact with the detector when a gross gamma count (with a single baseline discriminator) is performed. This procedure was proposed in the Standard Operating Procedure provided as Appendix A. A calibrated portable single channel analyzer (SCA) (differential discriminator) with a NaI detector with adequate resolution, would register and count detector output pulses from specific energies (such as 609 ke V from Bi-214) causing the recorded counts from the B-214 to dominate and increase the Ra-226 measurement accuracy. An SCA produces a logic output pulse only if the output pulse amplitude lies between the two levels or a "window."

Similar to the instrumentation used for the RSE characterization, the instrument that will be used for direct gamma radiation level measurement during this survey will consist of a 2x2 NaI scintillation detector (e.g., Eberline SPA-3) for detection of gamma radiation, connected to a ratemeter/scaler (such as Ludlum 2221) for processing and counting the detected gamma radiation. This instrument configuration has been used widely for this type of application, and is recommended by the MARSSIM. An SPA-3 scintillation detector is rugged with the highest sensitivity gamma radiation detection for field application and this type of field survey. The instrumentation will be calibrated as per SOP-1 included in the RSE Work Plan. The objective of the excavation control survey during the removal action will be to detect the presence of residual Ra-226 in soil at or below 2.24 pCi/g. This instrument configuration is designed to meet that objective. Daily function checks of the instruments will be performed in accordance with SOP-3 to assure proper operation.

The Minimum Detection Concentration (MDC) for both the static and scan gamma radiation survey will be calculated as discussed in SOP-1. Based on data collected during the RSE surveys, the instrument MDC is expected to be below or near 50% of the $DCGL_W$ (1.24 pCi/g) and $DCGL_{EMC}$ (2.0 pCi/g) for the survey. MDCs of about 0.6 pCi/g for a one-minute static survey and about 1.1 pCi/g for a scan survey were calculated for this instrument configuration.

3.1.2 Excavation Control Survey Protocol

Areas exceeding the IRA Action Level will be field located and marked with pin flags using the RSE and SRSE data and a differential global positioning system (DGPS). Additional radiation scanning will be used as appropriate to field delineate the impacted area boundaries. The areas may be divided into smaller subareas (e.g., 25 by 25 meter squares or 10-foot strips) to more efficiently control excavation, depending on the equipment used for excavation. The excavation fleet will remove the impacted soil in lifts based on the vertical extent of impacts in that area. The excavation control survey procedure is described in detail in SOP-3 of Appendix A. A scan radiation survey in combination with static measurements will be performed as specified in the SOP-3 to guide excavation in lifts until soil exceeding the cleanup level has been removed.

Following a soil excavation lift, a radiation scan will be performed with the detector at approximately 12 inches from the ground surface in a serpentine pattern along a transect or within the subdivided area at a rate of about one to two feet per second with the audio speaker set to 'on' to identify any locations that exceed the site cleanup level count rate by audio response and digital count rate display. The scan radiation survey will be conducted for 100% coverage of the area. The excavation will be repeated in lifts as necessary until the scan radiation survey indicates that soil exceeding the IRA Action Level has been removed from that area. One-minute static gamma radiation level measurements will be performed at several locations within this subdivided area following the final excavation lift and scan radiation survey. The static radiation level measurements will be recorded in the appropriate field form. When excavation control scans and static measurement levels at all points are below the IRA Action Level, excavation in the area will be considered complete and ready for the post-IRA status survey. The static radiation level measurements collected during the excavation control survey may be used as a part of the post-IRA status survey.

3.1.3 Soil Sampling for IRA-Specific Correlation

Surface soil samples will be collected during construction in order to update the direct gamma radiation level to soil Ra-226 concentration correlation which was developed for the RSE. The spatial relationship between the sample and the detector, sample geometry and secular equilibrium between Ra-226 and Bi-214, for the in-situ measurements is established by performing a site specific correlation. Generally in normal atmospheric conditions, only less than 25% of the radon from soil emanates out of the soil matrix, resulting in a secular equilibrium of over 75% in the field during the in-situ measurements. The correlation analysis will be conducted as per SOP-2 and SOP-15 using at least 10 to 15 surface soil samples in both the unnamed arroyo and step-out areas collected from locations coincident with stationary gamma scan locations, consistent with the RSE Work Plan.

Separate correlations are required for the NECR-1 step-out areas and the unnamed arroyo due to differences in the geometry of the arroyo channel versus the flat ground surface north of NECR-1. The correlation sample locations will be chosen in the field in a judgmental manner at a range of activity levels. The soil samples will be analyzed for Ra-226 only. A regression with an R^2 value of at least 0.8 will be used for converting the direct gamma radiation levels to Ra-226 soil concentrations. The correlations conducted for the Supplemental RSE for the NECR1 step-out and Home Sites areas were developed using regression analysis. The correlation achieved an R^2 value of 0.9 (greater than the 0.8 R^2 value required in the RSE).

3.1.4 Documentation and Evaluation of the Excavation Control Survey Results

Since the Ra-226 soil IRA action level is converted as the instrumentation count rate of the direct gamma radiation level using the IRA-specific correlation, conversion of the scan radiation survey counts during the excavation control survey data to Ra-226 concentration in pCi/g is not necessary. The excavation and removal field decisions will be made based on the count rates observed by the instrument. The excavation will be controlled using a gamma radiation level of 5,070 cpm for collimated detector and a level of 16,360 cpm for bare detector. Following the final scan radiation survey showing that the excavated area is below the cleanup level, notation will be made in the Scan/Walkthrough Gamma Radiation Survey Field Form (see SOP-3) indicating radiation levels less than the Action Level or the highest level observed.

3.2 POST-IRA STATUS SURVEY

Subsequent to completion of IRA excavation activities, a post-IRA status survey will be implemented that is consistent with MARSSIM guidance (EPA, 2000). The objective of the post-IRA status survey is to confirm that soils with Ra-226 in excess of the IRA Action Level have been removed from the IRA areas. Because the areas are being addressed due to Ra-226 impacts in excess of 2.24 pCi/g (the RSE FSL), they are considered Class 1 Areas and will therefore require a Class 1 Final Status Surveys subsequent to the final Removal Action. This post-IRA status survey is meant only to confirm that excavation activities have met the objectives of the IRA. However, the data collected during the survey may be included in the final Status Survey at a later date. A confirmational soil-sampling plan will be developed for the final Status Survey.

A radiation survey was designed in Section 3.7 of the RSE Work Plan consistent with MARSSIM to support Data Quality Objectives (DQOs) for Class 1 areas. The number of data points was determined using the Wilcoxon Rank Sum (WRS) test per MARSSIM guidance with statistical parameters selected to achieve a low error rate. Since the areas undergoing the IRA are Class 1 Areas, the post interim action status gamma survey will be conducted consistent with the RSE Work Plan for Class 1 Areas (MWH, 2006). Therefore, the post-IRA status survey will consist of Ra-226 soil concentration measurement by static direct gamma radiation measurements collected on an 80-foot grid in each area. Soil samples will be collected for laboratory analysis for Ra-226 at a minimum of 5% of the post-IRA status survey locations. If collecting 5% confirmation samples does not result in a minimum of 20 samples, additional soil samples will be collected to provide a minimum of 20 soil samples for laboratory analysis. Paragon labs will conduct the sample analysis via gamma spectroscopy method 901.1 and will report results to a limit of 1 pCi/g.

3.2.1 Post-IRA Status Survey Instrumentation

The instrumentation to be used for the post-IRA status survey will the same as that used for the excavation control survey, as discussed in Section 3.1.1. The equipment will consist of a 2x2 NaI scintillation detector (such as Eberline SPA-3) for detection of gamma radiation, connected to a portable ratemeter/scaler (such as Ludlum 2221). The gamma radiation levels in count rates will be converted to equivalent Ra-226 concentrations using the IRA-specific correlation, as discussed in Section 3.1.3.

3.2.2 Gamma Radiation Survey Protocol

The static direct gamma radiation level survey will be performed at 80-foot triangular grid nodes in each area. The grid nodes will be determined using Visual Sampling Plan (VSP) on an 80-foot triangular grid cast on a random origin during the RSE. The static radiation survey in the unnamed arroyo will be performed at perpendicular transects at 80-foot spacing across the IRA area. Three static radiation level measurements will be performed from each transect, one at each edge of the arroyo and one at the midpoint.

The static direct gamma radiation level measurements for the post-IRA status survey will be conducted following the IRA and the remedial action support surveys. The grid nodes will be field located using a DGPS using the grid node location coordinates from the RSE and SRSE. A daily function check of the instruments will be performed. The MDC for the static radiation survey will be calculated using the daily background count rate. A one-minute static direct gamma radiation level measurement with the collimated detector at approximately 12 inches above the ground surface will be performed at each 80-foot grid node in accordance with SOP-3. The direct gamma radiation level measurement with the location coordinates will be recorded in the Static Radiation Survey Field Form (see SOP-3). If any of the post-IRA status survey gamma readings are above 2.24 pCi/g Ra-226, the location will be further investigated using a scan radiation survey and marked as needed for addressing residual impacts.

The static gamma radiation survey results with the location coordinates will be documented in the field forms, Attachment C to SOP-3. The detector count rates obtained from the static gamma radiation survey will be converted to soil Ra-226 concentrations using the updated correlation.

The surveying conducted during excavation, which will have been conducted at 100% coverage, will be used to augment the post-IRA status survey data. Surface soil sampling will be conducted as part of the final removal action and therefore will not be conducted as part of the interim action, other than those collected for the correlation analysis.

4.0 RADIATION PROTECTION PROGRAM

A radiation protection program, as summarized in this section, will be incorporated into the Site Health and Safety Plan (HASP) to provide protection against ionizing radiation to workers, the general public, and the environment during the IRA. The HASP will be provided for EPA's review and comment in accordance with the approved schedule, prior to implementation of the IRA. The potential for radiological hazard during the IRA would be from uranium and its decay products. The radiation protection program will comply with applicable requirements of the U.S. Occupational Safety and Health Administration (OSHA) regulations 29 CFR Part 1910.1096 for internal and external ionizing radiation. The HASP will include the following components for radiation safety:

- Radiation Safety Organization will be established to implement radiation safety program, including radiation safety training.
- The IRA activities will be conducted to limit any radiation doses to include the following occupational standards:

  a. The annual limit is the more limiting of:
     1. The total effective dose equivalent equal to 5 rems; or
     2. The sum of the deep-dose equivalent and committed dose equivalent to any individual organ equal to 50 rems.

  b. The annual limits to the lens of the eye and to the skin are:
     1. An eye dose equivalent of 15 rems; and
     2. A shallow-dose equivalent of 50 rems to the skin or to any extremity.

  c. The annual occupational dose limits for a minor (under the age of 18 years) is 10% of the annual dose limits for an adult as discussed above.

  d. The radiation dose limit to an embryo/fetus during entire pregnancy, due to occupational exposure of a declared pregnant woman, will be 0.5 rem (500 mrem).

- The IRA activities will be conducted to limit dose for individual members of the public as follows:

  a. Total effective dose equivalent of 0.1 rem (100 mrem) per year to individual members of the public; and
  b. Maximum dose rate of 0.002 rem/hour in the unrestricted area from external radiation sources.

- Radiation surveys and monitoring will be implemented to evaluate the magnitude and extent of radiation levels, airborne concentrations and quantities of radioactive material; and potential radiological hazards.
- Personal monitoring for internal and external exposure, as necessary.
- Personnel and equipment decontamination and monitoring.
- Use of administrative and engineering controls, as necessary, to control internal and external radiation exposures.
- Use of personal protective equipment, including respiratory protection equipment, as necessary.
- Internal and external radiation dose assessment.

Records of radiological monitoring, surveys, safety meetings and trainings, investigations and corrective actions will be maintained.

5.0 SUBMISSION OF PROPOSED SCHEDULE AND INTERIM REMOVAL DELIVERABLES TO EPA AND NNEPA

Within the number of Working Days (a day other than Saturday, Sunday and Federal Holidays) specified below which shall run from the Effective Date of the AOC, UNC/GE will submit to EPA with a copy to NNEPA, as provided in the AOC, the following additional deliverables, in accordance with the requirements of this Work Plan and the AOC. Unless otherwise agreed to by EPA, all submittals required by this Work Plan will be subject to two-week EPA review and approval as provided in the AOC:

a. Proposed IRA Schedule, listing timing for all Tasks and Plans covered by this Work Plan (including all plans below and the As-Built Report) – 10 working days from the Effective Date;
b. Proposed Health & Safety Plan ("HASP") – 10 Working Days from the Effective Date;
c. Proposed Communication Plan (including Field Change Protocol) – 10 Work Days from the Effective Date;
d. Proposed Temporary Relocation Plan – 10 Working Days from the Effective date;
e. Proposed Traffic Plan - 10 Working Days from the Effective Date;
f. Proposed Construction Plan – 15 Working Days from the Effective Date;
g. Proposed Erosion and Stability Plan- 15 Working Days from the Effective Date:
h. Proposed Vegetation Survey and Vegetation Cover Plan – 45 Working Days from the Effective Date: and
i. Proposed Red Water Pond Road Characterization Plan – 15 Working Days from the Effective Date:

MWH will use the previously EPA-approved Quality Assurance Project Plan (QAPP) and Sampling & Analysis Plan (SAP) provided in the August 30, 2006 Final Removal Site Evaluation Work Plan for this work. Plans identifying the proposed sampling locations will be included in the Construction Plan and Red Water Pond Road Characterization Plan.

In addition to the hard copies specified in the AOC, an electronic copy of all deliverables created pursuant to this Work Plan should be provided electronically to the following email addresses:

Andrew Bain: Bain.Andrew@epa.gov
Harry Allen: Allen.HarryL@epa.gov
David Taylor: davidataylor@navajo.org
Freida White: freidasw@juno.com
Stanley Edison: pasi_swa@hotmail.com
Michele Dineyazhe: dineyazhe.michele@epa.gov

6.0 INTERIM REMOVAL ACTION AS-BUILT REPORT

Subsequent to the IRA field activities, UNC will prepare an as-built report. The report will provide a detailed description of the IRA activities that were performed, as well as descriptions of any deviations from the work plan, and the gamma surveying and soil analytical results. An updated base map with revised topography will be prepared and will show the extent of IRA activities.

7.0 REFERENCES CITED

Ecology & Environment (E&E), 2007. *NECR Home Site Investigation Trip Report, NECR Home Sites, Red Water Pond Road,* Church Rock, McKinley County, New Mexico.

EPA, 2000a. *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), EPA 402-R-97-016, Rev. 1.

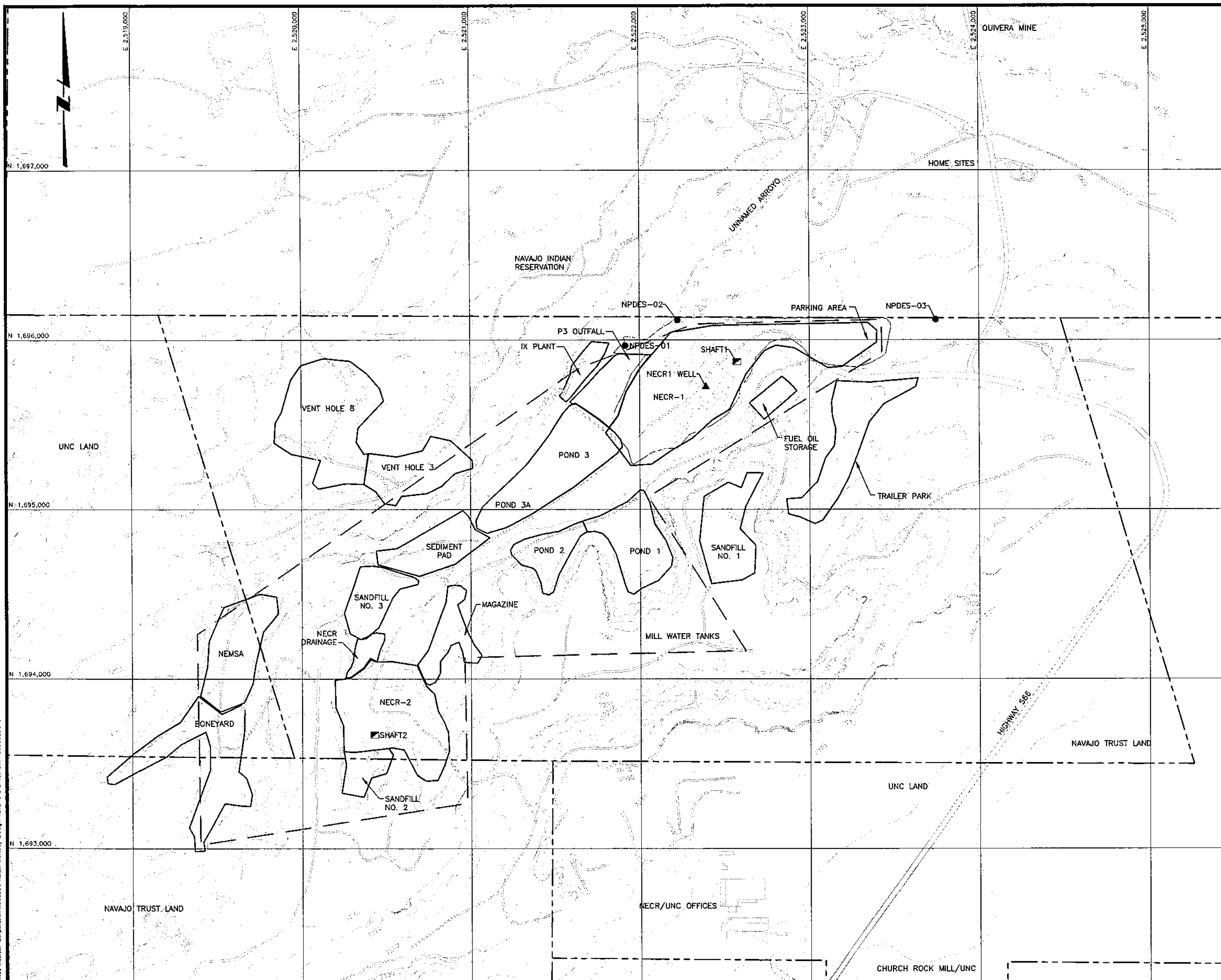
MWH, 2005. *Storm Water Pollution Prevention Plan*, Northeast Church Rock Mine Site.

MWH, 2006. *Removal Site Evaluation Work Plan*, Final, Northeast Church Rock Mine Site.

MWH, 2007. *Removal Site Evaluation Report*, Final, Northeast Church Rock Mine Site.

MWH, 2008. *Supplemental Removal Site Evaluation Report*, Draft, Northeast Church Rock Mine Site.

Figures



LEGEND:

- EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- PERMIT BOUNDARY
- FACILITY BOUNDARY
- APPROXIMATE OWNERSHIP BOUNDARY
- ROADS
- NATURAL DRAINAGE
- PHYSICAL STRUCTURE
- ● NPDES LOCATION
- ▲ WELL LOCATION
- SHAFT LOCATION

SCALE
300 0 300 600 FEET
CONTOUR INTERVAL = 5 FEET

REV	DESCRIPTION	TECH	ENG	DATE
B	ISSUED FOR REVIEW	CF	TL	08/20/08

DISCLAIMER
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1. SURFACE TOPOGRAPHY GENERATED FROM AERIAL PHOTOGRAPHS DATED MAY 2007 BY COOPER AERIAL SURVEYS CO. NEW MEXICO WEST STATE PLANE COORADINATES, NAD 83, US FEET.

DESIGNED BY	T.LEESON	08/20/08
DRAWN BY	E.MARKS	08/20/08
CHECKED BY	T.LEESON	08/20/08
APPROVED BY	T.LEESON	08/20/08
PROJECT MANAGER	T.LEESON	08/20/08
CLIENT APPROVAL		
CLIENT REFERENCE NO		

UNC
P.O. BOX 3077
Gallup, New Mexico 87305-3077

PROJECT LOCATION: NORTHEAST CHURCH ROCK MINE
PROJECT: INTERIM REMOVAL ACTION WORK PLAN
TITLE: SITE LAYOUT

MWH

FIGURE: 1 OF 4
REVISION: B
FILE NAME: 1005500D042

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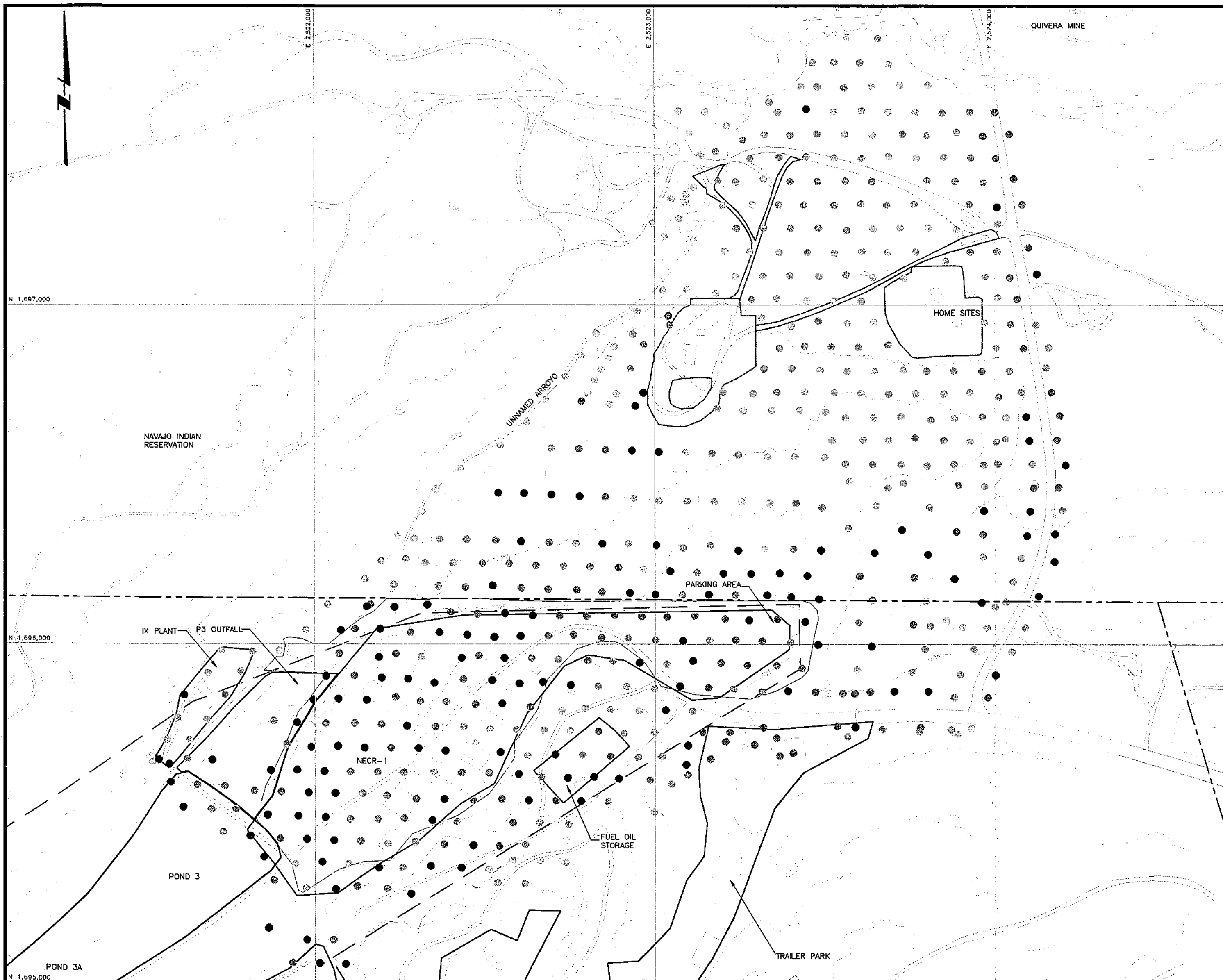

LEGEND:

- EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- APPROXIMATE OWNERSHIP BOUNDARY
- EPA REMOVAL ACTION BOUNDARY
- PERMIT BOUNDARY
- FACILITY BOUNDARY
- ROADS
- NATURAL DRAINAGE
- PHYSICAL STRUCTURE

STATIC GAMMA MEASUREMENT LOCATIONS SHOWING EQUIVALENT Ra-226 (pCi/g) CONCENTRATION

- <2.24
- 2.24–6.0
- 6.0–10
- 10–50
- >50

SCALE
150 0 150 300 FEET
CONTOUR INTERVAL = 5 FEET

ISSUE	DESCRIPTION	TECH	ENG	DATE
B	ISSUED FOR REVIEW	CF	TL	08/20/08

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PROJECT MANAGER	T.LEESON	08/20/08
CLIENT APPROVAL		
CLIENT REFERENCE NO		

UNC
P.O. BOX 3077
Gallup, New Mexico 87305-3077

PROJECT LOCATION: NORTHEAST CHURCH ROCK MINE

PROJECT: INTERIM REMOVAL ACTION WORK PLAN

TITLE: REMOVAL SITE EVALUATION GAMMA ANALYTICAL RESULTS

MWH

FIGURE: 2 OF 4 | REVISION: B

FILE NAME: 1005500D043

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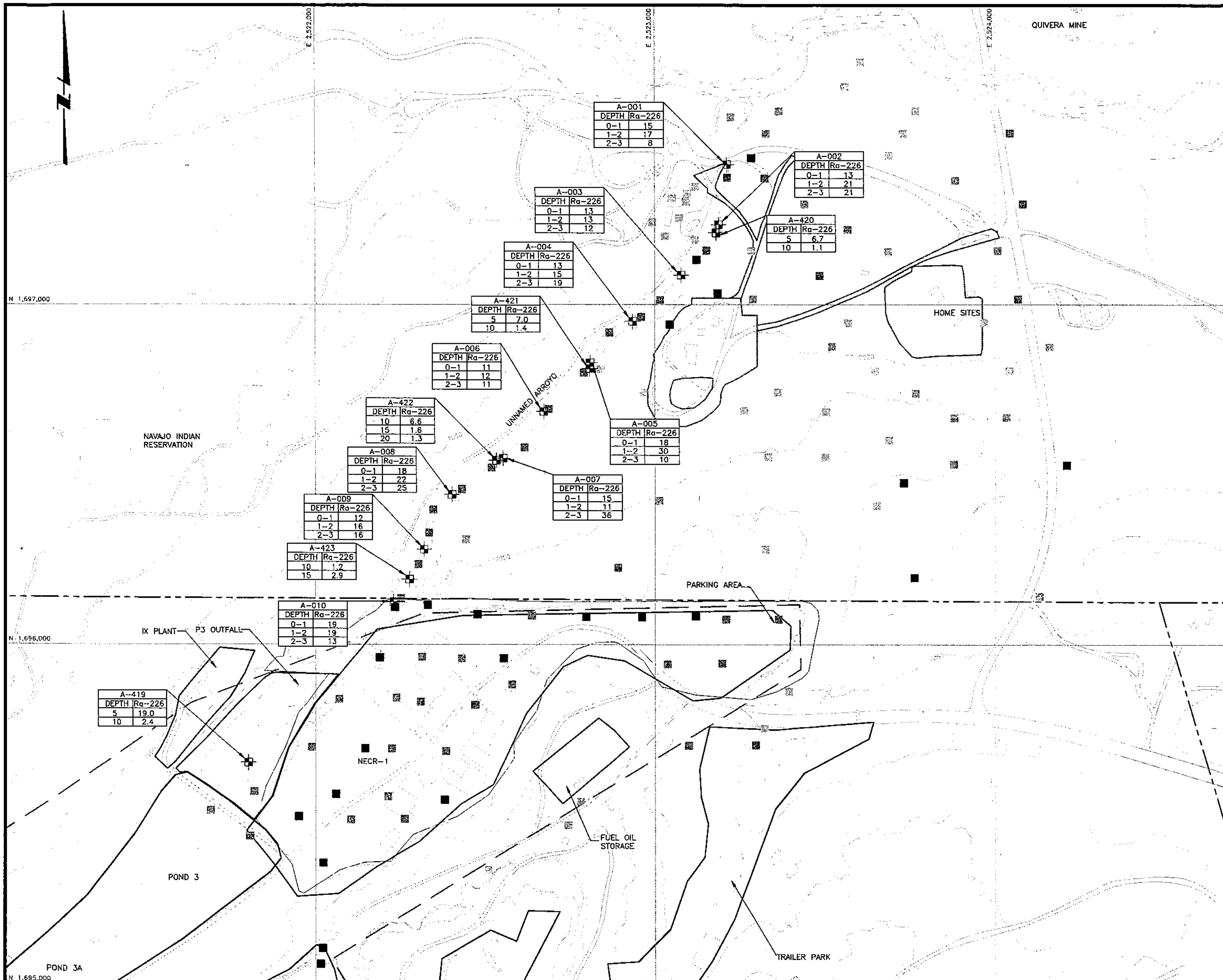

LEGEND:

- EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- APPROXIMATE OWNERSHIP BOUNDARY
- EPA REMOVAL ACTION BOUNDARY
- PERMIT BOUNDARY
- FACILITY BOUNDARY
- ROADS
- NATURAL DRAINAGE
- PHYSICAL STRUCTURE
- SUBSURFACE SOIL SAMPLE LOCATION (SUPPLEMENTAL RSE)
- SUBSURFACE SOIL SAMPLE LOCATION (RSE)

SURFACE SOIL SAMPLE LOCATIONS SHOWING Ra-226 LABORATORY RESULTS (pCi/g)

- <2.24
- 2.24-6.0
- 6.0-10
- 10-50
- >50

SCALE 150 0 150 300 FEET
CONTOUR INTERVAL = 5 FEET

REV	DESCRIPTION	TECH	ENG	DATE
B	ISSUED FOR REVIEW	CF	TL	08/20/08

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PROJECT MANAGER	T.LEESON	08/20/08
CLIENT APPROVAL		
CLIENT REFERENCE NO		

UNC
P.O. BOX 3077
Gallup, New Mexico 87305-3077

PROJECT LOCATION: NORTHEAST CHURCH ROCK MINE
PROJECT: INTERIM REMOVAL ACTION WORK PLAN
TITLE: REMOVAL SITE EVALUATION SOIL ANALYTICAL RESULTS

MWH

FIGURE 3 OF 4 | REVISION B
FILE NAME 1005500D045

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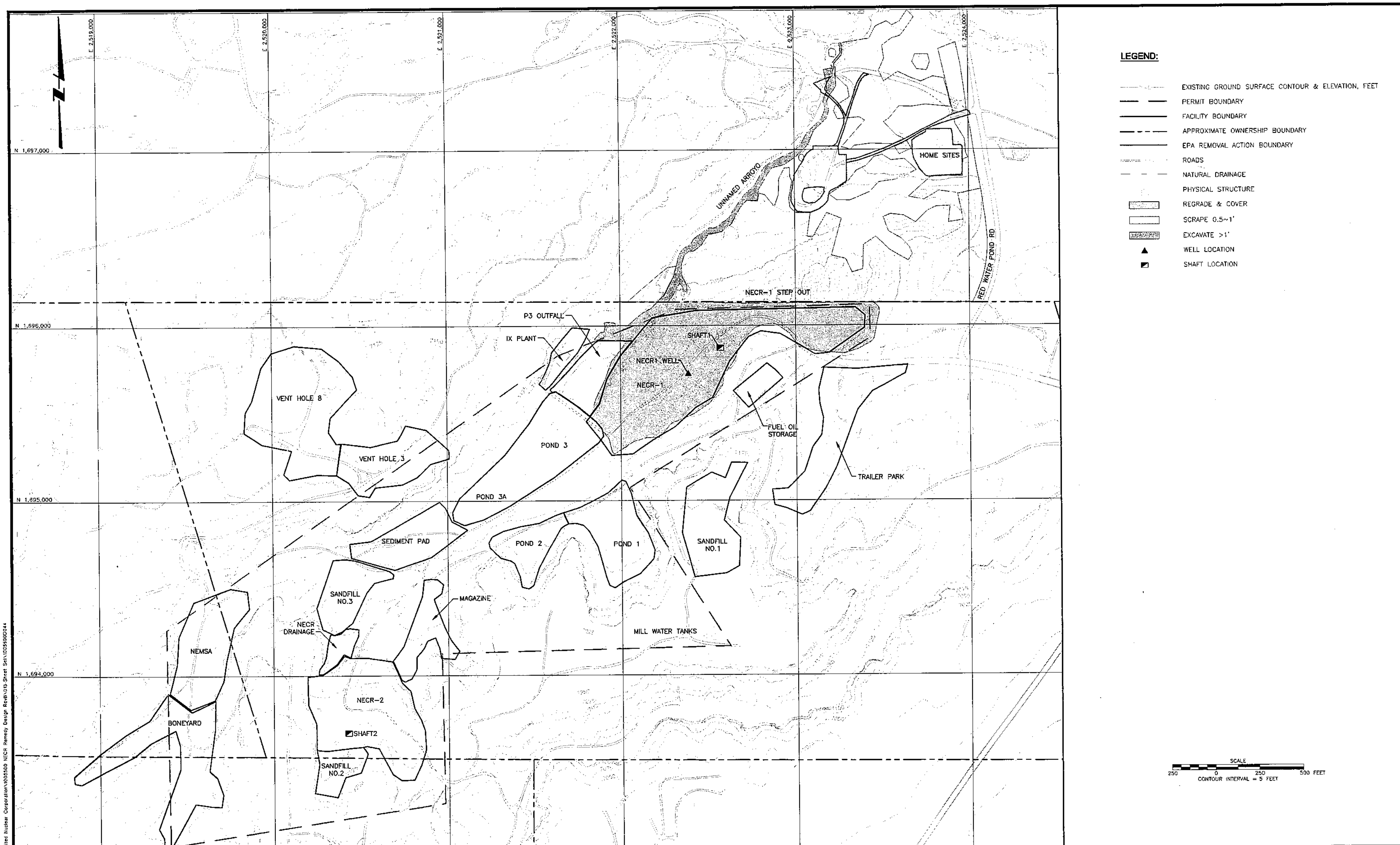

ISSUE/REV	DESCRIPTION	TECH	ENG	DATE
B	ISSUED FOR REVIEW	CF	TL	08/20/08

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PROJECT MANAGER	T.LEESON	08/20/08
CLIENT APPROVAL		
CLIENT REFERENCE NO		

UNC
P.O. BOX 3077
Gallup, New Mexico 87305-3077

PROJECT LOCATION: NORTHEAST CHURCH ROCK MINE
PROJECT: INTERIM REMOVAL ACTION WORK PLAN
TITLE: INTERIM REMOVAL ACTION AREAS

MWH
FIGURE: 4 OF 4
REVISION: B
FILE NAME: 1005500D044

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Appendix A

MWH

APPENDIX A

STANDARD OPERATING PROCEDURES

SOP-1a

AVM Environmental Services, Inc.

CALIBRATION OF THE SCALER RATEMETER And the 2"x2" NaI SETECTOR

For Gamma Radiation Survey @ UNC's NECR Mine Site

1. SCOPE

1.1 Purpose

To provide a standard procedure for calibration of the Ludlum Ratemeter, model 2221 with a 2"x2" NaI Scintillation Detector (the Ludlum 44-10 or Eberline SPA-3).

The Ludlum 2221 is a portable, battery operated, self-contained counting instrument designed for operation with scintillation, proportional or G-M detectors. When combined with a 2"x2" NaI scintillation detector, the Ludlum 2221 is used for the detection and measurement of gamma radiation. This instrument configuration is used for detection of surface soil gamma radioactivity.

1.2 Applicability

This instrument will be calibrated every twelve months, after repairs, or when the instrument function check fails. This method can be used with any Scaler/Ratemeter with a 2"x2" NaI scintillation detector configuration.

2. REFERENCES

2.1 Technical Manual for Scaler Ratemeter, Model 2221

3. REQUIREMENTS

3.1 Tools, Material, Equipment

3.1.1 Small screwdriver.

3.1.2 Ludlum Model 500 Pulser or equivalent.

3.1.3 A source of sufficient gamma radiation activity to allow a response for high voltage plateau and function check. A 1% uranium ore in a sealed can is used.

3.1.4 Efficiency calibration for Ra-226 gamma survey is performed using DOE Grants calibration site (GPL).

3.2 Precautions, Limit

3.2.1 The detector to Scaler/Ratemeter connector cable could easily be damaged if the weight of the 2"x2" NaI detector is suspended with it.

3.2.2 The NaI scintillation crystal is fragile. Shock to the crystal could cause a fracture or a crack, which could impact operation.

3.2.3 Do not leave the reading lamp on for any length of time as it will rapidly drain the battery voltage.

3.3 Acceptance Criteria

The instrument response to the calibration source should be within ±20%.

4. LUDLUM 2221 OPERATION CALIBRATION

Record Scaler/Ratemeter information (model and serial number) on the Scaler/Ratemeter Calibration Form. Record information about the calibration source (Pulser and/or source, 1% uranium ore standard).

4.1 Check the battery condition by pressing the "BAT" button with instrument switched on. If the meter does not indicate the battery charge above 5.3 volts, replace the four (4) D-cell batteries.

4.2 Set the threshold value as follows:

4.2.1 With the instrument turned on, press the threshold button. Read the displayed reading. If necessary adjust the "THR" adjustment screw until the threshold reads 100.

NOTE: The 'THR" adjustment screw is located under the calibration cover

4.3 Set the WIN (window) IN/OUT to OUT.

4.4 Connect the Ludlum 500 Pulser to the 2221.

4.5 Switch SCALER/DIG RATEMETER switch to DIG RATEMETER.

4.6 Select 400 CPM on the Pulser (multiplier switch to 1 and count rate adjusted to 400 cpm).

4.7 Adjust the pulser amplitude above the set threshold (100 mV) until a steady count rate is observed.

4.8 Record the meter rate count response in AS FOUND column on the calibration form. If the meter response is not within 10% of the Pulser set count rate of 400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board for 400 cpm on the meter.

4.9 Repeat steps 4.6 to 4.8 for 4000, 40,000 and 400,000 cpm pulses.

4.10 Switch the SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

4.11 Select 400 counts on the pulser (multiplier switch to 1 and count rate adjusted to 400)

4.12 Count the pulses on the meter for one minute by pressing COUNT switch.

4.13 Record the meter response counts in AS FOUND column on the calibration form. If the meter count is not within 10% of the pulser set counts of 400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board and repeat step 5.12 until a count of 400 is observed on the meter.

4.14 Repeat steps 4.11 to 4.13 for 4000, 40,000 and 400,000 pulses.

If the meter reading could not be set within 10% of the pulses generated by the pulser, the meter requires repair and calibration prior to use.

The Ludlum 2221 is ready for detector calibration and operation.

5. DETECTOR HIGH VOLTAGE AND BACKGROUND CALIBRATION

Record Scaler/Ratemeter (Ludlum 2221) and 2"x2" NaI detector (Eberline SPA-3 or Ludlum 44-10) information (model and serial number) on the Scaler/Detector Calibration Form. Record information about the calibration source (1% uranium ore standard).

5.1 Connect the calibrated Ludlum 2221 to the 2"x2" NaI detector.

5.2 Turn the Ludlum 2221 ON. Set WIN ON/OFF to OFF.

5.3 Check Threshold setting. Should be at 100 mV.

5.4 Switch SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

5.5 Set HV to 500 VDC.

5.6 Expose the detector to the 1% uranium ore can by placing directly under the detector.

5.7 Obtain one-minute counts with the detector exposed to the source at every 50-volt increment until voltage plateau is passed and sudden increase in the counts is observed. (Usually the for the 2"x2" NaI detector, the high voltage plateau maximum voltage is about 1300 to 1400 VDC.). Record the counts under the READING CPM SOURCE in the calibration form.

5.8 Return HV setting back to 500 VDC.

5.9 Remove the source away from the detector. Obtain one-minute background counts with the detector shielded from the source at every 50-volt increment until similar voltage to the source high voltage plateau reading. Record the counts under the READING CPM BACKGROUND in the calibration form.

5.10 Plot voltage versus cpm reading for both the source and background high voltage data. From the plot, select the optimum operating high voltage, which is usually at least about 50 volts above the knee of the plateau curve for a greater counting stability. The optimum high voltage should be also within the background plateau curve for background counting stability.

5.11 Set the Ludlum HV at the optimum operating voltage determined above.

The Ludlum 2221 and the 2"x2" NaI detector configuration is ready for efficiency calibration and establishing the operating background and source function check.

6. OPERATING BACKGROUND AND SOURCE FUNCTION CHECK DETERMINATION

6.1 Set the Ludlum 2221 to Scaler mode, Count Time at 1 minute, with WIN OUT and THR at 100.

6.2 Remove any type of sources away from the detector. Obtain five one-minute background counts. Record the background counts in the calibration form. Average the five one-minute background counts. Record the average background counts in the calibration form. The daily function check background counts should be within 20% of this average.

6.3 Expose the 1% uranium ore source (in the sealed can). Note the exact location of the source to the detector. Obtain five one-minute background counts with the detector exposed to the source. Record the source counts in the calibration form. Average the five one-minute source counts. Record the average source counts in the calibration form. The source position to the detector for the function check should be exactly the same as this calibration, and the source counts for the daily source function check counts should be within 20% of this average.

7. EFFICIENCY CALIBRATION

7.1 Using the Map in the DOE Field Calibration Report (DOE/ID/12584-179) go to the Grants calibration site. Locate GPL pad (87.78 pCi/gm Ra-226, 0.50 pCi/gm Th-232 and 15.58 pCi/gm K-40) as shown in the Grants Calibration Site layout in the DOE report.

7.2 Set the Ludlum 2221 to Scaler mode, Count Time at 1 minute, with WIN OUT and THR at 100.

7.3 Obtain five one-minute counts with detector at the center of the pad at about 12 inches from the pad surface. Record the counts on the Calibration Form. Also obtain five one-minute counts with detector collimated at same height and record the counts on the Form.

7.4 Average the five calibration counts (cpm) and record on the form and calculate efficiency for collimated and uncollimated (bare) detector.

Efficiency (cpm/pCi/gm) = Cal Pad average one-minute counts (cpm)/87.78 pCi/gm

This efficiency may be used for calculating instrument Minimum Detectable Concentration (MDC).

8. MINIMUM DETECTABLE CONCENTRATION CALCULATION

8.1 MDC for Static Gamma Radiation Measurement (for 0.05 probability for both false positive and false negative errors)

$$MDC = C \times [3 + 4.65\sqrt{B}]$$

Where

C = Detector calibration factor, pCi/gm/cpm (for this survey as determined above).
B = Number of background counts that are expected to occur while performing a sample measurement.

Example: If the background count from the function check for the detector is 7862 cpm, and the detector efficiency is 0.001418 pCi/gm/cpm (705 cpm/pCi/gm), then the MDC for a one minute static measurement would be:

$$MDC = 0.0014 \text{ pCi/gm/cpm} \times [3 + 4.65\sqrt{(7862 \text{ cpm}}\,] = 0.59 \text{ pCi/gm}$$

8.2 MDC for Scan Gamma Radiation survey

The scan MDC is assumed for a scan rate of about 3 feet per second and a one second interval (based on a detector that is focused on about 36 inches diameter area at about 12 inches from ground surface). Also, a surveyor efficiency (p) of 0.5 is assumed. First calculate the Minimum Detectable Count Rate (MDCR) as follow:

$$MDCR = d' \times \sqrt{(bi \times (60/i)}$$

Where:

d' = value for true positive and false positive proportion. A value of 1.38 will be used for 95% true and 60% false positive proportion.
bi = number of background counts in the interval i (cpm/60 sec/min for one second interval).

For a detector background count of 7820 cpm, the MDCR for one second interval would be:

$$MDCR \text{ cpm} = (1.38) \times \sqrt{(7820 \text{ cpm} \times 1 \text{ sec} \times 1 \text{ min/60 sec})} \times 60 \text{ sec/min} = 945 \text{ cpm.}$$

Then calculate the $MDCR_{surveyor}$ using surveyor efficiency (p) of 0.5 as follow:

$$MDCR_{surveyor} = MDCR/\sqrt{p^5} = 945 \text{ cpm}/\sqrt{0.5} = 1{,}337 \text{ cpm.}$$

From the $MDCR_{surveyor}$, calculate the scan MDC using the following:

$$\text{Scan MDC} = MDCR_{surveyor}, \text{ cpm} \times C, \text{ pCi/gm/cpm}$$

Where: C = Detector calibration factor, pCi/gm/cpm (for this survey as determined above).

For a C of 0.0014 pCi/gm/cpm (705 cpm/pCi/gm), the Scan MDC would be:

$$\text{Scan MDC} = 1{,}337 \text{ cpm} \times 0.0014 \text{ pCi/gm/cpm} = 1.87 \text{ pCi/gm}$$

The integration count time for static measurement may be increased, and the scan rate for radiation scan survey may be reduced to lower MDCs to desired levels. The Ludlum 2221/2"x2" NaI detector configuration is ready for a site-specific soil Ra-226 to gamma radiation level calibration (SOP-2a) and performing field gamma radiation survey (SOP-3a). A daily function check must be performed prior to use.

Attachment A, SOP #RAD-01a
AVM Environmental Services Inc.

Scaler/Ratemeter Calibration Form

Model ______________________ S/N _______________

Calibration Source ____

Threshold (input sensitivity), Found at ____________ mV Left or Set at ________ mV

Window, In/Out ________ Window ____________ mV

Pulser Amplitude Set @ ______________________ mV

Range/Mode	Calibration Point (Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading

HV Set @ ____________ VDC

Date ____________________ Calibrated By ______________________________

Attachment B, SOP #RAD-01a
AVM Environmental Services Inc.
Scaler/Ratemeter - Detector Calibration Form

Scaler/Ratemeter ______________________________
Detector ______________________________

Source: ______________________ Strength: ______________

Scaler/Ratemeter Threshhold set @ _______mV, Window IN/OUT ________, Window _____ mV

HV	Reading, CPM (Source)	Reading, CPM (Background)
500		
550		
600		
650		
700		
750		
800		
850		
900		
950		
1000		
1050		
1100		
1150		
1200		
1250		
1300		
1350		
1400		

Background reading at designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

Count Readings with 1 percent U_3O_8 can directly under shielded probe on designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

HV Set @ ______________ VDC (Instrument) ______________ VDC (DVM Fluke 8020]

Input Sensitivity (THR), mV ______________

Function Check with 1 percent U_3O_8 ore in can. Can Directly under the detector.
Acceptable Function check range is: ______________ to ______________ CPM

Count Readings for Calibration Pad GPL (87.78 pCi/gm Ra-226)

	Bare (Uncollimated)		Collimated
#1	________ cpm	#1	________ cpm
#2	________ cpm	#2	________ cpm
#3	________ cpm	#3	________ cpm
#4	________ cpm	#4	________ cpm
#5	________ cpm	#5	________ cpm
Average	________ cpm	Average	________ cpm
Eff(avg cpm/87.78 pCi/gm	________ cpm/pCi/gm	Eff	________ cpm/pCi/gm

Date ______________________ By ______________________

SOP -2a
AVM Environnemental Services, Inc.
Direct Gamma Radiation Level to Ra-226 Soil Concentration Correlation
For UNC's NECR Mine Site

1.0 Purpose

The purpose of this procedure is to develop a correlation between Ra-226 concentrations in surface soil and direct gamma radiation level. The correlation is developed basically for a site-specific calibration of field instrumentation (2'x2' NaI scintillation detector), for determining Ra-226 concentration in surface soil by performing direct gamma radiation level survey. The correlation will be used to determine Ra-226 concentrations in surface soils by direct gamma radiation survey at the Northeast Church Rock Mine Site (NECR).

2.0 Scope

Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 KeV at about 4% intensity. This low energy and intensity of the Ra-226 gamma radiation emission makes impractical to determine Ra-226 in the field by direct gamma radiation measurement. However Bi-214, a Ra-226 decay product, emits high energy gamma radiations (46.3 % intensity @ 609.3 keV, 15.1% intensity @ 1120.3 keV and 15.8% intensity @ 1764.3 keV) at a total of approximately 80% intensity. The gamma radiations of Bi-214 can be easily and accurately measured in the field utilizing a NaI scintillation detector, such as 2x2 NaI Scintillation detector having high gamma radiation sensitivity The Ra-226 levels in soil could be measured as a surrogate for gamma measurement of Bi-214 gamma radiation levels, as to the measurement described in Section 4.3.2 of the MARSSTM. Bi-214 is a decay product of Ra-226 through radon-222, a gaseous form, some of which emanates from soil. This phenomenon results in activity disequilibrium between Ra-226 and Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different geometric characteristics of a particular soil. Therefore, a site-specific calibration is necessary. Previous studies have shown that about 20% of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that significant (about 80%) of this would decay into Bi-214 in the soil matrix.

If the soil geometry and other parameters such as moisture, radon emanation fraction, contamination distribution profile, gamma ray shine from nearby sources, and land topography are consistent, the ratio of Bi-214 to Ra-226 would be consistent. This means there would be a direct correlation between Bi-214 gamma radiation levels and Ra-226 concentrations in the soil. The gamma radiation from other naturally occurring isotopes in soil, such as and Th-232 decay products and K^{40}, may contribute to gross gamma radiation intensity. In addition, background gamma radiation from cosmic rays also contributes to gross gamma radiation intensity. However, the gamma radiation level from such naturally occurring isotopes and sources are generally at a constant level. A linear regression would identify such a constant to correct for and minimize interference with the gamma radiation level and Ra-226 soil concentration correlation.

The correlation procedure is designed to calibrate a 2"x 2" NaI scintillation detector by determining a site-specific correlation between gamma radiation level and Ra-226 concentration in soil. The gross gamma radiation intensity (count rate) will be measured at ten locations. Soil samples will be collected from these locations for Ra-226 analysis by an off-site laboratory. The locations of the soil samples and gamma radiation level measurement for correlation may be based on the predominant concentration expected in field or concentration of interest. Direct gamma radiation level or gamma radiation exposure rate measurements may be made to select sampling locations. A linear regression will be performed between gamma radiation count rate and corresponding Ra-226 concentrations in soil to determine the Correlation. The goal is to attain a correlation coefficient (r^2) of 0.8 or better.

Ra-226 contamination in soil at the NECR varies from background level to over 100 pCi/gm distributed in surface (0-6") to subsurface soils. The removal action of the contaminated soil at the NECR is expected to change the contamination distribution and concentration to a fairly homogeneous distribution at or near the cleanup level in surface soils. Therefore, the contamination distribution assumption for correlation for remedial action support survey and final status survey will be for homogeneous distribution in surface soils near the cleanup level concentration.

3.0 Instrumentation

A 2"x2" NaI Scintillation detector (an Eberline SPA-3 or Ludlum 44-10 detector) and a Scaler/Ratemeter, (Eberline ESP-1/2 or Ludlum Model 2221) will be used for field gamma radiation level measurements and to select sampling locations. The Scaler/rate meter will be calibrated, using SOP -1a to assure that it properly counts the electronic pulse generated and sent by the detector. An optimum operating high voltage for the detector will be established by performing a high voltage plateau on the detector using SOP -1a. The input sensitivity (threshold) of the Scaler/Ratemeter will be set @ 100 mV to avoid interference from low level background radiation. The pulses generated by the detector for gamma radiation (609 KeV) from Bi-214 are significantly higher than 100 mV, as verified by using 1% uranium ore standard.

During the excavation control survey (remedial action support survey), it is likely that the Ra-226 concentration in soil near the excavated areas is elevated. Gamma radiation shine from such areas may interfere with gamma radiation level measurement at excavated areas, as the high energy gamma radiation can travel long distance in air, up to 50 feet, before ionizing. If needed, shine interference will be reduced by placing the detector in a 0.5-inch thick collimated lead shield. In addition to obtaining a correlation for a bare (uncollimated) detector, a correlation will also be developed for a lead collimated detector by obtaining gamma radiation level measurements for both collimated and uncollimated detector at each location.

A radiation survey in the arroyo for bed sediment would require different geometry of the survey system detector compared to surface soils in a fairly plain geometry. During the radiation survey for arroyo bed sediments, gamma radiation shine from the arroyo banks would also interfere with the survey. Therefore, a separate correlation with soil samples and gamma radiation levels would be developed for survey in the arroyo.

4.0 Gamma Radiation Level Measurements and Soil Sample Collection for Correlation

Gamma radiation measurements for the correlation will be performed using static gamma radiation survey as described in the SOP -3a. The gamma radiation survey and surface soil sample locations will be identified by gamma ray count rate to retrieve the desired range of concentrations from background to about 10,000 cpm with collimated detector for correlation for excavation control and Post-IRA status survey. The sampling location will be spread through the correlation range. The selected sampling location areas will be relatively flat terrains, and large enough so that moving around several steps in each direction should not affect readings significantly. For the selected sample location, three one-minute counts will be obtained at each location. The detector will be approximately 12 inches from the ground surface.

Soil samples for the correlation will be collected using surface soil sampling SOP-15. A five-point composite sample at a depth of 0" to 6" will be collected from each of the gamma radiation level measurement location. One soil sample aliquot point will be from the center point directly under the detector, and the other four aliquots from four points that are 12 inches from the center points in four directions (90 degrees apart). Each soil sample aliquot will be approximately 200 grams, collected by using the hand scoop method if soil texture is loose, or a using a hand augur if soil texture is sufficiently compacted. The sampling locations will be marked with flags. The five 200-gram soil sample aliquots will be combined (total of 1000 gram) in a mixing bowl, homogenized and placed in a sample bag. Each sample bag will be marked and labeled with appropriate sample identification. Soil sampling equipment will be decontaminated between each sampling location using SOP-5. Soils samples will be shipped to an off-site vendor laboratory for Ra-226 analysis using EPA gamma spectroscopy method 901.0.

5.0 Linear Regression Analysis

To determine the correlation between gamma radiation level counts and corresponding Ra-226 concentration in soil content, i.e. to determine a calibration equation, a liner regression analysis will be performed on the sample Ra-226 concentration in pCi/gm, Y, and the associated gamma radiation level count rate, cpm at X, from all the sample locations using a least-square liner regression and plotting the results.

Linear regression data will be summarized by the generalized equation:

$$Y = mX + b$$

where,

Y = soil concentration in pCi/gm,
m = slope, pCi/gm/cpm
X = count rate (the mean) in cpm
b = constant, y intercept

This correlation will provide a site specific calibration factor (m) in pCi/gm/cpm for the 2"x2" NaI detector, with a constant (b) to correct for any interference, specifically at lower range.

SOP-3a
AVM Environnemental Services, Inc.
Field Gamma Radiation Survey for Ra-226 Concentration in Soil
@ UNC's NECR Mine Site

1.0 SCOPE

1.1 Purpose

This procedure will be used to determine the Ra-226 concentration in surface soil by direct gamma radiation level survey for conducting Excavation Control (Remedial Action Support) survey for the Interim Removal Action (IRA) and for the Post-IRA survey at the Northeast Church Rock Site (NECR).

1.2 Applicability

This SOP will be used by AVM Environmental Services, Inc for performing Excavation Control (Remedial Action Support) survey for the IRA and as a component of the Post-IRA survey at the Northeast Church Rock Site.

2.0 EQUIPMENT AND MATERIALS

2.1 Ludlum 2221 or Eberline ESP Scaler/Rate meter coupled with a Ludlum 44-10 or an Eberline SPA-3 2"x2" NaI crystal scintillation detector for direct gamma radiation detection. (SPA-3 and Ludlum 44-10 are both similar 2"x2" NaI crystal scintillation detectors).

2.2 A global positioning system (GPS) with real time differential correction capability and a data logger. Currently AVM uses a Starlink Invicta 210S Receiver with antenna unit and TDS Ranger data logger with TDS SOLO surveying software. The Starlink Invicta 210S Receiver is capable of real time differential position correction using OMNI STAR satellite subscription correction or WAAS correction.

2.3 Collimating lead shield for the 2"x2" NaI detectors, if needed to reduce gamma-ray shine interference and focus on area of interest under detector. The 0.5-inch thick collimating lead shield, which surrounds the NaI crystal, is contained within a protective marlex housing.

2.4 A vendor calibrated exposure (uR/hr) meter.

2.5 Map of survey areas with marked grid nodes and transects. Ink pen and appropriate Field Survey Forms to record survey readings and notes.

2.6 Measuring tape, pin flags, area markers.

3.0 INSTRUMENT CONFIGURATION & OPERATIONS

Prior to any instrument function check or the operation, the technician will read the Technical Manual for the instrument operations (Ludlum 2221 or ESP-2) and the correlation Method (SOP- 2a) for the rationale behind the gamma radiation surveys.

The field gamma radiation level survey for Ra-226 content in soil will be performed using an Eberline

ESP or Ludlum 2221 Rate meter/Scaler. The Rate meter/Scaler is connected to a 2"x2" NaI crystal scintillation detector (SPA-3 or Ludlum 44-10) which detects gamma radiation emitted from Bi-214, a decay product of Ra-226 in the soil. The detector will be held at approximately 12 inches from the ground surface. For a survey of high energy gamma radiation of 609 to 1700 KeV, the bare (uncollimated) detector should be sensitive to at least an area of about ten feet radius under the detector. The Model 2221 Scaler/Rate meter with external RS232 connector can be coupled to a data logger, also connected to a GPS receiver where the gamma radiation count rate in cpm would be logged with its corresponding location coordinates.

For radiation surveys where significant shine interference is present from nearby areas, the 2"x2" NaI crystal scintillation detector will be installed in a 0.5 inch collimating lead shield to reduce gamma shine interference. For a direct gamma radiation survey in the unnamed arroyo, the detector will be collimated to avoid radiation shine interference from the arroyo banks. The detector shield is contained within a protective marlex housing. During the survey, the detector will be held approximately 12 inches above ground level, which should focus and be most sensitive to approximately 36 inch diameter area under the detector.

The instrumentation must be calibrated consistent with SOP-1a prior to use.

3.1 Instrument Function Check

An operational function check will be performed on the Scaler/Rate meter (ESP or Ludlum 2221) and the detector (SPA-3 or Ludlum 44-10) each day prior to any field surveys. Verify calibration validity for the Scaler/Rate meter and the detector. Calibration date for the instruments must be within one year. If not, the instrument must be calibrated with a certificate in file. The function check will be performed in field office. The following function check procedures will be used and the pertinent information recorded on the Scaler/Rate meter-Detector Function Check Form (Attachment A).

3.1.1 Scaler/Rate meter General Setting

If an Eberline ESP Scaler/Rate meter is used for the instrument configuration, the calibration constant must be set @ 1.0+00; and dead time must be set @ 1.4-05 sec.

If Ludlum 2221 Scaler/Rate meter is used for instrument configuration, the WIN toggle switch must be in the OUT position.

3.1.2 Visual inspection

Perform a visual inspection of the instrument, cables, detector and the shield, checking for signs of any damage. Test for possible electrical shorts in the cable (with the instrument in the audio mode, move the cable and note for any sudden increase in counts on the Scaler/Rate meter).

3.1.3 Calibration Due

Verify calibration validity for the Scaler/Rate meter and the detector. Calibration date for the instruments must be within one year.

3.1.4 Battery charge

Assure that the Scaler/Rate meter battery is functional. For ESP Scaler/Rate meter it should not be indicating a "Low BAT" signal. For Ludlum 2221, the battery voltage digital readout must be at least 5.3 volts.

3.1.5 High Voltage

The detector high voltage must match that determined during high voltage calibration (HV Plateau) for that detector.

3.1.6 Threshold (input sensitivity)

Check and make sure that the Scaler/Rate meter threshold is set at 100 mV. If not, set the threshold at 100 mV. Ludlum 2221 Threshold can be set by the instrument digital read out display.

3.1.7 Window

If Ludlum 2221 Scaler/Rate meter is used for instrument configuration, the WIN toggle switch must be in OUT position.

3.1.8 C.C. Calibration Constant

If an Eberline ESP Scaler/Rate meter is used for the instrument configuration, the calibration constant must be set @ 1.0+00; and dead time must be set @ 1.4-05 sec.

3.1.9 Background Counts

The background counts will be determined for the same time interval as the field survey count time, generally one minute. The background counts will be performed at the designated location in the field office. A location will be designated in the field office for obtaining the required daily background counts. Keep all beta/gamma radiation sources away from the detector while performing the background check. The background function check counts must be within 20% of the background counts obtained during the detector high voltage calibration.

3.1.10 Source Function Counts

Obtain the gamma radiation source, (1% U_3O_8 ore standard sealed in a red can marked Function Check Source"). The 1% ore standard was used to determine the acceptable count range for the detector during calibration. Place the source at the same location on the detector used to obtain the source function check counts during calibration. Count the source for one minute and note the counts in cpm. The source function check counts must be within 20% of the source counts obtained during the detector and Scaler/Rate meter calibration.

3.1.11 Instrument Tolerance

The Scaler/Rate meter–detector detecting and counting tolerance is expressed as percent deviation from the mean of the acceptable count range. The background counts and the source function check counts must be within 20% of the mean established following instrument calibration. If the source count is outside this range, pull the instrument from service. The instrument will be repaired or re-calibrated prior to use.

3.1.12 Technician

After completing the function check, initial in the column marked TECH of the function check form.

3.2 Instrument Minimum Detectable Concentration Calculation

If required, calculate Minimum Detectable Concentration (MDC) for the instrumentation using the function check background readings as described in SOP-1 (Instrument MDC Calculation). Calculate MDC for appropriate survey, i.e. Direct Measurement MDC for static (stationary) gamma radiation survey and scan MDC for scan or walkthrough gamma radiation survey. Record the MDC in the Function Check Form (Attachment A).

4.0 FIELD GAMMA RADIATION SURVEYS

The direct gamma radiation level survey for Ra-226 in surface soil will be conducted as either scan survey (walkthrough) or static survey (stationary) measurements.

4.1 Scan Radiation Survey

Scan radiation surveys (walkthrough surveys) will be performed by walking with the detector at about 12 inches from the ground surface with the scaler/rate meter in count RATE MODE. Scan surveys will be performed within each survey area by walking in a serpentine shape along transects to identify and locate any hot spots and contaminated area boundaries during the excavation control survey. The scan surveys may also be performed as a component of the final status survey.

4.2 Static Radiation Survey

Static radiation surveys will be performed at any point or location of interest during excavation control survey, and at specified grid nodes within survey areas for the final status survey. Also, static survey measurement will be performed at each correlation sampling point. The detector will be held at about 12 inches from the ground surface. The scaler/rate meter will be set in the count SCALER MODE. A one- minute count (cpm) of gamma radiation level will be obtained at each location for static gamma radiation survey.

4.3 Remedial Action Support (Excavation Control) Survey

Excavation control survey will be performed to guide excavation of contaminated soil exceeding the cleanup level during the IRA at the NECR. Consistent with the IRA Work Plan, the Ra-226 IRA off-site action level for contaminated soil at the NECR is 2.24 pCi/gm, which is equivalent to the direct gamma radiation count of 5,214 cpm for the collimated detector? In order to consider the statistical uncertainty associated with radioactive decay, the direct gamma radiation level equivalent to the cleanup level is reduced by 1.96σ (standard deviation) to provide assurance at a 95% confidence level that the measured direct gamma radiation level count is below the cleanup level count 5,214 cpm. Therefore, the direct gamma radiation cleanup level of 5,070 cpm for the collimated detector will be used initially in the field for the excavation control. Cleanup level for the bare (uncollimated) detector will be 16,360 cpm (the 16,619 cpm equivalent to 2.24 pCi/gm reduced by 1.96σ). This direct radiation cleanup level may change as cleanup progresses; therefore, contact your supervisor to obtain the current direct radiation cleanup level. Excavation control survey will be performed using combination of scan radiation survey and static radiation level measurements as follow:

1. Perform the function check as indicated in Section 4.1 of this procedure. In area, such as north and west of the NECR-1 near the slope, where gamma radiation shine is expected, used the collimated detector.
2. Insure that the Scaler/Rate meter (ESP or Ludlum 2221) is set in RATE mode. Turn the Scaler/Rate meter audio speaker to the ON position. For Ludlum 2221 Scaler/Rate meter, set the RESP (response) toggle switch to F (fast) position. Set the audio rate toggle switch to x1, x10 or x100 position and familiarize yourself to the audio rate at the action level count rate. The audio toggle rate set at x10 is appropriate for the field survey.

3. Using the IRA Work Plan Figure 2 and 4, area boundary location coordinates, and DGPS to field locate and mark appropriate area exceeding the cleanup level with pin flags. Radiation scanning may be necessary between the outer points to delineate the contaminated area boundaries. Coordinate the marked area with the excavation crew. The area may be divided into small subareas such as 100 square meter areas, or 10 feet strips to efficiently control excavation based on equipment used for excavation. The excavation fleet will remove the contaminated soil in necessary thickness lift initially based on vertical extent of contamination.

   Prior to performing excavation control in the field, hold a tail gate safety meeting each day with the excavation crew to coordinate safety procedures during the excavation control survey.

   IT IS IMPORTANT TO COORDINATE WITH THE EXCAVATION CREW THE EXCAVATION AND SURVEY SEQUENCE FOR YOUR SAFETY. ESTABLISH NECESSARY SAFETY COORDINATION WITH THE EXCAVATION CREW. ALWAYS WEAR AN ORANGE SAFETY VEST WHILE PERFORMING SURVEY IN THE FIELD.

4. Following the initial excavation lift, assure that the excavation equipment is out of the way and the area is clear and safe, perform a radiation scan with the detector at approximately 12 inches from the ground surface by walking in a serpentine pattern along a transect or within the subdivided areas with the audio speaker ON to identify any locations that exceed the site action level count rate by audio response and digital count rate display. The scan survey for the excavation control will be performed for 100% coverage of an area. Note that the collimated detector at about 12 inches from ground is most sensitive within an area of about three feet diameter under the detector, and about 10 feet diameter under the bare detector. The scan gamma radiation survey form (Attachment B) may be used to note any comments.

5. If no point or a location exceeding the action level is identified within the area by the scan, perform one-minute static radiation measurement at several points (about five points within a 100 square meter area) using the static radiation measurement as described in steps 2 through 5 of Section 4.4. Obtain the static measurement point locations using the DGPS. Record the static measurement readings and location coordinates in the static gamma radiation survey field form (Attachment C). If all points are below the cleanup level, the excavation is complete and ready for the Post-IRA status survey. The static radiation measurements may be used as a part of the Post-IRA status survey. If any of these points exceeds the cleanup level, notify the excavation crew and guide the contaminated soil excavation repeating step 4 until all locations or points are below the cleanup level.

6. If the radiation scan following the initial soil excavation lift shows portions the area above the

cleanup level, or any static measurement point is above the cleanup level, mark out those areas with pin flags and coordinate with the excavation crew for the additional excavation of contaminated soil as necessary at those locations until the scan survey shows no points or location above the cleanup level and repeat step 5 at those locations.

7. If the radiation scan following the initial soil excavation lift still shows most or all of the area above the cleanup level, the contamination in entire area is deeper than the initial lift. Coordinate with the excavation crew for additional soil excavation and repeat 5 and 6 as necessary until the area is clean.

4.4 Post-IRA Status Survey

The Post-IRA status survey includes scan radiation survey and static radiation survey. The scan radiation survey would have already been performed at 100% coverage during the excavation control survey for IRA support. This information will be used for scan radiation survey requirement for the Post-IRA status survey. The static direct gamma radiation level measurements for the Post-IRA survey will be implemented following the IRA and the remedial action support surveys. Static direct gamma radiation level survey will be performed at 80-foot triangular grid nodes in each area. The grid nodes were determined using a visual Sampling Plan (VSP) on an 80-foot triangular grid cast on a random origin during the RSE for most of the areas undergoing the interim remedial action. One-minute static gamma radiation survey will be performed at specified grid nodes or points within survey areas as a part of the Post-IRA status survey to demonstrate cleanup of areas. The technician will perform the static (stationary) gamma radiation survey as follows:

1. If the detector needs to be collimated for the area of interest, place the detector in the 0.5 inch lead collimator. Perform the function check as indicated in Section 4.2 of this procedure.

2. Insure that the Scaler/Rate meter (Ludlum 2221) is set in scaler (integration) mode and the integration time is set for one minute. Turn the Scaler/Rate meter audio speaker to the ON position.

3. Obtain the cleanup level direct gamma radiation count rate based on the correlation for the final status survey for bare and collimated detector.

4. Locate the final status survey points (grid node) using survey point location figures, the static survey point coordinate data, and the DGPS system.

5. Hold the detector at approximately 12 inches from the ground surface above the desired survey point. Obtain a one minute integrated count.

6. Record the counts in cpm and appropriate corresponding survey point information (location ID and/or coordinates etc) on the Static Gamma Radiation Survey Field Form (Attachment C).

7. If any of the reading is above the cleanup level based on the revised correlation for the final status survey, mark the survey point with a pin flag for investigation and addressing any residual contamination.

8. Repeat step 4 to 6 for additional static radiation measurements.

9. The Ra-226 concentration in the soil will be calculated from the gamma radiation survey counts (cpm) using the calibration equation established from the correlation for that detector. The results from the static gamma radiation survey and soil sampling results will be compared to the 2.24 pCi/gm Ra-226 level for demonstrating compliance with removal action of contaminated soil. If needed, data will then be evaluated using statistical method to determine if they exceed cleanup level.

5.0 ATTACHMENTS

Attachment A	Scaler/Rate meter-Detector Function Check Form
Attachment B	Scan/Walkthrough Gamma Radiation Survey Field Form
Attachment C	Static Gamma Radiation Survey Field Form

Attachment A, SOP #RAD-3a
Scaler/Ratemeter - 2" x 2" NaI Detector Function Check
UNC's NECR Mine Site

Scaler/Ratemeter ID:______________________________

Function Check Source ID: 1% U_3O_8 Ore in Sealed can

2" x 2" Detector ID:______________________________

Acceptable background Count (cpm) Range (20%) ____________________ to ____________________

Acceptable Source Count (cpm) Range (20%) ____________________ to ____________________

Date	Physical Check	Cal Due	Battery(1) Volts or OK	HV Volts	Threshhold mV (2)	Window In or OUT(3)	C.C.(4)	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm	Tech

Note: (1) Battery Voltage for Ludlum 2221 must be >5.3 volts; (2) Threshhold must be at 100 mV; (3) Window Position must be OUT; (4) C.C. for Eberline ESP scaler must be 1.0+00

Attachment B, SOP #RAD-03a
Gamma Radiation Survey @ UNC's NECR Mine Site

Scan/Walkthrough Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter________________________________, Detector_______________________________________

Instrument Calibration Date: _____________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Area-Transect ID/Description	Gamma Radiation Reading Range CPM	Comments/Notes

Technician Signature ________________________________, Reviewed by ____________________________________

Attachment C, SOP #RAD-03a
Gamma Radiation Survey @ UNC's NECR Mine Site

Static Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter ____________________, Detector ____________________

Instrument Calibration Date: ____________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Point ID/Description	Survey Point Coordinate		Gamma Radiation Reading, CPM	Comments/Notes
		Northing	Easting		

Technician Signature ____________________, Reviewed by ____________________

STANDARD OPERATING PROCEDURE 15

SURFACE SOIL SAMPLING

STANDARD OPERATING PROCEDURE 15

SURFACE SOIL SAMPLING

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental surface soil samples for chemical and geotechnical analyses. The information presented in this SOP is generally applicable to the collection of all surface soil samples, except where the analyte(s) may interact with the sampling equipment. This SOP defines sample collection procedures using hand augers, shovels/trowels, and soil core samplers. Procedures for collecting subsurface soil samples are outlined in SOP-14.

This document focuses on methods and equipment that are readily available and typically applied in collecting surface soil samples. It is not intended to provide an all-inclusive discussion of sample collection methods. Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Such innovations shall be clearly described in the project-specific sampling plan and approved by the UNC Project Manager, MWH Project Manager, and the Quality Manager.

2.0 DEFINITIONS

Environmental Sample: A solid sample collected for chemical or geotechnical analysis. These samples are used to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, waste characterization, etc.

Hand Auger: A sampling tool consisting of a stainless steel tube with two sharpened spiral wings at the tip.

Shovel/Trowel: A sampling device consisting of a stainless steel spade attached to a handle.

Soil Core Sampler: A variable diameter stainless steel tube that can be attached to a hammer for driving into surface soil. The tube can also be fitted with retaining liners.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects site-specific sampling methods, sample locations, and constituents to be analyzed with input from other key project staff.

Quality Manager: Overall management and responsibility for the sampling methods, sample locations, and constituents to be analyzed with input from other key project staff and UNC personnel.

Field Team Leader (FTL) and/or Field Geologist, Hydrogeologist, or Engineer: Implements the sampling program and supervises other sampling personnel. Prepares daily logs of field activities.

Sampling Technician (or other designated personnel): Assists the FTL, geologist, hydrogeologist, or engineer in the implementation of tasks. Performs the actual sample collection, packaging, and documentation (e.g., sample label and log sheet, chain-of-custody record, etc).

4.0 SURFACE SOIL SAMPLING

4.1 BACKGROUND

Surface soil samples are typically collected from the ground surface to 6 inches below ground surface. Samples collected from greater than 6 inches below ground surface are referred to as subsurface soil samples. Surface soil samples may be collected as grab samples or as composite samples. The sample method is determined based on the physical characteristics of the site and matrix.

- Grab sample: A sample taken from a particular location. Grab samples are useful in determining discrete concentrations, but also provide spatial variability when multiple samples are collected.
- Composite sample: A number of samples that are individually collected then combined (homogenized) into a single sample for subsequent analysis. Composite samples are useful when averaged or normalized concentration estimates of a waste stream or an area are desired.

4.2 SAMPLING PROGRAM OBJECTIVES

The objective of surface soil sampling is to characterize chemical properties of the soil, and possibly identify potential sources of contaminants. Sampling objectives are typically diverse and dependent on the nature of the project data quality objectives. Details pertaining to sample locations, number of samples, and type of analyses required, shall be presented in project-specific work plans.

4.3 SAMPLING EQUIPMENT AND TECHNIQUES

A surface soil sample may consist of a single scoop or core, or the sample may be a composite of several individual samples. Surface soil samples shall be obtained using hand augers, shovels/trowels, or soil core samplers.

Hand Auger: A hand auger consists of a stainless steel tube with two sharpened spiral wings at the tip. The auger typically cuts a 2-inch to 3-inch diameter boring. Because the auger is hand-driven, penetration in dense or gravelly soil may be difficult. For surface soil sample collection, the procedures outlined below shall be followed. Procedures for sample handling and shipping are presented in SOP-12.

1. Advance the auger by hand into the soil, to the desired depth (6 inches or less for surface soil samples), by turning in a clockwise direction with downforce applied.
2. Retrieve the auger to the surface, preferably without rotation.
3. Fill sample jars using decontaminated stainless steel spatulas or spoons.
4. Place samples for other analyses into a stainless steel bowl for homogenization. Prior to homogenization, remove twigs, rocks, leaves and other undesirable debris if they are not considered part of the sample.

Shovel/Trowel: Various shovel/trowel designs and sizes are commercially available for a variety of sampling applications. These devices are hand-driven and are typically used for sampling relatively soft, unconsolidated soil deposits. Some designs (e.g., the sharpshooter™) can be driven into hard, rocky soil by opening a deep, narrow hole. Shovels or trowels used for surface soil sampling shall be made of stainless steel. The procedures outlined below shall be followed while collecting samples with shovels or trowels. Procedures for sample handling and shipping are presented in SOP-12.

1. Drive the shovel/trowel into the soil. If the soil is dense, use your own weight to drive the shovel by stepping on the rear edge of the shovel.
2. Retrieve the shovel/trowel to the surface.
3. Fill sample jars using decontaminated stainless steel spatulas or spoons.
4. Place sample for remaining analyses into a stainless steel bowl for homogenization. Prior to homogenization, remove twigs, rocks, leaves and other undesirable debris if they are not considered part of the sample.

Soil Core Sampler: Soil core samplers consist of variable diameter (commonly 1-2 inches), stainless-steel tubes that can be attached to a hammer using a cap to allow for driving into surface soil. The steel tubes can also be fitted with aluminum or stainless steel liners for the collection of undisturbed samples. Polyethylene liner caps are used to seal the ends of the tube after sample collection. Soil core samplers can be used to obtain soil samples for chemical or geotechnical analysis. The use of liners allows for the collection of undisturbed samples, minimal loss of volatiles, and easy shipping to the analytical laboratory. The procedures outlined below shall be followed when collecting surface soil samples using this method.

1. Attach a stainless steel cap to the soil core sampler.
2. Attach the sampler and cap assembly to the hammer.
3. For the collection of undisturbed soil samples, install stainless-steel liners in the sampler.
4. Push the hammer and sampler into the surface soil. For dense soil, turn hammer slightly clockwise to enhance penetration.
5. Once the desired sample depth is reached, retrieve sampler to the surface and detach the sampler from the hammer.
6. To collect samples for chemical analysis, empty contents of the sampler into a stainless steel bowl for homogenization. Prior to homogenization, remove twigs, rocks, leaves and other undesirable debris if they are not considered part of the sample.

5.0 DECONTAMINATION

All equipment used in the sampling process shall be decontaminated prior to field use and between sample locations. Decontamination procedures are presented in SOP-3. Personnel shall don appropriate personal protective equipment as specified in the project-specific work plan. Any investigation-derived waste generated in the sampling process shall be managed in accordance with the procedures outlined in the Work Plan.

APPENDIX B

SOIL LOSS CALCULATIONS

CALCULATION COVER SHEET

MWH

SHEET 1 OF 4

PROJECT TITLE:	UNC NECR IRA CONSTRUCTION PLAN
PROJECT NO:	1006690
CALCULATION TITLE:	NECR-1 Soil Loss Calcualtion

	NAME	DATE
PREPARED BY:	Robert Young	5/11/09
CHECKED BY:	John Hamm	5/11/09
REVIEWED BY:	John Hamm	5/11/09

REVISIONS				
DATE	**PURPOSE**	**PREPARED BY**	**CHECKED BY**	**REVIEWED BY**

INTRODUCTION

This soil loss analysis was prepared to estimate long term soil loss from the NECR-1 Pile at the Northeast Church Rock Mine Site. This analysis was performed as part of the NECR Interim Removal Action Plan, prepared for the United Nuclear Corporation (UNC).

METHODS

Soil loss was estimated using the Revised Universal Soil Loss Equation 2 (RUSLE2) version 1.26.6.4. (Foster and Yoder, 2006) RUSLE2 software is the primary tool used in erosion modeling by federal agencies (e.g., Office of Surface Mines and U.S. Forest Service) to assess soil loss for mine reclamation applications. RUSELE2 technology uses several factors in determining erosional extent including climate, soil properties, base management, slope length, shape, and gradient. The RUSLE2 soil loss equation is:

$$a=(r)(k)(l)(s)(c)(p);$$

where:

a = daily soil loss
r = rainfall/runoff
k = soil erodibility
l = slope length
s = slope steepness
c = cover management
p = supporting practices

To obtain average annual soil loss, RUSLE2 sums all daily soil loss values (a) provided by the above equation. Site-specific parameters were entered in a soil loss model in order to obtain average annual soil loss for the drainage channel slopes and the outslopes of the NECR-1 pile at the NECR mine site. These parameters were:

1. R-factor of 13 (NRCS, 1999)
2. Time variant k factor based on topsoil stockpile soil characteristics
3. 1% and 5% grade, 137 foot (average) and 310 foot (max) slope length for NECR-1 drainage channel slopes
4. 42% grade, 125 foot (max) slope length for the NECR-1 outslope
5. Bare ground, no revegetation or natural growth factored into calculation
6. Perfect contouring, no row grade
7. Normal residue burial

Regional climate and soil data were input into RUSLE2 directly from the U.S. Department of Agriculture, Natural Resource Conservation Service. This database provided specific time-variant annual rainfall data as well as provided a soil type that most represents the stockpiled topsoil that will be used for backfill purposes.

SOIL LOSS ANALYSIS

Using the climate and soil data from the NRCS database and the slope designs for the NECR-1 Pile, RUSLE2 simulations estimated soil losses for several scenarios incorporating varying slope lengths and gradients that may be present on the NECR-1 Pile. In addition, rough surface base management practices were incorporated on the NECR-1 outslopes because doing so demonstrates a dramatic decrease in soil loss. The results of these simulations are shown below in Table 1.

Annual soil loss values were then used to estimate the amount of time it would take to erode away one inch of surface material using an assumed density of topsoil backfill material of 110 lbs/ft^3. These calculations are included in Table 2.

TABLE 1
SOIL LOSS ANALYSIS RESULTS

[illegible]	Horizontal Slope Length (ft)	Slope Grade (%)	Annual Soil Loss (t/ac/yr)	Time Duration for 1 Inch of Soil Loss (yrs)
NECR-1 Top Surface Drainage	137 (average)	1%	0.36	555
NECR-1 Top Surface Drainage	310 (max)	1%	0.38	526
NECR-1 Top Surface Drainage	137 (average)	5%	1.6	125
NECR-1 Top Surface Drainage	310 (max)	5%	1.7	118
NECR-1 Outslopes	125 (max)	40%	19	11
NECR-1 Outslopes	125 (max)	40% (rough surface)	4.9	41

CONCLUSIONS

Based on RUSLE modeling, six inches of cover material on the top surface and 12 inches of material on the slopes will be sufficient to prevent exposure of underlying material due to sheet erosion prior to implementation of final removal actions.

REFERENCES

Foster, George, Daniel Yoder, Jim Lyon, and Joel Lown. RUSLE2. Computer software. Vers. 1.26.6.4. Revised Universal Soil Loss Equation Version 2. 8 May 2009 http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

"RUSLE R-Factor Values for New Mexico." Map. USDA-NRCS. NRCS-NM, 1999.