PENNSYLVANIA INDEPENDENT OIL AND GAS ASSOCIATION
MARCELLUS SHALE COALITION

FIELD SAMPLING PLAN

Characterization of Naturally Occurring Radioactive Materials in the Oil and Gas Field

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1.0 INTRODUCTION

The Pennsylvania Independent Oil and Gas Association (PIOGA) and the Marcellus Shale Coalition (MSC) have developed this Field Sampling Plan (Plan) to describe the manner to collect data and analyze samples of naturally occurring radioactive material (NORM) and technologically enhanced NORM (TENORM) related to the oil and gas (O&G) exploration activities. The purpose of this study is to obtain representative samples from potential sources of NORM associated with all aspects of O & G drilling and operations and reach definitive conclusions about the potential for exposure. Sites and facilities that are candidates to be sampled include conventional and unconventional drilling through geological formations and associated waste water operations throughout the Commonwealth of Pennsylvania (PA). The following types of materials and processes are recommended to be sampled, including:

- Ambient air;
- Drill cuttings (vertical and horizontal);
- Natural gas;
- Natural gas processing pipes and equipment;
- Reuse and waste water generated on drilling sites;
- Sludge resulting from the processing of reuse and waste water from the well pad development process; and
- Landfill leachate.

The Commonwealth of Pennsylvania, Department of Environmental Protection (DEP) published a Field Sampling Plan and Quality Assurance Project Plan in April, 2013.[1,2] The study by PIOGA and MSC is intended to augment the DEP study and provide samples that are representative of the media being tested and use the proper sampling and testing procedures in order to compare results. Members of PIOGA and MSC perform exploration activities by conventional and unconventional drilling through various subsurface layers of rock to produce oil and natural gas. The production of oil and gas creates produced water and flowback water, as well as drill cuttings and sources of off gassing, which are potentially impacted by NORM and/or TENORM. Unconventional O&G process water (e.g., flowback and produced water) sample results indicate elevated concentrations of radium-226 (Ra-226), a common NORM radionuclide and the element associated with the natural uranium decay series with the highest mobility. The scope of work for this Plan is focused on the O&G operations, equipment, and features related to the exploration and production of natural gas from various geologic formations and also the potential for TENORM in water transferred to treatment facilities for processing. Sampling activities will include but are not limited to:

[1] Pennsylvania Department of Environmental Protection, "Part I - Field Sampling Plan", April, 2013.
[2] Pennsylvania Department of Environmental Protection, "Part II - Quality Assurance Project Plan", April, 2013.

- Vertical and horizontal drill cuttings;
- Onsite pits containing cuttings;
- Production water;
- Flowback water;
- Filter socks;
- Filter presses;
- Compressed gas lines;
- Off gassing;
- Well pads;
- Centralized impoundments;
- Waste water facility sludge;
- Waste water facility influent and effluent water;
- Piping and casing scale;
- Vapor capture systems;
- Fresh proppant sands; and
- Drilling muds.

The DEP has not established occupational exposure regulations/standards for NORM or TENORM. The American National Standards Institute (ANSI) published a standard addressing the control and release of NORM and TENORM.[3] The standard applies to industries or activities that are not covered by existing federal or state regulations. The standard provides radiation exposures be limited to less than 100 millirem (mrem), above background, from all pathways and sources of radioactivity (except radon and its short-lived decay products) and practices associated with site and facility operations.

Pennsylvania established disposal criteria for solid waste impacted with TENORM.[4] Specifically, the Commonwealth limits the exposure of future residents, the hypothetical resident farmer, from a permitted landfill to 25 mrem/yr from all pathways, including radon. This Plan describes and presents procedures and protocols for field radiological surveys and sampling that is suitable to characterize NORM and TENORM, including types, quantities, sample technique, chain of custody, onsite radiological analysis, off-site physical, chemical, and radiological laboratory analysis.

It is important to understand the movement and exposure pathways of TENORM through the entire O&G process. In this regard, the purpose of this comprehensive study is to have a more complete understanding of TENORM in O&G activities and waste disposal operations, and to document and evaluate potential radiation exposure to workers and the public, as well as to ensure protection of the

[3] American National Standards Institute , "Control and Release of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)", ANSI/HPS N13.53-2009, March, 2009.
[4] Pennsylvania Department of Environmental Protection, “Final Guidance Document on Radioactivity Monitoring at Solid Waste Processing and Disposal Facilities”, Document Number 250-3100-001, January 2, 2004.

environment. The sampling and analysis will assist in determining radiological isotopes of concern and in evaluating their potential mobility in the environment. The members of PIOGA and MSc are encouraged to participate in this study and collect representative samples at the same time as the DEP. At such time as data are available, each member should provide the results and the entire laboratory report so that the results can be summarized by PIOGA and MSC. The names of the operators and location of the well sites will be kept confidential.

2.0 SITE DESCRIPTION

2.1 Facilities to be Sampled

The sampling locations associated with O&G activities will vary from site to site throughout the state. The study will include survey and sample events on active and inactive O&G sites, and waste water facilities. Each site may have its own discrete water storage and residual waste storage locations.

Various O&G facilities will be evaluated for TENORM generation and handling. PIOGA and MSC intend to identify O&G facilities across the state, including conventional and unconventional wells, which should be characterized. The overall approach is to select sites that will be representative of radiological conditions of O&G facilities throughout Pennsylvania. Previous studies indicate that the presence of TENORM varies according to the location, depth and the operational phase of the well. Consequently, discrete grab samples from multiple sampling events at each site will be composited. This approach will ensure representative samples of both fluids and solid waste generated by O&G drilling and production practices and will more accurately reflect statewide geologic conditions, drilling methods and well types.

Preferred locations are well sites, waste water treatment facilities, gas distribution facilities and reconditioning well equipment facilities. The types of samples are described as follows, including:

Well Sites Selection Criteria:

- Select well sites in unconventional shale formations from the "dry" gas areas predominantly in the northern and central parts of the state and "wet" gas area found predominantly in the southwestern part of the state;
- Select one or more Utica formation well sites and other conventional shale formations (e.g., Geneseo, Burket and Rhinestreet) as they become available. Include conventional shallow O&G well sites in the Oriskany sandstone formation;
- Sample from conventional horizontal wells (e.g., Penneco wells);
- Sample, as applicable, during the five phases of development including, vertical drilling, horizontal drilling, fracturing, flowback and production; and
- Document the activities associated with well development and production equipment and operational facilities at each above-referenced site.

Waste Water Treatment Facility Selection Criteria:

- Select one or more representative samples of each type of waste water treatment plants, including CWT facilities, zero limit discharge (ZLD) facilities and well site treatment units; and

- Select waste water treatment facilities that accept waste material from unconventional well sites in both wet gas as well as dry gas production areas.

Gas Distribution and End Use Operations Facility Selection Criteria:

- Assess facilities that compress, carry and distribute gas from the 'wet gas ' producing area of the state; and
- Assess facilities that compress, carry and distribute gas from the 'dry gas' producing area of the state. Include facilities that handle gas produced in Pennsylvania as opposed to those which handle gas imported from out of state. Include any major gas user (e.g., electrical generator), processing and storage facilities.

Well component reconditioning facilities, including major well casing or pipe reconditioning or de-scaling facilities in the Commonwealth, will also be selected for assessment.

2.2 Constituents of Concern

Primary constituents of concern (COCs) for O&G production radiological characterization include uranium (U-238), thorium-232, radium (Ra-226 and Ra-228), radon (Rn-220 and Rn-222) and any unsupported decay chain radionuclides. Radiological characterization will consist of field radiation surveys (gamma exposure rate) using portable survey meters, collection and screening of representative samples of solids and liquids, collection of swipe (smear) samples to determine removable alpha and beta surface contamination, and sampling of gas for radon analysis as appropriate.

3.0 SCOPE AND OBJECTIVES

This scope of this Plan is to examine the nature and extent of TENORM in the Pennsylvania O&G activities . Radiological support surveys and sampling performed for this TENORM study may consist of: (a) field alpha, beta and gamma screening measurements, and (b) sampling of various media for off-site radiological and laboratory analyses. This section summarizes the scope and objectives of these survey activities. A detailed description of field screening and sampling procedures are provided in subsequent sections.

3.1 Scope of Field Screening Activities

Field screening activities will consist of using field measurement instruments to identify the presence and approximate amounts of NORM and TENORM in cutting pits (open and closed), flowback and produced water, temporary water storage vessels and recycle systems, drilling rigs and associated equipment, offices, trailers and trucks, production equipment, waste water facilities, landfill leachate, and beneficial reuse areas. Screening of solid and aqueous samples and swipes (smears) samples will also be performed.

Direct-read radiological survey instruments will be used throughout the field operations of the project for scanning and surveying of personnel, equipment, materials and general areas. The survey instruments will be operated and maintained by PIOGA, MSC personnel or qualified contractors. Additional equipment that may be used on-site will be maintained and operated by the operator's technician(s) or subcontractors. Proposed instruments, detectors, and equipment (or their equivalents) to be used on-site during field screening are listed in Table 8.1, using the procedure described in Appendix A and B.

3.2 Scope of Field Sampling Activities

Field sampling will consist of collecting representative samples of environmental media from sources for either on-site measurements or off-site laboratory analysis. The following types of field samples will be collected are summarized in Table 8.2 and include:

- Drill cuttings, accumulated solids, scale, treatment water sludge, discharge sediment, soil samples and crystalline salts from brine water evaporation as appropriate for off-site radiological laboratory analyses for characterization and evaluation of potential mobility in the environment;
- Flowback and produced water, and waste water treatment influent and effluent, for off-site radiological laboratory analysis for characterization purposes;
- Solid and aqueous phases to be evaluated separately;

- Radon sampling of gas as appropriate to assess potential occupant/worker/public exposures; and
- Swipe (smear) samples to determine removable alpha and beta surface contamination as an indicator of potential inhalation or incidental ingestion exposures.

Off-site analysis of solid and aqueous samples may include the following parameters as specified in Section 5.0, gross alpha and beta, gamma spectroscopy to identify radionuclides, alpha spectroscopy for uranium (U-238, U-235, and U-234), radium (Ra-226), thorium (Th-232, Th-230, and Th-228), and for any unsupported decay chain radionuclides, and for radon (Rn-220 + Rn-222). The sample types and laboratory analysis requirements are summarized in Table 8.2. Minimum sample quantities, containers, and desired detection limits are summarized in Tables 8.3 and 8.4, using the procedure in Appendix C or D.

4.0 FIELD SCREENING AND TESTING ACTIVITIES

Procedures and activities for radiological field surveys and screening of solid and aqueous samples and sampling areas are described below. A summary of the materials to be sampled is provided in Table 8.2.

4.1 Radiological Surveys of Solid Sample Areas

Radiological surveys will be performed in areas where solid samples are collected, including:

- Gamma exposure rate surveys in units of micro-roentgen per hour (uR/hr) within and near sampling areas when possible; or
- Gross gamma surveys in units of counts per minute (cpm) in and around sampling areas; and
- Background exposure rate and/or gross gamma count rates measured outside the influence of sampling areas.

Background radiation levels will be documented in areas that are not impacted by the field operations or facilities. Results from any radiation survey equipment capable of measuring beta or gamma radiation will be recorded in the designated background location. Background radiation is established in order to verify that the results are not influenced by imported materials or equipment that may contain elevated concentrations of NORM or TENORM. The procedure to conduct a radiation survey for gamma exposure rates and the associated radiation background is provided in Appendix A.

4.2 Radiological Surveys of Aqueous Sample Areas

Radiological surveys will be performed on containerized water and/or sludge, and effluent discharge points including:

- Gamma exposure rate surveys in units of uR/hr around, on contact with, and one meter from water tanks/trucks full or partially full of water/sludge prior to sampling when possible, and/or at effluent discharge points; and
- Background exposure rates and/or gross gamma count rates measured outside the influence of sampling areas.

4.3 Radiological Surveys of Equipment and Structures

Radiological surveys will be performed on drilling rigs and well development equipment (e.g., platforms, pipes, tanks, etc.), including:

- Gamma exposure rate surveys in units of uR/hr on contact and at 1 meter from the surface of equipment and/or structures prior to sampling when possible; or

- Gross gamma surveys in units of cpm on contact with equipment and/or structures to be sampled;
- Total alpha and beta surface contamination in units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2);
- Removable alpha and beta surface contamination (smear) in units of dpm/100 cm^2; and
- Background exposure rates and/or gross gamma count rates measured outside the influence of sampling areas.

The procedure to conduct a radiation survey for gamma exposure rates and the associated radiation background is provided in Appendix A. The procedure to conduct a radiation survey for total and removable surface contamination, gross alpha and beta, is provided in Appendix B.

4.4 Radiological Surveys of Samples

Radiological surveys will be performed on all samples, including:

- Gamma exposure rate surveys in units of uR/hr on contact with sample container; and/or Gross gamma surveys in units of cpm on contact with sample container;
- Total alpha and beta surface contamination in units of dpm/100 cm^2; and
- Removable alpha and beta contamination (smear) in units of dpm/100 cm^2.

Background exposure rates and/or gross gamma count rates will also be measured outside the influence of samples and sampling areas.

The procedure to conduct a radiation survey for gamma exposure rates and the associated radiation background is provided in Appendix A. The procedure to conduct a radiation survey for total and removable surface contamination, gross alpha and beta radiation, is provided in Appendix B.

5.0 FIELD SAMPLING ACTIVITIES

This section of the Plan describes sampling and analyses to be performed by off-site laboratories. Field sampling will be performed for solid, aqueous, and gas samples as described below. Specific sampling parameters, laboratory analytical methods and numbers of samples are discussed further in Section 7.0 and summarized in Table 8.2, while analytical methods and sample volume, preservation, and holding times are summarized in Tables 8.3 and 8.4.

5.1 Objectives

The concentration of NORM and TENORM in each of the media types is variable. PIOGA and MSC recommend that multiple, representative samples of solid and aqueous media be collected and composited. The samples should be collected randomly from each medium in order to create an average sample for analysis. PIOGA and MSC are committed to avoid potential sample bias and not create a sample or a database of sample results that are the worst case or best case (biased with high results or low results, respectively).

5.2 Solid Samples

Various types of solid samples may be collected:

- Rock cuttings as produced on a drill rig including cuttings stored temporarily on site in lined pits or containers;
- Solid phase from flowback and produced water;
- Solids accumulated in vessels or on equipment;
- Scale from drill rigs and associated equipment;
- Wastewater treatment facility sludge;
- Wastewater treatment facility discharge sediments;
- Soil/salt samples from beneficial reuse areas;
- Fresh proppant sands; and
- Drilling muds.

5.2.1 Sample Types and Locations

Samples will be collected as outlined below:

5.2.1.1 Exploration and Production Site Sampling - This study will include sample events on active and inactive sites, including:

- Open/Operating Cuttings Pits - Sampling and laboratory analysis of the drill cuttings (solid material) stored in the open/operating pits. Cuttings from both the vertical and horizontal drilling phases will be sampled;

- Cuttings from closed-loop drill cutting systems;
- Flowback and produced water on sites, evaluate solid and aqueous phases separately;
- Temporary Water Storage Vessels and Recycle Systems (i.e., Hydraulic Fracturing Water Storage Tanks, Produced Fluids Tanks, Filtration Equipment, Water Trucks) - Collect and screen samples of solids accumulated in vessels for gross activity;
- Drilling Rigs and Associated Equipment - Collect and screen samples of solids (scale) accumulated on rigs, pipes used well casings and associated equipment; and
- Production Equipment (Separators, Heater/Treaters, Dehydration Units, Compressors) - If possible, collect and screen samples of solids accumulated in/on production equipment.

5.2.2.2. Waste Water Facilities Sampling

- Facilities that treat water from unconventional shale formations. A majority of those facilities are located in the western sector of Pennsylvania. Some of these facilities are also located in the Central or Eastern sector of the state;
- Facilities will include normal POTWs, specialized CWT facilities used for unconventional shale hydraulic fracturing water treatment operations and zero limit discharge (ZLD) facilities.
- Samples at each of the waste water facilities will be sampled on at least three different times;
- Solid samples will be taken at each facility during each of the 3 sample events: sludge from the treatment of the water and sediments at the effluent discharge point; and
- The operator will record any other pertinent data during each sample event, e.g., influent volume from unconventional shale operations, total influent flow, and effluent flow. To the extent possible, the operator will schedule the sampling of the sludge at its facility such that the samples are all related to the processing of the influent unconventional shale operations.

5.2.2 Sampling Methods

Solid samples will be collected using reusable or disposable sampling tools (e.g., stainless steel trowels or tubes). Sampling tools will be decontaminated prior to first use on-site, between sampling locations, and following last use on-site (i .e., before demobilizing that equipment) as appropriate based on survey data. The samples selected for analysis will be placed into laboratory approved containers immediately following collection and labels promptly affixed to the sample containers. The samples will be transported via delivery service under chain-of-custody control to the off-site subcontract laboratory for analysis. Table 8.3 identifies container types that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in Table 8.3. Sampling protocols for collecting samples of drill cuttings from conventional and unconventional wells are provided in Appendix C and D.

In the event that the operator is collecting its samples at the same time as the representatives from the DEP, the samples should be split or otherwise composited and homogenized before the samples are packaged. A split sample represents an industry practice for purposes of comparing testing results. All of the materials collected from that location are homogenized in a stainless steel bowl or disposable aluminum pan to the best that the material will allow. Multiple samples are collected from the homogenized material and submitted for the appropriate analysis.

Subsurface sampling, e.g., by hand auger will be considered when a gradient in the media sampled is suspected and the volume of material represented is not homogeneous. For example, for drill cuttings, in order to access cuttings from the horizontal zone, subsurface sampling of a cuttings pile maybe necessary. Samples will be collected at depth intervals, each approximately 15 centimeters deep, either using a hand auger or other appropriate sampling tool. Each segment will be field screened for gross gamma activity and/or exposure rate to determine if materials above ambient background are present in the sample. If materials are present in multiple contiguous intervals, all of the materials in those intervals will be homogenized in a stainless steel bowl or disposable aluminum pan to the best that the material will allow. A sample will be collected from the homogenized material and sent for the appropriate analysis. If conditions allow, an attempt may be made to down-hole log the auger hole to estimate the depth of activity encountered within the sample location.

For surfaces of internal components of natural gas production or processing equipment, samples will be collected in order to characterize the concentrations of lead (Pb-210) and polonium (Po-210). Previous studies indicate that the concentrations of TENORM are potentially elevated especially for the equipment that separate propane. The radiation surveys and measurement protocols, including smears, and scrapings for this equipment are provided in Appendix E. Sample locations will be based on the operational history of the equipment or the presence of elevated gamma radiation levels. After the equipment or pipe is opened, the wipe test and scraping can be collected from the inner surfaces.

Additional sample preparation as specified by the laboratory for specific analyses may be required. For gamma spectroscopy usually no field preparation is necessary. However, for gross alpha and beta analyses additional sample preparation may be necessary in the laboratory. For the purposes of radioactivity analysis, a consistent temperature for transport and storage, as low as 4° Celsius (C), is not required for any samples.

5.2.3 Quality Control

Quality Control samples will be collected to verify results of off-site laboratory and submitted at least 5% field replicate or split samples collected per total samples in a calendar quarter. Ten percent (10%) of the samples, based on the gross alpha and beta, and gamma spectroscopy results, will also be analyzed by alpha spectroscopy for isotopic uranium (U-238, U-235 and U-234), isotopic thorium (Th-232, Th-230 and Th-228), isotopic radium (Ra-226 and Ra-228), for any unsupported decay chain radionuclides (e.g., Pb-210 and Po-210), and for radon (Rn-220 and Rn-222).

5.2.4 Laboratory Analysis

Solid samples will be analyzed by gamma spectroscopy to identify TENORM radionuclides. Approximately 10% of the samples, based on the gamma spectroscopy results, will also be analyzed by alpha spectroscopy for uranium (U-238, U-235 and U-234), thorium (Th-232, Th-230 and Th-228) radium (Ra-226) and isotopic analysis for Ra-228 (a beta emitter) and for any unsupported decay chain radionuclides; and for radon (Rn-220 and Rn-222). Samples from gas processing equipment will be analyzed by appropriate analytical methods (low-energy gamma spectroscopy for Pb-210, and radiochemical analysis for Po-210).

Solid samples (excluding samples from gas processing equipment) will be dried and homogenized before being packaged for gamma spectroscopy. For samples being analyzed for Ra-226, the dried samples will be sealed in an air-tight container and stored for approximately 21 days in order to achieve secular equilibrium with the progeny of Ra226. The desired detection limits are provided in Table 8.3 and 8.4. For example, the detection limits for the analysis of solids should be able to achieve at least 1 picocurie of Ra-226 per gram.

5.3 Aqueous Samples

Various types of aqueous samples may be collected:

- Flowback, brines and other produced waters;
- Accumulated liquids from production equipment;
- Influent water from wells located in the Marcellus shale play;
- Waste water treatment facility effluent discharge water; and
- Various receiving water body samples.

5.3.1 Sample Type and Location

Grab samples will be collected as outlined below:

5.3.1.1 Exploration and Production Site Sampling

- Samples will be collected on active and inactive drill sites;
- Flowback and produced water on sites, evaluate solid and aqueous phases separately;
- Temporary Water Storage Vessels and Recycle Systems (Hydraulic Fracturing Water Storage Tanks, Produced Fluids Tanks, Filtration Equipment, Water Trucks) - Water tanks screened at greater than five (5) times background should be sampled and analyzed; and
- Production Equipment (Separators, Heater/Treaters, Dehydration Units, Compressors) - If possible, collect and screen samples of liquids accumulated inside production equipment.

5.3.1.2. Waste Water Facilities Sampling

- Facilities that treat water from unconventional shale formations. A majority of those facilities are located in the western sector of Pennsylvania. Some of these facilities are also located in the Central or Eastern sector of the state;
- Facilities will include normal POTWs, specialized CWT facilities used for Marcellus shale hydraulic fracturing water treatment operations and zero limit discharge (ZLD) facilities.
- Samples at each of the waste water facilities will be sampled at least three different times;
- At least two (2) aqueous samples will be taken at each facility during each of the three (3) sample events: influent from unconventional shale operations , total influent flow, and facility effluent discharge water. An additional solid sample will be collected from the waste-water sludge generated at the facility and a sediment sample will be collected at the effluent discharge point where applicable; and
- The operator will record any other pertinent data during each sample event, e.g., influent volume from unconventional shale operations, total influent flow, and effluent flow. To the extent possible, the operator will coordinate the sampling of the influent water and the effluent water with the facilities such that the samples are all related to the processing of the influent unconventional shale formations.

5.3.2 Sampling Methods

PIOGA and MSC recommend that representative samples be collected for flowback and production water by performing multiple collection events over the entire flowback period and initial production. A representative grab sample will be collected from the appropriate tank/outlet using a disposable Teflon® bailer or a reusable stainless steel thief sampler; contents of the selected sampling implement will be added directly to sample containers. Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. In cases where sample valves are available, samples may be collected directly into approved sample containers. The samples will be transported via overnight delivery service under chain-of-custody control to the off-site subcontract laboratory for analysis or transported to the on-site lab. Table 8.4 identifies container types to be used for collection of these samples. Once the sample is received by the off-site analytical laboratory, the laboratory personnel will immediately filter the sample using a 0.45 micron filters. The filtered sample will placed into a new pre-cleaned container and properly preserved. If a stainless steel thief sampler is used, it will be decontaminated prior to first use, between sampling locations, and following last use. Sampling equipment decontamination procedures are described in Section 5.5. For the purposes of radioactivity analysis, a consistent temperature, as low as 4° Celsius (C), is not required for any aqueous samples. Samples should be analyzed within 180 days of the sample date.

5.3.3 Quality Control

Quality Control samples will be collected to verify results of off-site laboratory and submitted at least 5% field replicate or split samples collected per total samples in a calendar quarter. Ten percent (10%) of the samples, based on the gross alpha and beta, and gamma spectroscopy results, will also be analyzed by alpha spectroscopy for isotopic uranium (U-238, U-235 and U-234), isotopic thorium (Th-232, Th-230 and Th-228), isotopic radium (Ra-226 and Ra-228), for any unsupported decay chain radionuclides, and for radon (Rn-220 and Rn-222).

5.3.4 Laboratory Analysis

Each of the samples will be split in two so that one sample is analyzed "as is" and the other sample is preserved, filtered (by the off-site laboratory), then analyzed (both the aqueous and the filter medium). Each of the samples will be analyzed for gross alpha and beta and by gamma spectroscopy to identify radionuclides. Approximately 10% of the samples, based on the gross alpha and beta, and gamma spectroscopy results, will also be analyzed by alpha spectroscopy for uranium (U-238, U-235 and U-234), thorium (Th-232, Th-230 and Th-228) radium (Ra-226) and isotopic analysis for Ra-228 (a beta emitter) and for any unsupported decay chain radionuclides; and for radon (Rn-220 and Rn-222). Laboratory analysis methods and the required detection limits for these parameters are identified in Table 8.4. For liquids, the preferred method should be able to achieve 5 picocuries of radium 226 and radium 228 combined per liter.

5.4 Gas Samples

Radon gas sampling occurs via several methods. The locations for samples will be those where persons are located routinely, such as control rooms or break rooms. Samples will not be collected in the head spaces of production equipment, such as evaporators, chemical tanks, or filter presses. Samples will also be collected for the processed natural gas, inside the distribution line. Samples for radon, in occupied areas and inside high pressure gas distribution lines, will be collected by qualified contractors.

The specific method chosen will depend on the characteristics of the sampling location, such as indoor or outdoor locations, relative humidity considerations and length of time of samples. The sampling methods available are activated charcoal analysis, electret ion chambers (both short- and long-term), alpha track detectors, continuous radon monitors and grab sampling. The contractor will determine the optimum method, according to the potential for exposure.

It will be necessary to determine the amount of radon that is contained within the product side mixed with methane, such as downstream processors and distributers of natural gas. Natural gas samples will be collected in an industry-approved sample container capable of direct sampling from the high pressure 800 to 1000 psi distribution lines. These sample containers will be delivered to the laboratory by the sample collector or some other ground transport method. Regulators will be applied to the sample container so the laboratory can collect a specific volume of methane. The methane will be captured inside a device typically used for capturing radon during radon emanation analysis. Standard radon emanation counting via gamma spectroscopy, Lucas cell, or equivalent as appropriate will be utilized to determine the concentration of radon.

5.5 Equipment Decontamination Procedures

Disposable sampling equipment will be used wherever possible to reduce decontamination requirements. When reusable equipment is used, such equipment will be decontaminated both prior to sampling in the field, between uses, and following the last use on each site, as appropriate. The following decontamination steps will be performed for reusable equipment, in the following order as necessary:

1) Potable water rinse;

2) Wash with laboratory-grade detergent (Alconox®, Liquinox® or equivalent);

3) Distilled water rinse;

4) Acetone, Isopropanol or Methanol rinse;

5) Distilled water rinse; and

6) Air drying.

6.0 DOCUMENTATION

6.1 Field Documentation

6.1.1 Log Books and Field Data Sheets

Information pertinent to field activities will be recorded on field logbooks. The logbooks will be bound and the pages will be consecutively numbered. Sufficient information will be recorded in the logbooks to permit reconstruction of site sampling activities. Information recorded on official project documents (e.g., survey forms, chains-of-custody, etc.) will not be repeated in the log books except in summary form or cross-reference notation where determined necessary. Field log books will be kept in the possession of the appropriate field personnel, or in a secure place when not being utilized during field work. Logbooks will become part of the final project file upon completion of the field activities. Entries recorded in log books will be made in blue or black, waterproof ink and may include, but not be limited to, the following information:

- Surveyor/sampler, date, and times of arrival at and departure from the site;
- Description of the field activity and summary of daily tasks;
- Names and responsibilities of field crew members;
- Sample collection method and number/volume of sample(s) collected;
- Information regarding activity changes and scheduling modifications;
- Field observations and weather conditions;
- Types of field instruments used and purpose of use, including calibration methods and results;
- Field measurements made and quantities/volumes of material sampled;
- Scanning/surveying of equipment and materials;
- Global Positioning System (GPS) coordinates as appropriate; and
- Days elapsed since flowback as applicable.

Additionally, the sampler will record any other pertinent data during each sample event, e.g., influent volume from Marcellus shale, total influent flow, and effluent flow. To the extent possible, the operator will coordinate the sampling of the influent water, the sludge and the effluent water with the facilities such that the samples are all related to the processing of the influent Marcellus shale industry water. Field data sheets and radiological survey forms may be used to record field information in addition to the use of log books. Information from the log books and sketches will be used in the summary report to document the conditions when samples were collected.

6.2 Sample Documentation

6.2.1 Sample Numbering System

A unique sample numbering scheme will be used to identify each sample collected and designated for on-site and off-site laboratory analysis. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be recorded on sample labels or tags, field data sheets and/or logbooks, chain-of-custody records and all other applicable documentation used during the project.

6.2.2 Sample Labels

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

- Sample identification number;
- Sample type (discrete or composite);
- Site name and area/location number;
- Analysis to be performed;
- Type of chemical preservative present in container;
- Date and time of sample collection; and
- Sample collector's name and initials.

6.2.3 Container Receipt Checklist

The condition of shipping package and enclosed sample containers will be documented upon receipt at the analytical laboratory. This documentation will be accomplished using a container receipt checklist utilized by the contract laboratory.

6.2.4 Chain-of-Custody Records

Chain-of-custody procedures implemented for the project will provide documentation of the handling of each sample from the time of collection until completion of laboratory analysis. The chain-of-custody form serves as a legal record of possession of the sample. An example is provided in Appendix F. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession;
- The sample is in the sampler's view after being in possession;
- The sample was in the sampler's possession and then was placed into a locked area to prevent tampering; and/or
- The sample is in a designated secure area.

Custody will be documented throughout the project field sampling activities by a chain-of custody form initiated each day during which samples are collected. The chain-of-custody will accompany the samples from the site to the laboratory and will be returned to the laboratory coordinator with the final analytical report. Personnel with sample custody responsibilities will be required to sign, date and note the time on a chain-of-custody form when relinquishing samples from their immediate custody or placing the samples into designated secure areas for temporary storage prior to shipment. Bills of lading or air bills will be used as custody documentation during times when the samples are being shipped from the site to the laboratory, and will be retained as part of the permanent sample custody documentation. Chain-of-custody forms will be used to document the integrity of all samples collected. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, chain-of-custody forms will be filled out for sample sets as determined appropriate during the course of fieldwork. The individual responsible for shipping the samples from the field to the laboratory will be responsible for completing the chain-of-custody form and noting the date and time of shipment. This individual will also inspect the form for completeness and accuracy. After the form has been inspected and determined to be satisfactorily completed, the responsible individual will sign, date, and note the time of transfer on the form. The chain-of-custody form will be placed in a sealable plastic bag and placed inside the container used for sample transport after the field copy of the form has been detached. The field copy of the form will be appropriately filed and kept at the site for the duration of the site O&G activities.

Chain-of-custody seals may also be placed on each container used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the containers. The chain-of-custody seals will be used to ensure that no sample tampering occurs between the time the samples are placed into the containers and the time the containers are opened for analysis at the laboratory. Container custody seals will be signed and dated by the individual responsible for completing the chain-of-custody form contained within the container.

6.2.5 Receipt of Sample Forms

The subcontract laboratory will document the receipt of samples by accepting custody of the samples from the approved shipping company. In addition, the subcontract laboratory will document the condition of the environmental samples upon receipt.

6.2.6 Documentation Procedures

The tracking procedure to be utilized for documentation of all samples collected during the project will involve the following steps:

- Collect and place samples into laboratory sample containers;[5]
- Complete sample container label information;
- Complete sample documentation information in the field logbook;
- Complete project and sampling information sections of the chain-of-custody form(s);
- Complete the air bill for the container to be shipped to off-site laboratory, if applicable;

[5] For the purposes of radioactivity analysis, a consistent temperature, as low as 4° Celsius (C), is not required.

- Perform a completeness and accuracy check of the chain-of-custody form(s);
- Complete sample relinquishment section of form(s) and place the form(s) into shipping container;
- Place chain-of-custody seals on the exterior of the container; and
- Package and ship the container to the laboratory.

The following steps will be made upon receipt of the container at the subcontract laboratory:

- Inspect each container and its contents;
- Perform the requested analyses; and
- Transmit original chain-of-custody form(s) with final analytical results from laboratory.

6.2.7 Corrections to Documentation

Original information and data in field logbooks, on sample labels, on chain-of-custody forms, and on any other project-related documentation will be recorded in blue or black waterproof ink and in a completely legible manner. Errors made on any document will be corrected by crossing out the error and entering the correct information or data. An error discovered on a document will be corrected by the individual responsible for the entry, if possible. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and corrections will be initialed and dated by the individual responsible for the entry.

6.3 Sample Packaging and Shipping

Sample containers destined for off-site laboratory analysis will be packaged in rigid-body containers, and will be stored in a secure area during the time period between collection and shipment to the off-site subcontract laboratory. For the purposes of radioactivity analysis, a consistent temperature, as low as 4° Celsius (C), is not required. Samples that exhibit elevated radiation levels may be subject to the US Department of Transportation (DOT) regulations, specifically Class 7, radioactive materials.[6] The shipper is responsible to verify that the regulations are satisfied.

6.4 Management and Retention of Records

Original copies of field data, field records, analytical data, training records, and other project specific documentation will be retained by the operator. Selected representatives of PIOGA and MSC will review and summarize the data.

[6] Title 49, Code of Federal Regulations, Part 173, Subpart I. "Class 7 (Radioactive) Materials. " April,2013.

7.0 LABORATORY ANALYSIS

The operator will select a radiochemistry laboratory, approved by the DEP, to complete the radiological analysis of solid and aqueous samples for characterization. Table 8.2 summarizes sampling and analysis requirements for the project. Tables 8.3 and 8.4 summarize sample collection, preservation, and holding time requirements for each applicable medium on this project. Samples will be transported to off-site laboratories for analysis in accordance with documented laboratory-specific standard methods listed in the Analysis Methods column of Table 8.2.

7.1 Gamma Spectroscopy

Radiological COCs for these samples may be quantified for activity concentrations directly via gamma decays, or inferred via decays of gamma-emitting progeny, after the laboratory has established that secular equilibrium exists between the parent and progeny radionuclides. Ra-226 may be measured directly by detection of its 186 kilo-electron volt (keV) energy line for high activity waste-sludge samples. However, the presence of U-235 can cause interference with direct Ra-226 detection since it has a gamma line of similar energy, 185 keV. The short-lived progeny of radium will be used to determine Ra-226 concentrations in the soil when background levels of Ra-226 are encountered, in the range of 1 to 10 pCi/g. After the sample is processed by the laboratory, dried and homogenized, the sample must be stored in an airtight container so the short-lived progeny can reach secular equilibrium. The sample is typically stored for at least 21 days before the sample is analyzed by gamma spectroscopy. The Ra-226 progeny, Bi-214, will then be in secular equilibrium with Ra-226 and will be analyzed to establish the concentration of Ra-226. Gamma spectroscopy will also be used to identify and determine the concentrations of other gamma emitting radionuclides that may be present in samples (e.g., Ra-228 by its short lived progeny Ac-228).

7.2 Quality Control

Initial and daily calibrations of the off-site laboratory gamma spectroscopy system will be performed using a mixed-gamma National Institute of Standards and Technology (NIST) traceable source. System QC will be ensured by tracking peak energy, peak resolution and net peak area for a high and low energy peak, based on daily source counts. These QC checks will be performed in accordance with applicable laboratory QC procedures.

8.0 Tables

Table 8.1 Field Screening Equipment

Instrument	Detector	Parameter
Ludlum Model 2224, or equivalent	Ludlum Model 43-89, alpha/beta scintillator, or equivalent	Portable scaler/ ratemeter for detecting alpha and beta radiation
Ludlum Model 2221, or equivalent	Ludlum Model 44-10, gamma scintillator, or equivalent	Portable scaler/ ratemeter for detecting gamma radiation
Ludlum Model 2929, or equivalent	Ludlum Model 43-10-1, or equivalent	Table top counter for detecting alpha and beta radiation
Bicron Microrem, or equivalent	Internally-mounted plastic gamma scintillator	Portable exposure rate survey meter for gamma radiation
Ludlum Model 3, or equivalent	Ludlum Model 44-9, thin window GM detector, or equivalent	Portable survey meter for detecting beta radiation
Ludlum Model 19, MicroR meter, or equivalent	Internally-mounted 1x1 NaI gamma scintillator	Portable exposure rate survey meter for gamma radiation

Table 8.2 Summary of Materials to be Sampled

Sample Type	Medium	Analytical Parameters	Analytical Methods	Frequency
Vertical and Horizontal Phase Drill Cuttings Vertical and horizontal drilling- radionuclides phase cuttings including cuttings stored temporarily on site in lined pits or containers Solid phase from flowback and produced water Solids accumulated in vessels or on equipment Scale from drill rigs and associated equipment	Soil or soil-like	Gamma spectroscopy to Identify and measure concentrations of TENORM radionuclides	USEPA 901.1 Modified	Once per site
Wastewater treatment facility sludge Wastewater treatment facility discharge sediments	Soil or soil-like	Gamma spectroscopy to Identify and measure concentrations of TENORM radionuclides	USEPA 901.1 Modified	At least three sample events
Flowback and produced waters Accumulated liquids from production equipment	Aqueous	Gross alpha and beta Gamma spectroscopy Ra-226 Ra-228	USEPA 900.0 or EPA Standard Method 7110C USEPA 901.1 Modified USEPA Method 903.0 Modified USEPA Method 904.4 Modified	Once per site (Composite)

Table 8.2 Summary of Materials to be Sampled (Continued)

Sample Type	Medium	Analytical Parameters	Analytical Methods	Frequency
Influent Marcellus shale industry water Wastewater treatment facility discharge water	Aqueous, filtered and unfiltered	Gross alpha and beta Gamma spectroscopy Ra-226 Ra-228	USEPA 900.0 or EPA Standard Method 7110C USEPA 901.1 Modified USEPA Method 903.0 Modified USEPA Method 904.4 Modified	At least three sample events
Samples collected from interior surfaces of gas processing equipment	Solids	Pb-210 Po-210	EML Pb-01 Modified EML Po-2 Modified	Once per site
Gas sampling	Gaseous	Radon	To be determined	

Table 8.3 Analytical Requirements for Solid Samples

Parameter	Analysis Method	Sample Quantity	Container Type	Detection Limit
Gross alpha and beta	USEPA 900.0 or EPA Standard Method 7110C	100 grams	Plastic	10 dpm
Ra-226 and Ra-228	USEPA 901.1 Modified	500 grams	Plastic	1 pCi/g
Isotopic Thorium	ASTM D3972-90M	100 grams	Plastic	0.1 pCi/g
Isotopic Uranium	ASTM D3972-90M	100 grams	Plastic	0.1 pCi/g
Gamma emitting radionuclides	USEPA 901.1 Modified	1 liter	Plastic	1 pCi/g
Pb-210	EML Pb-02 Modified	> 10 grams	Plastic	0.5 pCi/g
Po-210	EML Po-2 Modified	> 10 grams	Plastic	0.5 pCi/g

Note: There are no requirements for holding times or preservative. For the purposes of radioactivity analysis, a consistent temperature, as low as 4° Celsius (C), is not required.

Samples should be double bagged so as to avoid damage during shipping.

Samples should be analyzed within 180 days after sampling.

Table 8.4 Analytical Requirements for Aqueous Samples

Parameter	Analysis Method	Sample Quantity	Container Type	Detection Limit
Gross alpha and beta	USEPA 900.0	1 gallon	Plastic or glass	5 pCi/liter
Ra-226 (Total radium by alpha)	USEPA 903.0	1 gallon	Plastic or glass	1 pCi/liter
Ra-226 (Radon emanation)	USEPA 903.1	1 gallon	Plastic or glass	1 pCi/liter
Ra-228	USEPA 904.0	1 gallon	Plastic or glass	1 pCi/liter
Isotopic Thorium	ASTM D3972-90M	1 gallon	Plastic or glass	1 pCi/liter
Isotopic Uranium	ASTM D3972-90M	1 gallon	Plastic or glass	1 pCi/liter
Gamma emitting radionuclides	USEPA 901.1 Modified	1 gallon	Plastic or glass	5 pCi/liter

Note: There are no requirements for holding times or preservative. For the purposes of radioactivity analysis, a consistent temperature, as low as 4° Celsius (C), is not required.

Samples should be analyzed within 180 days after sampling.

9.0 Appendices

Appendix A Exposure Rate Measurements

1. Surveys shall be performed with a portable radiation survey instrument that is sensitive to gamma radiation (e.g., sodium iodide detector, microR meter, or microrem meter).
2. The instrument shall be turned on and permitted to stabilize for a minimum of 30 seconds prior to performing measurements.

3. Pre Operational Checks

3.1. Pre-operational checks shall be completed at the start and end of each day the instrument is used.

3.1.1. Each instrument shall be labeled with a unique identifier (e.g., serial number of detector and rate meter) to enable traceability to surveys and records.

3.1.2. Prior to each use, or at the start and end of each day the instrument is used, each instrument shall be checked for the following: battery function, operating voltage, reset button function, audible response function, physical damage,

3.1.3. Verify that the instrument was calibrated within 12 months prior to its use.

3.2. Test the instrument response to a reference radioactive source.

3.2.1. If any response is different from the mean measurement by more than 3 standard deviations (±3δ), that instrument shall be removed from service.

3.2.2. If any two consecutive daily responses exceed the mean measurement + the 2σ value, the instrument may be removed from service pending an evaluation of its operational status.

3.3. Document the instrument response to background radiation.

3.3.1. Response to background radiation shall be determined at the start and end of each day the instrument is used, at a reproducible location in the vicinity of the measurement site but not near known radiation sources.

3.3.2. Three readings should be obtained at the start of each work shift, and three readings obtained at the end of each work shift.

3.4. The results of the daily checks shall be recorded on a record sheet.

3.5. Instruments failing any pre-operational check shall be taken out of service, segregated from other instruments, tagged as "out of service", and repaired prior to use.

4. Radiation Survey

4.1. Surveys shall be conducted by walking slowly over the area of interest with the detector held at a height of approximately one meter above the ground (waist high).

4.1.1. An increase in the audible response or in the needle/indicator movement may indicate the presence of radioactivity.

4.1.2. The instrument shall be held stationary in the locations where the increased response is noted.

4.2. Readings shall be recorded on a radiation survey form.

4.3. Carefully note the position of the range selector switch when observing the survey meter reading.

4.4. Any comments and notations that may be necessary for interpretation of results should be recorded on the survey form.

4.5. The individual performing the survey shall sign and date the completed Radiological Survey Form.

Appendix B Surface Contamination Measurements

1. Total Contamination on Surfaces

1.1. Total (fixed plus removable) contamination shall be measured by direct survey with portable radiation survey instruments sensitive to beta/gamma radiation (e.g., pancake Geiger-Mueller detector, or equivalent) or alpha radiation (e.g., alpha scintillation detector), or equivalent).

1.2. The instrument shall be turned on and permitted to stabilize for a minimum of 30 seconds) prior to performing surveys.

2. Pre Operational Checks

2.1. Pre-operational checks shall be completed at the start and end of each day the instrument is used.

2.1.1. Each instrument shall be labeled with a unique identifier (e.g., serial number of detector and rate meter) to enable traceability to surveys and records.

2.1.2. Prior to each use, or at the start and end of each day the instrument is used, each instrument shall be checked for the following: battery function, high voltage, reset button function, audible response function, physical damage,

2.1.3. Verify that the instrument was calibrated within 12 months prior to its use.

2.2. Test the instrument response to a reference radioactive source.

2.2.1. If any response is different from the mean measurement by more than 3 standard deviations (±3δ), that instrument shall be removed from service.

2.2.2. If any two consecutive daily responses exceed the mean measurement + the 2σ value, the instrument may be removed from service pending an evaluation of its operational status.

2.3. Document the instrument response to background radiation.

2.3.1. Response to background radiation shall be determined at the start and end of each day the instrument is used, at a reproducible location that is in the vicinity of the measurement site but not near known radiation sources.

2.3.2. Three readings should be obtained at the start of each work shift, and three readings obtained at the end of each work shift.

2.4. The results of the daily checks shall be recorded on a record sheet.

2.5. Instruments failing any pre-operational check shall be taken out of service, segregated from other instruments, tagged as "out of service", and repaired prior to use.

3. Radiation Survey for Total Activity on a Surface

3.1. Surveys shall be conducted by moving the detector at a pre-determined rate and within 0.25 inch of the surface.

3.2. The speed that the detector moves over the surface is important. The detector should move at a speed less than 2 inches per second.
3.3. An increase in the audible response or in the needle/indicator movement may indicate the presence of radioactivity.
3.4. The detector shall be held stationary over the areas where an increased response is noted.
3.5. Any changes in the surface structure that may affect instrument response shall be documented on the radiation survey form.
3.6. Survey points with the highest count rates shall be identified and recorded on the radiation survey form, along with an estimate of the physical dimensions of the area with elevated readings.
3.7. The position of the range selector switch shall be noted when observing the meter reading.
3.8. Any comments and notations that may be necessary for interpretation of the results should be recorded on the radiation survey form.
3.9. The individual performing the survey shall sign and date the completed radiation survey form.

4. Survey Methods for Determining the Extent of Removable (Loose) Contamination on Surfaces

4.1. Loose contamination shall be measured with numbered dry disc smears wiped over a surface area of at least 100 cm^2, with the unnumbered side in contact with the surface.
4.2. If the item/area to be smeared is less than 100 cm^2, the smear results shall be recorded as "per smear", with the size of the smeared area noted on the radiation survey form.
4.3. A filter paper disc (unnumbered side down) shall be placed on the surface to be smeared.
4.4. The disc shall be moved over an "S"-shaped area using moderate pressure, covering approximately 100 cm^2 (16 square inches), or about 16 inches in length, or the entire surface, if it is less than 100 cm^2 in area.
4.5. The disc smear shall be placed in a sample holder such that individual smears are separated from each other to prevent cross contamination.
4.6. A sample number that uniquely identifies the smear shall be documented on the sample holder and on the radiation survey form.
4.7. Each smear may be submitted to an analytical laboratory for determination of gross alpha and/or gross beta activity (in units of dpm) as described in Table 8.3.

Appendix C Sampling Protocol for Conventional & Unconventional Oil or Gas Drill Cuttings

Sampling and analysis will be completed for every 1000 cubic yards of material (cuttings) or per well, whichever is more frequent and at least four discreet samples per well. Unconventional (Shale-Formations) gas wells shall be divided into two distinct sections for sampling and analysis. Unconventional (Shale-Formations) vertical drill cuttings are to include material encountered from the surface to the kick-off-point or above the shale formation. Horizontal drill cutting will include material from the kick-off-point or once the vertical drill encounters the shale formation to the end of the horizontal drilling. Separate or discrete samples will be taken to represent Brine, Pyritic, or Petroleum formations encountered within to drilling process.

a. The Driller will take discreet samples and place in 1 liter wide mouth amber bottles filled to within one inch of the top, after the material is dewatered or stabilized for transportation or handling. A minimum of four discreet samples per well / well section shall be collected.

   i. Estimate volume of cuttings from the well prior to drilling based on depth and diameter

   ii. If the well is expected to produce less than 1000 cubic yards of cuttings divide the depth of the well by four (4) to determine the four section of the well to be sampled.

   iii. A discrete sample shall be obtained from a similar area of each section – preferably the middle of each section.

   iv. If the well is expected to produce greater than 1000 cubic yards of cuttings – perform the sampling for the first 1000 cubic yards, then repeat the process for the remainder of the cuttings. It is unlikely that a single well would produce more than 2000 cubic yards of cuttings.

b. The 1 liter wide mouth amber bottles shall be labeled with proper id and a complete Chain of Custody filled out for the sample.

c. The following information must accompany the sample:

   i. Listed on the Chain of Custody

      1. Drilling Company Name

      2. County

3. Latitude and Longitude

4. Type of cuttings (Conventional well, Unconventional (Shale-Formations) Vertical or Horizontal)

5. Depth of well at time of sampling

6. Date and time of sampling

ii. Drilling Additives (This may be disclosed prior to sampling)

d. The sample bottles are to be stored on ice and shipped directly to the laboratory after sampling of well drill cuttings or section of the well, if the well in Unconventional (Shale formations), with completed Chain of Custody.

e. Non-typical Discrete Samples will also be taken to represent any non typical materials encountered during the drilling process. These samples are in addition to the four discreet samples based on sampling plan. Such non typical cutting materials are the product of:

- Brine
- Pyritic
- Petroleum bearing formations

Appendix D Sampling Protocol for Conventional & Unconventional Cuttings from a Pit

Sampling and analysis will be completed for every 1000 cubic yards of material (cuttings) or per well, whichever is more frequent and at least four discreet samples per well. The cuttings will be sampled from the on-site pit. Separate or discrete samples will be taken to represent Brine, Pyritic, or Petroleum formations encountered within the drilling process. If possible, sampling of the pit should be completed prior to adding cuttings that contain product.

a. After cuttings have settled in the pit, water shall be removed as per normal procedures using a vacuum truck.

b. A backhoe or excavator will be used to sample the pit.

   i. The Driller will take discreet samples and place in 1 liter wide mouth amber bottles filled to within one inch of the top. Samples should be dewatered as much as possible prior to filling glass sample jar. A minimum of four discreet samples per well shall be collected after all material is placed in the pit

   ii. Divide the pit into four equal sections using imaginary lines. Create a small hand drawn diagram of the pit and sections – make sure the area the blow-off enters the pit is marked on the diagram. Number the section in numerical order – use number 1 for the section the blow enters the pit.

   iii. Using a backhoe or excavator obtain 1 sample per imaginary quarter of the pit.

      1. One sample must be taken from the course cuttings in the quarter where the blow-off enters the pit

      2. The remaining three samples shall be taken from the other three quarters

      3. Samples can be taken at various depths from the pit

   iv. If the well is expected to produce greater than 1000 cubic yards of cuttings – divide the pit into eight sections and sample each section. It is unlikely that a single well would produce more than 2000 cubic yards of cuttings.

c. The 1 liter wide mouth amber bottles shall be labeled with proper id and a complete Chain of Custody filled out for the sample.

d. The following information must accompany the sample:

i. Listed on the Chain of Custody

1. Drilling Company Name

2. County

3. Latitude and Longitude

4. Type of cuttings (Conventional well, Unconventional (Shale-Formations) Vertical or Horizontal)

5. Depth of well at time of sampling - section of the on-site pit relating to the diagram on the COC.

6. Date and time of sampling

ii. Drilling Additives (This may be disclosed prior to sampling)

e. The sample bottles are to be shipped directly to the laboratory after sampling of well drill cuttings with completed Chain of Custody.

f. Non-typical Discrete Samples will also be taken to represent any non typical materials encountered during the drilling process. These samples are in addition to the four discreet samples based on sampling plan. Such non typical cutting materials are the product of:

- Brine
- Pyritic
- Petroleum bearing formations

Appendix E Characterize LPG Processing Equipment

1. Surveying LPG processing equipment that potentially contains TENORM inside the equipment will be performed by personnel specifically for alpha contamination surveys so as to provide a consistent and complete survey.
2. Fixed and removable survey measurements will be performed to identify activity that can be removed versus activity that is fixed on the surface of the contaminated item and cannot be easily removed.
3. Radiation surveys will be performed with radiation survey equipment that have been calibrated within 12 months of the survey. Daily operational checks will be performed on survey equipment to ensure proper accuracy (as specified in Appendix B).
4. Gamma scintillation detectors will used to measure the gamma radiation levels (in cpm) in contact with the surfaces being characterized.
5. Surfaces that exhibit more than 2 times the background gamma count rate will be characterized further.
6. An alpha particle survey instrument will be used to survey all accessible locations of the surface being characterized.
7. Surfaces that exhibit an alpha count rate of more than 10 cpm will be characterized further.
8. LPG processing equipment suspected of being impacted with TENORM (primarily Pb-210 and Po-210 inside propane separation and storage components) will be opened, if possible, to perform alpha radiation measurements of inner surfaces and to collect samples of solids (if present) on inner surfaces.
    - 8.1. The inner surface of small diameter piping or other LPG processing components will be surveyed for the presence of alpha and beta radiation using the procedure described in Appendix B.
    - 8.2. A sample for removable material from the inner surfaces will be collected, if possible. using the procedure as described in Appendix B.
    - 8.3. The survey procedures noted above will be repeated at other locations, if possible, inside the pipe and equipment.
    - 8.4. The individual performing the survey shall sign and date the completed radiation survey form.

Appendix F Example of Chain of Custody

HAWKMTN LABS INC
201 West Clay Avenue / Hazle Township, Pa 18202
PHONE (570) 455 - 6011 • FAX (570) 455 - 6321

CHAIN OF CUSTODY
SAMPLE SUBMISSION RECORD

Customer No.___________________
Work Order No._______________________

Drilling Company ID #
____
Phone Number
____
County
____
Latitude and Longitude
____________ ______________

Type of Cuttings:
☐ Conventional ☐ Unconventional (Shale-Formations)
☐ Vertical ☐ Horizontal

Type of Drilling:
☐ Air ☐ Foamer ☐ Air mist
☐ Mud ☐ Aqueous ☐ Non aqueous (oil) ☐ Synthetic

Grab #1 **Samplers Initials**
Time___________ __________
Depth of well___________

Grab #2 **Samplers Initials**
Time___________ __________
Depth of well___________

Grab #3 **Samplers Initials**
Time___________ __________
Depth of well___________

Grab #4 **Samplers Initials**
Time___________ __________
Depth of well___________

Drilling Additives (Please include a copy of MSDS – unless previously supplied)
____

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)	DATE	TIME
RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)	DATE	TIME
LOGGED IN BY: (SIGNATURE)				DATE	TIME