Prepared For:

WESTERN NUCLEAR, INC.
SPLIT ROCK MILL SITE
JEFFREY CITY, WYOMING

RADIOLOGICAL VERIFICATION PROGRAM

Prepared By:

SHEPHERD MILLER, INC.
Fort Collins, CO 80525

DECEMBER 1995

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EXECUTIVE SUMMARY

The following report presents the radiological cleanup and verification plan that will be implemented to verify that any areas surrounding the Split Rock Mill Site, which could have been contaminated with windblown tailing, has been decontaminated. Inherent to the plan described in this report is an ongoing commitment to data quality objectives which will ensure that all radiological data that are collected and analyzed are of sufficient and adequate quality and quantity for demonstrating compliance with applicable radiological standards. As such, following remediation of all areas exhibiting residual radioactivity in excess of applicable limits due to windblown tailing contamination, data obtained during final verification will be sufficient to support the decision to release areas of the Split Rock site, with the exception of areas isolated by the reclamation cover system, for unrestricted use.

Based on preliminary site scoping and historic process knowledge, it has been determined that all areas of the former Tailing Impoundment, mill areas and process solution ponds are within the boundaries of the reclamation cover system and have been, or will be, reclaimed beneath the final soil cover. Therefore, cleanup and verification of areas to be released for unrestricted use will concern only residual radioactive contamination of soils which resulted from historic disbursement, via wind erosion, of crushed ore and exposed tailing material. As such, it is believed that for the majority of areas, any contamination present at levels above applicable cleanup standards will exhibit secular equilibrium within the uranium series, or will be governed by an association with ^{226}Ra. The uranium isotopes ^{238}U and ^{234}U will only be present if the windblown material was ore. In the case of windblown tailing material, the highest parent product in the uranium series would be ^{230}Th since the uranium was removed in the milling process.

The following report provides a detailed discussion of the relevant history of the site, historical radiological data, and the technical issues that were evaluated to develop the proposed verification program. The technical issues evaluation was conducted to facilitate the design of the radiological correlation program, which forms the basis of the proposed radiological cleanup and verification plan. The purpose of the correlation program was to investigate and develop methods and procedures for conducting a gamma-radium correlation study. When the results of this study are complete, they will determine the correlation between ^{226}Ra content in the soils of 10m x 10m grids and the corresponding external gamma radiation exposure rate ("gamma") measurements from those grids.

As a result of the technical issues evaluation, several studies were incorporated into the correlation program, to aid in optimizing the design of the gamma-radium correlation study. The correlation program studies, discussed in subsequent sections of this report, were as follows:

1. the pre-reclamation radiological survey;
2. the background radiological constituent study;
3. the pre-verification scoping survey; and
4. the gamma-radium correlation study.

The radiological correlation program resulted in the development of two gamma survey methods which will be used to determine ^{226}Ra concentrations in soil.

Additionally, due to the nature of contamination, discussed previously, it is expected that all residual contamination will exhibit secular equilibrium within the uranium series whether the decay chain begins with ^{238}U or ^{230}Th. Therefore, an "association" between elevated levels of ^{226}Ra and elevated levels of U-nat and/or ^{230}Th will exist. That is; ^{238}U and/or ^{230}Th will be present at elevated concentrations only if ^{226}Ra is also present at elevated concentrations. Therefore, cleanup and verification of ^{226}Ra (which can be detected by external gamma radiation measurements) would be sufficient to assure cleanup of U-nat and/or ^{230}Th (which can not be detected by gamma survey methods). The existence of such an association will be demonstrated upon review of the correlation data, and will be continuously validated during verification based on random soil sampling.

In the event that isolated areas are identified where an association can not be demonstrated, this plan contains provisions for verifying radiological compliance in these areas based on a more extensive soil sampling program.

The program, as presented, allows for the cleanup and verification of all potentially contaminated areas associated with milling operations that are outside of the reclamation cover system. After the program is complete, these areas will be released for unrestricted use.

1.0 INTRODUCTION

The potential exists that areas of the Split Rock site which are outside of the reclamation cover system may have been contaminated by the historic disbursement of crushed ore and tailing material (i.e., by-product material) via wind erosion. Upon review of the scoping survey and correlation survey results (to be discussed later in this report) a determination will be made as to the lateral and vertical extent of said contamination.

Soils exhibiting residual radioactivity at concentrations above applicable radiological standards for release and unrestricted use as a result of disbursement of by-product materials will be excavated and placed in the Tailing Impoundment before the tailing reclamation cover is placed. These areas will then be verified for radiological compliance and released for unrestricted use.

Several site studies and technical evaluations were performed to develop the methods that will be used to determine areas that require cleanup and the specific procedures that will be used to verify removal of residual radioactive materials to concentrations which are below applicable regulatory limits. This report discusses these studies and evaluations in sufficient detail to provide an understanding of the logic and rationale that was used to develop the proposed cleanup and verification plan.

The cleanup and verification plan was developed to ensure that all areas to be released for unrestricted use are in full compliance with the ^{226}Ra cleanup requirements set forth in the Code of Federal Regulations, Title 10, Section 40, Appendix A, Criterion 6(c) (10 CFR 40 A6(c)), as well as the guidance concentration limits for U-nat as presented in 46 FR 52061.

Other U.S. Nuclear Regulatory Commission (NRC) guidance documents were also reviewed and used as appropriate during the development of this plan.

As presented in 10 CFR 40 A6(c), the applicable standard for cleanup of land contaminated by ^{226}Ra as the result of uranium byproduct material require that, on a 100 square meter basis, ^{226}Ra must not exceed background levels of ^{226}Ra by more than:

1. 5 pCi/g averaged over the first 15 cm below the surface; and
2. 15 pCi/g averaged over 15 cm thick layers more than 15 cm below the surface.

Although ^{230}Th contamination is not directly addressed by this standard, it is recognized that if ^{230}Th is out of equilibrium with ^{226}Ra and present at sufficiently high concentrations, in-growth of ^{226}Ra from ^{230}Th during the 1000 year design life can result in ^{226}Ra concentrations which exceed the standard. As such, this plan contains provisions for analyzing for ^{230}Th on a random basis, and calculating the resulting ^{226}Ra activity at 1000 years to ensure that the standard is not exceeded. This will be accomplished using the following standard ingrowth equation:

$$A_{(Th,0)} = \frac{A_{(Ra,t)} - A_{(Ra,0)} e^{-\lambda t}}{1 - e^{-\lambda t}}$$

Where:

$A_{(Th,0)}$ = activity of ^{230}Th at time=0;

$A_{(Ra,0)}$ = activity of ^{226}Ra at time=0;

$A_{(Ra,t)}$ = the standard limit of 5 or 15 pCi/g above background;

t = time = 1000 years; and

λ = the decay constant for ^{226}Ra = 4.32E-4 yrs^{-1}

In addition to the limits for ^{226}Ra and, by extension, ^{230}Th, this plan observes the guideline cleanup values of 10 pCi/g U-nat with daughters in equilibrium or 35 pCi/g U-nat without daughters present as discussed in 46 FR 52061.

1.1 Data Quality Objective Process

The Data Quality Objectives (DQO) process is a series of planning steps based on the scientific method that is designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application (NUREG-1505). The radiological verification plan presented in this report is based on the DQO process and was developed using each of the seven basic DQO steps to establish the plan objectives. Following is a statement of each DQO step and how it is addressed by this plan.

1. *State the problem.*
   The objective of this plan is to identify areas of the Split Rock Site which are contaminated with residual radioactive by-product materials and to cleanup residual radiological contaminants in any identified areas to levels which are below applicable radiological standards.

2. *Identify the decision.*
   When areas have been identified and cleaned up, all areas of the site, with the exception of the areas beneath the reclamation cover system, will be released for unrestricted use.

3. *Identify inputs to the decision.*

   Data supporting release for unrestricted use will be a combination of gamma surveys which will be used to both guide cleanup efforts, and document final compliance, as well as laboratory analyses of representative soil samples which will continuously validate the gamma survey results.

4. *Define the study boundaries.*

   The boundaries of areas to be verified will be determined based on the results of the scoping survey discussed in Section 2.4.3.

5. *Develop a decision rule that defines the conditions for choice among alternative actions.*

   Several decision rules have been identified. For gamma surveys, an action limit for cleanup will be developed based on statistical analyses of the data obtained from the radiological correlation program discussed in Section 3.0. For laboratory analyses of soil samples, the action level will be defined by the applicable limit for each constituent.

6. *Specify limits on decision errors.*

   As discussed in Section 3.4.3, the action limits for cleanup will be based on the lower 90% prediction limit on the correlation between external gamma radiation measurements, and actual 226Ra content in soils. For soil sample analyses, the 2σ counting uncertainty will be used.

7. *Optimize the design for obtaining data, i.e., the most time- and resource-effective sampling and analysis plan.*

   The primary focus of this plan has been to identify and develop methods which are time-and resource-effective. Section 3.2 of the plan presents the technical considerations which were evaluated in this regard, and Sections 3.3 and 3.4 discusses the actions which were taken to address these considerations.

1.2 Specific Data Quality Objectives

In addressing the DQO steps, several specific DQOs were identified as necessary to ensure that all radiological data that are collected and analyzed are of sufficient and adequate quality and quantity for demonstrating compliance with applicable radiological standards. The DQOs identified are as follows:

1. sufficient data should be obtained from a site review and scoping survey to clearly delineate areas of potential contamination;

2. all radiological verification data should be obtained using methods which are reliable, reproducible and operator independent;

3. evaluation of radiological verification data obtained in support of compliance demonstration should be statistically based and defensible;

4. final verification surveys should be performed at a frequency and density sufficient to adequately demonstrate compliance;

5. periodic performance checks should be performed on both field survey equipment and laboratory analytic results to ensure continued data quality.

2.0 RELEVANT SITE HISTORY

This section presents a brief discussion of both the operational history, and the radiological sampling history at the Split Rock Site, which is relevant to the cleanup and verification plan. This portion of the plan was compiled in response to the first data quality objective which relates to delineation of areas of potential contamination via site review and scoping surveys.

2.1 Relevant Operational History

The Split Rock uranium mill began production in 1957. Western Nuclear Inc. operated the mill and adjacent tailing disposal areas until 1981 under NRC Source Material License No. SUA-56. Uranium ore from the Crooks Gap and Gas Hills mining complexes was processed at the mill site, which lies approximately two miles north of Jeffrey City, Wyoming. The mill was on standby status from 1981 until 1986, when the license was amended to terminate use of the tailing pond as a disposal area. The result of this amendment was two-fold: first, WNI was required to submit a Tailing Reclamation Plan and second, the possession of by-product materials would was restricted to the area to be encompassed by the reclamation cover system.

During the summer of 1988, the uranium processing mill was decommissioned and demolished. The only remaining structures at that time included the office building, guard house, and electrical substation. The guard house and substation were thoroughly screened, for residual radioactive contaminants and were removed from the site in accordance with applicable NRC requirements for release of equipment for unrestricted use.

During the summer of 1990, tailing regrading was conducted at the site. The accomplishments of the project included grading the surface to the planned final subgrade configuration, removing the windblown tailing from areas outside of the reclamation cover system (see Section 2.4.2), and placing an interim cover over a portion of the Tailing Impoundment (Split Rock Mill Tailings Regrading and Interim Cover Report (1991, Docket 40-1162)).

2.2 Climate

The characteristic weather at the site is semiarid, having a mean annual precipitation of 12 inches and an average evaporation potential of 50 inches. The mean annual temperature is 45 degrees Fahrenheit. The prevailing wind direction is from the west/southwest to the northeast.

2.3 Site Geology

The site is located within the central high plains seismotectonic province. The tailings disposal area is located upon windblown eolian (dune) sand overlying lightly cemented alluvial and colluvial deposits known as the Split Rock formation. The dune sands in this area range from approximately 0 to 20 feet in thickness, while the Split Rock formation ranges from approximately 10 to 250 feet in thickness. This material overlies Precambrian granite.

2.4 Relevant Radiological Sampling History

2.4.1 License Condition #66 Survey

Western Nuclear Inc., License Condition #66 (SUA-56, 12/4/80) called for submittal of a gamma survey in the vicinity of the Split Rock Site and a plan for cleanup of any contaminated areas identified. In April 1981, a gamma exposure rate survey in eight compass directions from the Split Rock Mill Tailing Impoundment was conducted to determine the extent of windblown tailing. Exposure rate measurements were taken at 30-foot intervals along the transects. Exposure rate measurements were taken along the transects using a PRM-7.

The survey identified areas of apparent surficial contamination due to windblown tailing. However, the WNI report submitted August 14, 1981 to NRC, WNI contended that no cleanup action was warranted or justified at that time since migration of windblown tailing had been contained on site by the granite outcrops which surround the site. Further, it was projected that many of the areas which were identified by the survey would become part of the tailing basin within the foreseeable future.

2.4.2 Pre-Reclamation Radiological Survey

In September 1987, a gamma survey and soil sampling program was conducted at the Split Rock Mill Site by Radiant Energy Management. This was submitted to NRC on March 1, 1988. The purpose of the survey was to correlate external gamma radiation measurements with both ^{226}Ra, as well as U-nat, concentrations in soils on site. These correlations were then used to estimate the vertical and horizontal extent of contamination on site in order to obtain an estimate of the extent and volume of material to be cleaned up during reclamation. A complete discussion of this program can be found in the "Split Rock Mill Site Reclamation Plan" submitted to the NRC in June, 1987.

As shown in Figure 1, the Split Rock Mill Site was divided into eight areas for this study, designated as Area 1 through Area 8.

The primary conclusions of this study were as follows:

1. The "background" external gamma exposure rate on site was 16 μR/hr, corresponding to an average ^{226}Ra concentration of 1.5±0.5 pCi/g.

2. A correlation was developed relating external gamma exposure rates to 5 pCi/g above the background average.

3. Based on the ^{226}Ra concentration and gamma readings, the vertical and horizontal extent of contamination appeared to be minimal, with the exception of Area 7, which is downwind of the Tailing Impoundment.

2.4.3 Pre-Construction Radiological Survey

Pursuant to License Condition #33(A) (SUA-56, Amendment No. 43), WNI conducted a gamma survey In April 1990, across the windblown tailings area in the Northeast Valley (WNI, 1991, Docket 40-1162). A baseline was established and gridlines were set perpendicular to the baseline, in one hundred foot increments. Gamma readings were taken along these gridlines, using two Eberline PRM-7 Micro-R meters. As a result of this survey, approximately 220,150 cubic yards of material was excavated from a 45 acre section in the Northeast Valley and disposed of in the northeast end of the tailing basin

Composite soil samples were taken at ten locations and analyzed for ^{226}Ra. Additional tailing material was removed as necessary, until all soil samples indicated a ^{226}Ra concentration that was well below the 10 CFR 40 Appendix A Criterion 6(C) standard. In addition, a final gamma survey was conducted in September 1990. The gridlines established in April were resurveyed at that time to confirm that windblown tailings had been cleaned up to an acceptable level, that is that all readings were below the upper control limit of 32 μR/hr.

2.4.4. Current and Ongoing Surveys

Before each construction season, an external gamma radiation survey is conducted in each borrow area to confirm that affected soils have not been redeposited over the borrow soils. An external gamma radiation value of either 18 μR/hr in areas not affected by shine, or 30 μR/hr in areas affected by shine (i.e., within approximately 50 feet of either granite outcrops or exposed tailing) are used to determine if freshly deposited windblown tailing are present in the soil borrow area. Soils or materials exceeding these criteria are removed and placed in the Tailing Impoundment.

Random external gamma surveys are also conducted during borrow area excavation to identify affected soils present at depth in the soil borrow areas. The surveys are conducted by traversing the borrow area at least once each day during excavation, and at least once each shift if the soil volume excavated exceeds 15,000 cubic yards per day per borrow area. In the event that areas are identified which exceed the previously stated exposure values of 18 or 30 μR/hr, the material is excavated, segregated, and disposed in the Tailing Impoundment.

2.4.5. Verification Scoping Survey

In preparation for the WNI final verification survey a site scoping survey was conducted during the fall of 1995. The scoping survey was intended to supplement historical radiological sampling data and finalize the projected lateral and vertical extent of contamination at the site in order to limit unnecessary verification surveys in uncontaminated areas, and to insure that any windblown material which may be present at depth in areas of significant soil deposition were identified. The scoping survey was conducted concurrently with the radiological correlation program during the fall of 1995. The scoping survey consisted of extensive gamma measurements and soil samples taken from 10m x 10m grids in the vicinity of the Tailing Impoundment, as shown in Figure 2. The scoping survey grid system consisted of 519 10m x 10m grids oriented along radial lines extending from the center of the Tailing Impoundment out to the restricted area boundary. The 10m x 10m grids were spaced at 50 m centers along each radial line. 100% of all scoping grids were gamma surveyed, in accordance with the procedures described in Section 3.0. Composite soil samples were taken from approximately 10% of the scoping grids for laboratory analyses. In addition to surface gamma surveys and soil sampling, subsurface soil samples were taken to a depth of 10 feet at the 15 locations shown in Figure 3.

When the laboratory analyses of the soil samples are complete and the gamma-radium correlation has been established, the data obtained from the scoping survey will be reviewed to ascertain the lateral and vertical extent of contamination, and to establish the geographic limits of the final verification survey.

3.0 RADIOLOGICAL CORRELATION PROGRAM

The second data quality objective of this plan was to identify and develop methods for obtaining radiological verification data which will be reliable, reproducible, and operator independent. As such, the radiological correlation program was designed and implemented to identify and develop these methods.

As addressed in this section, the radiological correlation program consists of the following elements:

- Objectives of the radiological correlation program;
- Technical considerations that were evaluated;
- Final design considerations of the gamma-radium correlation study; and
- Implementation and results of the gamma-radium correlation study.

3.1 Objectives

The objectives of the radiological correlation program included the following:

1. Develop a correlation between external gamma radiation exposure rate measurements and ^{226}Ra content in soils. Gamma survey procedures developed from the correlation would provide a real time, cost effective method to determine areas that are contaminated and areas that are either not contaminated or have been decontaminated. The procedures would be used both during cleanup as well as to verify, in conjunction with soil samples, that areas are clean and suitable for release for unrestricted use.

2. Determine if an association exists between elevated concentrations of ^{226}Ra and elevated concentrations of U-nat and/or ^{230}Th in contaminated soil. The ^{230}Th and U-nat do not emit appreciable gamma radiation and, therefore, the gamma correlation procedure would not be useful in detecting ^{230}Th or U-nat in soil. Consequently, if it could be shown that removing the elevated residual ^{226}Ra in the soil resulted in removal of all elevated ^{230}Th and U-nat, cleanup procedures would be simplified and laboratory analyses for these two analytes could be dramatically reduced.

3. Redefine background radiological constituent concentrations. Given that the regulatory limits are expressed in terms of concentrations "above background", it was necessary to obtain a good understanding of both background concentrations and the variability of these concentrations across

the site. Furthermore, the 1987 radiological study defined background concentrations only for ^{226}Ra.

3.2 Technical Considerations

A series of technical considerations relevant to the radiological correlation program were evaluated, using available literature, to aid in designing the final radiological verification plan. The result of the technical consideration evaluation led to several preliminary studies that were conducted to determine the equipment and techniques used in the gamma-radium correlation study. These studies were conducted at the WNI Sherwood Site, located near Wellpinit, Washington. A summary of these studies is presented below, and a more complete discussion can be found in the Sherwood Project Mill Decommissioning Plan Addendum [Revision #6 (10/94)] (WNI, 1994).

3.2.1 Variable Intensities of Scattered Gamma Radiation

In designing the gamma-radium correlation study, it was recognized that extraneous external gamma radiation, from sources other than the soil within a given 10m x 10m compliance grid, could result in artificially elevated gamma measurements which would not necessarily be representative of that soil. This extraneous gamma radiation is commonly referred to as "shine".

Shine can exist when areas adjacent to the area being measured have high gamma emission rates. Shine can also be of concern when taking external gamma radiation measurements in areas of irregular topography. When the topography of an area being measured is not a flat, planar surface, detection of gamma radiation from areas outside of the area of interest can result. Sources of shine include: irregular topography, granite outcrops, the Tailing Impoundment and scattered environmental radiation.

Furthermore, the amount of shine that could occur would vary across the site. The amount of shine is a function of the intensity of the shine source and the distance from the source.

As a result of considering these issues, a comprehensive shielding study was incorporated into the correlation program, and the evaluation of a composite counting procedure was conducted. In addition, detection instrumentation was chosen to accommodate the setting of a lower limit discriminator which was used to reduce low energy scattered environmental radiation and compton scatter below the 609 keV total absorption peak of the ^{226}Ra decay product ^{214}Bi. By setting the lower limit discriminator, the low energy counts resulting from scattering were eliminated thus improving the resolution of the system.

3.2.2 Shielding

As described above, it was determined that shielding of the gamma detection probe should be considered. Literature indicated that a better gamma-radium correlation might be possible if the impact of shine could be minimized. Additionally, shielding would collimate, or focus, the detection probe to better measure the gamma radiation emitted from the soil directly under the probe and counting statistics would thereby be considerably improved. Since shielding has been used for similar applications in the past, available literature was reviewed to determine the applicability of the documented methods.

The Bendix Report (USDOE, 1984) presents an external shielding method that is commonly referred to as the "delta method". This method compares the difference between a gross unshielded gamma reading and a gamma reading taken over a 1/4 inch thick lead shield that is placed on the ground surface. The difference between these two readings, or the delta reading, is then used to estimate the gamma emission from the soil that is covered by the lead shield.

There are two problems with the Bendix Report method. First, the 1/4 inch lead shield is not thick enough to shield the detector from the gamma flux of the underlying soil. Second, use of the method generates a small numerical value (delta value), which is the difference between two large numbers, both of which have a high degree of variability (i.e. a high variance). This creates an inherently large variability within the delta value and, therefore, negatively impacts the quality of the data. This Bendix Report procedure was therefore excluded from consideration in designing the gamma-radium correlation program.

The second method that was reviewed was a self-shielding method, the Schiager and Smith "bucket method" (1982). This method measured the gamma rate from a representative soil sample by placing the detection probe in a hole at the center of a soil sample contained within a bucket. As a result, the soil itself provided the shielding. Because the Schiager and Smith method used a multichannel analyzer for gamma measurements, extended counting times coupled with high costs precluded this method from further consideration for the design of the Sherwood Radiological Correlation Program.

A slight variation of this self-shielding "bucket method", which would entail placing the probe into holes excavated in the grid to obtain in-situ measurements, was also considered.

It was recognized, however, that in order to adequately represent the average gamma emission rate of the entire grid, numerous holes would have to be excavated and individually probed. Based on the sample adequacy study, discussed below, it was subsequently determined that as many as 11 such holes might be required to adequately represent the average gamma flux over a 10m x 10m grid. Concerns regarding both the counting and measurement times and quality control of the probe measurement depths within any hole precluded this self-shielding method from further consideration in design of the Split Rock Radiological Correlation Program.

In summary, all of these external and self-shielding methods, discussed above, were dismissed because of either the extended sampling and counting times and corresponding high costs or the poor quality control associated with the detection and measurement methods.

Based on the review of the literature, it was decided that the only shielding that might prove useful would be extensive lead shielding placed around the gamma detector. The literature, however, did not provide quantitative information sufficient to calculate the required thickness of the shielding. Available information for shielding addressed point sources at a discrete energy level, which is unlike actual field conditions where the source is planar and has a spectrum of energies. Therefore, a field study to determine the required shielding configuration was deemed necessary.

3.2.3 Soil Moisture Impact on Gamma Attenuation

A literature review indicated that the moisture content of a soil might influence gamma emission rates from the soil and, therefore, might impact the gamma-radium correlation.

Literature indicated that the attenuation of gamma flux is a function of the increase or decrease in soil density as the result of moisture content changes.

The material at the Split Rock site is predominately sandy soil. Sand has a small water holding capacity, and the total range of densities for the possible range of water contents is small. It appeared unlikely that moisture content could significantly impact the gamma rates from the soils on site. However, without definitive information, it was decided that an evaluation of the impact of moisture content on gamma emission rates would be appropriate. A field test of moisture effects was carried out at the Sherwood Site in the summer of 1993 (WNI, 1994).

3.2.4 Gamma Equipment and Measurement Techniques

Many types of equipment are available for determining external gamma radiation. These range from complex multichannel analyzers (MCA) to simple μR meters. The available measurement techniques also range considerably from an operator dependent evaluation of the audio signal on a μR meter to a very long (1000 minute or more) count time using an MCA.

There were several objectives for measuring gamma emission rates that were used to determine the appropriate type of equipment and the procedures for the correlation program. These objectives were:

1. measurements should be quantitative;

2. measurements should be operator independent;

3. readings should be real time so that they could be used to direct clean up activities;

4. variation within each gamma measurement should be minimized;

5. equipment should be portable;

6. equipment and procedures should provide a method that is time and cost effective relative to soil sampling and laboratory analyses; and

7. measurement techniques should be simple and readily reproducible. Many of the methods, such as the use of a MCA by the Shiager and Smith "bucket method", were dismissed since they did not provide cost effective or real time data. Procedures using a simple μR meter or similar instrumentation were also dismissed due to a large variability for each measurement and the operator dependency of the interpretation of the measurement readings. Additionally, any reading would not be entirely quantitative since the reported value would be a single value recorded by reading a varying analog scale in the instrument.

From the available information, a gamma measurement system composed of a Ludlum Model 2350 data logger in conjunction with a Ludlum Model 44-10 high energy gamma detector was selected as the system which best satisfied the above objectives.

Based on the results of the Sherwood correlation program (WNI, 1994), it was determined that the optimum counting time for conducting the gamma surveys was 150 seconds for the integrated counting technique, and 120 seconds for the composite counting technique.

3.2.5 Statistical Issues

The third data quality objective of this plan was that the evaluation of radiological verification data obtained in support of compliance demonstration should be statistically based and defensible. As such, several statistical issues were identified to be important relative to the gamma measurements and the gamma-radium correlation. Those issues include the following:

1. the representativeness of both the gamma measurements and soil ^{226}Ra values;

2. the prediction interval that would be applied to the gamma-radium correlation to determine action levels; and

3. the statistics associated with gamma measurements.

Representativeness of gamma measurements and soil radium values.

It was recognized that in order to develop an acceptable gamma-radium correlation, the gamma measurements and soil radium measurements used to develop the correlation must be representative of each 10m x 10m regulatory compliance grid being measured. Steps taken to ensure that the gamma measurements were as representative as possible included the use of shielding to collimate the detector, the use of measurement techniques designed to determine the average gamma emission rates across the entire grid, and the investigation of various counting times to determine the optimum counting time required to quantify the average gamma flux from any given grid.

The representativeness of the soil ^{226}Ra concentration was addressed by determining the number of cores which would be taken over any grid for compositing to represent the average ^{226}Ra concentration of the grid. The number of cores required for the composite was a function of the variability of the ^{226}Ra concentrations in a grid. NUREG/CR-5849 (1992) suggested a 4 core composite. However, there is no assurance that 4 cores would adequately represent the grid. Therefore, a sample adequacy evaluation was considered to determine the required number of cores needed to statistically represent each grid.

Furthermore, it was determined that the analytic error of laboratory ^{226}Ra analyses must be small (on the order of 15% precision) in order to minimize the overall variability of the correlation.

<u>Correlation prediction intervals for establishing action levels.</u>

Once a gamma-radium correlation is obtained, a gamma measurement (reading) action level must be established. Gamma readings greater than this action level would indicate grid contamination; and readings less than the action level would indicate compliance with applicable regulatory limits.

Inherent to all statistical evaluations are levels of uncertainty. That is, there will be a given probability that a gamma reading less than the designated action level could be measured within a grid that is contaminated. This situation is referred to as a "false negative". Conversely, there is also a given probability that a gamma measurement taken from an uncontaminated grid would exceed the action level. This situation is referred to as a "false positive".

It was recognized that the number of false positives and false negatives should be minimized to the extent practicable, given all of the restraints of the Radiological Correlation Program. However, to be conservative, a higher priority was placed on minimizing false negatives by determining action levels based on the lower prediction interval around the gamma-radium correlation data.

Statistics of gamma measurements

The counting statistics or the precision associated with the gamma measurements could have a major impact on the gamma-radium correlation. Therefore, considerable effort was made to improve the gamma counting statistics. The elements that were considered to improve the counting statistics include:

1. collimation of the detector by using shielding;

2. the use of a 2-inch thallium activated sodium iodide [NaI(Tl)] crystal in the gamma detector (typical μR meters use a 1-inch crystal); and

3. setting the detection threshold below 609 keV to eliminate scattered low energy environmental radiation.

3.3 Design Elements

Prior to the gamma-radium correlation, a series of preliminary field (or pilot scale) investigations were conducted. These studies were instituted as a result of unanswered questions that were raised by the Technical Considerations evaluation discussed in Section 3.2 above. The primary purpose of these pilot scale studies was to aid in the development or selection of equipment and procedures which would form the basic design elements, or framework, of the gamma-radium correlation. These investigations attempted to quantify, or at a minimum qualify, the variables which would effect the gamma-radium correlation so that, where possible, design solutions could be implemented to minimize the influence of these variables and reduce the overall variability of the correlation, thereby resulting in a more accurate and useful gamma-radium correlation. A summary of these preliminary investigations is provided below in Sections 3.3.1 through 3.3.4.

3.3.1 Determination of Site Specific Background

The NRC defines cleanup and release standards in terms of acceptable concentrations above background, therefore it is important that an understanding of background radionuclide concentrations be obtained. As required under 10 CFR 40 Appendix A Criterion 6(c), the requirements for cleanup of soils contaminated with by-product material, resulting from uranium milling, specifies acceptable levels of ^{226}Ra in surface soils to be 5 pCi/g above background, averaged over the top 15 cm of soil and 15 pCi/g above background averaged over 15 cm thick layers more than 15 cm below the surface.

In an effort to establish background in the vicinity of the Split Rock Mill Site, and to confirm the results of the 1987 REM survey discussed in Section 2.4.1, soil samples were taken at sixteen remote locations surrounding the site. The sampling locations were selected from areas outside of the large rock outcrops which surround the Tailing Impoundment to minimize the possibility of contamination.

A hand-held auger was used to collect a total of 21 soil samples from the 16 locations. At all of the locations, surface samples were collected at a depth of 0-6 inches. At five of the locations, subsurface samples were collected as well, at a depth of 6-12 inches. The sampling locations are shown in Figure 4.

The laboratory chosen to perform the analyses was Yankee Atomic Environmental Laboratory in Bolton, MA. All samples are currently being analyzed for ^{226}Ra, ^{230}Th and U-nat. Upon completion of these analyses, the resulting data will be compiled to determine the average background concentrations for the radionuclides of interest.

3.3.2 Shielding Studies

In designing the gamma-radium correlation study it was recognized that the effects of extraneous gamma radiation (radiation from sources other than the soil within the grid of interest), could result in gamma flux measurements which would not necessarily be representative of the soil within a given regulatory compliance grid. The sources of extraneous gamma radiation, commonly referred to as shine, include: granite rock outcrops, the Tailing Impoundment and scattered environmental radiation.

As discussed previously, a literature review was conducted to determine if information was available to aid in determining an appropriate shielding thickness and configuration which would limit the effects of shine. It was determined that the majority of information available was in the form of laboratory data generated using point source studies on individual isotopes, and very little information existed which addressed the effects of environmental conditions which would be better characterized as large flat-planer sources composed of multiple isotopes with a wide range of emitted gamma energies.

Since little information was available pertaining to effective shielding of environmental radiation, a series of field studies were conducted in May 1993, on the Sherwood Mill Site near Wellpinit, WA. These studies were used to determine the size and configuration of lead shielding that would reduce the effects of shine and thus improve the gamma-radium correlation by obtaining gamma measurements which were representative of the soil within the compliance grid being measured.

The basic geometry of the shielding tested could be characterized as annuli of varying thickness and heights that were placed around the cylindrical gamma detection probe. Shielding annulus thickness of 1, 1.5, 1.75, and 2 inches were evaluated at heights of 1, 2, 3, 3.5, and 4 inches.

Each shielding configuration was tested at three locations which were selected to be representative of: 1) areas with insignificant amounts of shine; 2) areas of moderate shine; and 3) areas of high shine. A detailed description of the shielding studies is given in the Sherwood Radiological Verification Program (WNI, 1994). A copy of Appendix D from this report is provided in Attachment 2.

The result of the shielding studies indicated that a shielding configuration of 1.75-inches thick and 3-inches high, as shown in Figure 5, provided significantly better shielding than a shield of lesser thickness or height. Shields with dimensions greater than 1.75-inches thick and 3-inches high do not result in significant additional shine reduction.

3.3.3 Soil Sample Adequacy

The basic design of the gamma-radium correlation study consisted of correlating the external gamma radiation from 10m x 10m regulatory compliance grids to the laboratory measured ^{226}Ra concentrations representative of those grids. Therefore, to reduce the variability of the correlation, the soil samples taken from each grid would need to provide the best possible representation of the average ^{226}Ra concentration within each grid.

One common practice for obtaining samples that are representative of a given area is the collection of several samples that are composited to represent an average condition. The Manual for Conducting Radiological Surveys in Support of License Termination (NUREG/CR-5849, 1992) suggests the collection of 4 soil samples to represent constituent levels in a 10m x 10m grid. The general guideline given in NUREG/CR-5849 however, does not provide any assurance that the statistically "true" average radium concentration would be accurately represented by using only 4 samples. Therefore, a soil sample adequacy study was conducted to determine the number of individual samples that would require compositing to provide a reasonable level of assurance that the composite accurately represented the average radium in soil concentrations within a 10m x 10m grid.

Five 10m x 10m grids were selected randomly for this study in order to minimize any chance of biasing the results. The grid locations are shown in Figure 6.

Twenty surface gamma readings were taken within each grid using a 2-minute counting time. The gamma detector was placed on the ground surface and shielded by the 3 inch high, 1.75 inch thick lead shield. The location of each reading was selected randomly with no criteria other than an even distribution of readings across each 10m x 10m grid.

The data from each grid were analyzed statistically using a sample adequacy test which determines if, based on the sample standard deviation, the number of samples in a sample set are sufficient to accurately determine the mean of the population at a specified confidence interval. The sample adequacy test used is expressed as:

$$n_b = \left[\frac{tS_x}{kx}\right]^2$$

Where:

- n_b = the number of samples required for sample adequacy;
- t = the t statistic at the 90% confidence level;
- S_x = the standard deviation of the sample population;
- k = 0.1 for ±10% variability about the mean, and;
- x = the sample mean.

Based on these analyses, it was determined that a minimum of 11 individual cores should be composited from an individual grid to adequately represent the average radionuclide concentrations within a grid.

It should be noted that the methods, as described above, which were used to determine sample adequacy (i.e., gamma scintillation) resulted in sample adequacy determination of gamma emitting radionuclides only. For the purposes of this study, it was assumed that the variability observed in the major gamma emitting radionuclide, ^{226}Ra, would be representative of the variability exhibited by other radionuclides, i.e., U-nat and ^{230}Th.

3.3.4 Soil Moisture Content

The effect of soil moisture content on the measurement of external gamma radiation is neither a well known nor a well documented phenomenon. It is typically assumed that increased moisture content in soil results in attenuation of external gamma radiation. Some literature (NCRP 50, 1976) indicates that the attenuation of gamma radiation is primarily a function of the increasing soil density associated with increasing moisture content. Because the soil at the Split Rock site are characteristically sandy, the change in density due to the range of moisture contents that could exist can be expected to vary by a maximum of approximately 10%. This small difference is typically considered insignificant (Bendix Report, USDOE, 1984). However, no empirical field data relating to this issue could be found, leaving the relative magnitude of gamma attenuation unquantified.

In designing the Sherwood Project gamma-radium correlation study, it was recognized that if the attenuation of external gamma radiation as a result of soil moisture content was significant, procedural controls for conducting gamma measurements would need to be instituted to minimize the potential of accepting significantly attenuated gamma readings as real values (i.e., false negatives). Therefore, a series of field tests were conducted to quantify the results of varying soil moisture contents on external gamma radiation fluxes to aid in designing appropriate controls for conducting gamma surveys.

In designing the study, it was recognized that if procedural controls needed to be implemented, it would be easier and more cost effective to base those procedures on precipitation depth rather than actual moisture content since precipitation depth is a simpler parameter to measure in the field. The study was conducted by incrementally adding "precipitation" to a 10m x 10m grid by multiple passes of a water truck. Precipitation depths of 0.00, 0.10, 0.25, 0.50, 1.00, and 2.00 inches were incrementally added to the grid and gamma measurements were taken subsequent to each "precipitation event".

As discussed in the Sherwood Project Radiological Verification Program (WNI, 1994) the results of the soil moisture content tests indicated that, while there might be a general downward trend in external gamma radiation measurements with increasing precipitation quantities, the relationship was not well defined. In fact, in some cases gamma readings were observed to increase with additional precipitation depth. Further, the variability that was observed was typically within the counting error statistics at the 95% confidence level. Therefore, these results indicated that precipitation would not impact the gamma-radium correlation or final verification surveying, and no procedural controls would be required to restrict external gamma radiation surveys following normal precipitation events. A copy of Appendix F to the Sherwood Project Radiological Verification Program is provided in Attachment 3 to this report.

3.4 Gamma-Radium Correlation Study

The purpose of the gamma-radium correlation study was to determine the optimum methods and procedures for conducting radiological surveys for construction monitoring and for final verification of radiological compliance with applicable regulatory requirements. To accomplish this purpose, the following objectives were established:

1. To define effective techniques for determining the average ^{226}Ra content in the soils of a 10m x 10m grid by measuring external gamma radiation. This was accomplished by investigating several methods of measuring external gamma radiation and determining the statistical relationship between these measurements and the actual average ^{226}Ra concentrations as determined by laboratory analyses.

2. To determine appropriate action levels for conducting radiological surveys for cleanup monitoring and final verification surveying.

3. To develop general procedures for land surveying, soil sampling, soil sample handling, soil sample splitting, and other tasks associated with cleanup monitoring and final verification.

The gamma-radium correlation study began in August 1995. The study consists of external gamma radiation measurements which will be correlated with soil ^{226}Ra content for the 10m x 10m study grids.

3.4.1 Gamma Measurements

Two alternative gamma measurement techniques were used to establish gamma-radium correlations: 1) the integrated method; and 2) the composite method.

Integrated method

The integrated counting method consisted of a timed gamma count that was performed as a technician walked over each 10m x 10m grid for 150 seconds. The timed count was initiated at one corner of the grid and the technician walked over the grid in the pattern depicted in Figure 7, until the count time expired. The gamma detection probe was shielded using the 1.75-inch thick, 3-inch high lead shield (discussed in Section 3.3.2) which was mounted on a backpack frame. Following each grid count, the grid identification and the total gamma count were electronically stored in the data logger and subsequently transferred to an on-site computer for storage.

Composite method

The second technique developed and tested was a soil composite count. A measurement of external gamma radiation was taken on a composite soil sample (the same soil composite from which an aliquot was taken for laboratory analyses). This procedure was performed by placing the gamma detection probe, shielded with a 3-inch high, 1.75-inch thick lead shield, on the surface of the composite soil sample that has been placed in a 5-gallon bucket, as depicted in Figure 8.

The composite counting method is intended as a gamma surveying alternative to the integrated counting technique. This method will be used in situations where the integrated technique is found to be inappropriate due to extremely high shine, or in grids where the integrated technique is impractical due to steep or varying terrain, or dense vegetation. In such cases, a soil sample can be taken from the grid in question and removed to a remote location.

3.4.2 Soil Analyses

Soil samples were collected from each of the correlation grids where external gamma readings were taken. These soil samples are currently being analyzed for ^{226}Ra, ^{230}Th and U-nat.

The ^{226}Ra results will be used in conjunction with the gamma measurements to determine the gamma-radium correlation.

The ^{230}Th and U-nat analyses were performed to determine if an association exists between ^{230}Th and ^{226}Ra, as well as between U-nat and ^{226}Ra. An association means that if ^{226}Ra (which can be detected by a gamma survey) is cleaned up, ^{230}Th and U-nat (which cannot be detected by a gamma survey) are also cleaned up. Upon completion of the analyses, a determination will be made as to whether or not all grids with ^{230}Th and U-nat concentrations above the regulatory limit (as determined by the equation given in Section 1.0) are associated with ^{226}Ra concentrations which are above the regulatory limit.

As discussed previously, it is expected that an association can be demonstrated for all areas to be remediated and verified.

3.4.3 Gamma-Radium Correlations

Statistical analyses of the data obtained by the 2 gamma measurement techniques will be performed, using a computer application statistical package, to determine a correlation between external gamma radiation and soil radium content at the 90% confidence level.

Based on the results of the Sherwood Project correlation program it was determined that the gamma-radium correlations obtained using counting times of 150 seconds for the integrated method and 120 seconds for the composite method resulted in acceptable correlations, and little to no improvement in correlation results was observed by longer counting times. Therefore, the same counting times were used to obtain the data which will be used to develop the Split Rock site correlation.

3.5 Conclusions

The final conclusion of the Split Rock radiological correlation program will be the statistical determination of gamma survey action limits to be used during cleanup and final verification. These action limits will be developed based on the linear regression analyses of gamma readings vs. laboratory analyses on each of the correlation grids. The action limit will be established as the gamma reading corresponding a soil concentration of 5 pCi/g above background as determined by the lower 90% prediction limit of the relationship. It is currently anticipated that the laboratory results will become available early in 1996, at which time a detailed discussion of both the scoping survey and the gamma-radium correlation will be submitted.

4.0 QA/QC PROCEDURES

The fifth data quality objective of the radiological verification program is the periodic performance checking on both field survey equipment and laboratory analytic results to ensure continued data quality. As such, the overall success of the radiological verification program is largely dependent upon reliable QA/QC procedures.

4.1 Field Instrumentation

All gamma survey instrumentation used in the field will be initially and periodically checked to insure continuous reliable performance.

Prior to the beginning of each field season and as appropriate, all field instrumentation will be checked, cleaned, tested, and calibrated by the manufacturer.

During the course of the survey work, instruments will be calibrated on a daily basis using a reference check source of ^{137}Cs maintained in constant geometry. Prior to each working day, at midday, and at the end of the day, all instruments in use will be performance checked against a pitchblende uranium ore source maintained in constant geometry. Results of the performance checks will be tracked using control charts to detect any systematic drifts in the data that, over time, may lead to erroneous conclusions. Additionally, the instruments will be normalized such that each instrument will provide similar readings.

4.2 Laboratory Results

Extensive QA/QC of laboratory results will be performed throughout the course of verification sample analyses. The program will consist of internal laboratory controls such as splits, duplicates, blanks, and spikes.

In addition to internal QA/QC of analytic results, WNI will be administering a performance based quality program which is discussed below.

4.2.1 Performance Based Quality Assurance of Laboratory Analyses

Historically, many QA/QC programs for radiochemical analyses of soil samples, as well as other matrices, have been attempted using duplicate analyses of samples. There are essentially two methods for performing duplicate sample analyses. The first method is inter-laboratory comparison which involves the analysis of samples among two or more laboratories. The second method is intra-laboratory comparison which involves the multiple analysis of samples within a single laboratory.

In cases where an inter-laboratory comparison is used, if the results from two or more laboratories compare favorably, then there is some assurance that the reported results are both precise and accurate. However, If two laboratories report significantly different results on any given sample, it is difficult to determine which laboratory has reported correctly, and a costly search for both precision and accuracy typically results.

In cases where intra-laboratory comparison is used, if the results on a single sample compare favorably, the only assurance is of precision, i.e., reproducibility, with no assurance of accuracy.

Therefore, it can be seen that the use of inter-laboratory or intra-laboratory comparisons are, by themselves, inadequate to effectively evaluate the quality of laboratory results. However, by combining aspects of both methods, a hybrid QA/QC procedure for assessing laboratory results was developed around the concepts of the Standard Reference Sample (SRS) and the Performance Evaluation Sample (PES).

The principal strategy of this QA/QC plan can be stated as follows: if a laboratory can initially demonstrate acceptable analytic precision and accuracy for preset data quality objectives, then, an acceptance criterion based on analytic precision alone can be established for analytical results on subsequent samples.

4.2.1.1 Standard Reference and Performance Evaluation Samples

A SRS is a prepared sample for which the constituent concentrations have been determined and certified as accurate by a recognized authority such as the National Institute of Standards and Technology (NIST). The use of a SRS is essentially an inter-laboratory comparison between a laboratory of interest and the certifying authority. As stated previously, the typical problem with inter-laboratory comparisons is that if multiple laboratories return results that deviate significantly from each other, there is no easy way to determine which set of data is accurate. This problem is eliminated by using a SRS since the actual analyte concentrations are known and certified as accurate.

A PES is a prepared sample for which the constituent concentrations are not certified as accurate. However, the concentrations are known to a high degree of confidence within statistical limits based on preliminary characterization of the sample by a laboratory that has demonstrated an ability to produce both precise and accurate results on a SRS. The use of the PES is analogous to the utilization of a spike sample in QA/QC programs for water quality analysis. The PES is used on an ongoing basis and submitted to the laboratory as a double blind sample with groups of 10 to 20 other samples for analysis. If the reported results on a given PES aliquot are within the statistical limits of the characterization, the analyses of the accompanying samples is accepted as accurate. However, if the analyses on the PES aliquot are not within the statistical limits, alternative procedures are followed to determine whether the aliquot was outside of the limits due to laboratory error, or the aliquot was simply outside of the established confidence limits as could be expected statistically.

The question may be asked: why use a PES if a SRS is available. The answer lies in two parts. First a SRS is typically expensive and therefore cost prohibitive to use on an ongoing basis for continual QC monitoring on projects where several thousand samples are processed. Second a SRS is typically a highly processed substance which has been prepared to a very fine size fraction for purposes of homogeneity. For blind QC this is not practical because, other than silts, no soil will be visually similar to a SRS.

4.2.1.2 Plan Overview

The QA plan for laboratory analyses is a phased program that ultimately results in the ability to evaluate and defend both the precision and accuracy of laboratory results of radiochemical analyses of soil samples.

The first phase of the plan was the prequalification of laboratory methods and results. This was accomplished by a review of laboratory procedures followed by the submission of a SRS sample. Results of the SRS sample were reviewed to determine if the reported concentrations were consistent with the certified concentrations.

The second phase of the plan was the preparation and characterization of the PES. During this phase a soil sample, consisting of approximately 1.1 tons of material, was collected and aliquots of the material were tested to provide sufficient data to determine the concentration distribution of the radionuclides of interest within a given statistical confidence.

The third phase of the plan was the periodic submission of PES aliquots with the normal project work load for periodic QC of analytic results.

4.2.1.3 Phase I: Laboratory Prequalification

The first phase of the QA/QC program was the prequalification of laboratory methods and results. Yankee Atomic Environmental Laboratory (YAEL) was selected as the preferred laboratory to characterize the PES, and a review of the laboratories methods was conducted to determine the appropriateness of the analyses. Following the method review, a SRS sample was submitted to YAEL to determine if the laboratory employed the methods reliably and was capable of producing both precise and accurate results. The SRS was approximately a 500 gram sample of NIST standard reference material 4353 also known as Rocky Flats Soil Number 1 which was submitted blindly to the laboratory under the sample identification "silts". When the analyses on the SRS were reviewed, it was determined that the 2σ uncertainty of the analyses overlapped with the 2σ uncertainty of the sample certification for all analytes. Therefore, YAEL was confirmed as the selected laboratory and characterization of the PES commenced.

4.2.1.4 Phase II: Sample Preparation and Characterization

Material selection

As discussed previously, the ^{226}Ra concentrations can not exceed background by more than 5 pCi/g in the top 15 cm of soil, or 15 pCi/g in 15 cm thick layers below the top 15 cm layer

In addition to ^{226}Ra, the cleanup and verification plan includes ^{230}Th and total uranium as well. Therefore, it was determined that the PES should contain elevated levels of these constituents. The most reasonable location for obtaining a sample having the desired ^{226}Ra concentration and elevated ^{230}Th and uranium was in the vicinity of the former ore stockpiles. As such, a sample of soil/ore mixture could be obtained, based on gamma readings, which would have the appropriate ^{226}Ra concentrations and, because the elevated ^{226}Ra was due to ore, it could be expected that the ^{230}Th and uranium would be in equilibrium thus resulting in a sample which was elevated in regard to all three analytes of interest.

Sample Preparation

The PES program was designed to produce 1024 aliquots of approximately 500 to 1000 grams. As such, approximately 1024 kg, or 1.1 tons, of soil was required.

The exact location to be excavated for the PES was determined based on gamma surveys using the procedures described in this report. Based on these gamma surveys, a 10 x 10 meter grid was staked and approximately 1.1 tons of soil was sampled from the top 6 inches of the grid using soil sampling augers.

Possibly the most unique aspect of the PES preparation relative to similar QC type samples was that the sample was never ground or pulverized to a fine size fraction. The primary purpose for sample milling is to achieve a relatively high degree of homogeneity throughout the sample. However, under the provisions of this plan, it was deemed that the blind quality of an unpulverized sample outweighed the risk of excessive variability. Given that no data was available regarding the uniformity of an unpulverized sample, a calculated risk was taken and preparation of the PES proceeded with homogenization by mixing alone.

The PES was initially homogenized for 4 hours using a concrete mixing truck. After the first mix, the PES was split, using a riffle type splitter, into 2 halves, each weighing approximately 512 kg. Each half was then mixed again for 2 hours, and split in half resulting in 4 samples each weighing approximately 256 kg. Mixing and splitting continued from this point using conventional portable cement mixers until the sample had been split 2^{10} times resulting in 1,024 samples each with a weight of approximately 1000 g. Each sample was bagged in a 1 gallon zip-lock freezer bag and labeled with an identification number.

Laboratory preparation and analysis

Twenty eight aliquots of the PES were submitted to Yankee Atomic Environmental Laboratory for characterization of the sample. Approximately 800 g of each aliquot was uniformly blended and split into two sample aliquots; 30 grams for the isotopic uranium and thorium analyses, and 750 grams for ^{226}Ra by gamma-ray spectrometric analysis.

4.2.1.5 Statistical Analyses

As discussed previously, the PES was prepared to visually resemble typical soil samples taken for verification of radiological compliance. A PES aliquot is submitted with every 10 to 20 verification samples. If the result of the analysis on the PES is within the statistical limits of acceptability, the analyses on the accompanying verification samples is accepted as accurate.

The acceptance control limits for the PES were established using the 5 and 95 percentile parameters of the PES characterization data. Percentile parameters were used to establish the control limits because no assumptions regarding the underlying data distribution was necessary. Such would not be the case if parametric descriptive statistics were applied which require a normal distribution. It must be recognized that the expected success rate of passing the QC test, assuming that there have been no changes in the analytical precision and accuracy, is 90%. Therefore there is a 10% probability of failing the QC test even if the analyses on a particular aliquot are accurate. In recognition of this fact, procedures for identifying whether QC failures were due to analytic error, or PES variability were designed.

5.0 CLEANUP MONITORING AND VERIFICATION PROCEDURES

The procedures described in this section will be used to identify areas of contamination during cleanup activities, and to provide final verification of radiological compliance necessary to release the Split Rock Site for unrestricted use.

This section details the cleanup criteria that will be observed in making any compliance determinations, the establishment of a grid system for tracking and documenting progress, and the definition of areas.

The area types discussed in this section are defined by the nature and probability of contamination. Some of the area types described may not be used during the final verification survey, however they are discussed here in the event that the need for defining some localized areas in such ways may arise.

5.1 Cleanup Criteria

The cleanup criteria for the Split Rock site are given in 10 CFR 40 Appendix A Criterion 6(c) which states that, on a 100 square meter basis, concentrations of ^{226}Ra may not exceed 5 pCi/g above background in the top 15 cm of soil, or 15 pCi/g above background in 15 cm thick layers below the top 15 cm layer. The cleanup methods and procedures for Split Rock Site have been designed to meet these requirements, as well as the guideline vales of 10 pCi/g U-nat with daughters in equilibrium or 35 pCi/g U-nat without daughters present as discussed in 46 FR 52061.

In addition, this plan addresses elevated levels of ^{230}Th to ensure that, over the 1000 year design life, ^{226}Ra concentrations do not exceed the stated criteria as a result of ingrowth of ^{226}Ra from ^{230}Th. This will be accomplished on a grid-by-grid basis by calculating the ^{226}Ra activity at 1000 years resulting from ^{230}Th, and adding that value to the present ^{226}Ra activity. If this summation is less than the ^{226}Ra standard, the grid will be accepted as "in compliance".

Because these standards are a function of background radionuclide concentrations, WNI is currently administrating a site scoping program which has been designed to determine the background constituent levels at the Split Rock Site. Upon completion of this program, specific numeric values will be established as cleanup standard.

Compliance with the cleanup standards will be demonstrated primarily by gamma survey techniques. As previously discussed, based on process knowledge, all areas where contamination could be out of equilibrium relative to the uranium series (i.e., mill process areas, operational spill areas, process ponds, etc.) are within the reclamation cover system boundary. Therefore the primary mode of contamination outside of the reclamation cover system will be disbursement of exposed tailing or crushed ore via wind erosion. As such, it is expected that cleanup of soils having elevated ^{226}Ra by gamma surveying techniques will necessitate cleanup of U-nat and ^{230}Th as well.

To provide assurance that the gamma surveys adequately identify areas above the cleanup standards, confirmatory soil samples will be taken to insure that all of the radionuclides of concern are remediated.

Confirmatory soil samples will be collected and analyzed for U-nat, ^{230}Th, and ^{226}Ra. Confirmation samples will be obtained by compositing individual cores taken from 10m x 10m compliance grids. These cores will be approximately 3-inches in diameter and 6-inches deep. Only samples from 0-6 inches will be taken. Assuming that the subsurface samples taken during the scoping survey show no contamination at depth, subsurface samples will not be required because the constituents of interest are readily absorbed in soil and since any contamination would originate at the ground surface, the concentrations of contaminants will be greater near the surface and will decrease with depth. Therefore, if the surface sample (0-6 inches) is not contaminated, the soil below 6 inches will not be contaminated. Therefore, soil sampling in only the surficial 0-6 inch soil layer will be used to evaluate regulatory compliance.

5.2 Establishment of Area Grid Systems

The importance of collecting representative and reproducible data cannot be overstated. To ensure consistency within the cleanup and verification program, all work conducted under this section will be carried out in accordance with applicable WNI SOPs as presented in Attachment 1 to this report.

A 10m x 10m grid system will be established across all primary and secondary areas. Similarly, a 50m x 50m grid system will be established across all Tertiary grids. Each grid point will receive a unique identification number, and the northing and easting of each grid point will be determined. Grid points will be staked as necessary using land surveying procedures in accordance with WNI JCSOP-RS100 to guide cleanup monitoring and final verification.

5.3 Primary-1 Areas

Primary-1 (P1) areas are defined as areas of known or suspected contamination (affected areas) where there exists an association between elevated levels of ^{226}Ra and elevated levels of U-nat and ^{230}Th. As such, P1 areas can be cleaned up and verified using gamma surveying techniques. Therefore, the results of the gamma-radium correlation study will be used to establish action limits for cleanup monitoring and final verification of radiological compliance.

Cleanup monitoring gamma surveys will be conducted in all 10m x 10m P1 grids using the 150 second integrated count method in accordance with WNI JCSOP-RS50. If performance of the integrated count is precluded due to steep terrain, dense vegetation, or high shine, the composite counting method will be performed, in accordance with WNI JCSOP-RS80, on a representative soil sample obtained from the grid under consideration.

Gamma surveys will be conducted with a Ludlum Model 2350 data logger and a Ludlum Model 44-10 high energy gamma detector. The gamma detector will be shielded with a 1.75-inch thick, 3-inch high lead shield.

5.3.1 Compliance Criteria

Cleanup monitoring surveys will be used to establish areas to be remediated by soil excavation based on action levels which will be determined from the gamma-radium correlation.

Gamma survey data will be electronically logged in the data logger when the integrated or composite count time expires. These data will be subsequently down loaded to a computer for review. Upon reviewing the data, a determination as to the status of each grid will be made. If it is determined that the gamma survey result on a given grid is below the applicable action level, the grid will be designated "verified" and the cleanup monitoring survey will be documented as final verification of radiological compliance in accordance with Section 5.3.4.

5.3.2 Non-Conformity Actions

If review of gamma survey data indicates that the gamma survey measurement on a given grid is above the applicable action level set forth in Section 5.3.1, one of the following actions will be taken at the discretion of WNI:

1. further excavation followed by integrated gamma measurement; or

2. if, for a given grid, it is believed that the gamma measurement is above the applicable action level as a result of a physical condition such as shine, a composite count may be conducted in accordance with WNI JCSOP-RS80 in lieu of further integrated measurements; or

3. if, for a given grid, it is believed that the gamma measurement is above the applicable action level due to interference of natural gamma sources, within the soil matrix, a soil sample may be taken in accordance with Section 5.3.3 in lieu of further gamma surveys; or

4. if, for a given grid, it is believed that gamma measurements taken by either the integrated count method, the composite count method, or laboratory analyses on a corresponding soil sample exceed the applicable action level as a result of natural background concentrations of 226Ra or other radionuclides at concentrations greater than those used to establish the

action level, WNI may follow the provisions of Section 5.7 and demonstrate compliance based on the performance criteria detailed therein.

5.3.3 Confirmatory Soil Sampling

Confirmatory surface soil samples will be taken from 0-6 inches in 10% of the P1 grids verified by gamma measurement. Soil samples will be collected in accordance with WNI JCSOP-RS20, and if required, split in accordance with WNI JCSOP-RS40. Soil sample analyses will be conducted by a laboratory, selected by WNI based on demonstrated experience and reliability in conducting radiochemical analyses on environmental soil samples.

Confirmatory soil samples will be accepted as validation of radiological compliance based on the concentrations of ^{226}Ra, ^{230}Th, and U-nat reported by the analytical laboratory. For the surface 0-6 inch soil layer, three necessary conditions must be satisfied to demonstrate validation:

1. The sum of the reported 226Ra concentration plus the analytic counting error at the 95% confidence limit must not exceed 5 pCi/g above background;

2. The sum of the reported U-nat concentration plus the analytic counting error at the 95% confidence limit must not exceed 10 pCi/g above background; and

3. The reported 230Th concentration must not exceed A(Th,0) as calculated by the following equation:

$$A_{(Th,0)} = \frac{A_{(Ra,t)} - A_{(Ra,0)}e^{-\lambda t}}{1 - e^{-\lambda t}}$$

Where:

$A_{(Th,0)}$ = reported ^{230}Th concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,0)}$ = reported ^{226}Ra concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,t)}$ = 5 pCi/g above background;

t = 1000 years; and

λ = the decay constant for ^{226}Ra = 4.32E-4 yrs^{-1}

If all of the above conditions are satisfied, the grid will be designated "validated" and documented in accordance with Section 5.3.4.

If greater than 5% of the confirmatory soil sampling grids indicate that condition 1 is satisfied while conditions 2 and/or 3 are not satisfied, then P1 soil sample data will be evaluated to delineate areas requiring more extensive soil sampling due to a lack of association between ^{226}Ra and U-nat and ^{230}Th.

5.3.4 Documentation

All cleanup surveys, conducted by any method detailed in Section 5.3, will be recorded in cleanup/verification survey documents. Further, all documentation as required by

WNI JCSOP-RS20 or RS40 will be attached and /or cross referenced to cleanup/verification survey documents as appropriate.

When radiological compliance for a given grid has been demonstrated by any method detailed in Section 5.3.1, the grid will be designated "verified" and documented.

When, in accordance with Section 5.3.3, validation of gamma survey measurements has been demonstrated by laboratory analyses of a soil sample taken from a corresponding grid, the grid will be designated "validated" and documented.

All documentation will be retained and will constitute a portion of the permanent project record.

5.4 Primary-2 Areas

Primary-2 (P2) areas are defined as areas of known or suspected contamination (affected areas) where there exists no association between elevated levels of ^{226}Ra and elevated levels of U-nat and ^{230}Th. As such, P2 areas can not be cleaned up and verified using gamma surveying techniques. Therefore, all cleanup monitoring and final radiological verification will be accomplished by soil sample analyses.

Cleanup monitoring and verification soil samples will be collected in all 10m x 10m P2 grids in accordance with WNI JCSOP-RS20, and if required, split in accordance with WNI JCSOP-RS40. Soil sample analyses will be conducted by a laboratory, selected by WNI, based on demonstrated experience and reliability in conducting radiochemical analyses on environmental soil samples.

5.4.1 Compliance Criteria

Radiological compliance in each P2 grid will be determined based on the concentrations of U-nat, ^{230}Th, and ^{226}Ra as reported by the analytical laboratory for the corresponding soil sample. Upon reviewing analytical results, a determination as to the status of each grid will be made. For the surface 0-6 inch soil layer, three necessary conditions must be satisfied to demonstrate compliance:

1. The sum of the reported 226Ra concentration plus the analytic counting error at the 95% confidence limit must not exceed 5 pCi/g above background;

2. The sum of the reported U-nat concentration plus the analytic counting error at the 95% confidence limit must not exceed 10 pCi/g above background; and

3. The reported 230Th concentration must not exceed A(Th,0) as calculated by the following equation:

$$A_{(Th,0)} = \frac{A_{(Ra,t)} - A_{(Ra,0)}e^{-\lambda t}}{1 - e^{-\lambda t}}$$

Where:

$A_{(Th,0)}$ = reported ^{230}Th concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,0)}$	=	reported ^{226}Ra concentration plus the analytic counting error at the 95% confidence limit;
$A_{(Ra,t)}$	=	5 pCi/g above background;
t	=	1000 years; and
λ	=	the decay constant for ^{226}Ra = 4.32E-4 yrs^{-1}

If all of the above conditions are satisfied, the grid will be designated "validated" and documented in accordance with Section 5.4.3.

5.4.2 Non-Conformity Actions

If the analytic results for a soil sample in a given grid exceed the applicable limit as set forth by Section 5.4.1, one of the following actions will be taken at the discretion of WNI:

1. further excavation and subsequent soil sampling and analyses; or

2. if, for a given grid, it is believed that the laboratory analytic results on a corresponding soil sample exceed the applicable limits as a result of natural background concentrations of U-nat, 230Th, or 226Ra at concentrations greater than those used to establish the limit, WNI may follow the provisions of Section 5.7 and demonstrate compliance based on the performance criteria detailed therein.

5.4.3 Documentation

All soil samples taken in P2 areas for the purposes of cleanup monitoring or final verification of radiological compliance will be recorded in cleanup/verification survey documents. Further, all documentation as required by WNI JCSOP-RS20 or RS40, and all original laboratory reports will be attached and/or cross referenced to the cleanup/verification survey documents as appropriate.

When radiological compliance for a given grid has been demonstrated by any method detailed in Section 5.4.1, the grid will be designated "verified" and documented.

All documentation will be retained and will constitute a portion of the permanent project record.

5.5 Secondary Areas

Secondary (S) areas are defined as areas which are not believed to be contaminated (unaffected areas). They are placed around the perimeter of P1 and P2 areas, to insure that all contamination has been detected and cleaned up. Secondary areas are further defined as areas where there exists an association between elevated levels of ^{226}Ra and elevated levels of U-nat and ^{230}Th. As such, S areas can be cleaned up and verified using gamma surveying techniques. Therefore, the results of the gamma-radium correlation study will be used to establish action limits for cleanup monitoring and final verification of radiological compliance in these areas.

Cleanup monitoring gamma surveys will be conducted in all 10m x 10m S grids using the 150 second integrated count method in accordance with WNI JCSOP-RS50. If performance of the integrated count is precluded due to steep terrain, dense vegetation, or high shine, the composite counting method will be performed, in accordance with WNI JCSOP-RS80, on a representative soil sample obtained from the grid under consideration.

Gamma surveys will be conducted with a Ludlum Model 2350 data logger and a Ludlum Model 44-10 high energy gamma detector. The gamma detector will be shielded with a 1.75-inch thick, 3-inch high lead shield.

5.5.1 Compliance Criteria

Cleanup monitoring surveys will be used to establish areas to be remediated by soil excavation based on action levels which will be determined from the gamma-radium correlation.

Gamma survey data will be electronically logged in the data logger when the integrated or composite count time expires. These data will be subsequently down loaded to a computer for review. Upon reviewing the data, a determination as to the status of each grid will be made. If it is determined that the gamma survey result on a given grid is below the applicable action level, the grid will be designated "verified" and the cleanup monitoring survey will be documented as final verification of radiological compliance in accordance with Section 5.5.4.

5.5.2 Non-Conformity Actions

If the gamma survey results for a given secondary grid are above the applicable limit, as set forth by Section 5.5.1, one of the following actions will be taken at the discretion of WNI:

1. the grid may be reclassified as a P1 area for subsequent cleanup and verification; or

2. if, for a given grid, it is believed that the gamma measurement is above the applicable action level as a result of a physical condition such as shine, a composite count may be conducted in accordance with WNI JCSOP-RS80 in lieu of further integrated measurements; or

3. if, for a given grid, it is believed that the gamma measurement is above the applicable action level due to interference of natural gamma sources, within the soil matrix, a soil sample may be taken in accordance with Section 5.5.3 in lieu of further gamma surveys; or

4. if, for a given grid, it is believed that gamma measurements, taken by either the integrated count, method the composite count method or laboratory analyses on a corresponding soil sample, are above the applicable action level as a result of natural background concentrations of 226Ra or other radionuclides at a higher concentration than those used to establish the action level, WNI may follow the provisions of Section 5.7 and demonstrate compliance based on the performance criteria detailed therein.

5.5.3 Confirmatory Soil Sampling

Confirmatory soil samples will be taken in the 0-6 inch surface soil layer in 5% of the secondary grids verified by gamma measurement. Soil samples will be collected in accordance with WNI JCSOP-RS20, and if required, split in accordance with WNI JCSOP-RS40. Soil sample analyses will be conducted by a laboratory, selected by WNI, based on demonstrated experience and reliability in conducting radiochemical analyses on environmental soil samples.

Confirmatory soil samples will be accepted as validation of radiological compliance based on the concentrations of U-nat, ^{230}Th, and ^{226}Ra reported by the analytical laboratory. For the surface 0-6 inch soil layer, three necessary conditions must be satisfied to demonstrate validation:

1. The sum of the reported ^{226}Ra concentration plus the analytic counting error at the 95% confidence limit must not exceed 5 pCi/g above background;

2. The sum of the reported U-nat concentration plus the analytic counting error at the 95% confidence limit must not exceed 10 pCi/g above background; and

3. The reported 230Th concentration must not exceed A(Th,0) as calculated by the following equation:

$$A_{(Th,0)} = \frac{A_{(Ra,t)} - A_{(Ra,0)}e^{-\lambda t}}{1 - e^{-\lambda t}}$$

Where:

$A_{(Th,0)}$ = reported ^{230}Th concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,0)}$ = reported ^{226}Ra concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,t)}$ = 5 pCi/g above background;

t = 1000 years; and

λ = the decay constant for ^{226}Ra = 4.32E-4 yrs^{-1}

If all of the above conditions are satisfied, the grid will be designated "validated" and documented in accordance with Section 5.5.4.

If greater than 5% of the confirmatory soil sampling grids indicate that condition 1 is satisfied while conditions 2 and/or 3 are not satisfied, then soil sample data will be evaluated to delineate areas requiring more extensive soil sampling due to a lack of association between ^{226}Ra and U-nat and ^{230}Th.

5.5.4 Documentation

All cleanup surveys, conducted by any method detailed in Section 5.5, will be recorded in cleanup/verification survey documents. Further, all documentation, as required by WNI JCSOP-RS20 or RS40 will be attached and/or cross referenced to cleanup/verification survey documents as appropriate.

When radiological compliance for a given grid has been demonstrated by any method detailed in Section 5.5.1, the grid will be designated "verified" and documented.

When, in accordance with Section 5.5.3, validation of gamma survey measurements has been demonstrated by laboratory analyses of a soil sample taken from a corresponding grid, the grid will be designated "validated" and documented.

All documentation will be retained and will constitute a portion of the permanent project record.

5.6 Tertiary Areas

Tertiary (T) areas are defined as areas having a low probability of contamination and no evidence to indicate contamination exists (unaffected areas). Tertiary areas are further defined as areas where there exists an association between elevated levels of ^{226}Ra and elevated levels of U-nat and ^{230}Th. As such, T areas can be cleaned up and verified using gamma surveying techniques. Therefore, the results of the gamma-radium correlation study will be used to establish action limits for cleanup monitoring and final verification of radiological compliance in these areas.

Cleanup monitoring gamma surveys will be conducted within 10m x 10m grids situated at the intersection points of the 50m x 50m tertiary grid lines. Gamma surveys will be conducted using the 150 second integrated count method in accordance with WNI JCSOP-RS50. If performance of the integrated count is precluded due to steep terrain, dense vegetation, or high shine, the composite counting method will be performed, in accordance with WNI JCSOP-RS80, on a representative soil sample obtained from the grid under consideration.

Gamma surveys will be conducted with a Ludlum Model 2350 data logger and a Ludlum Model 44-10 high energy gamma detector. The gamma detector will be shielded with a 1.75-inch thick, 3-inch high lead shield.

5.6.1 Compliance Criteria

Cleanup monitoring surveys will be used to establish areas to be remediated by soil excavation based on action levels which will be determined from the gamma-radium correlation.

Gamma survey data will be electronically logged in the data logger when the integrated or composite count time expires. These data will be subsequently down loaded to a computer for review. Upon reviewing the data, a determination as to the status of each grid will be made. If it is determined that the gamma survey result on a given grid is below the applicable action level, the grid will be designated "verified" and the cleanup monitoring survey will be documented as final verification of radiological compliance in accordance with Section 5.6.4.

5.6.2 Non-Conformity Actions

If the gamma survey results for a given tertiary grid are above the applicable limit, as set forth by Section 5.6.1, one of the following actions will be taken at the discretion of WNI:

1. the area of potential contamination may be determined and reclassified as a P1 area with a 10 m (1 grid) buffer zone of S grids outside of the established area of contamination; or

2. if, for a given grid, it is believed that the gamma measurement is above the applicable action level as a result of a physical conditions such as shine, a composite count may be conducted in accordance with WNI JCSOP-RS80 in lieu of further integrated measurements; or

3. if, for a given grid, it is believed that the gamma measurement is above the applicable action level due to interference of natural gamma sources, within the soil matrix, a soil sample may be taken in accordance with Section 5.6.3 in lieu of further gamma surveys; or

4. if, for a given grid, it is believed that gamma measurements, taken by either the integrated count method, the composite count method, or laboratory analyses on a corresponding soil sample are above the applicable action level as a result of natural background concentrations of ^{226}Ra or other

radionuclides at a higher concentration than those used to establish the action level, WNI may follow the provisions of Section 5.7 and demonstrate compliance based on the performance criteria detailed therein.

5.6.3 Confirmatory Soil Sampling

Confirmatory soil samples will be taken in the surface 0-6 inch soil layer in 5% of the tertiary grids verified by gamma measurement. Soil samples will be collected in accordance with WNI JCSOP-RS20, and if required, split in accordance with WNI JCSOP-RS40. Soil sample analyses will be conducted by a laboratory, selected by WNI, based on demonstrated experience and reliability in conducting radiochemical analyses on environmental soil samples.

Confirmatory soil samples will be accepted as validation of radiological compliance based on the concentrations of U-nat, ^{230}Th, and ^{226}Ra reported by the analytical laboratory. For the surface 0-6 inch soil layer, three necessary conditions must be satisfied to demonstrate validation:

1. The sum of the reported ^{226}Ra concentration plus the analytic counting error at the 95% confidence limit must not exceed 5 pCi/g above background;

2. The sum of the reported U-nat concentration plus the analytic counting error at the 95% confidence limit must not exceed 10 pCi/g above background; and

3. The reported 230Th concentration must not exceed A(Th,0) as calculated by the following equation:

$$A_{(Th,0)} = \frac{A_{(Ra,t)} - A_{(Ra,0)}e^{-\lambda t}}{1 - e^{-\lambda t}}$$

Where:

$A_{(Th,0)}$ = reported ^{230}Th concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,0)}$ = reported ^{226}Ra concentration plus the analytic counting error at the 95% confidence limit;

$A_{(Ra,t)}$ = 5 pCi/g above background;

t = 1000 years; and

λ = the decay constant for ^{226}Ra = 4.32E-4 yrs^{-1}

If all of the above conditions are satisfied, the grid will be designated "validated" and documented in accordance with Section 5.6.4.

If greater than 5% of the confirmatory soil sampling grids indicate that condition 1 is satisfied while conditions 2 and/or 3 are not satisfied, then soil sample data will be evaluated to delineate areas requiring more extensive soil sampling due to a lack of association between ^{226}Ra and U-nat and ^{230}Th.

5.6.4 Documentation

All cleanup surveys, conducted by any method detailed in Section 5.6, will be recorded in cleanup/verification survey documents. Further, all documentation, as required by WNI

JCSOP-RS20 or RS40 will be attached and/or cross referenced to cleanup/verification survey documents as appropriate.

When radiological compliance for a given grid has been demonstrated by any method detailed in Section 5.6.1, the grid will be designated "verified" and documented.
When, in accordance with Section 5.6.3, validation of gamma survey measurements has been demonstrated by laboratory analyses of a soil sample taken from a corresponding grid, the grid will be designated "validated" and documented.
All documentation will be retained and will constitute a portion of the permanent project record.

5.7 Compliance By Demonstrated Performance

Three performance based evaluation criteria were developed to be used in lieu of gamma surveying or soil sampling. The first criterion addresses material beneath the ground water table and the second and third criteria address soils or bedrock with naturally elevated background U-nat, ^{230}Th, or ^{226}Ra concentrations. If it can be demonstrated that any one of these performance based verification criteria are met, the compliance grid(s) in question will be determined to be clean.

Criterion 1

The first criterion will be that no samples or measurements will be taken in grids with soils that are beneath the ground water table. Radon will not diffuse through saturated materials, and the difficulty associated with excavating and sampling beneath the ground water table makes sampling or removing material neither feasible nor necessary.

Criterion 2

The second performance criterion addresses elevated background concentrations of U-nat, ^{230}Th, or ^{226}Ra in materials that may have been used as fill or road base. An example of such material would be crushed rock from the split rock formation outcrops around the site. These materials are known to exhibit higher background concentrations or various radionuclides when compared to the surrounding sandy soils. It is also known that contamination from milling operations would originate from the ground surface, and that U-nat, ^{230}Th and ^{226}Ra are readily adsorbed to soil. Therefore, if contamination from milling operations is present in an area, it will be at the greatest concentrations near the surface and will decrease with depth. If concentrations of U-nat, ^{230}Th or ^{226}Ra remain constant or increase with depth, the source of the elevated concentrations must be naturally elevated rather than contamination from the milling operations (11e2 material).

In order to account for this possibility, performance testing has been developed. A grid will be determined to be clean if contamination either remains constant or increases with depth. Specifically, in order to meet this performance criteria, the following must be achieved:

1. at least three feet of material must first be removed; and

2. the results from soil analyses from the next three consecutive 6-inch increments from the grid must indicate that the concentrations for both ^{226}Ra and ^{230}Th are increasing or are the same. Values will be considered to be the same if they differ by no more than 15% (15% variability can be attributed to precision in the laboratory analyses).

Criterion 3

The third performance criterion addresses elevated background radionuclide concentrations in bedrock material which becomes exposed during excavation. Regardless of external gamma exposure rate or measured radionuclide concentration, bedrock material will be considered to exhibit background radionuclide concentrations. When bedrock is exposed in a cleanup excavation, efforts will be made to remove loose material on the bedrock surface, but no excavation of bedrock will be attempted.

6.0 SUMMARY AND CONCLUSION

In all areas where an association has been established between ^{226}Ra and ^{230}Th and/or U-nat, external gamma measurement procedures, supplemented by soil sampling, will be used to direct cleanup and to verify that cleanup has been completed. In areas where no association has been established, all cleanup and verification surveys will be conducted by soil sampling exclusively. In addition to the gamma survey procedures and soil sampling, three performance criteria will be used in special cases to determine compliance. The verification program will provide the information necessary to release all potentially contaminated areas, with the exception of the Tailing Impoundment, for unrestricted use.

LIST OF REFERENCES

Berger, J.D., 1992, "Manual for Conducting Radiological Surveys in Support of License Termination", NUREG/CR-5849.

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Gogolak, C.V., 1995, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys", NUREG-1505

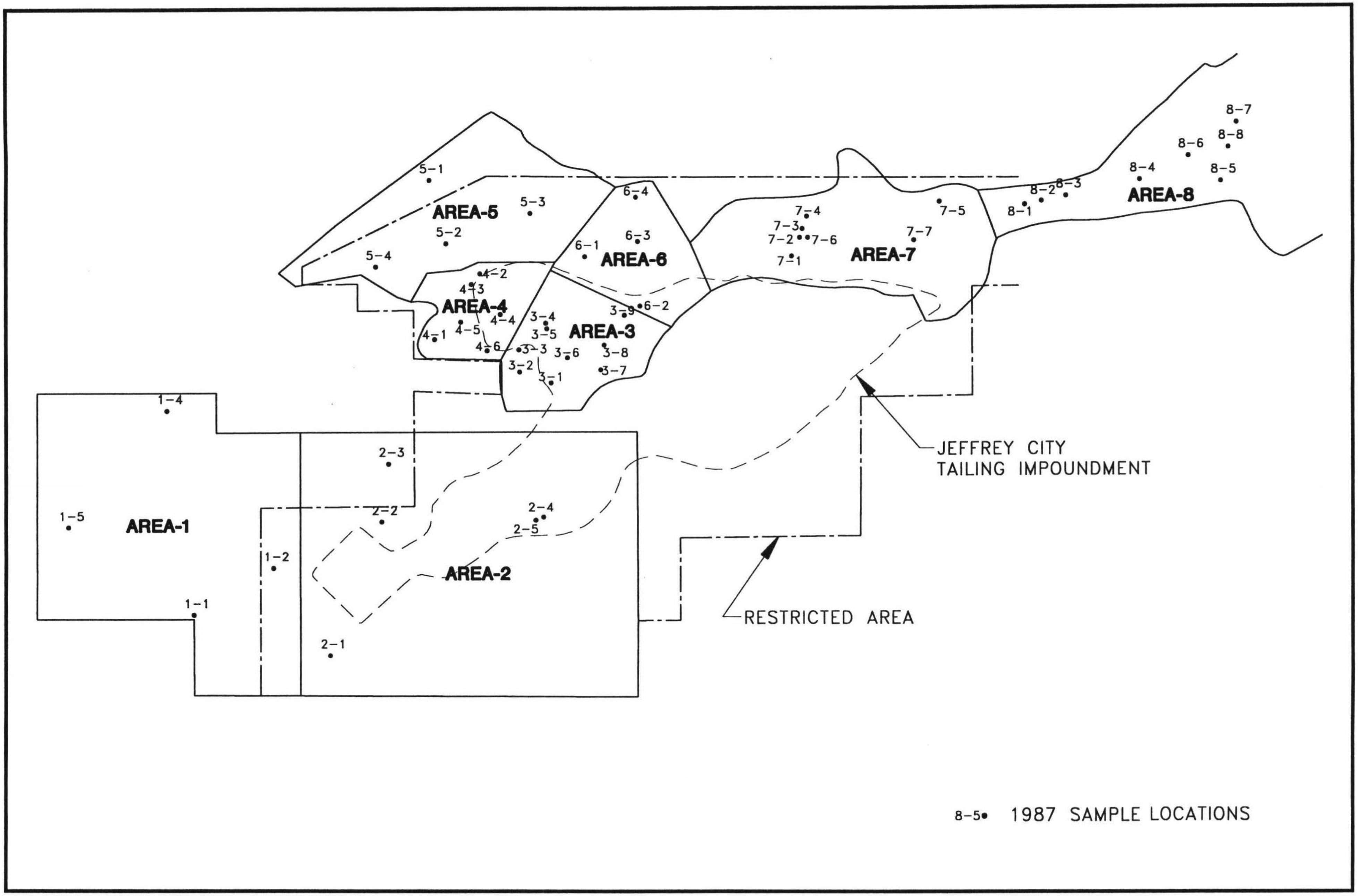
National Council on Radiation Protection and Measurement, (NCRP) 1976. Environmental Radiation Measurements, Washington D.C.

Schiager, K.J., Smith, J.W., 1982, "Simple Field Method For Determining Compliance With EPA Land Cleanup Standards," Proceedings of the Symposium on Uranium Mill Tailings Management, Colorado State University, Fort Collins, Colorado.

"Sherwood Project Mill Decommissioning Plan-Radiological Verification Program" Addendum [Revision #6 (10/94)] (WNI,1994)

"Split Rock Mill Tailings Regrading and Interim Cover Report", Docket 40-1162, February, 1991.

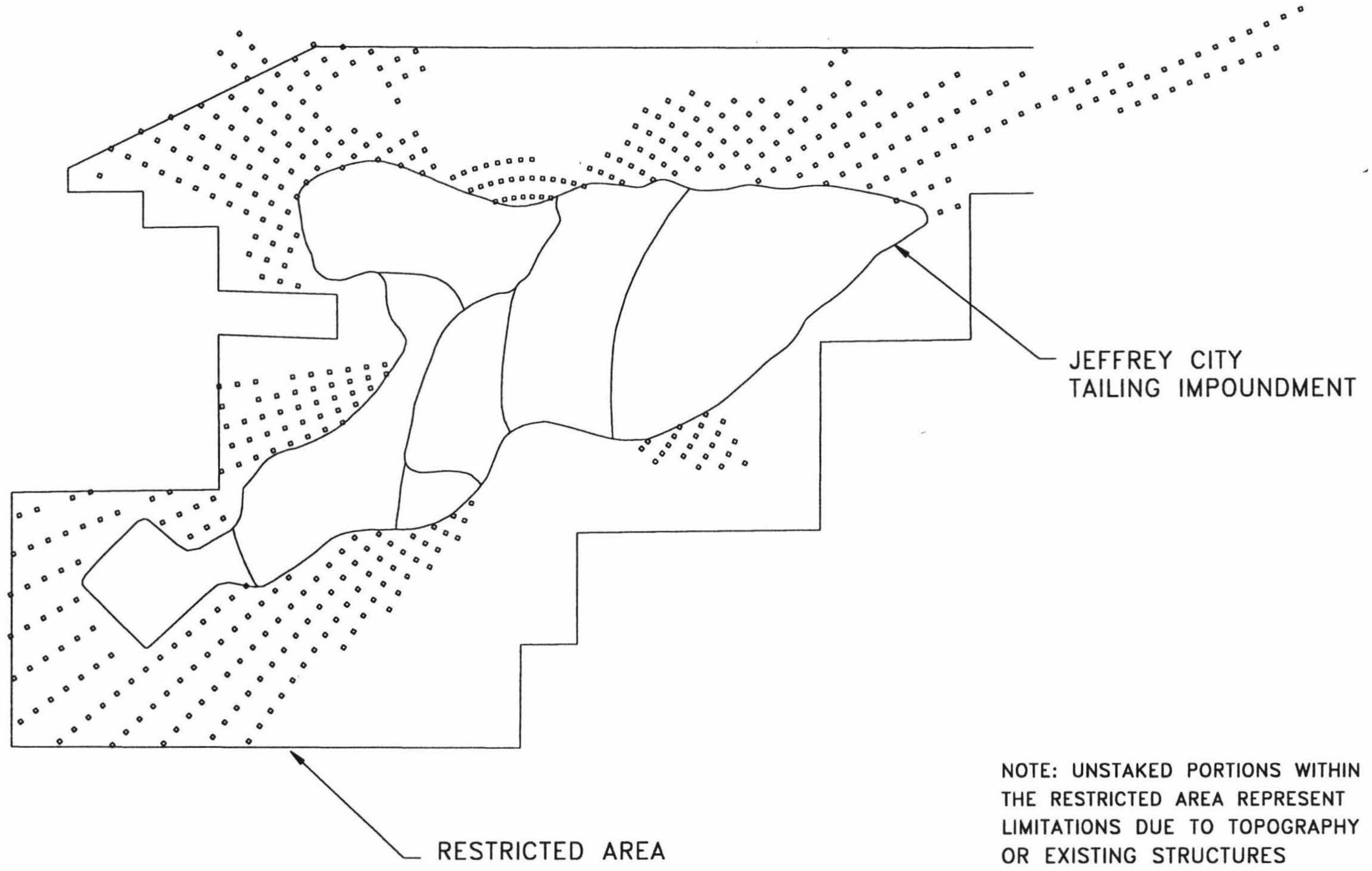
"Split Rock Mill Site Reclamation Plan", June, 1987.



SHEPHERD MILLER INCORPORATED

FIGURE 1
RADIOLOGICAL SURVEY AREAS–1987

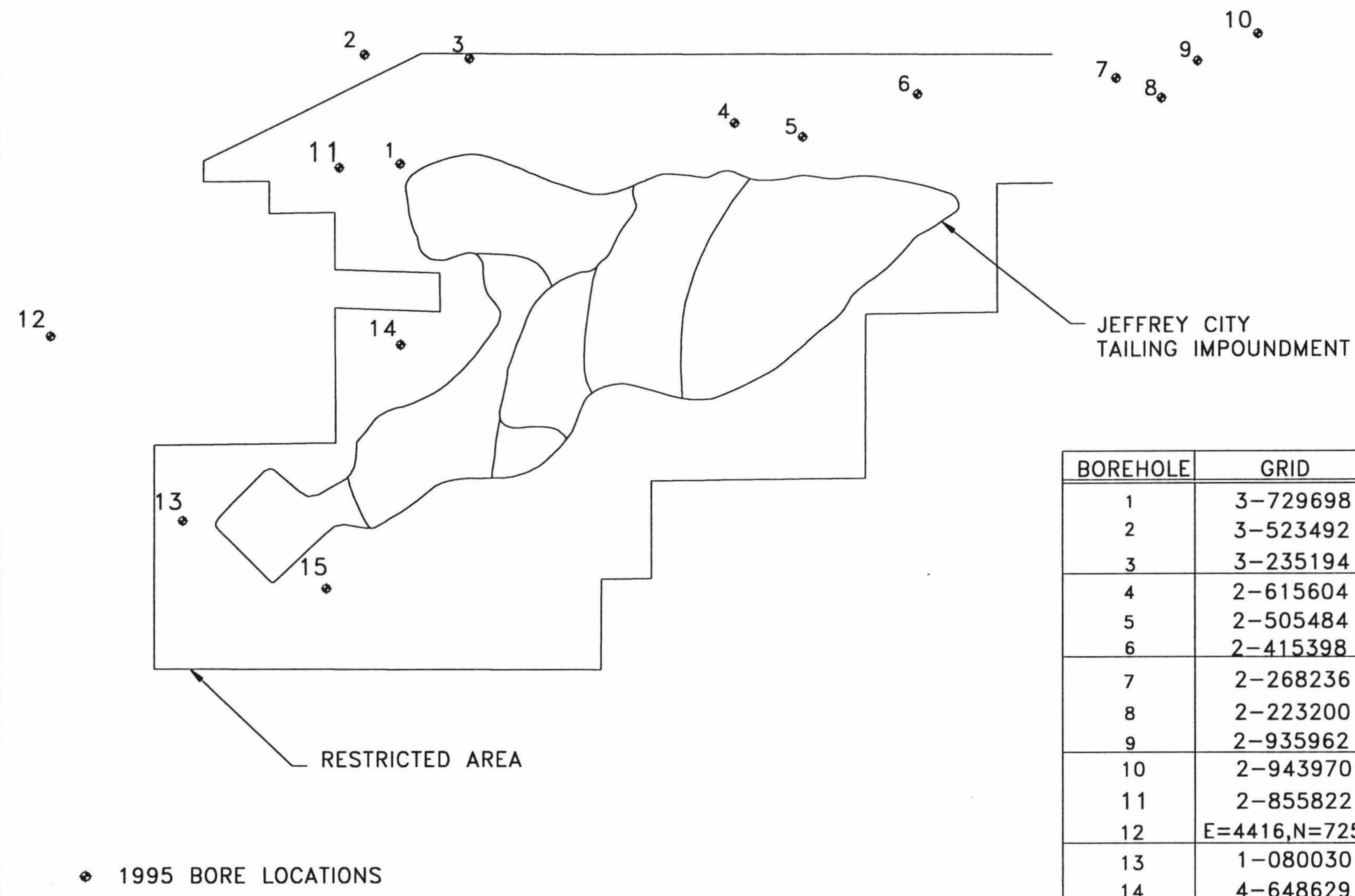
Date:	DEC., 1995
Project:	09–355
File:	FIG1



SHEPHERD MILLER INCORPORATED

FIGURE 2
GRID SYSTEM

Date:	DEC., 1995
Project:	09-355
File:	GRIDMAP



BOREHOLE	GRID	ELEVATION
1	3-729698	6311.0'
2	3-523492	6294.8'
3	3-235194	6325.9'
4	2-615604	6432.7'
5	2-505484	6435.9'
6	2-415398	6481.2'
7	2-268236	6442.2'
8	2-223200	6425.0'
9	2-935962	6410.7'
10	2-943970	6393.9'
11	2-855822	6310.1'
12	E=4416,N=7258	6299.0'
13	1-080030	6318.8'
14	4-648629	6354.5'
15	1-503450	6309.8'

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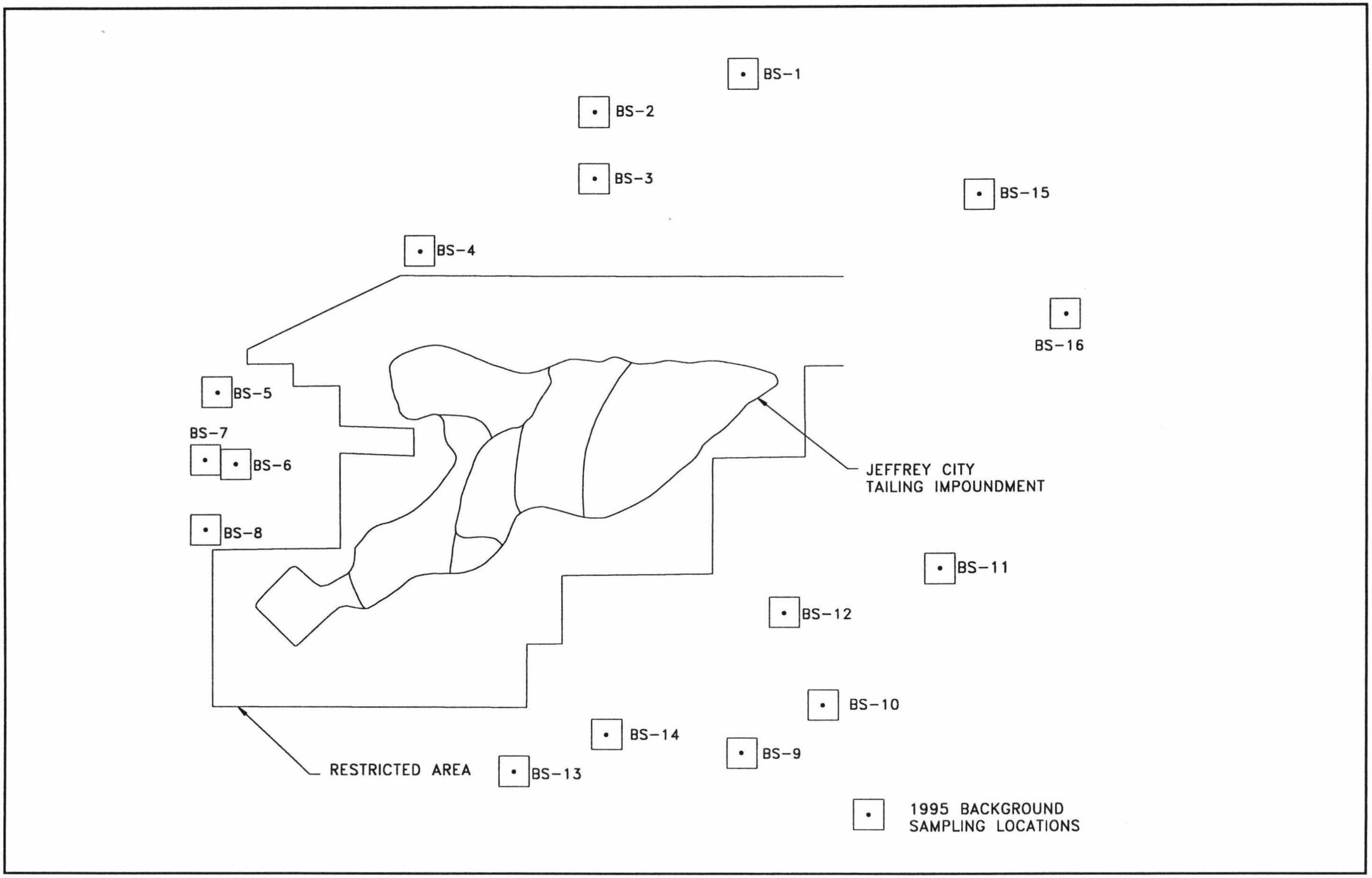
INCORPORATED

FIGURE 3
1995 BORE LOCATIONS

Date: DEC., 1995
Project: 09-355
File: BOREFIG



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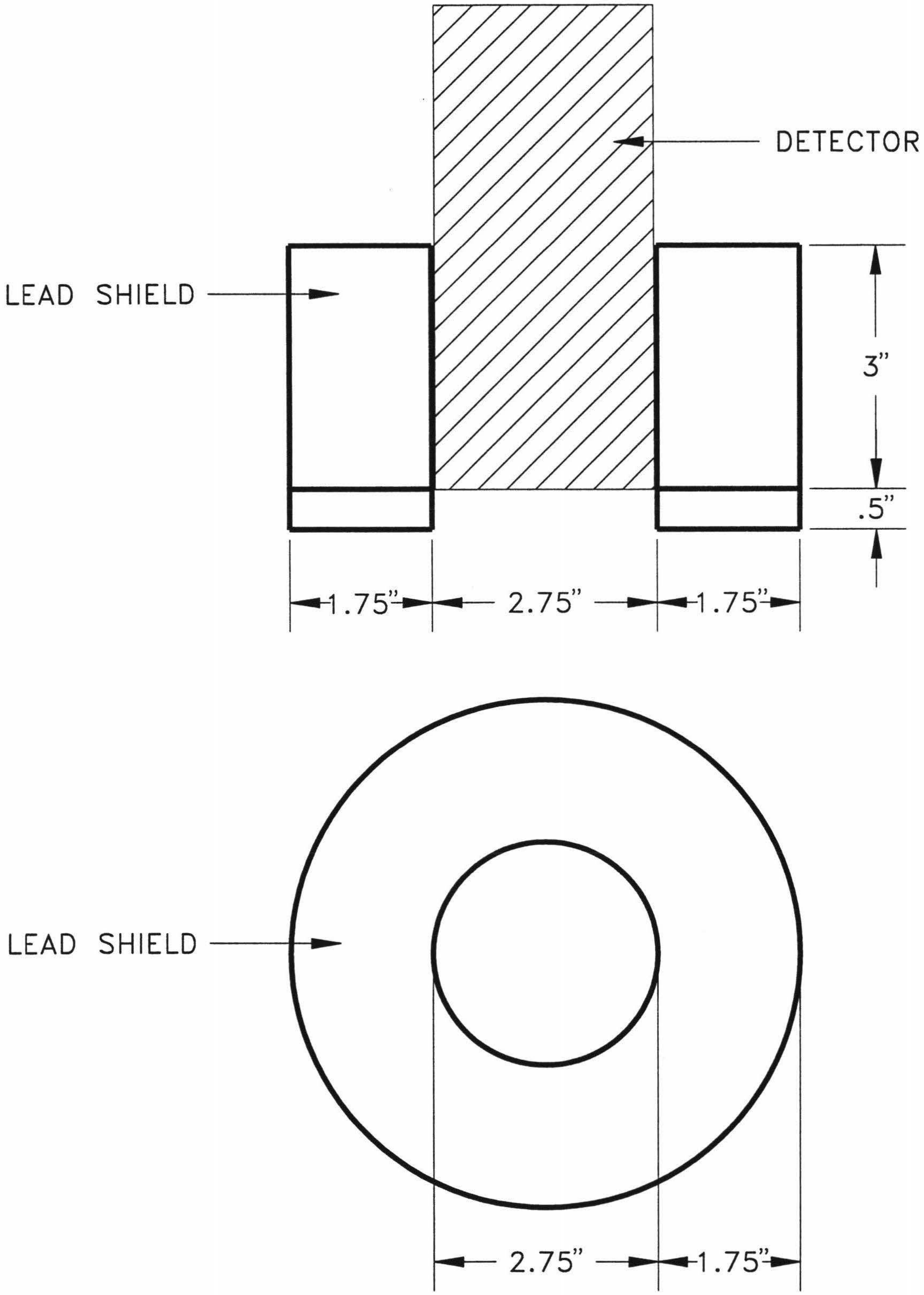
INCORPORATED

FIGURE 4
1995 BACKGROUND SAMPLING LOCATIONS

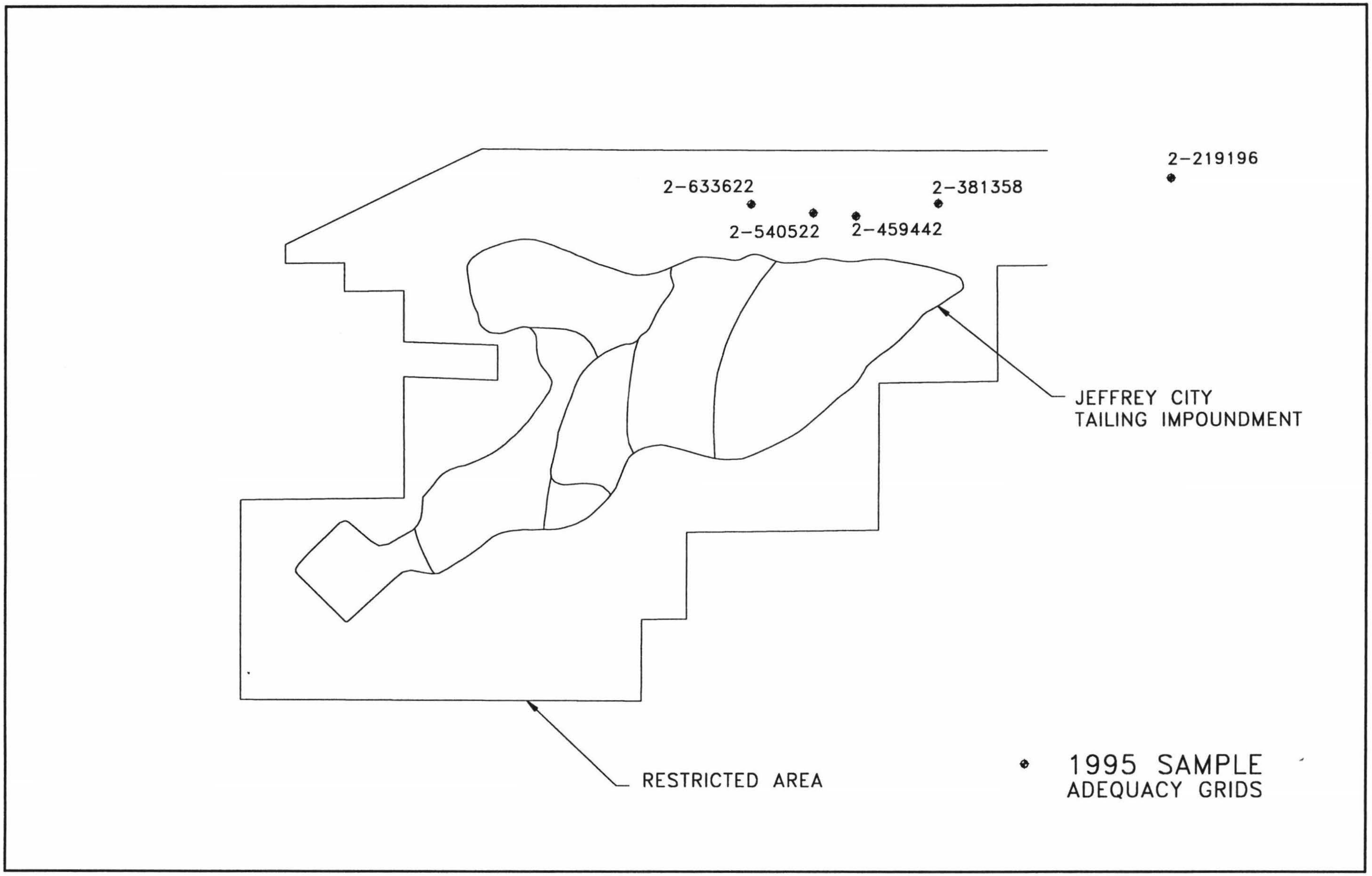
Date:	DEC., 1995
Project:	09-355
File:	BACKFIG



SHEPHERD MILLER
INCORPORATED

FIGURE 5
CONFIGURATION OF PORTABLE
LEAD SHIELD

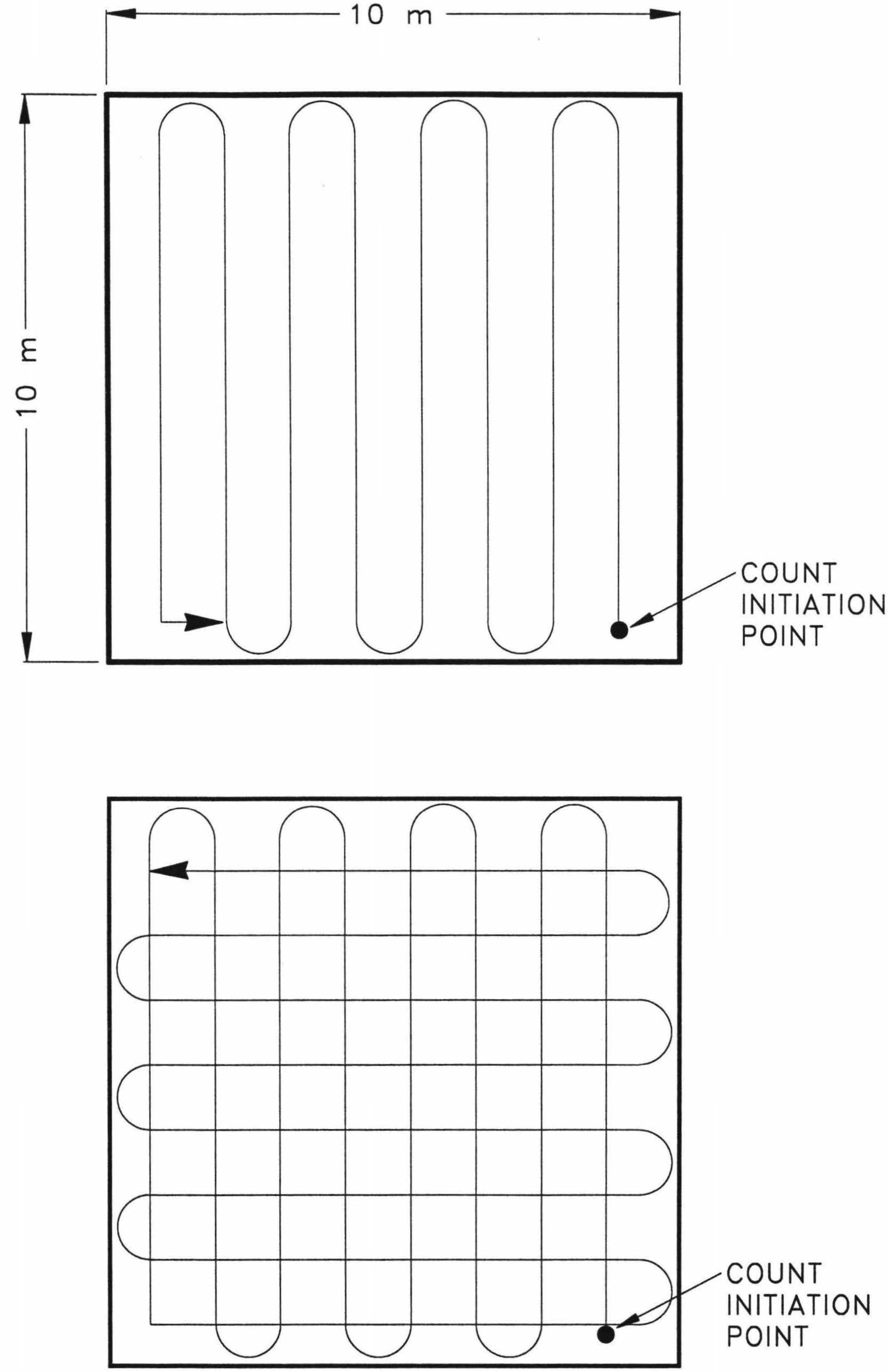
Date:	DEC., 1995
Project:	09-355
File:	LEAD



SHEPHERD MILLER INCORPORATED

FIGURE 6
SOIL SAMPLE ADEQUACY LOCATIONS

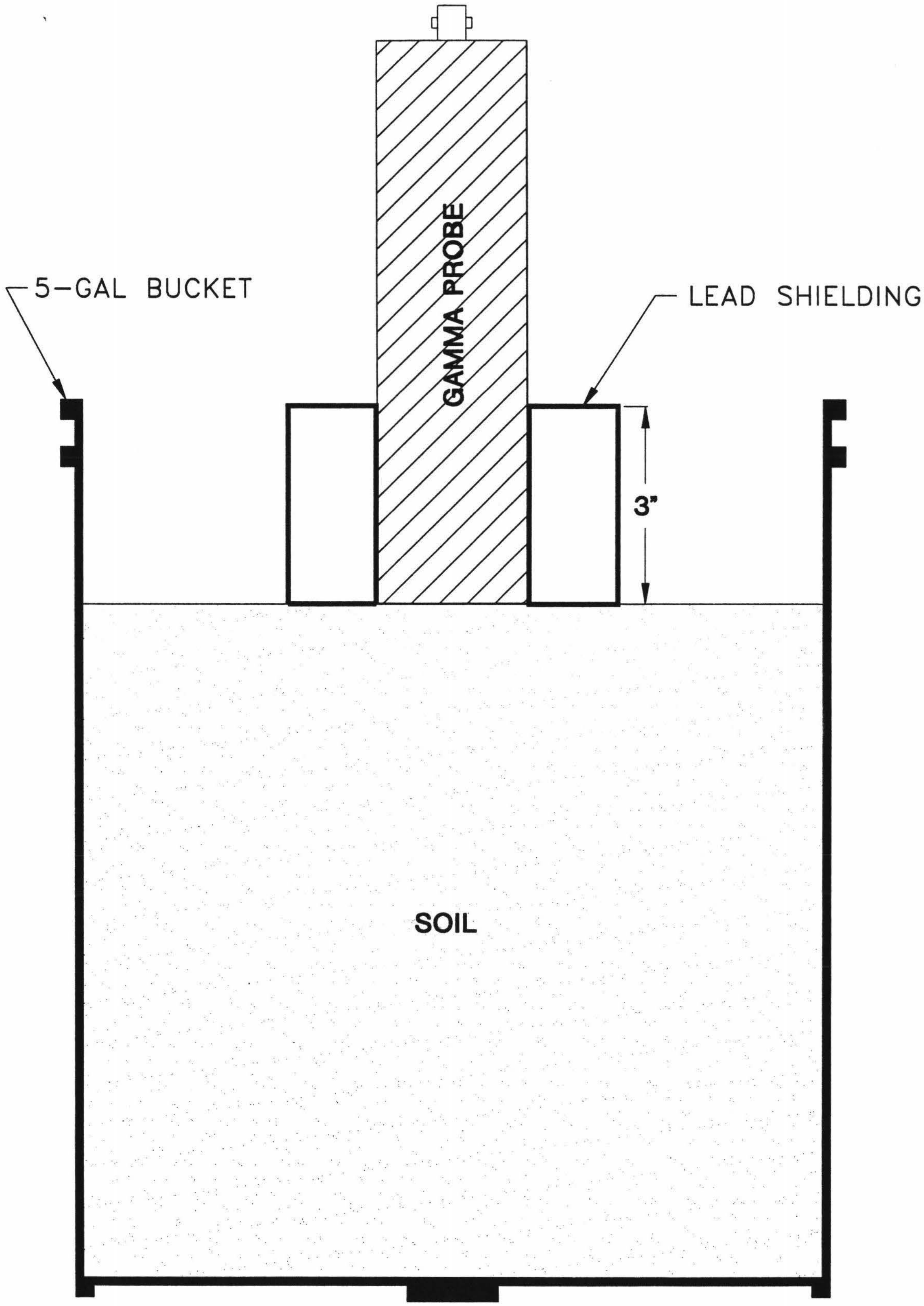
Date:	DEC., 1995
Project:	09-355
File:	FIG6



SHEPHERD MILLER INCORPORATED

FIGURE 7
INTEGRATED COUNT PATH

Date:	DEC., 1995
Project:	09-355
File:	WALK



SHEPHERD MILLER INCORPORATED

FIGURE 8
COMPOSITE COUNT

Date:	DEC., 1995
Project:	09-355
File:	BUCKET

ATTACHMENT 1

OPERATING PROCEDURE

GEOTECHNICAL DRILLING AND SAMPLING FOR DETERMINATION OF LATERAL AND VERTICAL EXTENT OF CONTAMINATION

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The lateral and vertical extent of contamination must be delineated on the Split Rock site. Therefore, an estimate of the subsurface extent of radiological contamination will be determined by laboratory analyses of soil samples taken at depth via the geotechnical drilling and sampling program described below.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,
2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site, and
3. operation of and with potentially hazardous equipment,
4. working around steep slopes and natural tripping hazards,
5. eye injury hazards from plants and from particulate matter, and

6. life threatening hazards from snake bites.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,

2. substantial steel-toed shoes,

3. safety glasses, and

4. any additional items specified under the Radiation Work Permit (RWP).

4.0 SAMPLING/TESTING EQUIPMENT

Borings will be made using a mechanically advanced hollow stem auger, and soil samples taken using a split spoon sampler capable of obtaining samples from a known depth.

The individual directing the sampling should have the following equipment and supplies:

1. a working surface which can be readily cleared of debris to avoid cross-contamination of samples,

2. Ziplock type sample storage bags,

3. a large knife for separating samples into sections, and

4. a felt-tip marker for sample identification on sample bags.

5.0 PROCEDURES

5.1 Sampling Locations

Sample locations shall be determined prior to drilling and shall be located based on accessibility and the required information to be gained.

5.2 Drilling

1. Borings will be advanced using a hollow-stem auger.

2. The borings will be advanced in increments to permit continuous sampling.

3. Each boring will be advanced to the desired depth.

5.3 Sampling

1. Sampling will be conducted according to the procedures given in ASTM D1586.

2. Samples will be taken in such a manner as to ensure that the material being sampled is undisturbed material below the auger bit.

3. The sample will be identified and logged in accordance with procedures given in ASTM D2487.

4. The sample will be separated into 1-foot increments. Each increment will be placed in a Ziplock type bag which will be marked to indicate the project number, date of sampling, boring location, and depth of boring.

5. Upon completion of sample logging and packaging, all loose material will be removed from the split spoon, sandcatcher, and head of the sampler with a wire or synthetic brush and the sampler will be returned to the Driller. The loose material will be removed from the working surface with a wire or synthetic brush.

5.4 Sample Testing and Storage

1. Samples submitted for testing will be analyzed for the following constituents:

   a) U-nat

   b) ^{230}Th

   c) ^{226}Ra

2. Samples submitted for testing will be packaged for shipping.

3. Samples which are not submitted for analyses will be placed in a suitable container and marked to indicate the contents. All containers

will be stored at Western Nuclear, Inc. in an area designated for sample storage.

6.0 EXIT SURVEY

Activities may occur within the Split Rock restricted area or areas known to contain residual radioactive materials as a result of operations. As such, the WNI RSO will require adherence to procedures for decontamination and exit surveying for surface contamination. This procedure, as described in the RWP, is as follows:

1. All sampling equipment (auger sections, bits, split-barrel samplers, etc.) will be cleaned of all visible loose material at a site specified in the RWP.

2. All equipment will be surveyed for residual contamination in accordance with WNI written operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

A copy of the field boring logs which will be used for this sampling program are attached.

All by-product contaminated soil that leaves the site for testing purposes shall be returned to the site for proper disposal in the Tailing Impoundment. The documentation will be maintained on file by WNI at the Split Rock site. A copy of the documentation will be provided to the Consultant by WNI for the Consultant's files.

OPERATING PROCEDURE

SOIL SAMPLING FOR DETERMINATION OF RADIOLOGICAL CONSTITUENT LEVELS

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

Soil sampling will be conducted to determine radionuclide levels in the soil.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,

2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site,

3. operation of and with potentially hazardous equipment,

4. working around steep slopes and natural tripping hazards,

5. eye injury hazards from plants and from particulate matter, and

6. life threatening hazards from snake bites.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,

2. substantial steel-toed shoes,

3. safety glasses, and

4. any additional items specified under the Radiation Work Permit (RWP).

4.0 SAMPLING EQUIPMENT

Borings will be made using hand operated augers. A coarse auger will be used for coarse-grained or rocky soils, and a fine auger will be used for fine-grained soils such as sand or clay.

Soil sampling will require the following equipment and supplies:

1. clean containers to place the soil samples in,
2. a felt-tip marker for sample identification on containers,
3. a wire or synthetic brush for cleaning the auger,
4. a heavy bar or pick

5.0 PROCEDURES

5.1 Sample Location and Identification Number

The soil samples will be collected in predetermined grids. The grid system will be constructed based on a 360 degree, radial array of the site. The sample identification number will correspond to the geographic location and specific corner grid points when oriented to a particular radial line. For example;

Sample ID# 1-745686

Where;
1 - Southwest Grid System
745 - Northwest Corner Gridpoint
686 - Southeast Corner Gridpoint

Sample ID# 3-845812

Where;
3 - Northwest Grid System
845 - Northwest Corner Gridpoint
812 - Southeast Corner Gridpoint

5.2 Number of Samples

The number of samples required to adequately represent radionuclide levels for the soil within a specific grid will be determined using the procedures described in SOP-RC30.

5.3 Augering Procedure

1. Prior to sampling, the auger will be cleaned with a wire or synthetic bristle brush to remove all soil remaining from samples collected in the previous grid. This will prevent cross-contamination of samples from two different grids. It will not be necessary to clean the auger between samples located within the same grid, only when moving to a different grid.

2. The sample will be augered to the desired depth. As the auger becomes full it will be necessary to periodically remove the auger from the sample hole to collect the contents. The contents will be placed in a clean container free of any contamination. This container will be used for the collection of all samples within a grid. When moving to a different grid a new container will be used. Some grids may require more than one container.

3. If rocks are encountered during the augering process, a pick or heavy bar will be used to break the rock into small pieces that can be collected with the coarse auger.

4. Once all samples in a grid are collected the container will be sealed and the identification number and date of sampling will be written on the top and side of the container(s). The container(s) will be placed in the center of the grid for verification of sample identification at the time of collection.

5. After each sample is split, all mixing and splitting equipment will be decontaminated using a stiff bristle wire or synthetic brush to remove all loose material.

5.4 Container Collection

The containers will be collected from each grid. The person collecting the containers will be responsible for verifying that the identification number on the container corresponds to the correct location, grid points, and soil type.

6.0 EXIT SURVEY

Activities may occur within the Split Rock site restricted area or areas known to contain residual radioactive materials as a result of operations. As such, the WNI RSO will require adherence to procedures for decontamination and exit surveying for surface contamination. This procedure, as described in the RWP, is as follows:

1. All sampling equipment (augers, picks, heavy bars, etc.) will be cleaned of all visible loose material at a site specified in the RWP.

2. Prior to leaving the Split Rock site, all equipment will be surveyed for residual contamination in accordance with WNI written operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

Prior to any field sampling, a sample set Lot Number will be assigned to the set of samples to be collected and recorded in the Master Sampling Log. Additionally, a Sampling and Splitting Log that indicates samples to be collected on the lot will be produced. At a minimum, the Sampling and Splitting Log will contain the following information:

1. the sample set Lot Number;

2. supervising sampler's name;

3. other sampler names;

4. the Quality Conformance Report number, if samples are taken in fulfillment of the requirements of a specific Quality Conformance Report;

5. sample identification codes;

6. sample collection location if not indicated by the sample identification code;

7. date of sampling;

8. the sample matrix;

9. the number of containers used to collect each individual original field sample.

A copy of the Split Rock Project Sampling and Splitting Log is attached.

The supervising sampler will initial each sample on the Sampling and Splitting Log in the column marked V as the sample is collected.

For samples that require splitting, the Sampling and Splitting Log will be relinquished, along with the samples, to the supervising splitter. The supervising splitter will check each sample and initial each sample on the Sampling and Splitting Log in the column marked R to indicate that the samples were received, and indicate the date that the samples were received. The Log will constitute an internal chain of custody record between the supervising sampler and the supervising splitter.

If sample shipping is required, the following procedure will be observed:

1. Upon receipt of samples, the individual responsible for shipping samples will initial each sample on the Sampling and Splitting Log in the column marked SHIP CHECK to indicate that all samples are being shipped to the destinations indicated on the Sampling and Splitting Log. Additionally, this will serve as a chain of custody between the individual responsible for shipping and the sampler or splitter.

2. The individual responsible for shipping will assign a Chain of Custody Record to each shipping container. A copy of the Split Rock Project Chain of Custody Record is attached. At a minimum, the Chain of Custody Record will include the following;

    1. the sample set Lot Number;

    2. the shipping container number;

    3. the identification code of each sample contained in the shipping container;

    4. the time and date of sampling;

    5. the matrix of each sample;

    6. the number of containers each individual sample is contained in.

3. After the Chain of Custody Records have been completed for all containers in the shipment, the individual responsible for shipping will verify shipment by checking the Chain of Custody Record for each container and initialing the column CHECK BY on the Chain of Custody Record to indicate that all samples shown on the Chain of Custody Record are contained in the shipping container. Immediately following verification of shipment for each container, the individual responsible for shipping will seal the container.

4. The individual responsible for shipping will log the shipment into the Shipping Log Book which will contain the following information;

    1. the sample set Lot Number;

    2. the date of shipping;

    3. the shipping ticket number;

4. the printed name and signature of the individual responsible for shipping.

5. The individual responsible for shipping will file all Sampling and Splitting Logs, Chain of Custody Records, and a photocopy of the shipping ticket as soon as the samples have been shipped.

If on site sample testing is required, the following procedure will be followed:

1. Upon receipt of samples, the individual responsible for testing will initial each sample on the Sampling and Splitting Log in the column marked LAB CHECK to indicate that all samples were received by the laboratory. This will serve as a chain of custody between the individual responsible for laboratory testing and the sampler or splitter.

2. The individual responsible for testing will log each sample on a Testing Docket which will indicate the following;

    1. the sample set Lot Number;

    2. the sample identification code;

    3. the date of sample receipt;

    4. all tests to be performed on each sample;

    5. disposition of the sample following testing.

3. The individual responsible for testing will review and complete all data sheets required by the tests performed on each sample and date the column marked COMPLETE on the Testing Docket immediately after all required testing on an individual sample has been completed.

4. After testing, the sample will be disposed of in the Tailing Impoundment.

5. The individual responsible for testing will file all Sampling and Splitting forms and Testing Dockets with the Consultant Project Manager or WNI Facility Manager as soon as testing on all samples is complete.

All by-product contaminated soil that leaves the site for testing purposes shall be returned to the site for proper disposal in the Tailing Impoundment. All documentation will constitute a portion of the permanent project record.

OPERATING PROCEDURE

SOIL SAMPLE ADEQUACY DETERMINATION BY EXTERNAL GAMMA RADIATION MEASUREMENT

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The objective of this procedure is to determine the number of surface soil samples which must be composited for laboratory testing in order to adequately represent the average ^{226}Ra contamination within a specified grid area.

It has previously been determined that 1 distinct soil type exists on the Split Rock site: sandy soil. The number of samples required to adequately represent this soil will be investigated under this procedure.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,

2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site, and

3. operation of and with potentially hazardous equipment.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,

2. substantial steel-toed shoes,

3. safety glasses, and

4. any additional items specified under the Radiation Work Permit (RWP).

4.0 EQUIPMENT

External gamma radiation measurements will be taken with a Ludlum model 2350 scaler with a Ludlum model 44-10 NaI(Tl) detector, or equivalent.

The person conducting the test should also have the following equipment:

1. 1.75-inch thick, 3-inch high lead detector shield,

2. spray paint for marking test locations.

5.0 PROCEDURES

5.1 Method of Sample Adequacy Determination

The number of surface soil samples which must be composited for laboratory testing in order to adequately represent the ^{226}Ra contamination within a specified area will be determined by taking multiple external gamma radiation measurements throughout a selected grid area of the same size. The external gamma radiation measurements will be evaluated using the sample adequacy equation:

$$n_b = \left[\frac{tS_x}{kx}\right]^2$$

where

n_b = the number of samples required for adequacy

t = the statistic at the 90% confidence interval

S_x = the standard deviation of the sample population

x = sample mean

k = 0.1 for ± 10% about the mean

5.2 Sampling Locations

1. Sample Adequacy Grids

A number of grids will be selected for sample adequacy determination. They will consist of 10-meter by 10-meter grids, selected at random, in order to minimize the potential for bias.

2. Sample Adequacy Points

External gamma radiation measurements will be taken throughout each grid. Sample adequacy points will be distributed throughout the grid such that even coverage of the grid is achieved.

Sample adequacy points within each grid will be selected without regard to any criteria other than even coverage of the grid.

5.3 External Gamma Radiation Measurements

1. External gamma radiation measurements will be taken at each sample adequacy point using a 2-minute surface scaler count as measured by a Ludlum model 2350 scaler with a Ludlum model 44-10 NaI(Tl) detector, or equivalent.

2. The scaler and detector assembly will be calibrated prior to use in accordance with JCSOP-RS70.

3. In order to minimize extraneous sources of gamma radiation, the 44-10 detector, or equivalent, will be placed in a 1.75-inch thick, 3-inch high detector shield for each sample adequacy point.

6.0 EXIT SURVEY

Activities may occur within the Split Rock restricted area or areas known to contain residual radioactive materials as a result of operations. As such, the WNI RSO will require adherence to procedures for decontamination and exit surveying for surface contamination. This procedure, as described in the RWP, is as follows:

surveying for surface contamination. This procedure, as described in the RWP, is as follows:

1. All sampling equipment will be cleaned of all visible loose material at a site specified in the RWP.

2. Prior to leaving the Split Rock site, all equipment will be surveyed for residual contamination in accordance with WNI written operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

Documentation will include:

1. the date and time each sample point was taken,
2. the grid location of each sample point,
3. the 2-minute scaler count of each sample point, and
4. all sample adequacy calculations.

This documentation will constitute a portion of the permanent project record.

OPERATING PROCEDURE

SOIL SAMPLE PREPARATION AND SPLITTING

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The primary objectives of this procedure are:

1) to provide representative soil samples in quantities necessary for laboratory testing;

2) to provide documentation of physical field samples;

3) to establish a chain of custody history for all field samples, and;

4) to provide a sampling and sample handling documentation which can be independently reviewed and verified.

2.0 HAZARDS

2.1 Hazardous Materials

These procedures may involve working around or near radioactive materials such as inorganic acids or bases (used for sample preservation). WNI maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.2 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the Western Nuclear, Inc. (WNI) Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. substantial steel-toed shoes,
2. safety glasses, and
3. any additional items specified under the Radiation Work Permit (RWP).

4.0 MIXING/SPLITTING EQUIPMENT

All mixing and splitting of samples will be performed in the truck shop at the Split Rock site. The following equipment will be used:

1. small power-driven cement mixer for soil mixing,
2. shovel for mixing the soil,
3. riffle-type soil splitter,
4. Ziplock type storage bags,

5. wire or synthetic bristle brush and broom for decontamination of equipment,

6. appropriate container for shipping samples,

7. 3/4-inch sieve,

8. felt-tip pen for labeling sample bags and containers,

9. laboratory QA/QC documents.

5.0 MIXING/SPLITTING PROCEDURE

The containers arriving in the lab will contain a composite of all soil samples taken within each grid. It will be necessary to thoroughly mix the contents of each container to provide a fair representation of the grid's soil matrix. In preparation for laboratory testing, each sample will be split repeatedly until two samples, approximately 1000 grams each, remain.

1. After the soil samples arrive in the laboratory, each sample will be documented on the Sampling and Splitting Log. A Sampling and Splitting Log is provided at the end of this section.

2. After documentation, the samples will be placed in an area designated for unsplit samples.

3. The material representing one sample will be emptied into the small cement mixer. The soil will be mixed thoroughly for a period of 5 minutes.

4. The mixed soil will then be evenly distributed in the splitter. From the initial split, half will be saved for future use, and the other half will be split again. After the container is filled with soil for future use, the excess from the splits will then be discarded and stored for proper disposal in the Tailing Impoundment. The sample will continue to be split until two 1000 gram samples remain.

5. The remaining 1000 gram samples will be placed in Ziplock type bags, labeled, and sealed. The labels on the bag will consist of location, date of sample, date of split, and project number.

6. Since cross-contamination will be of concern, extra care will be taken to ensure the work area, mixer and sample splitter have been properly cleaned after the processing of each grid sample. In addition, only one sample will be exposed to the air at any time; this reduces the chance of mislabeling, cross-contaminating, or losing a sample.

7. After each sample has been split, bagged, and labeled, it will be placed in containers for shipment to the laboratory. A Chain of Custody form will be placed in each container. Once the container is ready for shipment, the samples will be marked as shipped on the laboratory QA/QC form (Sampling and Splitting Log) and the container will be placed in an area designated for samples to be shipped.

8. After each sample is split, all mixing and splitting equipment will be decontaminated using a stiff bristle wire or synthetic brush to remove all loose material.

6.0 EXIT SURVEY

Activities may occur within the Split Rock restricted area or areas known to contain residual radioactive materials as a result of operations. As such, the WNI RSO will require adherence to procedures for decontamination and exit surveying for surface contamination. This procedure, as described in the RWP, is as follows:

1. All sampling equipment will be cleaned of all visible loose material at a site specified in the RWP.
2. Prior to being released from the Split Rock site, all equipment will be surveyed for residual contamination in accordance with WNI standard operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

Upon receipt of the samples from the supervising sampler, the supervising splitter will take custody of the samples and complete the second half of the Sampling and Splitting Log as follows:

1. The supervising splitter will check each sample and initial each sample on the Sampling and Splitting Log in the column marked R to indicate that the samples were received, and indicate the date that the samples were received.

2. The supervising splitter will indicate on the Sampling and Splitting Log the number of splits required and the destination of each split.

3. The supervising splitter will fill in the date of splitting on the Sampling and Splitting Log as soon as the sample has been split. This will serve as verification that the sample was split.

4. The supervising splitter will file all Sampling and Splitting Logs as soon as all samples have been split.

If sample shipping is required, the following procedure will be observed:

1. Upon receipt of samples, the individual responsible for shipping samples will initial each sample on the Sampling and Splitting Log in the column marked SHIP CHECK to indicate that all samples are being shipped to the destinations indicated on the Sampling and Splitting Log. Additionally, this will serve as a chain of custody between the individual responsible for shipping and the sampler or splitter.

2. The individual responsible for shipping will assign a Chain of Custody Record to each shipping container. A copy of the Split

2. The individual responsible for shipping will assign a Chain of Custody Record to each shipping container. A copy of the Split Rock Project Chain of Custody Record is attached. At a minimum, the Chain of Custody Record will include the following;

    1. the sample set Lot Number;

    2. the shipping container number;

    3. the identification code of each sample contained in the shipping container;

    4. the time and date of sampling;

    5. the matrix of each sample;

    6. the number of containers each individual sample is contained in.

3. After the Chain of Custody Records have been completed for all containers in the shipment, the individual responsible for shipping will verify shipment by checking the Chain of Custody Record for each container and initialing the column CHECK BY on the Chain of Custody Record to indicate that all samples shown on the Chain of Custody Record are contained in the shipping container. Immediately following verification of shipment for each container, the individual responsible for shipping will seal the container.

4. The individual responsible for shipping will log the shipment into the Shipping Log Book which will contain the following information;

    1. the sample set Lot Number;

    2. the date of shipping;

    3. the shipping ticket number;

4. the printed name and signature of the individual responsible for shipping.

5. The individual responsible for shipping will file all Sampling and Splitting Logs, Chain of Custody Records, and a photocopy of the shipping ticket as soon as the samples have been shipped.

If on site sample testing is required, the following procedure will be followed:

1. Upon receipt of samples, the individual responsible for testing will initial each sample on the Sampling and Splitting Log in the column marked LAB CHECK to indicate that all samples were received by the laboratory. This will serve as a chain of custody between the individual responsible for laboratory testing and the sampler or splitter.

2. The individual responsible for testing will log each sample on a Testing Docket which will indicate the following;

   1. the sample set Lot Number;

   2. the sample identification code;

   3. the date of sample receipt;

   4. all tests to be performed on each sample;

   5. disposition of the sample following testing.

3. The individual responsible for testing will review and complete all data sheets required by the tests performed on each sample and date the column marked COMPLETE on the Testing Docket immediately after all required testing on an individual sample has been completed.

4. After testing, the sample will be disposed of in the Tailing Impoundment.

5. The individual responsible for testing will file all Sampling and Splitting forms and Testing Dockets as soon as testing on all samples is complete.

All by-product contaminated soil that leaves the site for testing purposes shall be returned to the site for proper disposal in the Tailing Impoundment. The documentation will be maintained on file by WNI at the Split Rock site. All documentation will constitute a portion of the permanent project record.

OPERATING PROCEDURE

EXTERNAL GAMMA RADIATION MEASUREMENT BY THE INTEGRATED WALKING COUNT METHOD

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The objective of this procedure is to determine the level of gamma radiation in selected grids.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,
2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site,
3. operation of and with potentially hazardous equipment,
4. working around steep slopes and natural tripping hazards,
5. eye injury hazards from plants and from particulate matter, and
6. life threatening hazards from snake bites.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,
2. substantial steel-toed shoes,
3. safety glasses, and
4. any additional items specified under the Radiation Work Permit (RWP).

4.0 EQUIPMENT

External gamma radiation measurements will be taken with a Ludlum model 2350 data logger with a Ludlum model 44-10 NaI(Tl) detector, or equivalent.

The detector will be shielded from extraneous sources of gamma radiation by a 1.75-inch thick, 3-inch high lead shield.

5.0 EXTERNAL GAMMA RADIATION MEASUREMENT PROCEDURE

1. The operator will enter the grid location code into the instrument.

2. The operator will enter the scalar counting time into the instrument.

3. Once the count time is set, the operator will activate the count.

4. Immediately upon activating the count the operator will start from a grid corner and begin to walk back and forth across the grid in a linear fashion. The operator will attempt to walk at a uniform pace. Once the operator reaches the grid corner diagonally opposite from the starting grid corner, the operator will turn 90 degrees and walk perpendicular to the previous direction working back to the starting grid corner in the same fashion. The operator will walk the grid until the counting time expires, at which time the instrument will automatically log the reading and sound an alarm to indicate that the counting has been completed.

5. If more than one (1) counting time is required, the operator will repeat steps 1 through 4.

6. The instrument and detector will be calibrated daily and performance checks will be performed as described in SOP-RC70.

7. The data from the instrument will be down loaded periodically to a computer and stored for future analysis.

6.0 EXIT SURVEY

Exit surveys will be performed as required in the RWP, as deemed necessary by the RSO or as requested by any field personnel. The procedure will follow WNI standard operating procedures for surface contamination surveys.

7.0 DOCUMENTATION

All data will be electronically logged by the 2350 instrument, or equivalent. These data will include:

1. location of the scaler count,
2. scaler count,
3. counting time,
4. date count was taken,
5. time count was taken.

If an instrument is used that does not electronically record this information, all of the data shall be recorded in a field book. The field book will constitute a portion of the permanent project record.

OPERATING PROCEDURE

INSTRUMENT CALIBRATION AND PERFORMANCE CHECKS

WARNING: NO PROCEDURE IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The objective of this procedure is to perform instrument calibration and performance checks on external gamma radiation detection equipment to ensure proper working condition and performance of the instrumentation on a daily basis.

2.0 HAZARDS

This procedure will involve working with and handling a Cesium 137 performance check source. Cesium 137 is a high energy gamma emitter. All personnel will be required to wear a Thermal Luminescent Dosimeter (TLD) badge when performing this procedure. Time spent handling the source will be kept to a minimum. The check source will be stored in a lead shield when not in use.

3.0 PERSONAL PROTECTIVE EQUIPMENT

This operating procedure does not require any specific personal protective equipment.

4.0 EQUIPMENT

4.1 Calibration Equipment

The instruments will be calibrated using a reference Cesium 137 performance check source placed in reproducible constant geometry relative to the detector.

4.2 Instrument Precision

All instruments must consistently provide performance check readings within a margin of ± 20%.

5.0 PROCEDURES

5.1 Calibration Procedure

The instruments will be calibrated according to the manufacturer's specifications for calibration procedures.

5.2 Performance Check Procedure

The instruments will be checked according to the manufacturer's specifications for performance check procedures.

6.0 EXIT SURVEYS

Not applicable.

7.0 DOCUMENTATION

All instrument calibration and performance checks will be documented in the calibration log book. The log book will constitute a portion of the permanent project record.

OPERATING PROCEDURE

SOIL COMPOSITE COUNTING PROCEDURE FOR DETERMINATION OF RADIOLOGICAL CONSTITUENT LEVELS

WARNING: NO PROCEDURE IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The objective of this procedure is to determine the level of gamma radiation of soil in areas suspect of external gamma radiation from adjacent sources and from grids where topographic conditions prevent use of the backpack mounted instrument.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,

2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site, and

3. operation of and with potentially hazardous equipment.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. substantial steel-toed shoes,
2. safety glasses, and
3. any additional items specified under the Radiation Work Permit (RWP).

4.0 EQUIPMENT

Gamma radiation measurements will be taken with a Ludlum model 2350 data logger with a Ludlum model 44-10 NaI(Tl) detector, or equivalent. The detector will be shielded from extraneous sources of gamma radiation by a

1.75-inch thick, 3.0-inch high lead shield. A hand held terminal will be used to input the sample location ID number.

5.0 COUNTING PROCEDURE

The volume of material required for testing is approximately 5 gallons. The counting procedure will be performed in the on-site laboratory.

1. The sample will be placed into a clean 5 gallon bucket, free from any contamination, to a minimum level of 3/4 full.

2. The operator will place the 1.75-inch thick, 3.0-inch high shield in the bucket directly on top of the soil.

3. The operator will position the probe in the center of the shield.

4. The operator will input the location code for the sample.

5. The operator will input the count time.

6. Once the count time is set the operator will activate the count.

7. When the count has expired the instrument will automatically log the reading and sound an alarm to indicate the count has been completed.

8. The instrument and detector will be calibrated daily and performance checks will be performed as described in SOP-RC70.

9. Periodically the data from the instrument will be down loaded to a computer and stored for future analysis.

10. After testing the sample will be disposed of in the Tailing Impoundment.

6.0 EXIT SURVEY

Activities may occur within the Split Rock restricted area or areas known to contain residual radioactive materials as a result of operations. As such, the

WNI RSO will require adherence to procedures for decontamination and exit surveying for surface contamination. This procedure, as described in the RWP, is as follows:

1. All equipment will be surveyed for residual contamination in accordance with WNI written operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

All data will be electronically logged by the 2350 instrument, or equivalent. These data will include:

1. location of the scalar count,
2. scalar count,
3. counting time,
4. date count was taken,
5. time count was taken.

If an instrument is used that does not record this information electronically, all of the data shall be recorded in a field book. The field book will constitute a portion of the permanent project record.

OPERATING PROCEDURE

SOIL SAMPLING FOR DETERMINATION OF BACKGROUND LEVELS OF RADIOLOGICAL CONSTITUENTS

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

Soil sampling will be conducted to determine the background radionuclide levels in uncontaminated native soil.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,
2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site,
3. operation of and with potentially hazardous equipment,
4. working around steep slopes and natural tripping hazards,
5. eye injury hazards from plants and from particulate matter, and
6. life threatening hazards from snake bites.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,
2. substantial steel-toed shoes,
3. safety glasses, and
4. any additional items specified under the Radiation Work Permit (RWP).

4.0 SAMPLING EQUIPMENT

Borings will be made using a hand operated soil sampling auger. Background soil sampling will require the following equipment and supplies:

1. Ziplock type sample storage bags, gallon capacity,
2. shipping containers,
3. an auger,
4. a wire or synthetic brush for cleaning the auger,
5. a heavy bar or pick,
6. shovel,
7. tape measure and lath for measuring depth of sample hole,
8. painted lath to mark sample location,
9. felt-tip pen for sample identification on bags and containers.

5.0 PROCEDURES

5.1 Sample Location and Identification Number

The soil samples will be collected in predetermined locations. The sample identification number will correspond to the background sample location and sample depth. For example;

Sample ID# BS-1-0-6

Where;	BS	- Background Sample
	1	- Location
	0-6	- Depth is 0-6 inches

Sample ID# BS-8-6-12

Where;	BS	- Background Sample
	8	- Location
	6-12	- Depth is 6-12 inches

5.2 Sample Types

The background sampling program will consist of collecting standard samples and incremental samples. Standard samples are taken by augering a hole to the desired sample depth and collecting the sample. Incremental samples require taking samples in pre-determined increments from the ground surface to the desired depth. The specific sampling procedures are discussed in Sections 5.3 and 5.4.

5.3 Standard Sample Procedure

1. Prior to sampling, the auger will be cleaned with a wire or synthetic bristle brush to remove any soil remaining from the previous sample. This will prevent cross-contamination of samples from two different locations.

4. Prior to augering, the sample area will be brushed by hand to remove any foreign soil or debris that may have fallen onto the area. The samples will then be augered to the desired depth. As the auger becomes full it will be necessary to periodically remove the auger from the sample hole to collect the contents. The contents will be placed in a Ziplock type bag. The sample depth, identification number and date will be written on the bag and the bag will be placed in a clean container. The sample identification number will be verified at the time of collection.

5. If rocks are encountered during the augering process, a pick or heavy bar will be used to break the rock into small pieces that can be collected with the coarse auger.

6. A piece of lath will be used to mark the location of the sample hole.

5.4 Incremental Sample Procedure

1. Prior to sampling, the auger will be cleaned with a wire or synthetic bristle brush to remove any soil remaining from the previous sample. It will be necessary to repeat this process for each sample increment.

2. The sample will be augered to the first desired depth. As the auger becomes full it will be necessary to periodically remove the auger from the sample hole to collect the contents. The contents will be placed in a Ziplock type bag. The sample depth, identification number and date will be written on the bag and the bag will be placed in a clean container. All bags for each background sample location will be placed in the same container.

3. The soil will be excavated to the depth of the first sample. The hole must be large enough to prevent topsoil or other debris from falling onto the sample area. The sample area will be brushed by hand to remove any foreign soil or other debris that may have fallen onto the area. Repeat steps **1** and **2** to the next desired depth; then go to step **4**.

4. Steps 1-3 will be repeated until the desired number of samples have been obtained. The sample identification number and depth will be verified at the time of sample collection.

6. A piece of lath will be used to mark the location of the sample hole.

6.0 EXIT SURVEY

Activities may occur within the Split Rock restricted area or areas known to contain residual radioactive materials as a result of operations. As such, the WNI RSO will require adherence to procedures for decontamination and exit surveying for surface contamination. This procedure, as described in the RWP, is as follows:

1. All sampling equipment (augers, picks, heavy bars, etc.) will be cleaned of all visible loose material at a site specified in the RWP.

2. Prior to leaving the Split Rock site, all equipment will be surveyed for residual contamination in accordance with WNI written operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

Prior to any background sampling, a sample set Lot Number will be assigned to the set of samples to be collected and recorded in the Master Sampling Log. Additionally, a Sampling and Splitting Log that indicates samples to be collected on the lot will be produced. At a minimum, the Sampling and Splitting Log will contain the following information:

1. the sample set Lot Number;
2. supervising sampler's name;
3. other sampler names;
4. the Quality Conformance Report number, if samples are taken in fulfillment of the requirements of a specific Quality Conformance Report;
5. sample identification codes;
6. sample collection location if not indicated by the sample identification code;
7. time and date of sampling;
8. the sample matrix;
9. the number of containers used to collect each individual original field sample.

A copy of the Split Rock Project Sampling and Splitting Log is attached.

The supervising sampler will initial each sample on the Sampling and Splitting Log in the column marked V as the sample is collected.

For samples that require splitting, the Sampling and Splitting Log will be relinquished, along with the samples, to the supervising splitter. The supervising splitter will check each sample and initial each sample on the

Sampling and Splitting Log in the column marked R to indicate that the samples were received, and indicate the date the samples were received. The Log will constitute an internal chain of custody record between the supervising sampler and the supervising splitter.

If sample shipping is required, the following procedure will be observed:

1. Upon receipt of samples, the individual responsible for shipping samples will initial each sample on the Sampling and Splitting Log in the column marked SHIP CHECK to indicate that all samples are being shipped to the destinations indicated on the Sampling and Splitting Log. Additionally, this will serve as a chain of custody between the individual responsible for shipping and the sampler or splitter.

2. The individual responsible for shipping will assign a Chain of Custody Record to each shipping container. A copy of the Split Rock Project Chain of Custody Record is attached. At a minimum, the Chain of Custody Record will include the following;

    1. the sample set Lot Number;

    2. the shipping container number;

    3. the identification code of each sample contained in the shipping container;

    4. the time and date of sampling;

    5. the matrix of each sample;

    6. the number of containers each individual sample is contained in.

3. After the Chain of Custody Records have been completed for all containers in the shipment, the individual responsible for shipping will verify shipment by checking the Chain of Custody Record for each container and initialing the column CHECK BY on the Chain

of Custody Record to indicate that all samples shown on the Chain of Custody Record are contained in the shipping container. Immediately following verification of shipment for each container, the individual responsible for shipping will seal the container.

4. The individual responsible for shipping will log the shipment into the Shipping Log Book which will contain the following information;

    1. the sample set Lot Number;

    2. the date of shipping;

    3. the shipping ticket number;

    4. the printed name and signature of the individual responsible for shipping.

5. The individual responsible for shipping will file all Sampling and Splitting Logs, Chain of Custody Records, and a photocopy of the shipping ticket with the Consultant Project Manager as soon as the samples have been shipped.

If on site sample testing is required, the following procedure will be followed:

1. Upon receipt of samples, the individual responsible for testing will initial each sample on the Sampling and Splitting Log in the column marked LAB CHECK to indicate that all samples were received by the laboratory. This will serve as a chain of custody between the individual responsible for laboratory testing and the sampler or splitter.
2. The individual responsible for testing will log each sample on a Testing Docket which will indicate the following;

    1. the sample set Lot Number;

    2. the sample identification code;

3. the date of sample receipt;

4. all tests to be performed on each sample;

5. disposition of the sample following testing.

3. The individual responsible for testing will review and complete all data sheets required by the tests performed on each sample and date the column marked COMPLETE on the Testing Docket immediately after all required testing on an individual sample has been completed.

4. After testing, the sample will be disposed of in the Tailing Impoundment.

5. The individual responsible for testing will file all Sampling and Splitting forms and Testing Dockets with the Consultant Project Manager or WNI Facility Manager as soon as testing on all samples is complete.

6. All by-product contaminated soil that leaves the site for testing purposes shall be returned to the site for proper disposal in the Tailing Impoundment. The documentation will be maintained on file by WNI at the Split Rock site. A copy of the documentation will be provided to the Consultant by WNI for the Consultant's files.

OPERATING PROCEDURE

LAND SURVEYING FOR THE ESTABLISHMENT OF RADIOLOGICAL SAMPLING AND TESTING GRIDS

WARNING: NO PROCEDURE IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

To survey a grid system in the mill and tailing impoundment areas and to survey sampling locations.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,
2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site,
3. operation of and with potentially hazardous equipment,
4. working around steep slopes and natural tripping hazards,
5. eye injury hazards from plants and from particulate matter, and
6. life threatening hazards from snake bites.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,
2. substantial steel-toed shoes,
3. safety glasses, and
4. any additional items specified under the Radiation Work Permit (RWP).

4.0 SURVEYING EQUIPMENT

All surveying will be performed using standard surveying equipment.

The surveying team should have the following equipment and supplies:

1. required surveying equipment,
2. field book and site map,
3. lathe, hubs, hammer, and fluorescent paint or ribbon for setting and marking points.

5.0 PROCEDURES

5.1 Calculation of Grid Point Coordinates

A grid system will be established and the northing and easting coordinates of each grid corner will be determined. These coordinates will be supplied to the surveying team.

5.2 Establishment of Control Points

Existing control points will be used to survey the grid around the Tailing Impoundment. If additional control points are necessary to survey the grid system in the Mill or Tailing Area, a triangulation network between the new control point and two of the existing control points will be performed.

5.3 Survey Precision

When setting up the instrument, the northing and easting coordinate error must be less than 0.1 feet. When staking out grid points the coordinate error must be less than or equal to 0.4 feet.

5.4 Surveying Procedures

Standard surveying procedures as recommended by the surveying equipment manufacturer will be used for all surveying procedures.

A field check will be conducted every time the instrument is setup. This check will consist of simply turning to a point that has already been staked and verifying the lathe is on line.

6.0 EXIT SURVEY

Prior to leaving the Split Rock site, all equipment will be surveyed for residual contamination in accordance with WNI written operating procedures for surface contamination surveys on equipment released for unrestricted use. All surveys performed will be documented as part of the RWP.

7.0 DOCUMENTATION

All survey data will be electronically logged by the surveying instrument. These data will include:

1. date, time, location, and description of each point turned, and

2. list of northing, easting, and elevation of the control points.

If an instrument is used that does not record this information electronically, all of the data shall be recorded in a field book. The field book will constitute a portion of the permanent project record.

In addition to land surveying data, the surface contamination exit survey data sheet will be filed with the RSO and constitute a portion of the permanent project record.

RECONNA NCE SAMPLES

SPLIT ROCK MILL PROJECT
SAMPLING AND SPLITTING LOG

Lot No.________

Page_______of_______

Quality Compliance Report No.____________

COMPLETED BY SAMPLER						COMPLETED BY SPLITTER										
SUPERVISING SAMPLER: (Print/Signature)						SUPERVISING SPLITTER: (Print/Signature)										
OTHER SAMPLERS: (Print Names)						DATE RECEIVED:__________			DESTINATION OF SPLITS							
SAMPLE IDENTIFICATION	DATE	TIME	MATRIX	No. OF Containers	V.	R.	No. OF SPLITS	DATE SPLIT							LAB CHK	SHIP CHK
1.																
2.																
3.																
4.																
5.																
6.																
7.																
8.																
9.																
10.																
11.																
12.																
13.																
14.																
15.																
16.																
17.																
18.																
19.																
20.																

SPLIT ROC. MILL PROJECT
CHAIN OF CUSTODY RECORD

LOT No.________

Page______of______

Shipping Container No.____________

RESULTS TO | BILL TO

☐ ☐ Western Nuclear, Inc.
Split Rock Mill Project
Attn:_______________________
P.O. Box 630
Jeffrey City, WY 82310
Tel: (307) 544-2291 Fax: (307) 544-2291

☐ ☐ Shepherd Miller, Inc.
Attn:_______________________
1918 South Lemay
Fort Collins, CO 80525
Tel: (970) 490-2018 Fax: (970) 490-2102

SAMPLER: (Print Name/Signature)

ANALYSES REQUIRED

SAMPLE IDENTIFICATION	DATE	TIME	SAMPLE MATRIX	NO. OF CONTAINERS												CHECK BY
1.																
2.																
3.																
4.																
5.																
6.																
7.																
8.																
9.																
10.																

RELINQUISHED BY: (Signature/Company)	DATE	TIME	METHOD OF SHIPMENT	RECEIVED BY: (Signature/Company)	DATE	TIME
1.						
2.						
3.						
4.						
5.						

ATTACHMENT 2

APPENDIX D
SHIELDING STUDIES

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APPENDIX D
SHIELDING STUDIES

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1.0 PURPOSE AND OBJECTIVES

In designing the gamma-radium correlation study it was recognized that the effects of extraneous gamma radiation, radiation from sources other than the soil within the grid of interest, could result in gamma flux measurements which would not necessarily be representative of the soil within a given regulatory compliance grid. The sources of extraneous gamma radiation, commonly referred to as shine, include: elevated gamma radiation resulting from elevated Ra-226 or K-40 in areas adjacent to, but not part of the grid of interest; high energy radiation outside the grid of interest from sources such as Th-nat (known to be higher in the weathered quartz monzonite than in other soil types); and scattered environmental radiation.

A literature review was conducted to determine if information was available to aid in determining an appropriate shielding thickness and configuration which would limit the effects of shine. It was determined that the majority of information available was in the form of laboratory data generated using point source studies on individual isotopes, and very little information existed which addressed the effects of environmental conditions which would be better characterized as large flat-planer sources composed of multiple isotopes with a wide range of emitted gamma energies.

Since little information was available pertaining to effective shielding of environmental radiation, a series of field studies were conducted in May 1993. These studies were used to determine the size and configuration of lead shielding that would reduce the effects of shine and thus improve the gamma-radium correlation by obtaining gamma measurements which were representative of the soil within the compliance grid being measured.

2.0 EQUIPMENT AND PROCEDURES

2.1 Instrumentation

External gamma radiation measurements for the shielding study were taken using a system composed of a Ludlum Model 2350 data logger in conjunction with a Ludlum Model 44-10 high energy gamma detector. Prior to use, the system was configured in single channel analyzer mode by performing a windowed high voltage calibration around the 662 keV energy peak of a Cs-137 check source. By configuring the system in this way, it was possible to set a lower limit discriminator, or threshold. For the shielding study, a threshold of 550 kev was used in order to eliminate scattered low energy radiation and thus increase the sensitivity of the system to the major energies of interest which were the 609 keV, 1.12 MeV, and 1.76 MeV energies of the Ra-226 daughter product Bi-214.

2.2 Shielding Configurations

Shielding thicknesses of 1, 1.5, 1.75, and 2 inches were evaluated. Each shield consisted of a set of three, 1-inch high and two, 0.5-inch high annuluses. By stacking the annuluses, shielding heights of 1, 2, 3, 3.5, and 4 inches were tested. Because the data of interest were the net reduction of extraneous radiation resulting from varying shield thickness and heights, 4 inches of lead plates were placed below the probe to limit direct radiation from the underlying soil. A generalized diagram of the shielding configuration is given in Figure D.1.

2.3 Testing Locations

The two sources of significant shine which may effect the correlation and verification surveys are the mine overburden pile, located outside of the licensed area and along the western periphery of the Mill Area, and the tailing material in the Tailing Impoundment. In order to test the shielding over the full range of conditions under which the verification surveys would be performed, the following three locations, shown in Figure D.2, were selected for shield testing:

1. the toe of the mine overburden pile, representing high shine areas;
2. 150-feet from the toe of the mine overburden pile, representing areas with moderate shine; and
3. the pump house road, representing areas of minimal shine.

2.4 Testing

The 1.5, 1.75, and 2-inch shields were each tested at the three locations described above. The 1-inch shield was only tested at the pump house road location. This was because even at this location of minimal shine, the data indicated that a significant decrease in extraneous radiation was realized by the 1.5-inch shield as compared to the 1-inch shield (see Figure D.5), and therefore, further testing of the 1-inch shield was deemed unnecessary.

A gamma rate counting time of 2-minutes was used at the locations 150-feet from the mine overburden pile, and the pump house road. At the mine overburden toe location, a series of five 1-minute counts were taken in order to obtain data regarding counting variability. A summary of counting results for each shield configuration is given in Table D.1, and Tables D.2, D.3, and D.4 give the results of the multiple counts taken at the mine overburden toe location.

3.0 RESULTS

The results of the shield tests are plotted on Figures D.3, D.4, and D.5. These data reveal that a significant decrease in shine is realized by the 3-inch high, 1.75-inch thick shielding configuration as compared to the 2-inch high, 1.5-inch thick shield; but little additional decrease in shine is realized by a shield height greater than 3-inches or thicker than 1.75-inches.

A summary of the shielding results for the three test areas using the 3-inch high, 1.75-inch thick shield is shown in Figure D.6. A significant amount of shine is measured by the gamma detector using this shield configuration near the mine overburden pile. This demonstrates that the usefulness of the portable shield tested in this study may be limited in areas of high shine. Therefore, in designing the gamma-radium correlation study, consideration was given to a "maximum" shielding option in the event that action levels set using a portable shield could not be used in areas of high shine.

Final selection of the shielding configuration used in the gamma-radium correlation is discussed in Appendix G and was based on the findings of this study as well as physical constraints associated with conducting the gamma-radium correlation survey under field conditions.

TABLE D.1. RATE METER READINGS FOR SHIELDING TESTS (counts/min)

SHIELD HEIGHT (in.)	THICKNESS OF SHIELD ANNULUS (in.)									
	TOE OF WASTE ROCK PILE			150-FEET FROM WASTE ROCK PILE			PUMP HOUSE ROAD			
	1.5	1.75	2	1.5	1.75	2	1	1.5	1.75	2
0	6438	6438	6438	1705	1705	1705	1366	1366	1366	1366
1	3999	3623	3380	1152	1118	1022	916	825	754	654
2	1604	1403	1288	531	468	457	492	379	335	313
3	1127	891	832	307	255	229	449	300	227	225
3.5	1135	873	829	304	258	226	431	311	235	215
4	1076	878	816	285	229	221	420	301	226	210

TABLE D.2. 1.5-INCH SHIELDING TEST RESULTS AT TOE OF WASTE ROCK PILE
(counts/min)

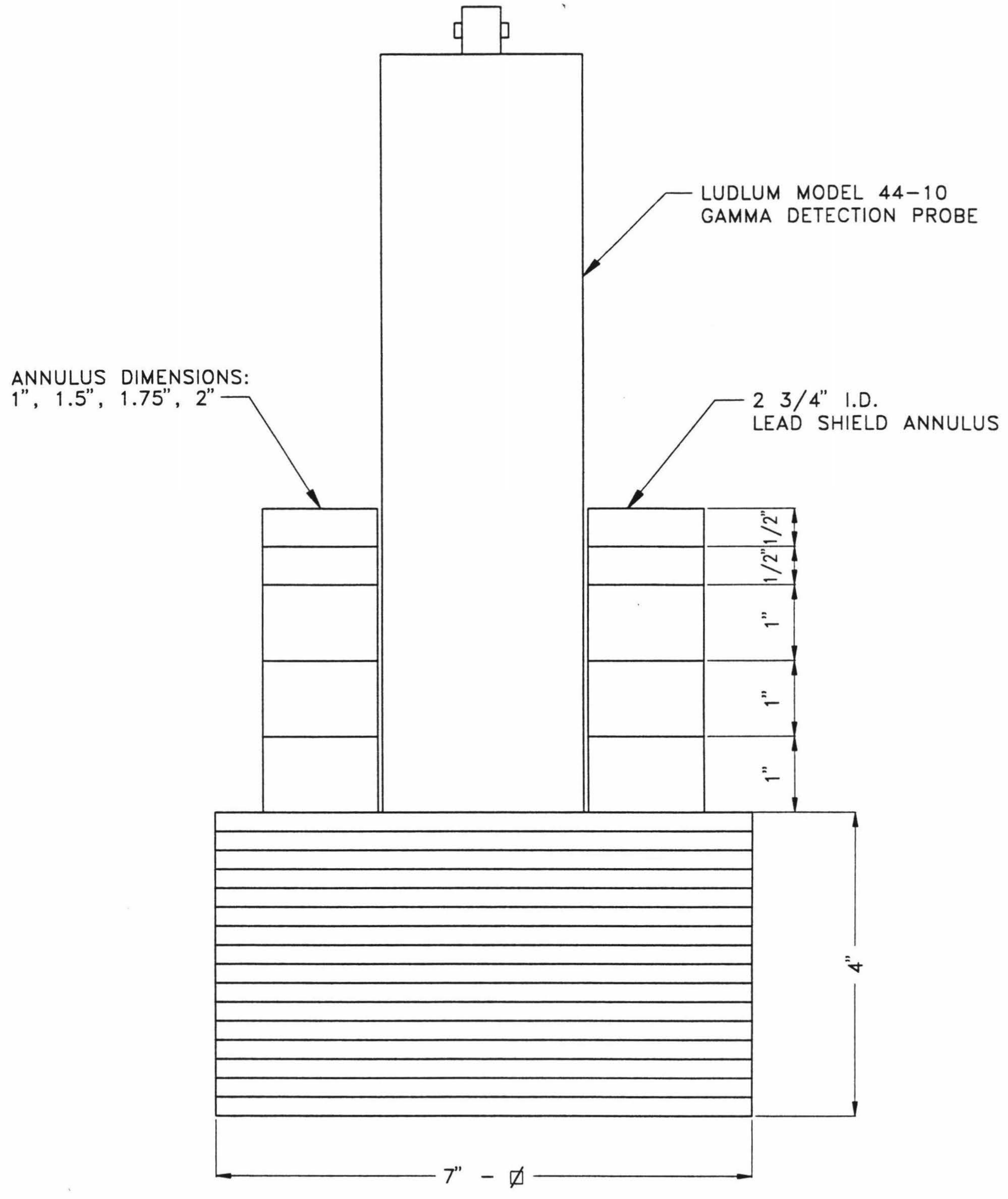
	SHIELD HEIGHT (in.)					
	0	1	2	3	3.5	4.5
	6476	3967	1656	1163	1188	1043
	6423	4123	1643	1093	1094	1095
	6479	3959	1557	1149	1091	1041
	6436	4026	1605	1153	1172	1065
	6374	3919	1559	1078	1132	1137
MAXIMUM	6479	4123	1656	1163	1188	1137
MINIMUM	6374	3919	1557	1078	1091	1041
MEAN	6438	3999	1604	1127	1135	1076
SDEV	43	79	46	39	44	40

TABLE D.3. 1.75-INCH SHIELDING TEST RESULTS AT TOE OF WASTE ROCK PILE
(counts/min)

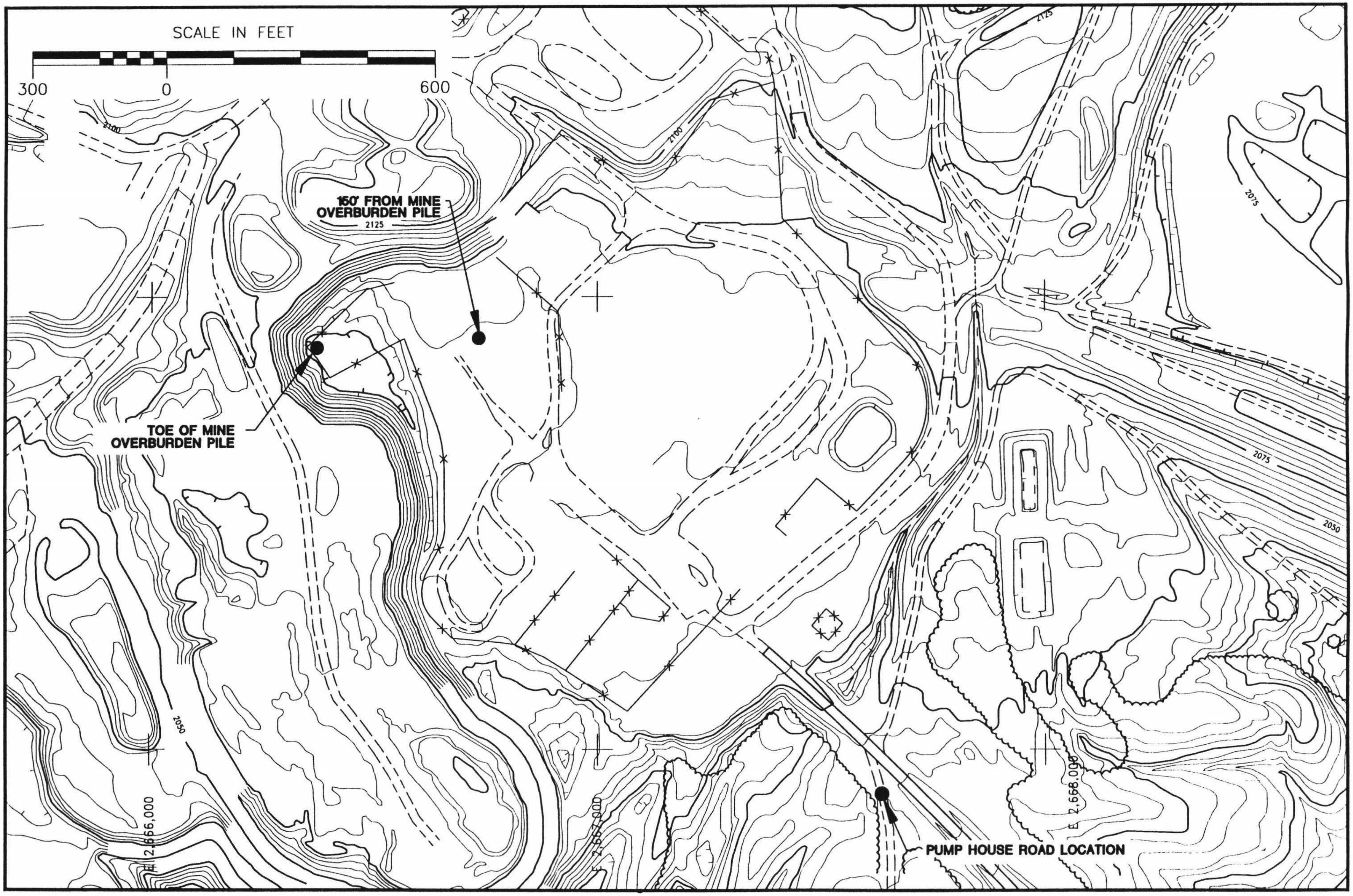
	SHIELD HEIGHT (in.)				
	1	2	3	3.5	4.5
	3573	1447	947	876	872
	3474	1393	883	904	894
	3698	1376	902	859	864
	3658	1382	903	897	884
	3714	1419	821	831	876
MAXIMUM	3714	1447	947	904	894
MINIMUM	3474	1376	821	831	864
MEAN	3623	1403	891	873	878
SDEV	100	29	46	30	11

TABLE D.4. 2-INCH SHIELDING TEST RESULTS AT TOE OF WASTE ROCK PILE
(counts/min)

	SHIELD HEIGHT (in.)				
	1	2	3	3.5	4.5
	3573	1447	947	876	872
	3474	1393	883	904	894
	3698	1376	902	859	864
	3658	1382	903	897	884
	3714	1419	821	831	876
MAXIMUM	3714	1447	947	904	894
MINIMUM	3474	1376	821	831	864
MEAN	3623	1403	891	873	878
SDEV	100	29	46	30	11



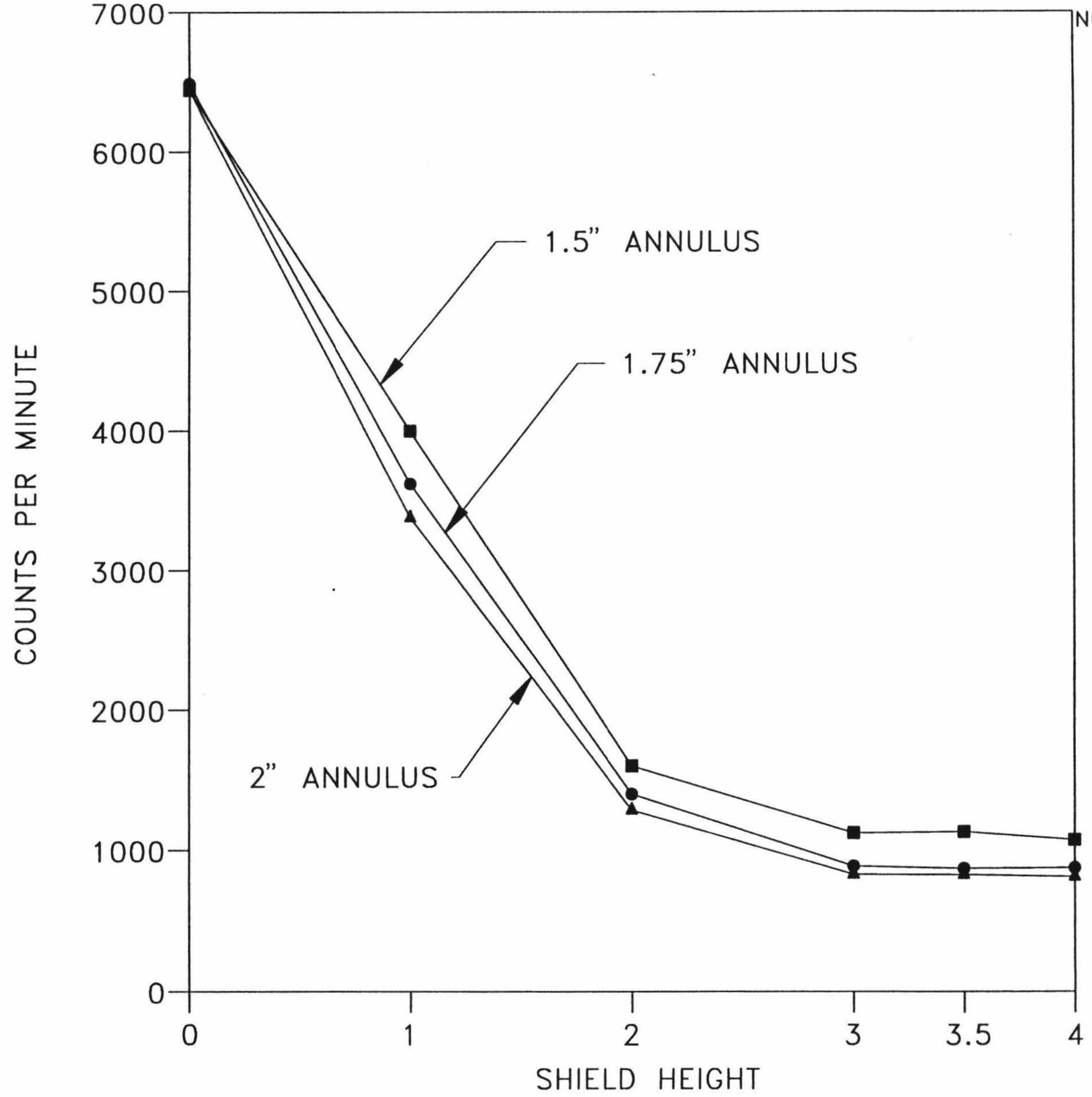
SMI SHEPHERD MILLER, INC.	FIGURE D.1 GENERALIZED SHIELDING CROSS-SECTION	Date: JULY, 1994 Project: 317 File: GSHIELD



SMI
SHEPHERD MILLER, INC.

FIGURE D.2
SHEILDING STUDY LOCATIONS

Date: JULY, 1994
Project: 317
File: SURVLOC

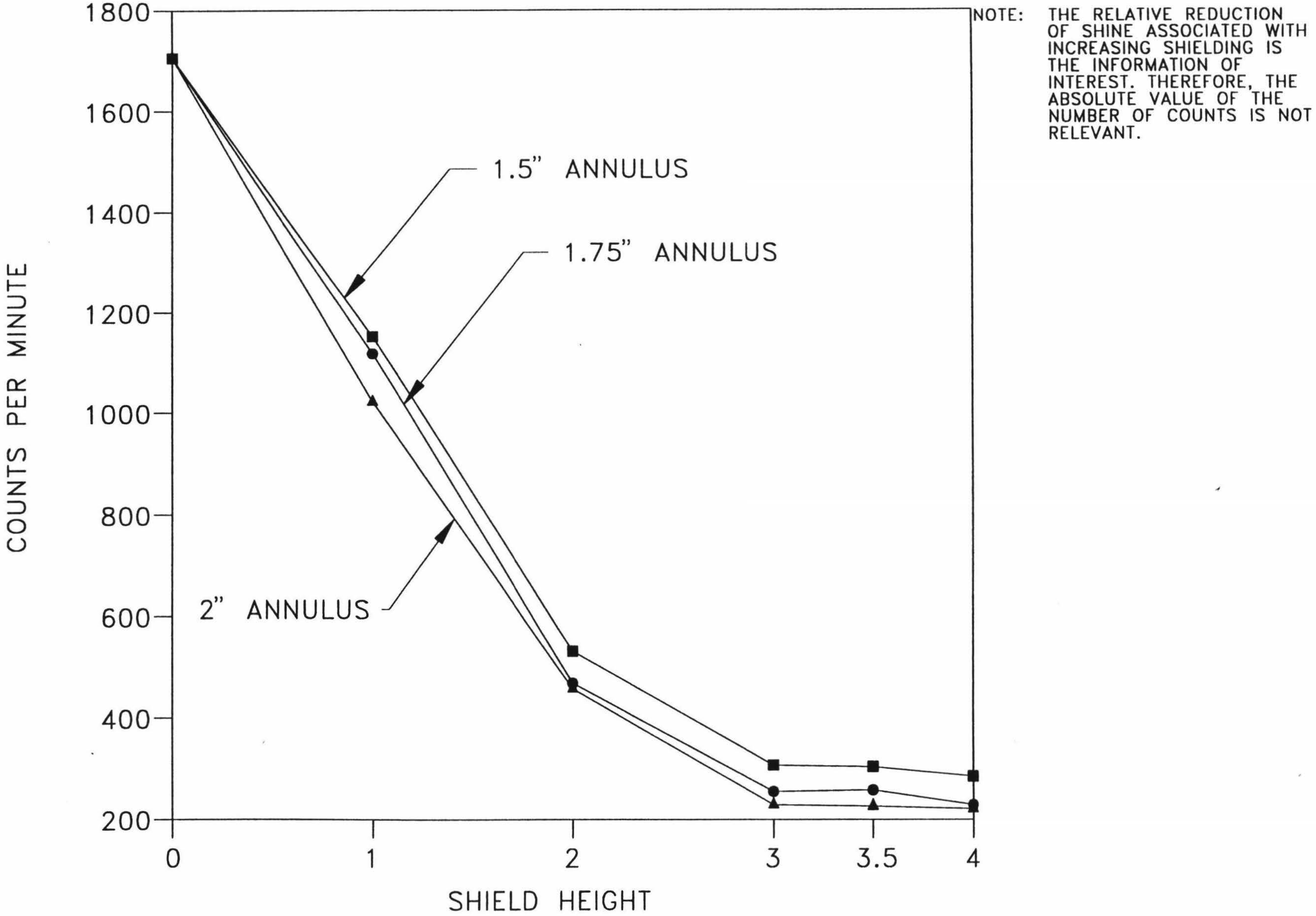


NOTE: THE RELATIVE REDUCTION OF SHINE ASSOCIATED WITH INCREASING SHIELDING IS THE INFORMATION OF INTEREST. THEREFORE, THE ABSOLUTE VALUE OF THE NUMBER OF COUNTS IS NOT RELEVANT.

SMI
SHEPHERD MILLER, INC.

FIGURE D.3
SHIELDING TEST RESULTS
AT TOE OF OVERBURDEN PILE

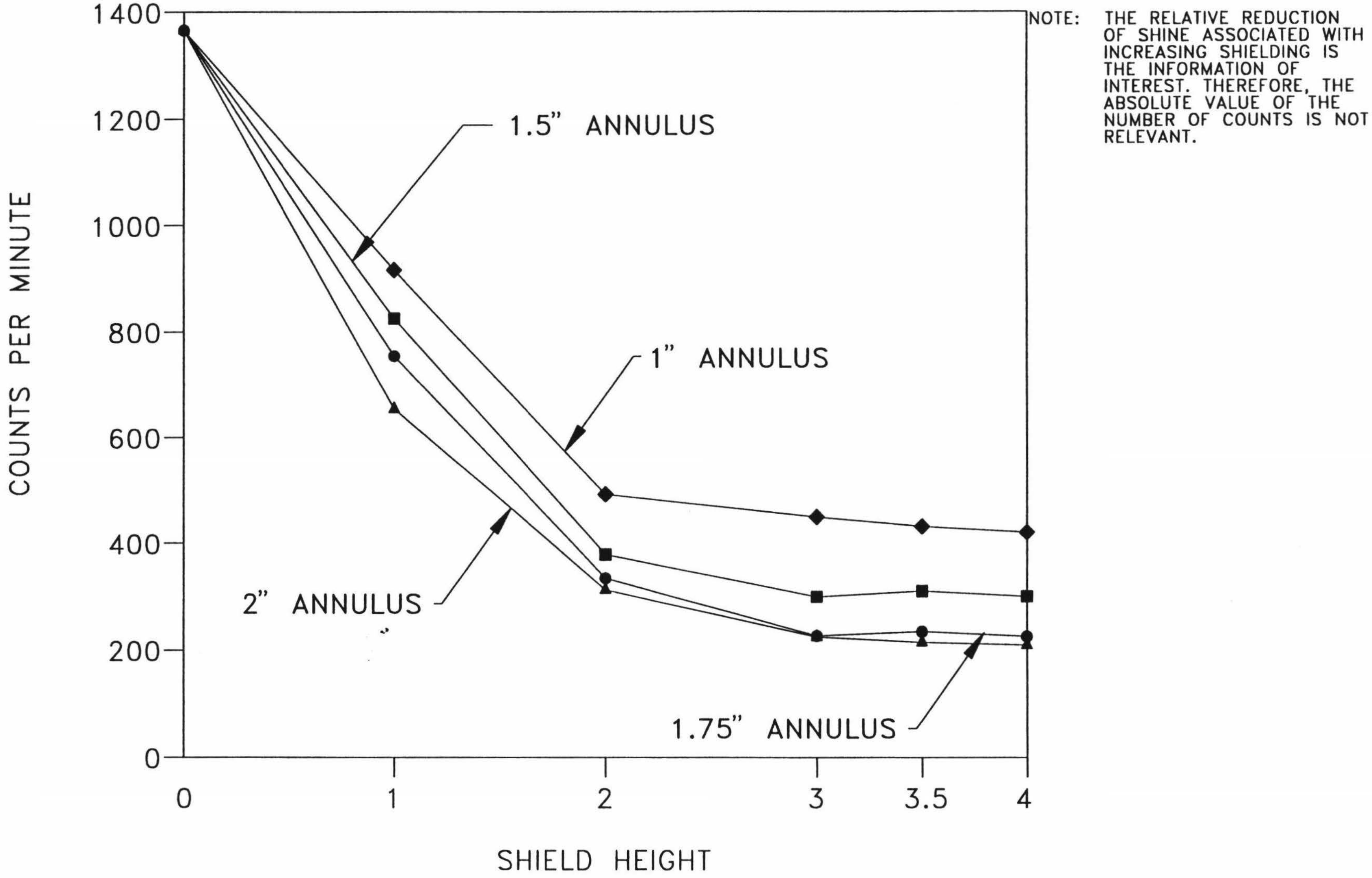
Date:	JULY, 1994
Project:	317
File:	TOE



SMI
SHEPHERD MILLER, INC.

FIGURE D.4
SHIELDING TEST RESULTS
150 FEET EAST OF OVERBURDEN PILE

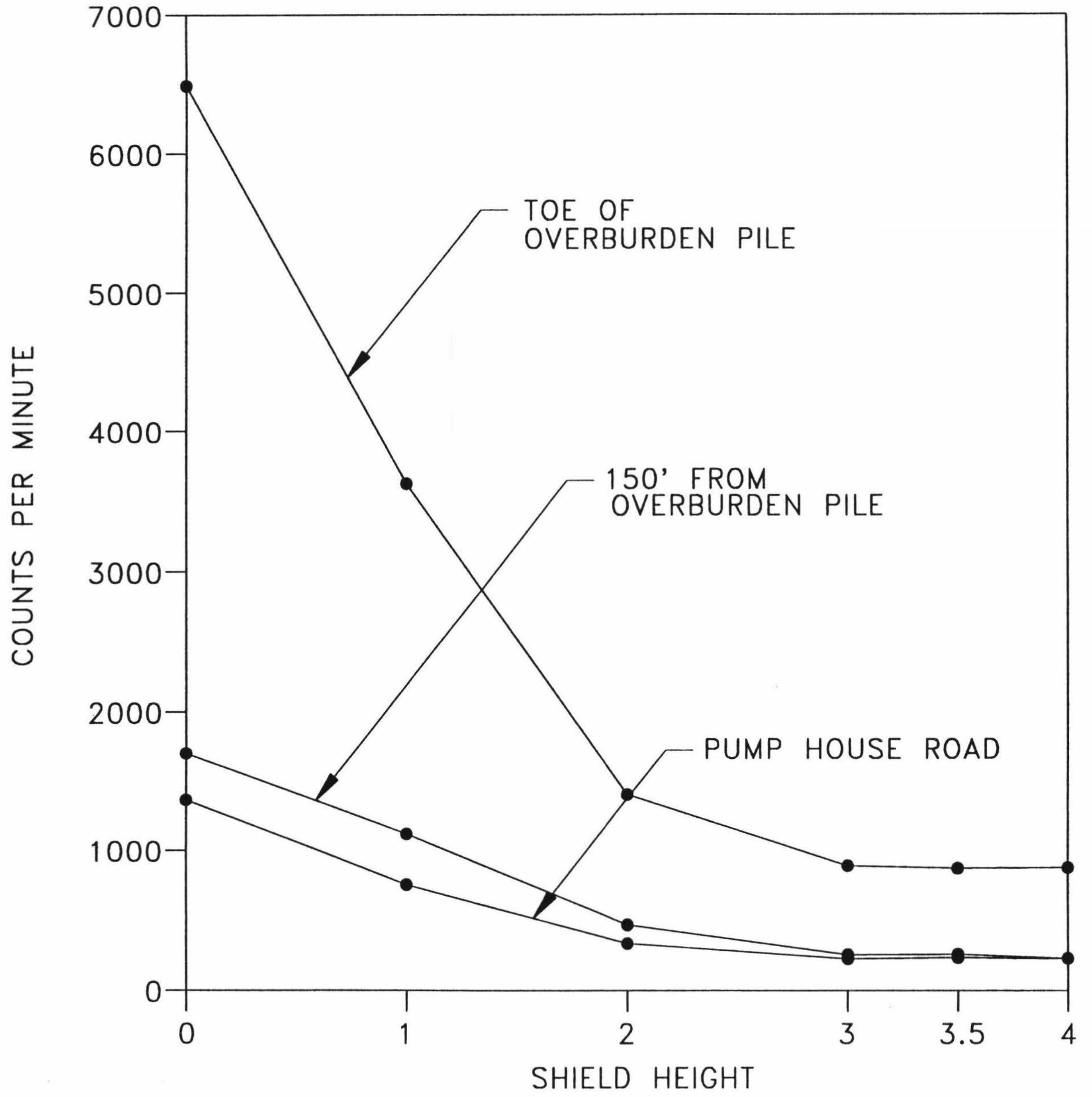
Date:	JULY, 1994
Project:	317
File:	150-FT



SMI
SHEPHERD MILLER, INC.

FIGURE D.5
SHIELDING TEST RESULTS
FROM PUMP HOUSE ROAD

Date: JULY, 1994
Project: 317
File: PUMP



SMI
SHEPHERD MILLER, INC.

FIGURE D.6
1.75 INCH SHIELD
RESULTS SUMMARY

Date:	JULY, 1994
Project:	317
File:	SUMMARY

ATTACHMENT 3

APPENDIX F
EFFECTS OF SOIL MOISTURE CONTENT ON THE MEASUREMENT OF EXTERNAL GAMMA RADIATION

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APPENDIX F
EFFECTS OF SOIL MOISTURE CONTENT ON THE MEASUREMENT OF EXTERNAL GAMMA RADIATION

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1.0 INTRODUCTION

The effect of soil moisture content on the measurement of external gamma radiation is neither a well known nor a well documented phenomenon. It is typically assumed that increased moisture content in soil results in attenuation of external gamma radiation. Some literature (NCRP 50, 1976) indicates that the attenuation of gamma radiation is primarily a function of the increasing soil density associated with increasing moisture content. For Sherwood site soils, the change in density due to the range of moisture contents that could exist for the soil can be expected to vary by a maximum of approximately 10%. This small difference is typically considered insignificant (Bendix Report, USDOE, 1984). However, no empirical field data relating to this issue could be found, leaving the relative magnitude of gamma attenuation unquantified.

In designing the gamma-radium correlation study, it was recognized that if the attenuation of external gamma radiation as a result of soil moisture content was significant, procedural controls for conducting gamma measurements would need to be instituted to minimize the potential of accepting significantly attenuated gamma readings as real values (i.e., false negatives). An example of possible procedural controls would be to specify that gamma measurements could not be taken for a given period of time following significant precipitation events. However, the rainfall event that would constitute "significant precipitation" and the waiting period following that event were unknown. Therefore, as described in this appendix, a series of field tests were conducted to quantify the results of varying soil moisture contents on external gamma radiation fluxes to aid in designing appropriate controls for conducting gamma surveys.

2.0 TESTING PROCEDURE

To simulate the anticipated field conditions under which the gamma-radium correlation and final verification surveys would be conducted, this study was done on a 10m x 10m grid and gamma measurements were taken using the integrated counting procedure described in WNI Standard Operating Procedure RS50 (SOP-RS50), provided in Attachment A, and discussed in Appendix G.

External gamma radiation measurements were taken with a system composed of a Ludlum Model 2350 data logger in conjunction with a Ludlum Model 44-10 high energy gamma detector shielded by the 3 inch high 1.75 inch thick lead shield. Prior to use, the system was configured in a single channel analyzer mode by performing a windowed high voltage calibration around the 662 keV energy peak of a Cs-137 check source in accordance with WNI SOP-RS70, provided in Attachment A. By configuring the system in this way, it was possible to set a lower limit discriminator, or threshold. For this study, a threshold of 550 kev was used in order to eliminate scattered low energy radiation and thus increase the sensitivity of the system to the major energies of interest which were the 609 keV, 1.12 MeV, and 1.76 MeV energies of the Ra-226 daughter product Bi-214.

As stated previously, the study was conducted using the same procedures which would be used for the gamma-radium correlation and final verification surveys. However, at the time the moisture content study was designed, it was not known what counting time would be used for those surveys. Therefore, exterior gamma radiation measurements were taken using counting times of 300 second and 600 seconds.

In designing this study, it was recognized that if procedural controls needed to be implemented, it would be easier and more cost effective to base those procedures on precipitation depth rather than actual moisture content since precipitation depth is a simpler parameter to measure in the field. Therefore, "precipitation" was incrementally added to the grid by multiple passes of a water truck. Preliminary experiments demonstrated that the water truck was capable of evenly distributing approximately 0.01-inches of precipitation with each pass through the grid. To further monitor the precipitation depth, a Thompson rain gage was placed in the center of the grid and monitored to ensure an accurate record of precipitation depth for comparison with gamma measurements. Precipitation depths of 0.10, 0.25, 0.50, 1.00, and 2.00-inches were incrementally added to the grid and gamma measurements taken at each depth.

3.0 RESULTS

The counting data obtained are summarized in Table F.1, and the original down-loaded instrument data are provided in Attachment B. As shown in Table F.1, the results of the soil moisture content tests indicated that while there may be a general downward trend in external gamma radiation measurements with increasing precipitation quantities, the relationship is not well defined. In fact, in some cases gamma readings were observed to increase with additional precipitation quantity. It can be seen from Table F.1 that the maximum difference in gamma readings after application of water, as compared to the dry value, is less than 5% for the 600 second counting time and less than 7% for the 300 second counting time. Further, the variability that was observed was typically within the counting error statistics at the 95% confidence level.

Based on these data, it was concluded that up to 2 inches of precipitation will not significantly affect external gamma radiation flux at the Sherwood Site. To put this depth of rainfall into perspective one must consider the following: 2 inches of precipitation constitutes approximately 0.5-inches more precipitation than the 100-year, 6-hour storm event and only 0.2 inches less than the 100-year, 24-hour storm event for this area.

Therefore, the findings of this study confirm the literature and indicate that normal precipitation events will impact neither the gamma-radium correlation nor the final verification surveys. No procedural controls will be necessary to restrict external gamma radiation surveys following normal precipitation events at the site.

TABLE F.1 EFFECTS OF PRECIPITATION DEPTH ON EXTERNAL GAMMA RADIATION MEASUREMENT

PRECIP DEPTH (in.)	TOTAL COUNTS[1]	
	300 Sec	600 Sec
0.00	9034 ± 189	17858 ± 262
0.10	8942 ± 185	17806 ± 262
0.25	8859 ± 184	17074 ± 256
0.50	8408 ± 180	17315 ± 258
1.00	8851 ± 184	17654 ± 260
2.00	8538 ± 181	17153 ± 257

[1]Counting errors reported at the 95% confidence level.

ATTACHMENT A
STANDARD OPERATING PROCEDURES

OPERATING PROCEDURE

EXTERNAL GAMMA RADIATION MEASUREMENT BY THE INTEGRATED WALKING COUNT METHOD

WARNING: NO SAMPLE OR FIELD DATUM IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK AND SAMPLE COLLECTION CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The objective of this procedure is to determine the level of gamma radiation in selected grids.

2.0 HAZARDS

2.1 Industrial Hazards

This procedure may involve several industrial hazards associated with mining and/or construction operations. These hazards include, but are not limited to:

1. large scale earth-moving equipment in the vicinity and on access roads,

2. debris and road conditions as well as equipment traffic posing significant safety hazards to driving while on site,

3. operation of and with potentially hazardous equipment,

4. working around steep slopes and natural tripping hazards,

OPERATING PROCEDURE

EXTERNAL GAMMA RADIATION MEASUREMENT BY THE INTEGRATED WALKING COUNT METHOD

5. eye injury hazards from plants and from particulate matter, and

6. life threatening hazards from snake bites.

2.2 Hazardous Materials

These procedures may involve working around or near hazardous materials such as inorganic acids or bases (used for sample preservation), and fuel and oil for portable equipment. Western Nuclear, Inc. (WNI) maintains the required material safety data sheet file available for all individuals to review prior to working with any such materials.

2.3 Radioactive Materials

These procedures may involve working around or near radioactive materials such as contaminated soils and/or equipment. All such activity will be directed by the WNI Radiation Safety Officer (RSO) and under the auspices of a Radiation Work Permit (RWP) issued only by the RSO. Within the RWP, the degree of radiological hazard is described and protection measures, procedures and equipment are prescribed. The industrial hazards and hazardous materials described above are also addressed within the RWP. Any concerns regarding these hazards are to be directed to the WNI RSO and documented.

3.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment required under this operating procedure are:

1. hardhat,

2. substantial steel-toed shoes,

3. safety glasses, and

4. any additional items specified under the Radiation Work Permit (RWP).

4.0 EQUIPMENT

External gamma radiation measurements will be taken with a Ludlum model 2350 data logger with a Ludlum model 44-10 NaI detector, or equivalent. The detector will be shielded from extraneous sources of gamma radiation by a 1.75-inch thick, 3-inch high lead shield.

5.0 EXTERNAL GAMMA RADIATION MEASUREMENT PROCEDURE

1. The operator will enter the grid location code into the instrument.

2. The operator will enter the scalar counting time into the instrument.

3. Once the count time is set, the operator will activate the count.

4. Immediately upon activating the count the operator will start from a grid corner and begin to walk back and forth across the grid in a linear fashion. The operator will attempt to walk at a uniform pace. Once the operator reaches the grid corner diagonally opposite from the starting grid corner, the operator will turn 90 degrees and walk perpendicular to the previous direction working back to the starting grid corner in the same fashion. The operator will walk the grid until the counting time expires, at which time the instrument will automatically log the reading and sound an alarm to indicate that the counting has been completed.

5. If more than one (1) counting time is required, the operator will repeat steps 1 through 4.

6. The instrument and detector will be calibrated daily and performance checks will be performed as described in SOP-RC70.

7. The data from the instrument will be down loaded periodically to a computer and stored for future analysis.

6.0 EXIT SURVEY

Exit surveys will be performed as required in the RWP, as deemed necessary by the RSO or as requested by any field personnel. The procedure will follow WNI standard operating procedures for surface contamination surveys.

7.0 DOCUMENTATION

All data will be electronically logged by the 2350 instrument, or equivalent. These data will include:

1. location of the scaler count,
2. scaler count,
3. counting time,
4. date count was taken,
5. time count was taken.

If an instrument is used that does not electronically record this information, all of the data shall be recorded in a field book. The field book will constitute a portion of the permanent project record.

OPERATING PROCEDURE

INSTRUMENT CALIBRATION AND PERFORMANCE CHECKS

WARNING: NO PROCEDURE IS WORTH THE LOSS OF LIFE OR LIMB. FIELD WORK CAN BE DANGEROUS. ALWAYS BE AWARE OF THE HAZARDS THAT YOU MAY ENCOUNTER IN THE FIELD AND TAKE THE NECESSARY PRECAUTIONS. NEVER ATTEMPT ANY FIELD ACTIVITIES WITHOUT THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.0 OBJECTIVE

The objective of this procedure is to perform instrument calibration and performance checks on external gamma radiation detection equipment to ensure proper working condition and performance of the instrumentation on a daily basis.

2.0 HAZARDS

This procedure will involve working with and handling a Cesium 137 performance check source. Cesium 137 is a high energy gamma emitter. All personnel will be required to wear a Thermal Luminescent Dosimeter (TLD) badge when performing this procedure. Time spent handling the source will be kept to a minimum. The check source will be stored in a lead shield when not in use.

3.0 PERSONAL PROTECTIVE EQUIPMENT

This operating procedure does not require any specific personal protective equipment.

OPERATING PROCEDURE

INSTRUMENT CALIBRATION AND PERFORMANCE CHECKS

4.0 EQUIPMENT

4.1 Calibration Equipment

The instruments will be calibrated using a reference Cesium 137 performance check source placed in reproducible constant geometry relative to the detector.

4.2 Instrument Precision

All instruments must consistently provide performance check readings within a margin of ± 20%.

5.0 PROCEDURES

5.1 Calibration Procedure

The instruments will be calibrated according to the manufacturer's specifications for calibration procedures.

5.2 Performance Check Procedure

The instruments will be checked according to the manufacturer's specifications for performance check procedures.

6.0 EXIT SURVEYS

Not applicable.

OPERATING PROCEDURE

INSTRUMENT CALIBRATION AND PERFORMANCE CHECKS

7.0 DOCUMENTATION

All instrument calibration and performance checks will be documented in the calibration log book. The log book will constitute a portion of the permanent project record.

ATTACHMENT B
FIELD DATA

ID		DATE	TIME	COUNTS	COUNT TIME	OPERATOR	2350#
M1412453	F	08/03/93	07:45	9034	300	D.KIFFER	98616
M1412453	F	08/03/93	07:57	17858	600	D.KIFFER	98616
M1412453	F	08/03/93	08:14	17806	600	D.KIFFER	98616
M1412453	F	08/03/93	08:21	8942	300	D.KIFFER	98616
M1412453	F	08/03/93	08:37	8859	300	D.KIFFER	98616
M1412453	F	08/03/93	08:49	17074	600	D.KIFFER	98616
M1412453	F	08/03/93	09:18	17315	600	D.KIFFER	98616
M1412453	F	08/03/93	09:24	8408	300	D.KIFFER	98616
M1412453	F	08/03/93	10:11	8851	300	D.KIFFER	98616
M1412453	F	08/03/93	10:24	17654	600	D.KIFFER	98616
M1412453	F	08/03/93	11:19	17153	600	D.KIFFER	98616
M1412453	F	08/03/93	11:26	8538	300	D.KIFFER	98616