RMRS Rocky Mountain Remediation Services, L L C
protecting the environment

PROCEDURE

DRILLING AND SAMPLING USING HOLLOW-STEM AUGER AND ROTARY DRILLING AND ROCK CORING TECHNIQUES

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1 0 PURPOSE

This standard operating procedure (SOP) discusses the equipment and procedures that will be used at the Rockv Flats Environmental Technology Site (RFETS) for drilling and obtaining samples of soil and rock using hollow stem auger and/or rotary drilling or rock coring techniques In general hollow stem auger coring will be the preferred technique for obtaining environmental samples of subsoil and weathered bedrock from boreholes at the RFETS and rotarv drilling or rock coring techniques will be the preferred method for obtaining unweathered (fresh) or deep bedrock samples This SOP describes the hollow stem auger drilling and sampling equipment the rotary and/or rock coring drilling and sampling equipment the installation of isolation casing between the alluvium and bedrock the use of special surface casing in known or suspected soil contaminated areas (SCA) the decontamination of equipment and the procedures and documentation that will be used for field data collection in order to attain acceptable standards of accuracy comparability and completeness

2 0 SCOPE

This document which supersedes procedures GT 02 Drilling And Sampling Using Hollow Stem Auger Techniques GT 03 Isolating Bedrock From Alluvium With Grouted Surface Casing and GT 04 Rotary Drilling And Rock Coring, constitutes a Standard Operating Procedure (SOP) that applies to all Rocky Mountain Remediation Services (RMRS) personnel and subcontractors conducting borehole drilling and sampling operations and related work at the RFETS The procedures described herein will be followed whenever drilling and sampling operations or associated activities are being performed

All field data documentation will meet the data quality objectives specified in the RMRS project work plan and/or other controlling documents

3 0 REQUIREMENTS

A RMRS or subcontractor representative with experience or training related to borehole drilling and sampling operations will conduct oversight and supervision of any drilling field operations All drilling and sampling is to be performed by a reputable firm with proven borehole drilling sampling, and well installation expertise

The following section identifies the personnel qualifications and the procedures and equipment required to conduct borehole drilling and sampling operations and related work

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3 1 Personnel Qualifications

Personnel overseeing drilling operations and performing the duties of the rig geologists should have a minimum of a B S or B A degree in geology and have applicable field experience Other qualified personnel may include geotechnical engineers or field technicians with an appropriate amount of applicable field experience or on-the-job training under the supervision of another qualified person

Personnel performing these procedures are required to have completed the initial 40-hour OSHA classroom training that meets Department of Labor Regulation 29 CFR 1910 120(e)(3)(i), and must maintain a current training status by completing the appropriate 8-hour OSHA refresher courses

Prior to conducting borehole and sampling operations and other related work, personnel are required to have a complete understanding of the procedures described within this and certain related SOPs Personnel will receive specific training regarding these procedures as necessary

4 0 PROCEDURES FOR DRILLING AND SAMPLING

4 1 Hollow-Stem Auger Technique

Hollow-stem augers are one type of continuous-flight auger used for advancing boreholes when discrete samples of the subsurface materials are obtained. They are particularly applicable for sampling materials with a tendency to cave in and for environmental sampling. The augers consist of sections of steel tubing (up to 5 feet long) with steel helical flights around the outside Segments of auger are added as the borehole advances, and samples are retrieved through the inside of the auger without having to remove the auger from the borehole during sampling

With this technique samples will be obtained either with standard split spoon or California drive samplers, or with a continuous core augering technique The continuous coring technique can obtain up to 5-foot-long cores in a 5-foot long sample barrel, however, at RFETS, sampling will be conducted in increments of 2 feet to enhance sample recovery unless otherwise specified in the Field Sampling Plan (FSP) Drive sampling will normally obtain a 12- to 18-inch long sample depending on the length of the sampler Visual logging of the alluvial and bedrock materials will be performed according to SOP RMRS/OPS-PRO 101, Logging Alluvial and Bedrock Material Sampling for chemical analysis is addressed in this SOP All sampling equipment will be protected from the ground surface with clear plastic sheeting All drilling and sampling activities will be conducted in accordance with the project Health and Safety Plan

4 1 1 *Equipment and Materials*

Some or all of the following equipment and materials are needed for hollow stem auger drilling and soil sampling Only the types of samplers required by the sampling specified in the FSP will be required on a given project Sample barrels will have permanent (welded or stamped) identification numbers on them

- Drill rig equipped for drilling and sampling with hollow stem augers
- Continuous core augering equipment (including 2 1/2 to 3 inch inside diameter sample barrel suitable for 2 foot sample rods)
- Standard split spoon sampler (ASTM D 1586)
- California spoon sampler
- Brass (or stainless steel) California liners (2 inch-diameter)
- 3 inch long stainless steel volatile/semi volatile organic analysis (VOA) sample liner for continuous auger core barrel
- Teflon® film (cut in 4-inch x 4-inch squares)
- Plastic caps for California and VOA liners
- Stainless steel mixing bowl and utensils
- Self adhesive labels
- Ice chests (sample shuttles)
- Long-handled bristle brushes
- Wash/rinse tubs
- Phosphate free lab-grade detergent (e g Liquinox)
- Location map
- Weighted tape measure
- Water level probe
- Distilled or deionized water
- Drums for containment of cuttings
- Appropriate health and safety equipment
- Field book with black waterproof pens
- Boring log forms
- Daily Field Drilling Activities Report (Form PRO 114A)

4 1 2 *Drilling Procedures*

Boreholes will be drilled by using hollow-stem augers and the sampling equipment required by the FSP All drilling equipment, including the rig, water tanks, augers, drill rods, samplers etc will be decontaminated before arrival at the work area. Between boreholes, all down-hole equipment will be decontaminated, and sampling equipment will be decontaminated between samples Equipment will be inspected for evidence of fuel oil or hydraulic system leaks (see SOP RMRS/OPS-PRO 127 Field Decontamination Operations, and SOP RMRS/OPS-PRO 070, Decontamination of Heavy Equipment at Decontamination Facilities) If lubricants are required for downhole equipment, only pure vegetable oil will be used

Before drilling, borings will have been located, numbered, and identified using stakes or marking paint on paved surfaces Buried metal objects will have been located by using geophysical methods and utility clearance will have been accomplished according to SOP RMRS/OPS-PRO 102 Borehole Clearing

After boreholes have been cleared and obstructions removed, an exclusion zone will be established according to the project Health and Safety Plan, and the drill rig will be set up The boring will be advanced to the depth indicated and sampled according to the FSP

For borings where environmental samples will be obtained in the bedrock, surface casing may be required. If surface casing is required, it will be installed according to Subsection 4 4 of this SOP The bottom of the surface casing will be embedded in the bedrock according to the procedures outlined in Subsection 4 4 The embedment may vary for monitoring wells according to the FSP or project-specific work plan After installing the casing, the bedrock will be drilled and sampled by using hollow-stem augers small enough to fit through the casing in boreholes designated for environmental sampling In boreholes that are drilled only for geologic logging, hydraulic or geotechnical testing, or monitoring well installation, the portion of the borehole below the casing may be drilled using conventional rotary or rock coring techniques as described in Subsection 4.2, (Rotary Drilling and Rock Coring) of this SOP This will normally allow for the use of a smaller diameter surface casing.

It is anticipated that most or all of the weathered bedrock can be drilled and sampled by using the continuous hollow-stem auger coring method. However, if bedrock that is sufficiently cemented to render this method ineffective is encountered in borings designated for environmental sampling, the cemented zone will be rock cored using filtered air as the drilling medium according to Subsection 4.2 Rotary Drilling and Rock Coring.

The borings will be logged lithologically by examination and classification of the samples Documentation will be completed by the site geologist according to Section 7 0 of this SOP SOP RMRS/OPS-PRO 101, Logging Alluvial and Bedrock Material, describes procedures for material classification and borehole logging

At the first indication of free water on the sampler or in samples, the time and estimated depth will be recorded

However it is frequently difficult to determine the true water level in hollow stem auger borings at the time of drilling particularly when drilling in low permeability soil or bedrock Therefore water levels will also be measured each day before drilling begins and recorded on Form PRO 114A In low permeability deposits it is possible for a borehole to be drilled below the groundwater level and not collect water for several hours or even days It is therefore important to note moisture changes in the samples when evaluating groundwater conditions at the time of drilling During the drilling and while the augers are being removed, the cuttings and unsaved portions of samples from the boring will be containerized according to SOP RMRS/OPS PRO 115 Monitoring and Containerizing Drilling Fluids and Cuttings and SOP FO 9 Handling of Residual Samples

4 1 3 *Sampling Procedures*

4 1 3 1 Continuous Core Auger Sampling

The continuous coring method advances a split barrel that is contained within the lead auger The augers rotate around the sampler and cut while the sample barrel is prevented from rotating Continuous core samples are collected in the barrel The barrel will be unlined except for a 3 inch long stainless steel VOA sample liner (if VOAs are collected) placed at the bottom end of the barrel directly behind the cutting shoe Once the core barrel has been removed from the borehole opened, scanned for VOA and radiological contamination (see SOP FO 15 Photoionization Detectors and Flame Ionization Detectors and SOP FO 16 Field Radiological Measurements) and measured, the VOA sample liner will immediately be capped with Teflon®-lined plastic caps sealed with electrical tape labeled and placed in a cooler with ice In order to obtain a composite sample for additional analyses including semi VOAs the sampler will be closed and placed in a safe location out of the direct sun until a sufficient interval of samples have been obtained Once the samples have been obtained, the core barrels will be opened and each sample will then be classified logged peeled composited, and placed in appropriate containers for analytical testing according to SOP RMRS/OPS PRO 069 Containing Preserving Handling and Shipping Soil and Water Samples Sample intervals and requirements for compositing will be defined in the FSP or project-specific work plan

Sample peeling will involve discarding the portion of sample that was in direct contact with the sampler Once the samples have been peeled, a linear scraping of the peeled samples will be placed in a stainless steel bowl and mixed with a stainless steel instrument Soil particles (gravel) larger than the jar mouth will be discarded Peeling and compositing will be conducted with separate decontaminated stainless steel instruments If the core is not coherent, core samples need not be peeled before sampling because it is difficult to be certain what parts of a noncoherent sample were in contact with the sampler

Samples for geotechnical testing will consist of approximately 3/4-filled pint sized glass jars with airtight lids placed in

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compartmented shipping cartons designed to prevent breakage of the jars Sample peeling is not required for geotechnical samples

4 1 3 2 Drive Sampling

Drive samples will be obtained in general accordance with ASTM Designation D 1586 After drilling to the predetermined depth, the standard split spoon or California sampler will be attached to the end of the drill rod and lowered to the bottom of the boring The standard 140-pound hammer assembly will then be attached to the top of the drill rod. The depth to the bottom of the sampler will be recorded, and reference marks at 6-inch increments will be placed on the drill rod. The test consists of driving the sampler with the standard 140-pound hammer dropped 30 inches

When using the 2-inch-outside-diameter (O D) standard split spoon sampler, drive the sampler through three 6-inch increments (or 100 blows, whichever occurs first) The sum of the last two increments is the Standard Penetration Count (Blow Count or N-value), and the first 6-inch increment is considered as seating. This procedure (recording the blow counts) is optional.

A California barrel with brass (or stainless steel) liners may be substituted for the standard split barrel The integrity of the sample can generally be better maintained since thin-walled liners containing the sample can be removed from the barrel and sealed. Since the California sampler is shorter than the standard split spoon sampler it will be driven only 12 inches Recording the blow counts for each 6-inch increment is optional However, several blows are required before marking and counting blows to seat the sampler

A California barrel has a 2 5-inch O D and a 2-inch inside diameter (I D) Modified California samplers with larger diameters are also available The liners for a conventional California barrel have a 1 94-inch I D Although not precisely equivalent, the blow count obtained by using a 2-inch I D California barrel is frequently considered to be comparable to the N-value obtained using a standard barrel Blow counts using larger samplers will not be equivalent, and larger hammers may be required to drive them under some conditions

A rope and cathead arrangement or automatic trip hammer will be used to obtain drive samples. If a rope and cathead arrangement is used, excessive turns of the rope on the cathead must be avoided, since this will result in friction and drag between the rope and cathead. Two turns of the rope on the cathead will be used and sufficient slack in the rope provided during hammer freefall to prevent excessive friction

Regardless of the tools utilized, drive samples will be scanned using the procedures outlined in SOP FO 15

Photoionization Detectors and Flame Ionization Detectors and SOP FO 16 Field Radiological Measurements Standard split spoon samples saved for geotechnical testing will consist of 3/4 filled pint sized glass jars with airtight lids placed in compartmented shipping cartons designed to prevent breakage of the jars Samples for VOA analytical testing will be obtained by placing a 3 inch long stainless steel VOA sample liner at the bottom end of the barrel directly behind the cutting shoe Composite samples for additional analyses including semi VOAs will consist of linear scrapes from three consecutive peeled samples (see Subsection 4 1 3 1) placed in containers described in SOP RMRS/OPS PRO 069 Containing Preserving Handling and Shipping of Soil and Water Samples For California liner samples the geotechnical samples may be saved in the liners with plastic end caps

4 1 3 3 VOC Sampling

Unless otherwise specified in the project specific work plan the following procedures apply when collecting VOC samples

- VOC samples will be collected from the base of every other 2-foot drive sample from the ground surface to the water table

- A VOC sample will be collected in the bottom of the first drive sample below the water table

- A final VOC sample will be collected from the base of the first drive within bedrock immediately below the alluvial material in unsaturated conditions

- Additional VOC samples will be collected as follows

  If a lithologic feature or OVA reading indicates the possibility that VOC contamination exists then a sample will be taken at the base of the next drive interval

  If the sampler is opened, scanned and a color change free product, or other physical evidence indicating the possibility for contamination is observed in a location other than where a pretargeted VOC sample is located, a 3 section will be immediately cut, pulled, wrapped, placed in a wide mouth jar and sealed The sample will be sent to the lab for subcoring and analysis

4 1 3 4 Quality Assurance/Quality Control Samples

Quality Assurance (QA) and Quality Control (QC) activities will be accomplished according to applicable project plans as well as quality requirements presented in this SOP

QA samples for soils fall into five categories

- Duplicate
- Matrix spike
- Matrix spike duplicate
- Equipment rinsate
- Field blank

SOP RMRS/OPS-PRO 069, Containing, Preserving, Handling, and Shipping Soil and Water Samples describes the general handling of samples Applicable project plans specify QA sample frequencies If insufficient sample material is available for the collection of a planned QC sample, the conditions that prevent the collection of the QC sample will be documented in the field log book and on the Daily Field Drilling Activities Report Form (PRO 114A) The Project Manager will be informed that QC samples were not collected as planned so that any impacts to the QA/QC goals established in applicable project plans can be evaluated.

If sufficient material is available to collect a planned QC sample, the QC sample will be collected and documentation will be recorded in the field log book and on the Daily Field Drilling Activities Report Form (PRO 114A) Sample collection procedures will be the same as those described in Section 5 0 for duplicate, matrix spike, and duplicate matrix spike samples These samples are intended to be as close to exact replicates of the original samples as possible They are obtained immediately adjacent to the planned samples that they are intended to duplicate The hollow stem auger barrel should be designed with ridges to incorporate two 3-inch stainless steel sample liners above the barrel shoe This design will be used to collect a VOA soil sample and its replicate Project or site-specific QC sample collection techniques will be addressed in either the field sampling plan, work plan, or Quality Assurance Addendum

A rinsate sample from sampling equipment is intended to check for potential contamination of the sample by the sampling equipment. For the soil sampling operation, a rinsate sample will be collected from sampling equipment with any liners in place before the sampling equipment is used. Approximately 3 liters of distilled water will be rinsed over a decontaminated sampler and collected in a large decontaminated stainless steel bowl A decontaminated glass or stainless steel beaker will be used to dip the water from the bowl and fill the sample bottles. The rinsate samples will be analyzed for the same parameters as the soil samples

Field blank samples are containers filled with clean water that are handled and moved the same as the other samples to check for potential cross contamination resulting from field handling and movement procedures

4 1 3 5 Drum Characterization

When obtaining geotechnical samples strictly for the purpose of characterizing the environmental materials present in drums the procedures covered in SOP RMRS/OPS PRO 115 Monitoring and Containerizing Drilling Fluids and Cuttings will apply Procedure RMRS/OPS PRO 115 describes the proper methods to manage investigation derived materials (IDM) the procedures to secure drums for containerizing the IDM and the monitoring of the IDM during the drilling and coring operations prior to filling the containers The final disposition of the IDM is covered in SOP FO 29 Disposition of Soil and Sediment Investigation Derived Materials but does not apply to the procedures covered in this SOP

During drilling operations environmental materials consisting of alluvium colluvium or bedrock sediments accumulate adjacent to the borehole and are then shoveled into drums As drums are being filled representative samples of the material filling the bottom middle and upper portion of each drum will be collected and composited in a stainless steel bowl kept in a safe location out of the sun These materials may be collected either from the material filling the drum, or as samples taken from the core representing the same interval contained in the drum As core is recovered each core is scanned for VOA or radiological contamination following the procedures in SOP FO 15 Photoionization Detectors and Flame Ionization Detectors and SOP FO 16 Field Radiological Measurements and is therefore representative of the material filling the drums The materials from up to four drums from a given borehole will be composited in this manner The samples will then be placed in the appropriate containers for analytical testing

When obtaining geochemical samples from drummed mixtures of bedrock and water resulting from drilling operations a bailer will be used to obtain a sample from the bottom, middle, and upper portion of a drum Material from up to four drums from a given borehole will be composited in this manner The samples will then be placed in the appropriate containers for analytical testing (NOTE in areas outside of IHSSs no further characterization sampling will be done than is stipulated in the Field Sampling Plan)

During drilling of boreholes if a recent borehole (within one year) that has been sampled is located within 10 feet of the present borehole no additional samples for drum characterization purposes only will be collected All cored material will be saved in case it is needed for future analysis

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4 2 Rotary Drilling and Rock Coring

Rotary drilling and rock coring methods that use air or water as the drilling media are common techniques employed to obtain stratigraphic, lithologic hydrogeologic, geotechnical and environmental data, as well as a means for monitoring well installation As stated in Subsection 4 1 of this SOP hollow stem continuous-flight augers will be the preferred technique for drilling boreholes to collect environmental samples of soil and rock. The use of air or water can alter analytical chemistry or physical property test results by altering sample moisture, by volatilizing contaminants (in the case of air), or by washing them away (in the case of water) Using water when drilling can also alter the groundwater chemistry in the vicinity of the borehole, and needs to be accounted for during the development of wells Rotary drilling and rock coring may be used for advancing boreholes with or without environmental sampling in zones of hard material that cannot be penetrated with augers

Samples obtained for analytical chemistry testing will be prepared and contained in general accordance with the procedures outlined in Subsection 4 1 3 of this SOP In general, air will be the drilling medium used when it is necessary to penetrate cemented zones of rock in auger borings drilled for environmental sampling Water will typically be used as the drilling medium when drilling relatively deep bedrock wells and when obtaining rock core exclusively for geologic logging Alternatively, dual-tube air percussion or ODEX drilling methods using water or air may be appropriate for some conditions Sonic drilling methods require little or no water, air, mud, or other circulation medium for penetration The appropriate work plan will outline drilling requirements for each project.

4 2 1 *Equipment and Materials*

The following is a list of equipment and materials for rotary drilling

- Air compressor with appropriate air filter(s)
- High pressure steamer/sprayer
- Wash/rinse tubs
- Weighted tape measure
- Phosphate-free, lab-grade detergent (e g., Liquinox)
- Water level probe
- Appropriate health and safety equipment
- Drums for containment of cuttings and fluids (see SOP RMRS/OPS-PRO 115, Handling of Drilling Fluids and Cuttings)
- Boring log form (Form PRO 101A)
- Field activities report form
- Pint-sized plastic jars with screw caps for cuttings (see SOP RMRS/OPS-PRO 101, Logging Alluvial and

Bedrock Material)

- Black waterproof (permanent) marking pens

Additional equipment for rock coring will consist of the following

- Core barrel assembly
- Wire line or core rods
- Core boxes with wooden blocks
- Measuring tape
- Camera (if separate logging facility is utilized)
- Core barrel rack
- Plastic wrap for core
- Drill rig with appropriately sized drill bits and rods
- Portable recirculation tanks for water rotary
- Preapproved water supply for water rotary
- Conveyance equipment (pumps and hoses)

4 2 2 *Drilling Procedures*

Boreholes will be drilled using a rig equipped with rotary drilling equipment capable of advancing the borehole to the depth specified in the (FSP) All drilling equipment, including the rig water transportation tanks bits and drill rods will be decontaminated according to SOP RMRS/OPS PRO 127 Field Decontamination Operations and SOP RMRS/OPS PRO 070 Decontamination of Heavy Equipment at Decontamination Facilities These decontamination procedures will also be followed between boreholes for downhole equipment and between work areas of different contaminant characterization for the drilling rig Drilling equipment will be inspected to ensure that hydraulic system and fuel leaks do not introduce organic contamination on site or into the borehole Any leaks that may introduce such contamination will be repaired before drilling If lubricants are required for downhole equipment, only pure vegetable oil will be used

Borehole locations will be cleared before drilling according to SOP RMRS/OPS-PRO 102 Borehole Clearing Drill fluids and cuttings will be handled according to SOP RMRS/OPS PRO 115 Monitoring and Containerizing Drilling Fluids and Cuttings Boreholes will be abandoned according to SOP RMRS/OPS PRO 117, Plugging and Abandonment of Boreholes All procedures will be conducted according to the applicable Health and Safety Plan Project-specific requirements will be addressed in a work plan

4 2 3 *Rotary Drilling Techniques*

Conventional rotary drilling involves the introduction of a drilling medium (air or fluid) into the borehole through the drill rods and circulation of the medium back up the hole to remove drill cuttings The hole is advanced by the cutting action of a rotating drill bit at the bottom of the hole Reverse circulation methods are similar to conventional rotary methods except that the drilling medium is injected down the annulus between an inner and outer double casing and returns back up the inside of the inner casing Some reverse circulation methods use rotary techniques, some use non-rotating percussion techniques, and some use a combination of the two When rotary drilling, samples of cuttings saved for geotechnical testing or future geologic reference will be placed in pint-sized plastic jars with screw-on tops and saved in core boxes

4 2 3 1 Drilling With Water

Water used for rotary drilling will consist of RFETS potable water Water transportation tanks and conveyance equipment will be contaminant-free and dedicated for the use with preapproved water to ensure that the preapproved water introduced into the borehole is also contaminant-free Portable decontaminated water recirculation tanks will be used for rotary operations Excavated sumps or pits (lined or unlined) will not be used. If caving becomes a problem during drilling with water, super Gel-X (powdered bentonite) or biodegradable drilling additives such as guar gum may be added to the RFETS potable water to stop uptake of water by the formation and to prevent hole loss All drilling additives must be pre-approved by RMRS before use in a borehole, and they must be noted on the applicable documentation Decontamination of tanks and conveyance equipment will also be conducted in accordance with SOP RMRS/OPS-PRO 127, Field Decontamination Operations, and/or SOP RMRS/OPS-PRO 070, Decontamination of Heavy Equipment at Decontamination Facilities.

4 2 3 2 Drilling With Air

Conventional air compressors used for air rotary methods contain oil for lubricating moving parts and compress air and oil in their operation. To avoid introducing contaminants into the borehole, an RMRS-approved filtration system designed to provide oil-free air will be used. Depending on the requirements of the particular project, such a system may consist of an air-cooled aftercooler, a regenerative dryer, a coalescing filter, and a particulate afterfilter all arranged in series The particular filtration system design will depend on the compressor equipment, the project requirements, and anticipated ambient conditions The filtration system will be matched appropriately to the compressor's capacity so that the reduction in the flow of air to the drilling equipment is tolerable The filtration system components will be changed or monitored according to the requirements of the design during operation and a record of this kept on the field activities report form (see Section 7 0 Documentation)

Dust control measures mav also be required according to the Field Operations Plan (FOP) and Health and Safetv Plan (HSP) The airborne dispersion of cuttings can be controlled to some extent bv circulating the return air through a vortex or cvclone See SOP FO 1 Air Monitoring and Particulate Control for more information

4 2 4 *Rock Coring*

Continuous core samples collected using rock coring methods can be used to obtain relatively undisturbed samples of rock for stratigraphic lithologic hydrogeologic and environmental data Conventional rock coring methods use a diamond or insert coring bit instead of a conventional tricone or granular rotary bit

Continuous core samples will be extracted from the core barrel placed on core racks or directly placed into a core storage box It will then be logged by qualified personnel according to SOP RMRS/OPS PRO 101 Logging Alluvial and Bedrock Material All core boxes will contain appropriate size blocks that will show the depths of the recovered core (top and bottom) from each run any intervals of no recovery and intervals where samples for analytical analysis or geotechnical testing have been removed Coring equipment will be decontaminated according to SOP RMRS/OPS PRO 127 Field Decontamination Operations

Air or water drilling media used for coring must be contaminant free Therefore the provisions required in Subsections 4 2 3 1 and 4 2 3 2 for drilling fluids also apply to rock coring procedures

4 2 5 *Sonic Drilling Techniques*

Sonic drilling is achieved by a drill head that transmits high frequency pressure waves through steel drilling pipe to create a cutting action at the tip of the drill bit Pressure waves are created by center-rotating offset balanced roller weights The frequency of the drill string causes the column to vibrate elastically along its longitudinal axis In the resonant condition the drill string acts as a flywheel transmitting maximum power to the drill bit This power combined with slow rotation to expose fresh material to the bit and slight downward pressure advances the drill string through soil and rock without the addition of a drilling medium

Because the drilling action and thin wall design of the drill string either forces the displaced material into the wall of the borehole or into the core barrel very little waste cuttings are generated

Samples will be obtained by vibrating the drill bit and rotating the core barrel to the desired depth advancing the outer drill pipe and then pulling the sample to the surface via the wireline Once at the surface the sample will be vibrated or hydraulically extracted from the core barrel into a plastic sleeve or clean sample tray After a sample is collected, the core barrel will be decontaminated and readied to retrieve the next sample

4 3 Procedure for Isolating Bedrock from the Alluvium

This section describes the procedures that will be used at the RFETS to install surface casing (where required) grouted into the top of bedrock to isolate the bedrock from the alluvium The intent of implementing this procedure is to prevent cross-contamination from the alluvium into the bedrock This may be required for environmental sampling of the bedrock in boreholes and for construction of bedrock monitoring wells

If required, surface casings will be installed in boreholes drilled and logged according to procedures outlined in Subsection 4 1 of this SOP and in SOP RMRS/OPS-PRO 101 Logging Alluvial and Bedrock Material All drilling and sampling equipment will be decontaminated according to SOP RMRS/OPS-PRO 127, Field Decontamination Operations, and/or SOP RMRS/OPS-PRO 070, Decontamination of Heavy Equipment at Decontamination Facilities Drilling and sampling equipment will be protected from the ground surface with clear plastic sheeting or placed on clean drill racks

4 3 1 *Equipment and Materials*

The following is a list of equipment and materials used for surface casing installation

- Drill rig with appropriately-sized augers
- Surface casing
- Cement of approved quality and American Colloid Pure Gold Bentonite grout (or approved equivalent)
- Rubber grout-displacement plug (1/2-inch diameter larger than inside diameter of casing)
- Tremie pipe and grout pump
- High pressure steamer/sprayer
- Mechanical grout mixer
- Weighted tape measure
- Water level probe
- Pipe cutter
- Appropriate documentation forms
- Drums for containment of cuttings
- Appropriate health and safety equipment
- Pre-approved water from a potable source (for mixing grout)

- Distilled or deionized water
- Plastic Sheeting

4 3 2 *Casing Requirements*

Surface casing will consist of new schedule 80 poly vinyl chloride (PVC) or steel well casing PVC casing will be used for nominal casing diameters of 6 inches or less Larger casings will be steel Joints will be watertight threaded couplings made without welds solvents or lubricants The casing will be embedded into the top of bedrock and extend to approximately 1 foot above the ground surface Casing centralizers are optional and if required can be attached to the casing to allow uniform grouting If required, at least 2 centralizers will be installed, one within 5 feet of the bottom and the other within 5 feet of the top of the casing All surface casing will be free of foreign material and will be decontaminated according to SOP RMRS/OPS PRO 127 Field Decontamination Operations Decontaminated casing will be stored in plastic sheeting or kept on clean racks prior to use

4 3 3 *Grout Requirements*

The grout mixture will consist of cement and reduced pH bentonite grout (American Colloid Pure Gold or approved equivalent) mixed according to the manufacturer's recommendations The mixture will contain 5 to 10 percent bentonite by weight and have a minimum density of 13 to 15 pounds per gallon after mixing The density will be measured using a mud balance

4 3 4 *Drilling Methods*

Boreholes will be drilled into the top of bedrock using hollow stem augers Alternatively conventional rotary or reverse circulation rotary methods may be used however due to the variability of these methods their use may be outlined in a project-specific work plan Drilling equipment including the rig, augers, drill rods, and samplers will be decontaminated according to SOP RMRS/OPS PRO 127 Field Decontamination Operations and SOP RMRS/OPS PRO 070 Decontamination of Heavy Equipment at Decontamination Facilities The borehole will be of sufficient diameter to allow 2 inches of grout between the casing and the borehole

The embedment of casing into the bedrock will be a minimum of 3 to 5 feet into the weathered bedrock However the intent is to place the bottom of the casing approximately 3 feet below the interface describing a substantial reduction in hydraulic conductivity If the uppermost weathered bedrock is highly weathered and/or fractured this embedment depth will be adjusted downward Based on field experience at RFETS casing may be emplaced to depths of up to 60 feet in highly weathered or fractured bedrock to ensure a good seal When very shallow bedrock boreholes are augered to total depth in uncontaminated areas, surface casing will not be used Instead the borehole will be drilled and grouted in one day

Surface casing will be emplaced to a depth that will isolate the upper hydrostratigraphic unit (UHSU) from the lower hydrostratigraphic unit (LHSU) If unweathered claystone is encountered at the base of the UHSU surface casing will be embedded a minimum of 3 feet into the LHSU If the core samples indicate siltstone or sandstone immediately below the base of the UHSU, drilling will continue until a minimum of 3 feet of unweathered claystone is encountered. The surface casing may then be installed

4 4 Surface Casing Installation and Sealing Procedures

Surface casing will be installed by one of the three procedures described in this section Method 1 is the preferred method for installing surface casing at RFETS because it reduces the waste volume of grout and it can be used in holes of all depths. The project specific field sampling plan can specify which method, or can defer to any one of the three methods, depending on the field conditions encountered and the preference of the RMRS project manager or designee

Method 1

Install the surface casing by placing the casing into the borehole, filling the casing with grout and then forcing the grout from within the casing by pushing a rubber plug down the casing, thus displacing the grout out through grout ports at the bottom of the casing Implementing this method is intended to provide a uniform seal from the base of casing to the ground surface The steps for casing installation are described below

1 Measure the borehole total depth using a weighted tape measure Calculate the volume of grout required for the annular space between the casing and the borehole wall Increase the volume by 10 to 30 percent depending on drilling conditions and diameter of borehole

2 Drill or cut three equally spaced 1-inch diameter holes, slots, or triangles (grout ports) into the wall of the casing immediately above the bottom of the casing. The distance between the bottom of the casing and the holes will not exceed the length of the rubber plug.

3 Lower the surface casing into the borehole through the augers or drill casing.

4 Remove the augers and pump the calculated grout volume into the surface casing.

5 Place a rubber or equivalent plug, intended for displacing grout from within the surface casing, inside the surface casing and force it down to within 0 25 to 0 5 foot of the bottom of the surface casing using drill

rods or water pressure Add RFETS potable water to the inside of the casing as the plug is being forced down The water will aid in equalizing the pressure of the grout on the plug until the grout has set After grout has been observed at ground level on the outside of the surface casing the depth of the plug will be checked with the tape measure

6 Place a protective cover over the top of the casing and allow the grout to set for at least 24 hours

7 After the grout has set, drill out the grout and plug to a depth of 2 to3 feet from the bottom of the surface casing and remove or change out the fluid from the borehole by air lift methods or bailing Remove the water inside the casing by air lift methods or bailing before the plug is drilled out and the borehole is advanced past the bottom of the casing

Method 2

Method 2 is the same as Method 1 with the following modifications The surface casing may be installed by filling the borehole with grout as the augers are removed, placing the casing into the grout filled borehole after auger removal then forcing the grout from within the casing using a rubber plug

Method 3

Place surface casing with threaded PVC cap or rubber plug on bottom end into borehole Fill surface casing with potable water to ensure positive pressure Following installation of surface casing in the borehole a 2 to 3 foot thick bentonite seal consisting of ¼ inch bentonite pellets will be placed at the bottom of the annulus surrounding the surface casing If the borehole annulus does not contain water potable water will be added to hydrate the pellets prior to grouting Following the installation of the bentonite seal the grout seal will be emplaced in the annular space between the augers or drill casing and the surface casing Upon removal of each section of auger or drill casing additional grout will be added to the annulus The grout will be emplaced by means of a tremie pipe The grout will be allowed to set for 24 hours before advancing the borehole

4 5 Specialized Surface Casing Installation Procedure

In areas of known or suspected soil contamination, a procedure for installing a special surface protective casing has been devised that can eliminate, or substantially reduce the potential of carrying contaminants into the subsurface during drilling operations This method is referred to as the Aseptic Drilling and Sampling Technique and was first used at RFETS in 1994 The aseptic method is illustrated in Figure Pro 114-1 (consisting of two pages) which shows five phases from initial surface sampling through excavation and surface casing emplacement, that precede the actual drilling operations

To prevent or substantially reduce the possibility of cross contamination occurring between potentially contaminated surface soil and the soil or sediments adjacent to the well screen, the following steps will be followed

- A soil sample will be collected in accordance with SOP-RMRS/OPS-PRO 120 Surface Soil Sampling using the Rocky Flats method (Figure PRO 114-1, Phase 1) The sample will be analyzed to determine the ambient constituent concentrations.
- A hole approximately 18 to 20 inches in diameter will be drilled or excavated at the site to a depth exceeding the extent of contamination (Figure PRO 114-1, Phase 2)
- A 16-inch or appropriate size diameter steel casing will be cemented in place (Figure PRO 114-1 Phase 3)
- After allowing 24 hours for cement set up time, a sample can be collected at the bottom of the excavation as illustrated (Figure PRO 114-1, Phase 4) and submitted for laboratory analysis.
- A sealing protective cover will be installed over the casing (Figure PRO 114-1, Phase 5), and the site will remain secured pending the analysis of the bottom hole sample, or a decision by the RMRS project manager to continue drilling operations
- Upon receiving an acceptable laboratory analysis, a well can be drilled and installed according to the procedures outlined in this SOP and SOP RMRS/OPS-PRO 118, Monitor Well and Piezometer Installation.
- If the initial sample analysis are unacceptable, additional drilling, telescoped casing, and/or sampling may be required to isolate contaminant zones

5 0 BORING COMPLETION OR ABANDONMENT

After the borehole has been advanced to its final depth it will either be abandoned or completed as a monitoring well according to the procedures in SOP RMRS/OPS-PRO 117, Plugging and Abandonment of Boreholes, or SOP RMRS/OPS-PRO 118, Monitoring Wells and Piezometer Installation

The boring location stake will be left in the ground adjacent to the borehole, and a board or other cover placed over the hole until it has been grouted and abandoned according to the procedures in SOP RMRS/OPS-PRO 117 All boreholes to be abandoned with a depth greater than 1 foot will be grouted the same day that abandonment is completed.

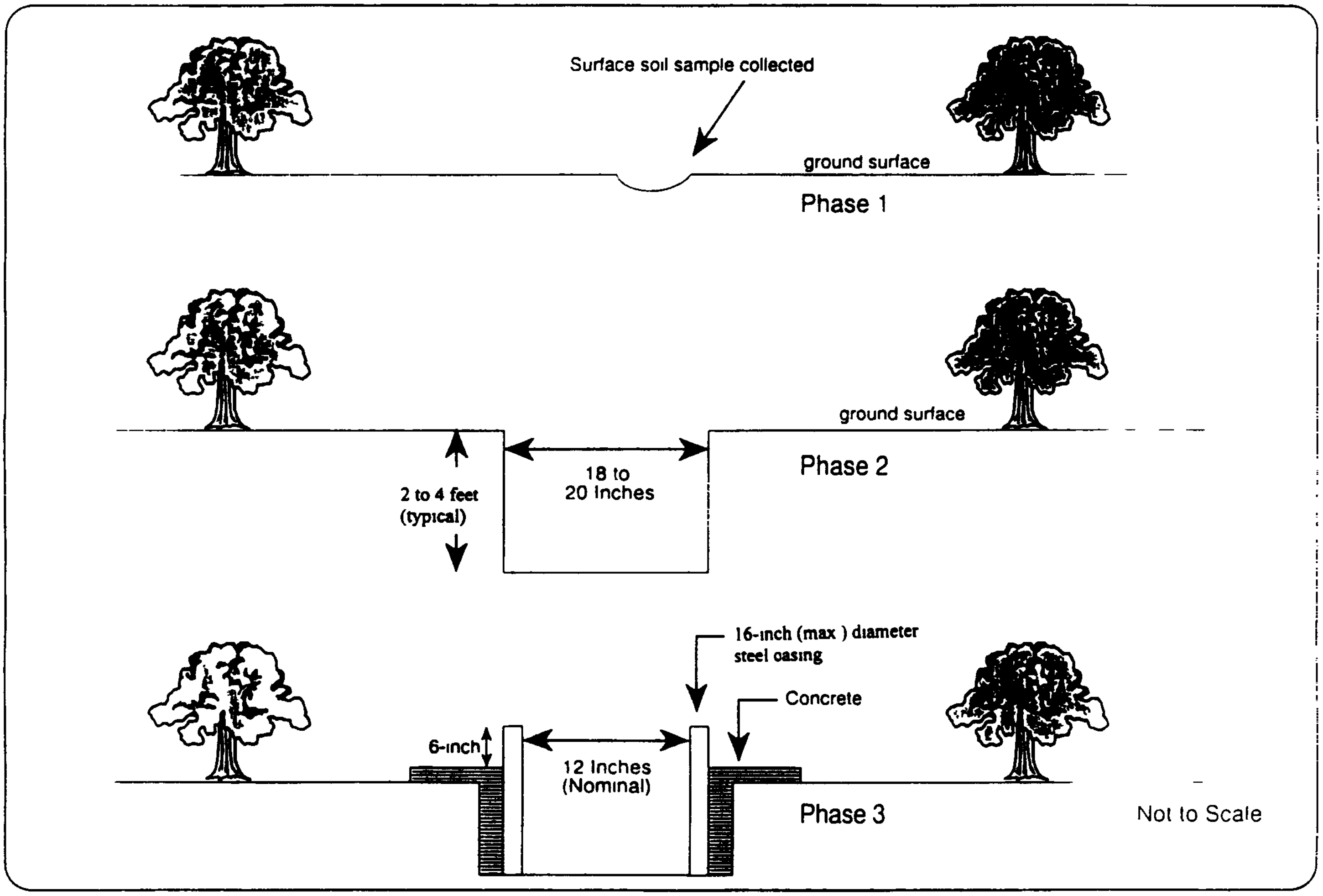

FIGURE PRO 114 1
Schematic Diagrams of the Phases of Specialized Surface Casing Installation

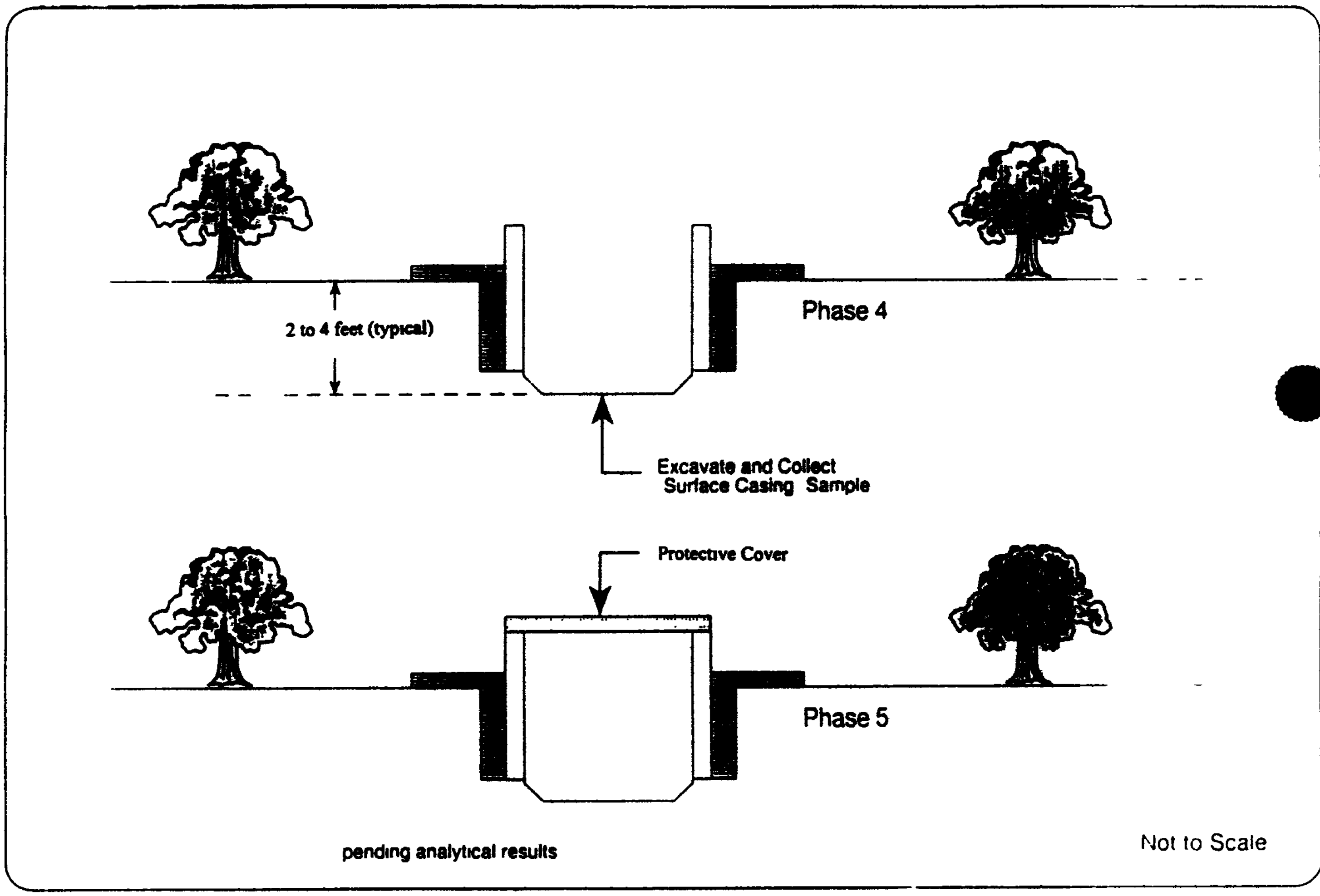

FIGURE PRO 114-1 (continued)

Schematic Diagrams of the Phases of Specialized Surface Casing Installation

Page 2 of 2

6 0 DECONTAMINATION

Generalized equipment decontamination procedures will include

- Sampling equipment Decontamination will be conducted between individual sampling points to minimize potential cross contamination Sampling equipment will be decontaminated according to SOP RMRS/OPS PRO 127 Field Decontamination Operations During drilling and sampling decontaminated quipment will be placed on new plastic or racks until it is used At least two sets of samplers will be available so that one set can be used while the other is being decontaminated When coring bedrock using water as a circulating medium no decontamination of core barrels or measuring tapes is necessary between coring runs The core barrels and measuring tapes will be decontaminated after each boring is complete

- Drilling equipment Decontamination of augers drill stems drill bits, and other down hole equipment will be conducted after each boring is complete Drill rigs will be decontaminated when moved out of work area, when they become unusually dirtv as a result of site or drilling conditions (at the discretion of the site or project manager) or when moved to a new work area that has a different contaminant characterization Decontamination of drilling equipment is described in more detail in SOP RMRS/OPS PRO 070 Decontamination of Heavy Equipment at Decontamination Facilities

7 0 DOCUMENTATION

All information required by this SOP will be documented on the Borehole Log Form (Form PRO 101A) and the Daily Field Drilling Activities Report Form (Form PRO 114A) The Daily Field Drilling Activities Report Form will be filled out for each day of drilling at a given borehole location and, in situations where more than one boring is drilled and completed per day per drill rig, at least one form will be completed per boring The borehole log will include information on subsurface material classification and lithology The Daily Field Drilling Activities Report will include the following information and have space for comments and documentation of general observations

- Project name and borehole identification
- Subcontractors
- Location Code
- Date
- Weather conditions
- Drilling company and driller

- Geologist and other crew members
- Equipment descriptions (rig, augers, bits, etc)
- Borehole depth
- Sample number
- QC Code
- Time
- OVM readings
- Drilling fluid used (if any)
- End-of-day status (in progress or drilling completed)
- Chronological record of activities

The above information will be entered into the field data capture program (see procedure RMRS/OPS-PRO 072 Field Data Management)

8.0 REFERENCES

8 1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods. EPA/540/P-87/001 December 1987

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final EPA/540/G89/004 October 1988

RCRA Facility Investigation Guidance Interim Final. May 1989

RCRA Groundwater Monitoring Technical Enforcement Guidance Document. EPA, OSWER-9950 1 Washington D C September 1986

8 2 INTERNAL REFERENCES

Related SOPs cross-referenced by this SOP are as follows

- SOP RMRS/OPS PRO 069 Containing Preserving Handling and Shipping Soil and Water Samples
- SOP RMRS/OPS PRO 070 Decontamination of Heavy Equipment at Decontamination Facilities
- SOP RMRS/OPS PRO 072 Field Data Management
- SOP RMRS/OPS PRO 101 Logging Alluvial and Bedrock Material
- SOP RMRS/OPS PRO 102 Borehole Clearing
- SOP RMRS/OPS-PRO 115 Handling of Drilling Fluids and Cuttings
- SOP RMRS/OPS PRO 117 Plugging and Abandonment of Boreholes
- SOP RMRS/OPS-PRO 118, Monitoring Wells and Piezometer Installation
- SOP RMRS/OPS-PRO 120 Surface Soil Sampling
- SOP RMRS/OPS PRO 127 Field Decontamination Operations
- SOP FO 08 Monitoring and Containerizing Drilling Fluids and Cuttings
- SOP FO 09 Handling of Residual Samples
- SOP FO 15 Photoionization Detectors and Flame Ionization Detectors
- SOP FO 16 Field Radiological Measurements
- SOP FO 29 Disposition of Soil and Sediment Investigation Derived Materials
- Well Abandonment and Replacement Program Final Report, EG&G Rocky Flats March 1995

U S DEPARTMENT OF ENERGY

FORM PRO 114A (Rev 0)

Rocky Flats Environmental Technology Site

DAILY FIELD DRILLING ACTIVITIES REPORT

Project Name ______ Subcontractor: ______ Date ______

Location Code ______ Rig Type ______

Drilling Co ______ Drilling Method. ______

Driller ______ Drilling Fluid: ______

Geologist ______ Bit Diameter ______ Inches

Crew Members ______ Bit Type ______

______ Total Depth ______ Feet

Sample #	QC Code	Time	(C)omp (G)rab	Depths Start	(Ft) End	Types OVM ______ Reading (PPM)	α ______ β ______ Readings	(CPM)

End of Day Status In Progress ______ Drilling Completed ______

Chronological Record of Activities and Comments ______

______

______

______

Was there fluid in the hole at the beginning of the daily drilling operation? Yes ______ No ______

If yes what was the water level? ______ Ft.

Completed By ______ Date ______

Print Name Signature

Checked By ______ Date. ______

Print Name Signature

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