SOP-2
AVM Environnemental Services, Inc.
Field Gamma Radiation Survey for Ra-226 Concentration in Soil
For Gamma Radiation Surveys at Uranium Mill and Mine Sites

1.0 SCOPE

1.1 Purpose

This procedure will be used to determine Ra-226 concentration in surface soil by direct gamma radiation level survey for conducting Characterization, Excavation Control (Remedial Action Support) survey and status survey at uranium mill and mine sites.

1.2 Applicability

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

2.0 EQUIPMENT AND MATERIALS

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

2.2 A global positioning system (GPS) with real time differential correction capability and a data logger. Currently AVM uses a Magellan MobileMapper CX (MMCX) with TDS SOLO surveying software. The MMCX is a data logger and a DGPS system which is capable of real time differential position correction using WAAS signal.

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

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

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

2.6 Measuring tape, pin flags and area markers.

3.0 INSTRUMENT CONFIGURATION & OPERATIONS

Prior to any instrument function check or the operation, the technician will read the Technical Manual for the instrument operations (Ludlum 2221 or ESP-2) and the correlation method (SOP- 1) for the rationale behind the gamma radiation surveys.

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

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

The instrumentation must be calibrated consistent with SOP-3 prior to use.

3.1 Instrument Function Check

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

3.1.1 Scaler/Ratemeter General Setting

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

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

3.1.2 Visual inspection

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

3.1.3 Calibration Due

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

3.1.4 Battery charge

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

3.1.5 High Voltage

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

3.1.6 Threshold (input sensitivity)

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

3.1.7 Window

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

3.1.8 C.C. Calibration Constant

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

3.1.9 Background Counts

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

3.1.10 Source Function Counts

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

3.1.11 Instrument Tolerance

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

3.1.12 Technician

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

3.2 Instrument Minimum Detectable Concentration Calculation

If required, calculate Minimum Detectable Concentration (MDC) for the instrumentation using the function check background readings as described in SOP-3. Calculate MDC for appropriate survey, i.e. Direct Measurement MDC for static (stationary) gamma radiation survey and scan MDC for scan or walkthrough gamma radiation survey. Record the MDC in the Function Check Form (Attachment A).

4.0 FIELD GAMMA RADIATION SURVEYS

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

4.1 Scan Radiation Survey

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

A GPS based gamma radiation scan survey can be performed to log gamma radiation rate with corresponding point location coordinates in a data logger. This scan survey can be performed by walking the area with 2x2 NaI detector with ratemeter coupled with a DGPS/data logger unit. The GPS-gamma scan survey system will consist of a Ludlum 2221 Ratemeter/Scaler with SPA-3 2x2 NaI Detector coupled to a Magellan MobileMapper CX (MMCX). The MMCX is a real time DGPS with data logging capabilities using a TDS SOLO surveying software. The Ludlum 2221 will be operated in ratemeter mode, allowing a gamma count rate (cpm) to be logged with its corresponding coordinates in 2-second interval. Appropriate walk-over transect spacing based on the scan coverage rate will be used for this survey.

You can partially automate the logging process by logging points by interval. You can log points after a specified time period has elapsed. The procedure for using the Log By Interval function is described below:

1. Select **Log** > **Log by Interval**, or tap the **Log by Interval** button in the Mode Toolbar. This will open the **Select Feature to Log** screen.
2. You will be prompted to select a feature and to complete the attribute entry. When you tap on the **OK** button in the **Attributes** screen, the **Log by Interval** screen will be displayed.
3. Select between **Log by TIME interval.**
4. Enter the **2.00 Seconds** log interval in the **Log every** field.
5. Tap the **Start** button to begin logging by interval.

The first point will be logged at your current position. Once you have waited the specified time another point will be logged. This will continue until you tap the **Pause** button or close the screen. At the end of each survey day, the field data will be downloaded into a computer and processed for tabularization and mapping. Download the survey file as follow:

Select **File** > **More** > **Export** to open the **File Export** screen.

You may select the **Export Format** by tapping on the down arrow to the right of the selection box. choose Text, All exported files are stored in \My\Documents\SOLO\Export by default, otherwise. If **Prompt for filename** is selected, you can customize the names as each file is created.

Depending upon the export format selected, you may choose to export your features in two ways; a unique file for each feature layer, or one file.

With **Text *.txt** selected as the **Export Format**, tap **Options** to display the text options. You may turn these options on/off using the checkbox next to each option.

When you are satisfied with your selections, tap the **Export** button to create the file(s) in the selected format

4.2 Static Radiation Survey

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

4.3 Remedial Action Support (Excavation Control) Survey

Excavation control survey will be performed to guide excavation of contaminated soil exceeding the 2.24 pCi/g Ra-226 cleanup level during the IRA at the NECR, which is equivalent to the direct gamma radiation count of 5,075 cpm for the collimated detector based on the SRSE updated correlation.. This direct radiation cleanup level may change as cleanup progresses; therefore, contact your supervisor to obtain the current direct radiation cleanup level. Excavation control survey will be performed using combination of scan radiation survey and static radiation level measurements as follow:

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

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

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

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

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

5. If no point or a location exceeding the action level is identified within the area by the scan, the excavation is complete and ready for the Interim Status survey.

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

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

4.4 Interim Status Survey

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

1. If the detector needs to be collimated for the area of interest, place the detector in the 0.5 inch

lead collimator. Perform the function check as indicated in Section 4.2 of this procedure.

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

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

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

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

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

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

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

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

5.0 ATTACHMENTS

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

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

Scaler/Ratemeter ID:______________________ Function Check Source ID: 1% U_3O_8 Ore in Sealed can

2" x 2" Detector ID:______________________ Acceptable background Count (cpm) Range (20%) ______________ to ______________

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

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

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

Attachment B, SOP-2
Gamma Radiation Survey @ UNC's NECR Mine Site

Scan/Walkthrough Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter ____________________, Detector ____________________

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

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

Survey Area/Unit Decsription ____________________

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

Technician Signature ____________________, Reviewed by ____________________

Attachment C, SOP-2
Gamma Radiation Survey @ UNC's NECR Mine Site

Static Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter_________________________, Detector ____________________________________

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

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

Survey Area/Unit Decsription ____

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

Technician Signature ________________________________, Reviewed by ________________________________

SOP-3
AVM Environmental Services, Inc.
Calibration of the Scalar Rate Meter And the 2"x2" NaI Detector
For Gamma Radiation Surveys @ Uranium Mill and Mine Sites

1. SCOPE

1.1 Purpose

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

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

1.2 Applicability

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

2. REFERENCES

2.1 Technical Manual for Scaler Ratemeter, Model 2221

3. REQUIREMENTS

3.1 Tools, Material, Equipment

3.1.1 Small screwdriver.

3.1.2 Ludlum Model 500 Pulser or equivalent.

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

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

3.2 Precautions, Limit

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

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

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

3.3 Acceptance Criteria

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

4. LUDLUM 2221 OPERATION CALIBRATION

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

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

4.2 Set the threshold value as follows:

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

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

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

4.4 Connect the Ludlum 500 Pulser to the 2221.

4.5 Switch SCALER/DIG RATEMETER switch to DIG RATEMETER.

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

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

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

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

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

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

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

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

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

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

The Ludlum 2221 is ready for detector calibration and operation.

5. DETECTOR HIGH VOLTAGE AND BACKGROUND CALIBRATION

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

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

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

5.3 Check Threshold setting. Should be at 100 mV.

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

5.5 Set HV to 500 VDC.

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

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

5.8 Return HV setting back to 500 VDC.

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

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

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

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

6. OPERATING BACKGROUND AND SOURCE FUNCTION CHECK DETERMINATION

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

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

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

7. EFFICIENCY CALIBRATION

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

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

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

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

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

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

8. MINIMUM DETECTABLE CONCENTRATION CALCULATION

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

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

Where

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

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

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

8.2 MDC for Scan Gamma Radiation survey

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

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

Where:

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

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

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

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

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

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

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

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

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

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

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

Attachment A, SOP-3
AVM Environmental Services Inc.

Scaler/Ratemeter Calibration Form

Model_______________________ S/N _______________

Calibration Source____

Threshold (input sensitivity), Found at____________ Left or Set at _______

Window, In/Out_______ Window ___________

Pulser Amplitude Set @_____________________mV

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

HV Set @__________ VDC

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Date ___________________ Calibrated By ______________________________

Attachment B, SOP-3
AVM Environmental Services Inc.
Scaler/Ratemeter - Detector Calibration Form

Scaler/Ratemeter ________________________________
Detector ____________________________________

Source: ______________________ Strength: ____________

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

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

Background reading at designated function check location in office.

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

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

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

HV Set @____________ VDC (Instrument) ____________ VDC (DVM Fluke 8020B

Input Sensitivity (THR), mV ______________

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

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

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

Date ______________________ By ________________________________

SOP-4
AVM Environmental Services, Inc.
Field Soil Gamma Radiation Screening Procedure
For Gamma Radiation Surveys at Uranium Mill and Mine Sites

1.0 Introduction

This field soil screening procedure for Ra-226 consists of measuring 609 KeV peak gamma radiations of Bi-214, a decay product of Ra-226 through Rn-222. The 609 KeV gamma radiation counts of the sample soil is compared to a reference soil from the Site with a known Ra-226 concentration for field screening. Although the Rn-222 is a gas and the soil is not sealed, the soil retains about 70% of Rn-222 gas within the soil matrix, resulting in a significant amount of Bi-214 decay product and its gamma radiations. Bi-214 609 KeV gamma radiation is at fairly high intensity (46%) and isolated, which minimizes interference from other energy gamma radiations. For a quick estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration (similar to screening level), which is not previously sealed, the 609 KeV gamma radiation level of Bi-214 can be measured (pulse height analysis) for field screening. A single channel analyzer (SCA), such as Ludlum L221 integrated with Ludlum 44-20 3x3 NaI scintillation detector can be used to measure radiation of a particular energy of Bi-214. The sample is then placed in a heavily shielded counting chamber (plastic bag lined 1.5 inch thick x 7.5 Inch ID x 12 inch tall lead ring collimator with a 1.5 inch thick lead bottom shield). The heavily shielded counting chamber lowers the background counts thus lowers the detectable concentration. The 3x3 NaI detector lined with a plastic sheet is then placed on the sample inside the chamber and 609 KeV gamma radiation counts are obtained and compared to the reference soil and sample soil for field screening.

2.0 L2221/44-20 Window Operation and Energy Calibration Procedure

The following procedure calibrates threshold directly in keV.

1. Place RATEMETER multiplier switch to LOG position.

2. Unscrew and remove CAL cover.

3. Press HV pushbutton. The HV should read out on the display directly in volts. While depressing the HV pushbutton, turn HV potentiometer maximum counterclockwise. The HV should be less than 50 volts.

4. Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.

5. With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.

6. Switch WIN IN/OUT to OUT.

7. Connect the probe (Ludlum 44-20) and expose to Cs-137 source.

8. Increase HV (if HV potentiometer is at minimum, it will take approximately 3 turns before any change is indicated). While increasing the HV, observe the log scale of the ratemeter. Increase HV until ratemeter indication occurs.

9. Switch WIN IN/OUT switch to IN.

10. Turn the HV control until maximum reading occurs on the log scale. Increase HV until reading starts to drop off, then decrease the HV for maximum reading.

11. Turn RATEMETER selector switch to the X1K position.

12. Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

13. Carefully adjust HV potentiometer until maximum reading is achieved on the range scale. The instrument is now peaked for Cs137 on both the LOG and Linear scales. Record HV for energy calibration.

    NOTE: When the THR control is adjusted, the effective window width remains constant. As an example, if the THR is set at 559, the WIN at 100, a 609 KeV peak +559 (100 divided by 2) will be centered in the window. Then the threshold point is equivalent to 559 KeV with a 100 KeV window and calibrated for 100 KeV per turn. Now if the threshold is reduced to 250, the threshold is equivalent to 250 KeV, but the window (100) is still equal to 100 KeV. Proportionally, this represents a broader window.

14. Set THR at 559 and window at 100 for Bi-214 609 KeV (559 to 669 KeV ROI) gamma radiation measurement. Expose the detector with a 1% Uranium ore function check source and obtain a one minute counts. Remove the function check source and obtain a one minute background counts.

3.0 Field Soil Screening Procedure

1. Setup the L2221 parameters (HV, Threshold and Window) obtained during energy calibration above and connect the 44-20 detector. Make sure the window toggle switch is in the IN position.

2. Setup the counting chamber shield in back of pick-up truck.

3. Perform function check with 1% Uranium ore function check source.

4. Line the counting chamber by inserting a plastic bag to prevent cross contamination.

5. Obtain one gallon of reference soil. Place approximately 1 inch of soil at the bottom of the lined chamber. Place plastic sheet lined (to prevent cross contamination) 44-20 detector facing crystal down and on top of the one inch soil bed in the center of the chamber. Placed remainder of the one gallon soil around the detector without any void. Sample is wrapped around the detector crystal, similar to the Marinelli Beaker geometry to provide the best counting efficiency.

6. Obtain a 5-minute integrated count with L2221 in Scaler mode and record.

7. Remove detector, and the soil with liner bag. Insert new plastic bag in the chamber for liner, and re-line detector with new plastic sheet. Repeat step 5 and 6 for sample soil (one gallon). Change counting chamber liner and detector liner between every sample.

AVM Environmental
Services Inc.
L2221 SCA/L44-20 Energy
Calibration Form

SCA: L2221, SR #68782	Detector: Ludlum 44-20 (3x3 NaI Scintillator)

Calibration Source: Cs-137 Check Source, 5 uCi (August 2008) For 662 KeV Peak Cal

Threshold (input sensitivity) **652**

Window, In/Out **IN** Window **20**

HV Initial __________, At Peak __________

Maximum CPM: __________

HV Set @__________ VDC

For Bi-214 609.2 KeV Peak (559 - 659 KeV ROI), Set Threshold @ __________, Window @ __________

Calibration Check w 1% U3O8 Ore Check Source: __________ CPM

Date __________ Calibrated By __________

AVM Environmental Services, Inc.
Field Soil Sample Gamma Radiation Screening Form

Instrumentation : Scaler/Ratemeter____, Detector ___________________

Instrument Calibration Date: ________, Instrument Function Check Performed: ____

1 Gallon Soil sample in lined 1.5 inch thick lead Ring (collimator) with 3 inch thick steel bottom shield

Survey Area/Unit Decsription _________________________________

Date/Time	Soil Sample ID	609 (559-669) Kev Gamma Radiation Counts	Comments

Technician Signature ________________________ Reviewed by _____________________________

MWH

APPENDIX A.2

MWH STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURES PRE-DESIGN STUDIES CHURCH ROCK MINE AND MILL SITE	SOP-01 Revision: 0
HOLLOW STEM AUGER DRILLING, SAMPLING, AND CONE PENETRATION TESTING (CPT)	Date: August 2013

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1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedure for hollow stem auger (HSA) drilling and collecting geotechnical soil samples, as well as cone penetration testing (CPT). The borings and test locations will be conducted at locations specified in the Work Plans. The sample intervals and test parameters are specified in the Work Plans. The procedures presented here are intended to be general in nature to allow various methods to be used based on variable site specific conditions.

2.0 PROCEDURES

2.1 BOREHOLE AND TEST LOCATIONS

Borehole locations will be initially located by a surveyor or by field staff using hand-held GPS coordinates provided in the Work Plans. Locations may be adjusted as needed in any direction from the preliminary location to facilitate drill rig access or to obstacles. Actual (adjusted) locations based on GPS coordinates will be noted on the field logs at time of drilling.

On completion of backfilling of each borehole, the location will be marked with a survey stake, noting the borehole number as provided in the Work Plans. On completion of backfilling and marking by survey stakes of all boreholes, ground surveys will be completed to locate the boreholes according to the marked locations.

2.2 CONE PENETRATION TESTING

A CPT(u) rig capable of measuring pore pressures in-situ and performing seismic CPTs will be used to advance the cone penetrometer through the tailings and native site soils (as applicable) according to the procedures outlined in ASTM D5778 (ASTM, 2012). If necessary, waste rock or other stiff surficial soils that cannot be penetrated without damaging CPT equipment will be penetrated using hydro-punch or auger drilling method to provide a pilot hole through such layers prior to CPT sounding.

The cone penetrometer will be advanced into the tailings at a constant rate to provide a continuous profile of the material. The cone penetrometer will be advanced until refusal. Should refusal occur at a significantly shallower depth than expected, the rig will be moved five feet and the penetrometer will again be advanced until the anticipated depth at that location is reached.

If perched water is encountered, pore pressure dissipation tests will be performed, once per sounding location, where positive pore pressure conditions exist, or as directed by the supervising field engineer or geologist. In order to properly measure pore pressures, the operator will saturate the porous stones within the probe before each test is started.

2.3 HOLLOW STEM AUGER DRILLING

The boreholes will be drilled with hollow stem augers (HSA) of various sizes. Soil sampling may include continuous core, California barrel samples, standard split spoon samples, and Shelby tube samples. Drill cuttings will be placed on the ground adjacent to the boreholes. In areas of concern, the cuttings will be placed on plastic sheeting, until they can be returned to the borehole.

2.4 SOIL SAMPLING

The types and frequencies of soil samples will be provided in the Work Plans. Descriptions of the proposed sample types are included in the following sections.

2.4.1 Continuous Core Samples

Continuous core samples will be collected with a five-foot long continuous sampler barrel advanced inside the HSA as the HSA are advanced. Acrylic sample sleeves (30 or 60-inches long) may be used within the continuous core sampler to collect samples of sensitive materials. The continuous sampler barrel will be retrieved, opened, and the recovery measured/recorded. Out of place soils (slough) at the top of the sampler will be discarded. The soil core will be transferred intact to a core-logging table or truck bed, and core depth intervals marked with legible labels. Samples may be either removed from the core barrels prior to logging, or may be retained in transparent liners.

Photos of the labeled soil core will be taken. The samples will be logged and classified as specified in under Sample Descriptions and in SOP-17 Soil Logging. After logging and photographing the core, samples may be retained by one of two procedures at the discretion of the field geologist or geotechnical engineer, as follows:

1. Bulk samples: zones of similarly classified materials greater than 1-foot thick may be placed in bulk sample containers and handled as specified in Section 2.4.5. Adjacent core materials from the subsequent run or runs having similar classifications may be combined (composited) with the previously collected bulk samples. Subsamples of minor strata (less than 1 foot thick) having distinctly different field classifications than adjacent major strata, and samples for moisture testing will be placed in 1 gallon resealable bags and placed inside the sample buckets on top of the associated bulk composite samples.

2. Liner samples: Samples collected in transparent plastic liners may be retained in the liners. Liner caps will be sealed with plastic tape. Sample orientation will be indicated by an arrow pointing up or a "T" on the top cap.

Sample buckets, bags, and retained liners will be marked with the boring number and depth interval in accordance with SOP-14.

2.4.2 Split-spoon Samples

Split-spoon samples will be collected by driving the split spoon ahead of the HSA with a 140-lb hammer falling 30 inches. The sampler will be driven 18 inches and blow counts will be recorded for 6-inch intervals. Various diameters of split-spoon samplers may be used. The HSA will be advanced into the soils as necessary to provide discrete sample intervals. When retrieved, the split-spoon sampler will be opened, the recovery will be measured/recorded, and the soil described as specified in Section 2.4.6.

Split-spoon samples will be collected on a maximum of five feet vertical intervals. The sampled interval will be placed in gallon resealable bags. Out of place soils (slough) at the top of the sampler will not be sampled. Samples will be labeled and handled as specified in SOPs-06, 14, and 17. Sample depth will be the starting depth of the sample.

2.4.3 California Split-barrel Samples

California split-barrel samples will be collected by driving the California split barrel ahead of the HSA with a 140-lb hammer falling 30 inches. The California split-barrel sampler will be driven 18 inches and blow counts will be recorded for 6-inch intervals. California split-barrel samples will be collected utilizing a 2.5-inch outside diameter (OD) California split barrel sampler lined with three 2-inch diameter by 4-inch long brass liners, plus additional brass liners as necessary to fill the California split barrel sampler. Alternate sampler diameters may be considered for use, depending on the application.

The sample recovery will be measured/recorded and the soil described as specified in Section 2.4.6. The bottom two, 4-inch long, brass liners will be retained and capped; other recovered soils will be discarded. The brass liners will be labeled with the project number, borehole, sample depth, liner identification, sample date, and orientation. Sample depth is defined as the starting depth of the sample drive. Brass liner identification is “A” for the bottom brass liner and “B” for the brass liner above the “A” brass liner. Sample orientation is an arrow pointing up, a “T” on the top cap, or the orientation of the sample labeling.

2.4.4 Shelby Tube Samples

Shelby tube samples will be collected at locations and intervals specified in the Work Plans. Shelby tube samples will be collected by hydraulically advancing a 3-inch diameter (or other approved diameter), 30-inch long, Shelby tube sampler two feet or to refusal. The recovery will be measured and the soils described as specified in Section 2.4.6 by inspecting the soils at the top and bottom of the Shelby tube.

The Shelby tubes will be sealed before transport. The bottom cap will be secured with plastic tape. Melted wax (paraffin or paraffin with beeswax) will be poured into the top of the Shelby tube to stabilize and seal the top of the sample and be used to seal the end tape and caps. Spacers may also be used to stabilize the samples within the tubes. The top cap will then be secured with plastic tape (see SOP-06).

Both the Shelby tube and the top cap will be labeled with the job number, borehole, sample interval, orientation, and sample date. Shelby tubes must be handled, transported, and stored vertically and cushioned against shock and vibration.

2.4.5 Bulk Samples

Bulk samples will be collected at intervals specified in the Work Plans. Bulk samples may be collected from continuous core samples (Section 2.4.1), or auger cuttings as indicated in the Work Plans and placed in plastic buckets (3.5 or 5 gallon) for geotechnical testing and classification.

The sealed buckets will be labeled and handled as specified in the SOP-14.

2.4.6 Sample Descriptions

Soils will be described and classified in general accordance with SOP-17 (Soil Logging) and ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM, 2009). Sample descriptions will include soil type, moisture content, color (Munsell Color), density or consistency, plasticity, grain-size and shape, and other descriptors, as applicable.

Boreholes will be logged on MWH Borehole Log forms. An example MWH Borehole Log form for recording field information is attached to this SOP as Appendix A. Sample intervals, recovery, blow counts (if performed), soil descriptions, and sample time will be recorded.

2.4.7 Field QA/QC Samples

Field duplicate and equipment blank samples for geotechnical samples will not be collected. Equipment blanks of geotechnical sampling equipment will not be collected.

2.5 DECONTAMINATION

HSA and CPT equipment will be decontaminated by removing visible material with a scraper or brush between test holes. Geotechnical sampling equipment will be decontaminated by removing visible material with a scraper or brush between samples. Equipment will be decontaminated at the drill sites. See also SOP-31 for additional details.

2.5.1 Borehole and CPT Abandonment

Abandonment specifics will be described in the Work Plans and may vary depending on the sampling location at the site. HSA boreholes and CPT holes will be abandoned with bentonite grout and/or soil cuttings. Bentonite grout, when used, will be placed to within about 1 to 2 feet from the ground surface, or to the top of the radon barrier, then the top of the borehole will be backfilled with drill cuttings, or cover material.

3.0 DOCUMENTATION AND RECORDS MANAGEMENT

Field data will be recorded in bound field books or on MWH Borehole Log forms (Appendix A). Documentation and records procedures are specified in SOP-14. Field data collected during CPT will be recorded in bound field books and by the instruments associated with the cone penetrometer. Data recorded by the cone penetrometer instrumentation will be provided, by the operator, to MWH within seven days of completion of CPT activities.

4.0 REFERENCES

ASTM. 2012. Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils. ASTM D5778-12. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2009. Standard Practice for Description and Identification of Soils (Visual- Manual Procedure). D2488-09a. American Society for Testing and Materials, West Conshohocken, PA.

APPENDIX A

SAMPLE BOREHOLE LOG

BORING LOG NUMBER:

SHEET ___ OF ___

LOC. ID: ELEVATION: DATUM:

PROJECT NAME.: DRILL DATE:

INCLINATION: AZIMUTH: HAMMER WEIGHT: DATE FINISHED:

LOCATION SKETCH

DEPTH (UNITS)	BORING METHOD	SOIL PROFILE — SOIL DESCRIPTION	GRAPHIC LOG	SAMPLES — USCS	NUMBER	TYPE	BLOW COUNT/6"	RECOVERY	ADDITIONAL COMMENTS
0									
5									
10									
15									
20									
25									
30									
35									
40									
45									

DEPTH UNITS: ____________

DRILLING CONTRACTOR: ____________

DRILLER: ____________

LOGGED BY: ____________

CHECKED BY: ____________

REV. No.	REVISIONS	REV. DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY

SOIL BORING LOG FORM

MWH

PROJECT No.:

AutoCAD FILE:

SCALE: FIGURE No:

Boring #: MW#: Project: Sheet of

PID/OVA	Sample Interval	Recovered (in.)	Blow Counts / 6 in.	Retained for Analysis.	Casing Type & Size	Annulus Filler	Depth (Feet)	USCS Soil Type	Soil Description	Estimated % Of				
										Gravel	Sand			Silt/Clay
											Coarse	Med.	Fine	
							2							
							3							
							4							
							5							
							6							
							7							
							8							
							9							
							0							
							1							
							2							
							3							
							4							
							5							
							6							
							7							
							8							
							9							
							0							
							1							
							2							

QA/QC

STANDARD OPERATING PROCEDURES PRE-DESIGN STUDIES CHURCH ROCK MINE AND MILL SITE	SOP-06 Revision: 0
SAMPLE MANAGEMENT AND SHIPPING	Date: July 2013

STANDARD OPERATING PROCEDURE 06
SAMPLE MANAGEMENT AND SHIPPING

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LIST OF ATTACHMENTS

1.0 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) describes the requirements for sample identification, handling, storage, chain-of-custody (COC) documentation, and shipping. The purpose of this SOP is to define sample management activities as performed from the time of sample collection to the time they are received by the laboratory.

These procedures apply to all work conducted for MWH clients, by MWH, or under direction of MWH at the Church Rock Mine and Mill sites during Pre-Design studies. The information in this SOP may be used by direct reference or incorporated into project-specific plans. Deviations or modifications to procedures addressed herein must be brought to the attention of, and approved by, the Project Manager.

2.0 SAMPLE MANAGEMENT PROCEDURES

2.1 SAMPLE CONTAINERS

Samples will be placed in containers that are appropriate for the type of sample collected and the analyses that will be performed.

2.1.1 Chemical Samples

Samples to be submitted for chemical analysis will be placed in contaminant-free containers. Containers will be stored in cool, dry, clean areas to prevent exposure to fuels, solvents, and other non-site related impacts. Sample containers with preservatives added by the laboratory will not be used if held for an extended period on the job site or exposed to extreme heat conditions.

The sample containers to be used will be dependent on the sample matrix and analyses desired. Sample containers will be filled with adequate headspace if necessary (approximately 90 percent) for safe handling upon opening, except containers for volatile organic compound (VOC) analyses, which will be filled completely with no headspace. The no-headspace requirement applies to both soil and groundwater samples.

Once opened, the containers will be used immediately. If the container is used for any reason in the field (e.g., screening) and not sent to the laboratory for analysis, it will be discarded. Prior to discarding the contents of the used container and/or the container, disposal requirements will be evaluated to assess whether the contents or the container require disposal as a hazardous material. The containers will be stored (before and after sampling) remain separate from solvents and other volatile organic materials.

2.1.2 Geotechnical Samples

Samples to be submitted for geotechnical analysis will be collected in brass or plastic sleeves, or Shelby tubes as undisturbed samples, or in plastic bags or buckets as bulk samples. Undisturbed tube samples will be capped with plastic end caps and taped at both ends and/or sealed in re-sealable plastic bags to maintain sample moisture content. For Shelby tube samples, spacers will be used to stabilize the samples along with cheesecloth and wax. Wax will then be used in addition to plastic caps to seal both ends of each sample prior to prevent moisture loss.

2.2 FIELD SAMPLE IDENTIFICATION AND LABELING

2.2.1 Field Sample Identification

A protocol for field sample identification will be clearly defined at the beginning of the project based on client requirements and will be carried forward throughout the duration of the project. A coding system will be used to uniquely identify each sample collected.

The sample identifier should include sufficient information to allow for quick data retrieval and tracking throughout the project. This information could include the company name, date of sample collection, area of sample collection (such as Central Cell, East Borrow, etc.), test pit or boring identification, and depth of sample collection. As an example, the sample identifier "MWH-31JUL2013-EB-TP-1 @ 4-5"" would designate a sample collected by MWH on July 31, 2013 from Test Pit #1 in the East Borrow area from a depth of 4 to 5 inches. Regardless of the specific format used, it should be defined at the beginning of the project and carried forward through the duration of the project.

2.2.2 Sample Label

A sample label similar to that shown in Attachment 1 will be affixed to all sample containers. The sample label, at a minimum will be completed with the following information:

- Client name, project title, or project location
- Sample location
- Sample identification number
- Date and time of sample collection
- Type of sample (grab or composite)
- Initials of sampler
- Preservative used (if applicable)
- Label number (if applicable)

Alternatively, the above information may be written directly on the sample containers with permanent, waterproof ink.

If a sample is split with another party, identical labels will be attached to each sample container.

2.3 SAMPLE HANDLING AND STORAGE

After labeling, each aqueous sample will be refrigerated or placed upright in a cooler. Wet ice, in double re-sealable bags (to prevent leakage), will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled and maintained at 4 degrees Celsius (°C) $\pm$ 2 °C prior to and during transport to the laboratory.

Geotechnical samples will be stored in a sturdy box, cooler, plastic bucket, or similar container. Care should be taken to store the samples out of direct sunlight. Shelby tubes and similar undisturbed samples will be stored upright and will be protected from excessive vibration and disturbance. If samples will be stored for several days prior to transport to the laboratory, they should be stored in a secure location rather than in a vehicle to protect them from vibration and disturbance.

Some sample types require specific handling procedures, including:

- Compressed gas cylinders
- Radioactive substances
- Biological hazards
- Chemical warfare agents
- Drugs (controlled substances)
- Explosive ordnance
- Explosives (as per the Department of Transportation [DOT])
- Shock-sensitive materials

If any of these materials are associated with a project, the field personnel must follow the health and safety procedures defined in the project-specific plans.

2.4 SAMPLE PRESERVATION

The requirements for sample preservation are dependent on the desired analyses and the sample matrix. Sample preservation requirements outlined in the project-specific work plan will be followed. When an acid or base is used as preservative, pH paper will be used to determine if an adequate amount of preservative is being used to preserve analytical samples. When testing pH for VOC samples, a third VOC sample will be collected, tested with pH paper, and then disposed of properly.

2.5 QUALITY CONTROL SAMPLES

The number and types of quality control (QC) samples to be collected for a project will be defined in the project-specific plans. The following briefly describes field QC samples that may be collected during a field program.

2.5.1 Trip Blanks

Trip blanks are used to assess cross-contamination of samples for VOC analysis from sample containers or during sample transport and storage at the laboratory. Trip blanks consist of 40 milliliter (ml) amber glass vials filled by the laboratories with acidified reagent-grade water, then sealed by the laboratories prior to shipment. Trip blank vials accompany the empty bottles to the site and remain with the samples throughout sample collection and shipment.

2.5.2 Equipment Rinseate Blanks

Equipment rinseate blanks are used to evaluate sample equipment decontamination procedures and are prepared in the field (after decontamination of sampling equipment is complete). These samples are prepared by collecting the final equipment decontamination rinse water into the appropriate sample container.

2.5.3 Filter Blanks

If water samples are collected for dissolved metals analysis, a filter blank (for each lot of filters) should be collected prior to sample collection to evaluate whether the filter is a source of metals to the samples. This sample is collected in the field by passing the source water through the same filter type that will be used to filter water media for dissolved metals analysis.

2.5.4 Duplicate Samples

Duplicate field samples (water samples) are used to assess variability in the sample media and to assess sampling and analytical precision. A duplicate sample pair is a single aqueous grab sample that is split into two samples during collection. If the field duplicate is being submitted blind to the laboratory, one of the samples is labeled with the correct sample identification and the other is labeled with fictitious sample identification. Regardless of whether the samples are submitted blind to the laboratory or not, the field duplicate and parent sample are submitted to the same laboratory as two separate samples.

2.5.5 Replicate Samples

Replicate field samples (air, soil, or sediment) are used to assess variability in the sample media and to assess sampling and analytical precision. A replicate sample pair is a single soil grab sample that is split into two samples during collection. If the field replicate is being submitted blind to the laboratory one of the samples is labeled with the correct sample identification and the other is labeled with a fictitious sample name. Regardless of whether the samples are submitted blind to the laboratory or not, the field replicate and parent sample are submitted to the same laboratory as two separate samples.

2.6 SAMPLE HOLDING TIMES

The holding times for samples will depend on the analysis and the sample matrix. Unless otherwise specified, holding times listed in project-specific work plans will be followed. For geotechnical samples, holding times do not apply. However, samples will be shipped as soon as possible and kept cool to prevent drying and mold growth.

2.7 CHAIN-OF-CUSTODY (COC)

Chain-of-custody procedures require a written record of the possession of individual samples from the time of collection through laboratory analyses. A sample is considered to be in custody if it is:

- In a person's possession
- In view after being in physical possession
- In a secured condition after having been in physical custody
- In a designated secure area, restricted to authorized personnel

2.7.1 COC Record

The COC record, similar to the example shown in Attachment 2, will be used to document the samples collected and the required analyses. Information recorded by field personnel on the COC record will include the following:

- Client name
- Project name
- Project location
- Sampling location
- Signature of sampler(s)
- Sample identification number
- Date and time of collection
- Sample designation (grab or composite)
- Sample matrix
- Signature of individuals involved in custody transfer (including date and time of transfer)
- Airbill number (if appropriate)
- Number and type of samples collected for each analysis
- Type of analysis and laboratory method number
- Any comments regarding individual samples (e.g., organic vapor meter readings, special instructions)

All COC entries will be made using indelible ink and will be legible. Any errors will be corrected by drawing a single line through the incorrect entry, entering the correct information, and then initialing and dating the change. Unused portions of the COC form will be crossed out with a single strike through and initialed and dated by the field sampler.

If the samples are transferred directly from the field sampler to the laboratory, both the receiving and relinquishing individuals will sign the COC. If samples are transported to the laboratory by a commercial carrier, signed airbills or other applicable bills of lading will serve as evidence of custody transfer between the field sampler and carrier as well as carrier and laboratory.

The sampler will retain copies of the COC record and airbills, or bills of lading. If the COC records are sequentially numbered the record number and airbill number will be cross-referenced in the field logbook or appropriate field form.

2.7.2 Custody Seals

Custody seals, similar to the label shown in Attachment 3, will be used on each sample (if required) and/or shipping container to ensure custody. Custody seals used during the course of the project will consist of security tape with the date and initials of the sampler. As a minimum, custody seals will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected. If required by the client, a seal will be placed on each sample container so that it must be broken to gain access to the contents. Because VOC samples may be subject to contamination by the tape, VOC sample containers will first be secured in a re-sealable plastic bag. The plastic bag will then be sealed with a completed custody seal. If the seals are serially numbered, these numbers will be cross-referenced in both the field logbook and the COC form.

2.7.3 Sample Register/Sample Tracking

The sample register maybe electronic or a bound logbook with sequentially numbered pages. The sample register is used to document which samples were collected each day. The sample register is also used as the key to correlate field samples with duplicate samples. Information that will be recorded in the sample register includes the following:

- Client name
- Project name and location
- Job number
- Date and time of collection
- Sample identification number
- Sample designation (e.g., grab or composite, etc.)
- Sample matrix (e.g., soil, groundwater, etc.)
- Number and type of bottles
- Type of analysis
- Sample destination
- Sampler's initials

If the sample register is electronic, a hard copy of each day's sampling activities will be maintained in the field logbook.

2.8 SAMPLE SHIPPING

Geotechnical samples will be preserved and transported in general accordance with ASTM D4220. Shelby tube samples and brass liners will be transported vertically in the orientation in which they were obtained. If the samples will be driven to the laboratory by field staff, they will be secured for transport against excessive vibration inside the cab of the vehicle on the seats. If the samples will be shipped by a commercial carrier, shipping containers designed to maintain orientation and minimize disturbance will be used.

Procedures for packaging and transporting samples to the laboratory are based on the actual chemical, physical, and hazard properties of the material. The procedures may also be based on an estimation of contaminant concentrations/properties in the samples to be shipped. Samples will be identified as environmental samples, excepted quantities samples, limited quantities samples, or standard hazardous materials.

- Environmental samples are defined as solid or liquid samples collected for chemical or geotechnical analysis.
- Excepted quantities involve the shipment of a few milliliters of either an acid or base preservative in an otherwise empty sample container.
- Limited quantities are restricted amounts of hazardous materials that may be shipped in generic, sturdy containers (this includes geotechnical samples of mill tailings).
- Standard hazardous material shipments require the use of stamped/certified containers.

Samples other than those listed above (refer to Section 2.3) must be shipped according to the requirements of 49 CFR 173.24 and other applicable Federal, state, and local regulations. Prior to the collection and shipment of these samples, shipment requirements will be researched, a written description of shipment procedures will be prepared, and the description reviewed and approved by a MWH certified industrial hygienist prior to sample collection. These shipment procedures will be included in the project-specific plans. Examples of such samples include materials that potentially contain asbestos, radioactive materials, explosives, and chemical warfare agents, and transformer fluids (refer to Section 2.3).

The following paragraphs describe standard sample shipping procedures for different types of samples. Any exceptions to these procedures will be defined in the project-specific work plan. If the samples to be collected are potentially limited quantity or standard hazardous materials the most current DOT regulations must be reviewed to ensure that the most current shipping procedures are used. The carrier service selected for transport may also be able to provide information needed for sample shipping procedures. It is the responsibility of the sampler to understand Department of Transportation requirements and limitations associated with the shipment of all types of samples.

No samples, other than geotechnical samples, will be held on site for more than 24 hours, except during weekend field activities. Samples collected on the weekend will be stored under refrigeration and shipped the following Monday. Sampling activities for analytes with extremely short holding times, such as 24 hours, will not be scheduled for weekend collection.

Occasionally, multiple coolers or packages will be sent in one shipment to the laboratory. One cooler will have the original COC Record and the other coolers will have copies. The plastic bag in which the COC Records are placed will be marked appropriately “ORIGINAL” or “COPY.” In addition, the outside of the coolers will be marked to indicate how many coolers are in the shipment (i.e. “1 of 2” or “2 of 2”).

2.8.1 Environmental Samples

Hand-Delivered Samples: For aqueous or solid samples that will be hand carried to the Contract Laboratory the following procedures apply:

- Sample labels will be completed and attached to sample containers as described in Section 2.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler.
- Wet ice in double re-sealable bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled during transport to the laboratory.
- To prevent the sample containers from shifting inside the cooler, the remaining space in cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC Record will accompany the samples to the laboratory.
- A copy of the COC Record will be retained for the project files.

Commercial Carrier: For aqueous or non-geotechnical solid samples that are shipped to the Contract Laboratory via a commercial carrier the following procedures apply:

- Sample labels will be completed and attached to sample containers as described in Section 2.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler. If the container has a drain, the drain will be taped shut and a large plastic bag used as a liner for the cooler. Each sample will be placed in a separate re-sealable or bubble-wrap bag. As much air as possible will be squeezed from the bag before sealing. Bags may be sealed with a custody seal if required by the client.
- Wet ice in double re-sealable bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled and maintained at 4°C ± 2°C during transport to the laboratory. Dry ice will not be used. In addition, experience has shown that blue ice is inadequate to maintain sample temperature and it will not be used for sample preservation.
- To prevent the sample containers from shifting inside the cooler, the remaining space in the cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC Record will be placed in a waterproof plastic bag and taped to the inside of the cooler lid.
- The lid will be secured by wrapping strapping tape completely around the cooler in two locations.

- As a minimum, custody seals similar to those shown in Attachment 3 will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected.
- The airbill will be filled out before the samples are handed over to the carrier. The laboratory will be notified if MWH personnel suspect that the sample contains any substance for which the laboratory personnel should take safety precautions.
- A copy of the COC Record and the signed air bill will be retained for the project files.

Geotechnical Samples: Geotechnical samples may be hand-delivered or shipped in a sturdy box or other container. No ice is necessary. Enough packing material will be added so that samples remain undisturbed. COC procedures as described previously will be followed to generate defensible data. Any hazardous nature of the samples, including any organic vapor measurements, name of suspected contaminants present, and the approximate range of concentrations, if know, should be noted on the COC Record.

2.8.2 Excepted Quantities

Usually, corrosive preservatives (e.g., hydrochloric acid, sulfuric acid, nitric acid, or sodium hydroxide) are added to otherwise empty sample bottles by the analytical laboratory prior to shipment to field sites. However, if there is an occasion whereby personnel are required to ship bottles with these undiluted acids or bases, the containers will be shipped in the following manner:

- Each individual sample container will have not more than 30 milliliters of preservative.
- Collectively, these individual containers will not exceed 500 milliliters in the same outer box or package.
- Despite the small quantities, only chemically compatible material may be placed in the same outer box, i.e., sodium hydroxide, a base, must be packaged separately from the acids.
- Federal Express will transport nitric acid only in concentrations of 40 percent or less.
- A "Dangerous Goods in Excepted Quantities" Label will be affixed to the outside of the outer box or container. Information required on the label includes:
  - Signature of Shipper
  - Title of Shipper
  - Date
  - Name and Address of Shipper
  - Check of Applicable Hazard Class
  - Listing of UN Numbers for Materials in Hazard Classes.

2.8.3 Limited Quantities

Occasionally, it may become necessary to ship known hazardous materials, such as pure product (e.g., light or dense non-aqueous phase liquids, geotechnical samples of uranium mill tailings). DOT regulations still permit the shipment of many hazardous materials in "sturdy" packages, such as an ice chest or cardboard box (not a specially constructed and certified container), provided the following conditions are met:

- Each sample bottle of liquid is placed in a plastic bag, and the bag is sealed. Each VOC vial is wrapped in a paper towel, and the two vials are placed in one bag. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape for additional security.
- Each bottle of liquid is placed in a separate paint can, the paint can is filled with vermiculite, and the lid is affixed to the can. The lid must be sealed with metal clips, filament, or evidence tape. If clips are used, the manufacturer typically recommends six clips.
- The outside of each can will contain the proper DOT shipping name and identification number for the sample. The information may be placed on stickers or printed legibly. A liquid sample of an uncertain nature will be shipped as a flammable liquid with the shipping name "FLAMMABLE Liquid N.O.S." and the identification number "UN1993." If the nature of the sample is known, Title 49, Cold of Feral Regulations, Parts 171 to 177 (49 CFR 171-177) will be consulted to determine the proper labeling and packaging requirements. The carrier should be contacted to ensure that the information provided is correct.
- The cans are placed upright in a cooler that has had the drain plug taped shut inside and outside and lined with a large plastic bag. Approximately 1 inch of packing material, such as vermiculite or other type adsorbent sufficient to retain any liquid that may be spilled, is placed in the bottom of the liner. Three sizes of paint cans may be used: pint, half-gallon, and gallon. The pint or half-gallon paint cans may be stored on top of each other; however, the gallon cans are too high to stack. The cooler will be filled with additional packing material, and the liner will be taped shut. Only containers having chemically compatible material may be packaged in each cooler or other outer container.
- The COC Record will be paced inside a sealed plastic bag and attached to the inside of the cooler lid. The sampler retains one copy of the COC Record. The laboratory will be notified if the sample is suspected of containing any substance for which the laboratory personnel should take safety precautions.
- The lid will be secured by wrapping strapping tape completely around the cooler in two locations. As a minimum, custody seals similar to those shown in Attachment 3 will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected.

- The following markings are placed on the side of the cooler:
  - Proper Shipping Name (Column B, List of Dangerous Goods, Section 4, IATA Dangerous Goods Regulations [DGR])
  - UN Number (Column A, List of Dangerous Goods, Section 4, IATA DGR)
  - Shipper's name and address
  - Consignee's name and address
  - The words "LIMITED QUANTITY"
  - Hazard Labels (Column E, List of Dangerous Goods, Section 4, IATA DGR)
  - "Cargo Aircraft Only" (if applicable as identified in 49 CFR 172.101).
  - Two Orientation (Arrow) labels (indicating "This End Up") placed on opposite sides of the cooler.
- The Airbill/Declaration of Dangerous Goods form will be completed as follows:
  - Shipper's name and address
  - Consignee's name and address
  - Services, Delivery & Special Handling Instructions
  - Passenger or Cargo Aircraft (cross off the non-applicable items. Up to 25 pounds of flammable solid per cooler can be shipped on a passenger aircraft. Up to 1 quart of flammable liquid per cooler can be shipped on a passenger aircraft and up to 10 gallons of flammable liquid can be shipped on a cargo aircraft).
  - Cross out "Radioactive" under Shipment Type
  - Nature and Quantity of Dangerous Goods
  - Proper Shipping Name (Column B, List of Dangerous Goods, Section 4, IATA DGR)
  - Class or Division (Column C, List of Dangerous Goods, Section 4, IATA DGR)
  - UN Number (Column A, List of Dangerous Goods, Section 4, IATA DGR)
  - Packing Group (Column F, List of Dangerous Goods, Section 4, IATA DGR)
  - Subsidiary Risk, if any (Column D, List of Dangerous Goods, Section 4, IATA DGR)
  - Quantity and type of packing (number and type of containers: for example, "3 plastic boxes", and the quantity per container, "2 L", is noted as "3 Plastic boxes X 2 L". This refers to 3 plastic boxes (coolers are referred to as plastic boxes) with 2 liters in each box.
  - Packing Instructions (Column G, List of Dangerous Goods, Section 4, IATA DGR). Note: Only those Packing Instructions in Column G that begin with the letter "Y" may be used. These refer specifically to the Limited Quantity provisions.
  - Authorization (Write in the words Limited Quantity)
  - Emergency Telephone Number (List 800-535-5053. This is the number for INFOTRAC.)

- Printed Name and Title, Place and Date, Signature

2.8.4 Standard Hazardous Materials

Shipment of hazardous materials using this option presents the most difficulty and expense. However, there may be occasion whereby a hazardous material cannot be shipped under the Limited Quantity provisions, e.g., where there is no Packing Instruction in Column G, List of Dangerous Goods, IATA Dangerous Goods Regulations, that is preceded by the letter "Y."

In such cases, the general instructions noted above but for non-Limited Quantity materials will apply, but with one important difference: standard hazardous materials shipment requires the use of certified outer shipping containers. These containers have undergone rigid testing and are, therefore, designated by a "UN" stamp on the outside, usually along the bottom of a container's side. The UN stamp is also accompanied by codes specifying container type, packing group rating, gross mass, density, test pressure, year of manufacturer, state of manufacturer, and manufacturer code name. The transport of lithium batteries in Hermit Data Loggers is an example of a standard hazardous material, and where only a designated outer shipping container may be used. Contact the DOT for the most current shipping regulations.

2.9 TRAINING

The U.S. Department of Transportation requires that all employees involved in any aspect of hazardous materials transport (shipping, transport, receipt, preparing documents) receive training at least bi-annually. Project Managers have the overall responsibility for ensuring all sampling staff have appropriate training.

3.0 REFERENCES

U.S. Environmental Protection Agency, 1996. *EPA Test Method for Evaluating Solid Waste Physical/Chemical Methods* (SW-846), U.S. EPA Third Edition, September 1986; Final Update III, December 1996.

ATTACHMENT 1
SAMPLE LABEL

MWH	LABEL NUMBER
PROJECT NAME/LOCATION	SAMPLE DATE SAMPLE TIME
	PRESERVATIVE
SAMPLE LOCATION	SAMPLER'S INITIALS
FIELD ID NUMBER	GRAB COMPOSITE
ANALYSIS	