

SAMPLING AND ANALYSIS PLAN

COLORADO SCHOOL OF MINES RESEARCH INSTITUTE
SITE ENVIRONMENTAL ASSESSMENT

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1.0 INTRODUCTION AND SCOPE

This *Sampling and Analysis Plan* (SAP) addresses activities to be performed by or under the direction of New Horizons Environmental Consultants, Inc. (New Horizons) to obtain field measurements and/or samples of environmental media from the former Colorado School of Mines (CSMRI) facility located in Golden, Colorado (Site) as part of the site environmental assessment and response.

The site covers an area of approximately 5 acres. It is located on the south side of Clear Creek, approximately one-half mile east of the intersection of U.S. Highway 6 and Highway 58 near the west end of 12th Street. It contains floor slabs of 14 buildings and associated foundations, retaining walls, roads, walks, gutters, drainage trenches, and other features of the former CSMRI campus. The buildings and features were constructed over a time span of several decades, leading to a diversity of materials and associated radiological and chemical constituents.

Numerous industrial mineral research projects were conducted at the Site from 1912 until approximately 1985. Some of these projects utilized materials that contained elevated (above background) levels of radioactive materials. The research projects utilized approximately 16 buildings on the Site that have since been removed. However, many of the foundations and floor slabs from these buildings remain at the Site.

The U.S. Environmental Protection Agency (EPA) performed a CERCLA emergency removal action after a 1992 water main rupture that released water into an inactive settling pond located on the CSMRI site. The removal action involved excavation of 22,000 cubic yards of soil that was later disposed of as a special solid waste at a local solid waste landfill. The EPA emergency removal action was completed in 1997.

The Colorado Department of Public Health and Environment (CDPHE) issued a Radioactive Materials License for the CSMRI site (License 617-01). The license authorizes storage of naturally occurring, source, and byproduct materials.

This project will include the following field operations:

- Remove and dispose of concrete, asphalt;
- Survey and sample newly exposed soils as well as any soil areas not previously surveyed.
- Perform monitoring required to measure and control employee and worker exposure to radioactivity during the performance of field operations.

This SAP establishes methodologies for obtaining field measurements and describes techniques for identifying sampling locations and for obtaining samples of construction and environmental media. The SAP also describes means for packaging and transporting samples to the selected laboratory for analysis.

2.0 SAMPLING AND ANALYSIS SUPPORTING MATERIAL REMOVAL

Instrument surveys will be performed during material removal operations to ensure that fugitive radiologically impacted material is not dispersed beyond the site during material removal operations. Other instrument surveys will be performed to ensure that demolition solid waste debris shipped for disposal does not contain radioactive constituents.

2.1 Transportation Vehicle Survey

Equipment, tools, and transportation vehicles, including transportation vehicles used for hauling solid waste will be surveyed before entering the site to determine a baseline radiological status. Before leaving the site, equipment, tools, and transportation vehicles will be resurveyed to determine that radioactive materials above the incoming baseline are not present in excess of the allowable levels established by the United States Nuclear Regulatory Commission (USNRC) in Regulatory Guide 1.86 or such other limit as may be established by the Colorado Department of Public Health and Environment (CDPHE) for this operation. New Horizons proposes to use the USNRC limits for uranium as the applicable site release criteria. These criteria are:

Not more than 5,000 disintegrations per minute per 100 square centimeters (dpm/100cm²) total α and β radioactivity. Not more than 1,000 dpm/100cm² removable α and β radioactivity.

Equipment, tools, and transportation vehicle surveys will involve the following specific activities.

- Determine instrument background.
- Determine instrument efficiency.
- Survey and document incoming equipment, tools, and transportation vehicles for total surface radioactivity.
- Survey and document outgoing equipment, tools, and transportation vehicles for total surface radioactivity.
- Survey and document outgoing equipment, tools, and transportation vehicles for removable surface radioactivity if necessary.
- Survey and document outgoing loaded transportation vehicles for gamma radiation.

Each of these activities is further described in the following sections.

2.1.1 Determine Instrument Background

Instrument local background will be determined on a weekly basis. Local background measurements will be obtained in the instrument storage and maintenance facility at the Site. Background is determined in the following manner:

- Secure and store all radioactive sources so that they will not interfere with the instrument background determination. Place calibration and check sources in a metal box and secure the box in a metal cabinet as far removed from the instrument as possible within the instrument storage and maintenance facility.
- Make sure that the instrument collimator shield has been removed.
- Obtain one long background count of at least 10 minutes' duration.
- Obtain at least 10 one-minute background counts.
- Calculate the counts per minute from the long count and its 95% confidence interval assuming a Poisson distribution.
- Determine the average counts per minute from the one-minute counts and its 95% confidence interval from the measured values.
- The average of the one-minute counts should lie within the range of the counts per minute value obtain from the long count \pm its 95% confidence interval. Perform corrective measures in accordance with the *Quality Assurance Project Plan (QAPP)* if this condition is not achieved.
- Determine background again with the collimator in place and the probe oriented vertically with the crystal pointing down (i.e., the normal orientation when obtaining measurements in the field).
- Record the background value for each instrument in accordance with the QAPP.

Each day that an instrument is used, the background count rate will be checked by obtaining a one-minute background count. The daily background count should lie within the \pm 95% confidence interval for the weekly series of at least 10 one-minute counts. Corrective measures will be performed in accordance with the QAPP if this condition is not achieved. If the background is within the acceptable window, the instrument may be used for survey activities. If the background is outside the acceptable window, appropriate corrective actions will be implemented as directed by the RSO or his designee, and the background rechecked.

2.1.2 Determine Instrument Efficiency

Instrument efficiency is determined by exposing the instrument to a known-value radioactive source for a fixed period of time. Typically, α standard sources use ^{230}Th as the alpha particle source. Beta standard sources typically use ^{99}Tc as the beta particle source. However, other radionuclides can be used for these purposes. The efficiency calibration source must have a documented certified activity traceable to NIST standard reference material.

The efficiency determination will be performed by obtaining a series of 10 1-minute source counts using a fixed and reproducible geometry between detector and source. The average

count rate will be calculated, the standard deviation. The average count rate divided by the known source disintegration rate will determine the instrument efficiency. Twice the standard deviation of the average count rate divided by the known source disintegration rate gives the allowable uncertainty in the efficiency.

Each day that an instrument is used, a single source count will be obtained and compared to the instrument efficiency window established for the week. If the efficiency is within the acceptable window, the established average value efficiency for the instrument may be used. If the efficiency is outside the acceptable window, appropriate corrective actions should be implemented as directed by the RSO or his designee, and the efficiency rechecked.

2.1.3 Incoming Equipment Surveys

All equipment entering the site will be surveyed to determine the level of surface radioactivity that may be present. Equipment surfaces will be surveyed for alpha radioactivity. Each tire of wheeled equipment will be surveyed at one ground contact location. Selected locations on metal surfaces will also be surveyed.

Survey measurements will consist of instantaneous measurements of alpha activity. Alpha activity will be measured using a Ludlum model 43-5 or equivalent large area scintillation detector. Survey limits for the CSMRI site are 5,000 dpm/100cm². These limits will be converted to equivalent instrument counts per minute by dividing the applicable disintegration rate by the instrument efficiency and active detector area.

Alternatively, timed counts may be obtained from survey locations for increased accuracy if instantaneous counts are near an acceptance limit.

Incoming instrument surveys will be recorded on an incoming equipment survey form. This form will include the following information:

- Equipment identification, including manufacturer, model number, serial number, owner's identification number, and/or license plate number as necessary to uniquely identify the item being surveyed.
- Model and serial numbers of the detectors and counters used to perform the survey.
- Name of the person performing the survey.
- A sketch of the equipment. Schematic drawings are sufficient if they permit accurate location of measurements.
- The numerical value of the instantaneous alpha count rates at each measurement location.
- Date and time of the survey.

A wipe sample will be obtained from any survey location that shows surface radioactivity in excess of 1,000 dpm/100cm². The location of the wipe sample and the results of the wipe sample measurement will be indicated on the incoming equipment survey form. Equipment

with more than 1,000 dpm/100 cm² removable radioactivity will be rejected or decontaminated before entering the site.

2.1.4 Outgoing Equipment Survey

Equipment leaving the site, including transportation vehicles for demolition debris, will be surveyed before leaving the site. The release survey will be conducted in the same manner as the incoming equipment survey. The release survey will be documented on an equipment release survey form. The equipment release survey and the matching incoming equipment survey will be compared. If the equipment item has acquired net fixed or removable radioactivity in excess of the site release criteria, it must be decontaminated and resurveyed before leaving the site.

2.1.5 Gamma Radiation Transportation Survey

Trucks hauling demolition debris from the site will also receive a gamma radiation survey using a dose rate meter such as the Ludlum model 19 or equivalent. Measurements will be made along the center of the load on both sides and the rear of the vehicle's cargo bed at contact and at a distance of one meter. A separate measurement will be obtained in the driver's cabin. Gamma radiation measurements will be recorded on a separate transportation gamma radiation survey form.

The purpose of this gamma radiation survey is to ensure compliance with requirements for transportation of radioactive materials. The materials to be removed from the site, even the impacted materials, are of such low activity that transportation restrictions are unlikely to even be approached. A second purpose of this gamma survey, however, is to ensure that none of the non-impacted material, which will be disposed of as ordinary solid waste, exhibits detectable gamma radiation above the local background, since such material may be summarily rejected by the receiving disposal facility. Any load of non-impacted solid waste that exhibits detectable gamma radiation anomalies during this survey must not leave the site. Any such load will be stockpiled in a designated staging area and be managed appropriately thereafter.

3.0 SITE WIDE RADIOACTIVITY SURVEY

Following removal of the concrete, and asphalt, a site-wide surface radioactivity survey will be performed. This survey will address the following areas:

- Soil areas exposed by removing the concrete pads,
- Soil areas exposed by removing the asphalt paving,
- Previously unsurveyed soil areas on the site,
- Soil areas that may have been significantly altered or disturbed by demolition and waste removal operations, and
- Any other soil areas as directed by CSM or CDPHE.

The following sections describe how this soil survey will be performed.

3.1 Geographical Positioning System

Ground control for the survey will be provided by an on-site geographical position system (GPS). The GPS will consist of a base station and one or more backpack-type mobile receivers. The GPS will be capable of locating positions within ± 0.5 meters.

The base station will be placed in a location where its transmitter can “see” the entire survey area, and which provides clear signal reception from at least one GPS satellite. The base station will be maintained in location throughout the survey and any other activities requiring GPS location. The base station location will be established using conventional land survey methods from an established benchmark. The initial location of the base station will be identified by a Colorado registered land surveyor.

3.2 Survey Instrumentation

Survey operations will be performed using sodium iodide (NaI) gamma scintillation detectors, such as the Ludlum model 44-10 2-inch NaI detector matched with a suitable counting instrument such as the Ludlum model 2221 or 2250. These will consist of 3" NaI gamma scintillation detectors matched with a suitable counting instrument provided with a data logger and capable of collecting paired data from the detector and the GPS backpack unit simultaneously. Unless specifically directed otherwise, the collimator will not be used on the gamma detector for general survey work, although collimated and net terrestrial radiation measurements may be collected at selected anomalous locations at the direction of the project manager.

3.2.1 Determine Instrument Background

Instrument local background will be determined on a weekly basis. Local background measurements will be obtained in the instrument storage and maintenance facility at the Site. Background is determined in the following manner:

- Secure and store all radioactive sources so that they will not interfere with the instrument background determination. Place calibration and check sources in a metal box and secure the box in a metal cabinet as far removed from the instrument as possible within the instrument storage and maintenance facility.
- Make sure that the instrument collimator shield has been removed.
- Obtain one long background count of at least 10 minutes' duration.
- Obtain at least 10 one-minute background counts.
- Calculate the counts per minute from the long count and its 95% confidence interval assuming a Poisson distribution.
- Determine the average counts per minute from the one-minute counts and its 95% confidence interval from the measured values.

- The average of the one-minute counts should lie within the range of the counts per minute value obtain from the long count \pm its 95% confidence interval. Perform corrective measures in accordance with the Quality Assurance Project Plan (QAPP) if this condition is not achieved.
- Determine background again with the collimator in place and the probe oriented vertically with the crystal pointing down (i.e., the normal orientation when obtaining measurements in the field).
- Record the background value for each instrument in accordance with the QAPP.

Each day that an instrument is used, the background count rate will be checked by obtaining a one-minute background count. The daily background count should lie within the \pm 95% confidence interval for the weekly series of at least 10 one-minute counts. Corrective measures will be performed in accordance with the QAPP if this condition is not achieved. If the background is within the acceptable window, the instrument may be used for survey activities. If the background is outside the acceptable window, appropriate corrective actions will be implemented as directed by the RSO or his designee, and the background rechecked.

3.2.2 Determine Instrument Efficiency

Instrument efficiency is determined by exposing the instrument to a known-value radioactive source for a fixed period of time. Typically, α standard sources use ^{230}Th as the alpha particle source. Beta standard sources typically use ^{99}Tc as the beta particle source. However, other radionuclides can be used for these purposes. The efficiency calibration source must have a documented certified activity traceable to NIST standard reference material.

The efficiency determination will be performed by obtaining a series of 10 1-minute source counts using a fixed and reproducible geometry between detector and source. The average count rate will be calculated, the standard deviation. The average count rate divided by the known source disintegration rate will determine the instrument efficiency. Twice the standard deviation of the average count rate divided by the known source disintegration rate gives the allowable uncertainty in the efficiency.

Each day that an instrument is used, a single source count will be obtained and compared to the instrument efficiency window established for the week. If the efficiency is within the acceptable window, the established average value efficiency for the instrument may be used. If the efficiency is outside the acceptable window, appropriate corrective actions should be implemented as directed by the RSO or his designee, and the efficiency rechecked.

3.2.3 Determine Net Downward Vertical Background

Net downward vertical background is used to determine the value of background radiation emanating from the surface of the soil. This value is important for determining the boundary between impacted and non-impacted material in an environment that is affected by radiation shine from adjacent impacted areas, or materials. Measurements obtained using the net

downward vertical background are relatively insensitive to contributions from low levels of adjacent radiation shine. Because different types of earth materials have different levels of inherent radioactivity from naturally occurring materials, separate values of the net downward vertical background will be obtained from undisturbed soil. Net downward vertical background will be determined by the following method.

- Using the previous survey information, select 10 locations of soil that can reasonably be expected to be non-impacted. Nearby off-site locations of similar characteristics may also be used for this purpose.
- Obtain a suitable shield at least 2 times the diameter of the detector face. The shield should be a disk or plate of iron or steel at least 2 inches in thickness. This shield will be used to effectively block the downward vertical component of the background radiation.
- At each selected location, obtain a one-minute count using the gamma scintillation probe and collimator. The probe should be resting on the surface with the probe face pointing down.
- Repeat the measurement with the shield resting on the surface and the probe face down on the upper surface of the shield.
- Obtain the net downward vertical background by difference.
- After 10 measurements have been obtained, calculate the average and 95% confidence interval of the net downward vertical background for the soil.

This determination does not need to be repeated as long as the instrument background as determined in section 3.2.1 remains stable.

3.2.4 Calculate the Minimum Detectable Activity

Minimum detectable activity (MDA) is a function of instrument background. Therefore, an MDA will be calculated for each background condition determined in sections 2.2.1 and 3.2.1. The MDA will be calculated using the following equation:

$$\text{MDA} = 3 + 4.65(B)^{0.5} \quad \text{where B is the background counts per minute}$$

Areas of the soil surfaces that contain radioactivity in excess of the applicable survey MDA will be considered impacted and will be removed, managed, and disposed of as impacted materials. For purposes of the confirmatory survey, the applicable MDA will be the net downward vertical MDA.

3.3 Establish a Site-Wide Grid

A 3-meter by 3-meter grid will be established over the entire site. This grid will be established to ensure that all survey areas are examined, and to track progress of the survey while it is underway. Because actual survey ground control will be provided by GPS, the grid does not need to be established using a registered land surveyor. Grid locations will be marked in the field using stakes, flags, and tape at a sufficient density to permit the survey

crews to maintain their orientation while performing survey operations. A map of the site grid will be prepared, and used to track progress of the survey and plan future survey activities. Anomalities will be marked on this map for further investigation.

3.4 Survey Procedure

3.4.1 General Site Survey

Instrument background and operation checks (described previously) will be used during the general site survey. In addition, the survey crew will ensure that the GPS and detector outputs are being properly acquired by the instrument data logger before commencing routine survey operations.

The survey will be conducted in a systematic manner along the established grid. The active end of the detector will be passed evenly over the ground at a distance of no more than 4 to 6 inches above the surface. The rate of horizontal travel and the spacing between survey passes will be established by the project manager using preliminary survey measurements to ensure that the minimum desired area of elevated radioactivity will be detected. These survey requirements and the local radioactivity background have not yet been determined and so cannot be specified in advance.

Instantaneous gamma radiation measurements and GPS locations will be acquired at 5-second intervals unless specified otherwise by the project manager. Survey activities may be conducted until the data logger capacity is approximately 75% used, at which time survey operations will be terminated until the data logger can be downloaded and cleared.

The general site survey will be conducted until all designated areas have been examined. Each day's survey progress will be recorded on a site map. Unless specifically directed otherwise, the next day's survey activity will begin where the previous day's activity ended until all contiguous areas have been surveyed.

3.4.2 ISOCS Measurements

In-Situ Object Counting System (ISOCS) measurements may be obtained in select areas during the soil scanning survey. The number and location of ISOCS measurements will be determined by New Horizons based on the results of the site survey and site conditions.

ISOCS measurement may be obtained from each potentially impacted area. The location of the maximum observed radioactivity in each impacted area will be measured using this system, in addition to other locations that may be selected by New Horizons. Additionally, at least one ISOCS measurement will be obtained at a location outside the boundary of each impacted area.

ISOCS measurements may be used to provide a field determination of the specific radionuclides present in the impacted area, as well as a measurement of the anticipated

activity of impacted material. ISOCS measurements in the non-impacted area will be used to confirm that the boundary between impacted and non-impacted areas has been accurately determined.

Each ISOCS measurement location will be determined using GPS. Measurement locations will be indicated on maps of the site or portions of the site. A hard copy of each gamma spectrum obtained using ISOCS will be generated, and a written interpretation of the measurements will be generated for the project records. New Horizons will use the ISOCS measurements to make any needed adjustments to identify boundaries of the impacted and non-impacted areas.

ISOCS determines both the identity and activity of radioactive substances in the material examined. In the event that unanticipated radionuclides or activity is detected using ISOCS,

3.4.3 Anomalies

Radiological and other anomalies during the site survey are anticipated. Anomalies may consist of radioactivity spikes, areas of distinctly elevated radioactivity, areas of distinctly low radioactivity within an area of elevated radioactivity, visually discolored soils, odd odors, or any other condition that distinctly distinguishes a particular location from its surroundings.

Anomalies will be flagged in the field using a distinctive marker such as a uniquely colored pin flag or other readily identified marker so that the location can be easily found. The surveyor will note the anomaly in his field notebook, together with a description of the anomalous condition and the grid coordinates.

Radiological anomalies will be subject to further examination. This examination may consist of a variety of instrumental measurements. Spot surveys will be performed in and around the anomaly to more clearly define its boundaries. Net terrestrial radioactivity measurements may be performed to define the location of a subsurface source.

ISOCS measurements may be obtained to identify the type and activity radionuclides in areas with elevated readings. Other anomalies will be investigated as directed by the project manager based on their observed characteristics.

Each anomaly will be described in the project records, together with any further investigation that was performed. The results of these investigations will be recorded. Any follow up investigations and their results will also be noted.

3.5 Mapping and Documentation

A final survey map will be prepared. This map will indicate the site survey grid, recorded survey point locations as provided by the GPS, and the surface radioactivity measured at that

location. The final survey map will also include any identified radiological anomalies. Other anomalies may also be included if they are relevant to future site remediation activities.

A narrative will be prepared to accompany the final survey map. This narrative will include a timeline of the survey, any unanticipated difficulties encountered during the survey, deviations from the survey plan, and the results of any additional survey investigations, such as detailed surveys around radiological anomalies.

4.0 SURFACE SOIL SAMPLING

The site survey results will be used to guide surface soil sampling activities. Samples will be obtained from a variety of locations to permit general site characterization as well as the identification and delineation of areas of elevated radioactivity.

4.1 Sample Site Selection Criteria

Surface soil sampling for the Site will be in the form of a characterization survey. As such, the primary concern is the description of areas of elevated radioactivity. All elevated radioactive anomalies will be candidates for surface soil sampling, as will be all areas of generally elevated radioactivity identified during the surface survey. The number and boundaries of these anomalies and generally elevated areas is not known at this time, so specific sample locations cannot be specified. The following general criteria will be used for selecting soil sample locations:

- Spot anomalies less than 10 m² in area will be sampled at the approximate center or surface radiological maximum of the anomaly.
- Areas of generally elevated surface radioactivity will be sampled at a density of at least one sample per 10 m² of elevated area unless directed otherwise by the project manager.
- Additional samples may be obtained based on historical use of an area.

Additional surface soil samples may be obtained in order to characterize the site as a whole. These surface soil samples will be distributed over the entire site without regard to survey measurements. The number of these non-specific surface soil samples cannot be specified in advance, because the number of surface soil samples required to characterize radiological anomalies and areas of generally elevated radioactivity is unknown. However, the technical approach for the site characterization calls for not less than 25 percent of the surface soil samples to be acquired from areas that did not exhibit elevated surface radioactivity. These samples will be distributed over the entire site (except areas sampled as anomalies or elevated areas) on a systematic basis to provide information on the distribution of radionuclides in site surface soils.

The project manager will select targeted surface soil sample locations based on site survey results. The remaining surface soil sample locations will be evenly distributed over areas not identified as containing elevated surface radioactivity by the soil surface survey.

4.2 Soil Sample Instrumental Surveys

Each surface soil sample location will be surveyed using gamma radiation instruments. The following measurements will be obtained:

- Uncollimated gamma radiation at the surface of the soil,
- Uncollimated gamma radiation at a distance of one meter above the soil surface, and
- Terrestrial gamma radiation.

Additional survey instrument measurements adjacent to the selected surface soil sample location may also be obtained at the direction of the project manager.

Radioactive anomalies and other selected surface soil sample locations will be examined using ISOCS to identify the radionuclides present and their activity. ISOCS measurements may also be obtained for surface soil samples obtained in areas of generally elevated radioactivity. A certain number of sample locations selected by the project manager will be examined using ISOCS without regard to surface radioactivity measurements.

The results of all surface soil sample location radiation survey measurements, including a hard copy of the ISOCS spectrum (if used) will be included in the sampling records.

4.3 Surface Soil Sampling Methodology

Surface soil samples will be obtained from the uppermost 15 centimeters of surface soil. The sample should be approximately cylindrical in cross section so that all horizontal components are equally represented in the sample.

A variety of techniques are acceptable for surface soil sampling. Samples may be dug out with a trowel or bulb-planting tool. Manually driven split spoon samplers may also be used to obtain a truly cylindrical soil sample.

One field duplicate will be obtained for every 20 surface soil samples. The duplicate will be prepared by thoroughly homogenizing the field sample and splitting it into two equal portions for laboratory analysis.

4.4 Sample Documentation

Each sample obtained for laboratory analysis will be documented. Sample documentation includes the following:

- Sample location, referencing the site-wide grid together with GPS reading,

- Physical description,
- Sample number,
- Results of radioactivity survey conducted in accordance with section 5.2,
- Date,
- Name of sampler, and
- Any other information relevant to the sample or the use of the analytical data.

Sample documentation will be retained as part of the project record.

4.5 Sample Packaging and Transportation

Samples for radioactive analysis will be double bagged using zipper sealed plastic bags. If chemical analysis will also be performed on the sample, it will be placed in a wide-mouth glass jar with a chemically inert seal or gasket. Each sample should be labeled as specified in the QAPP.

Samples for radioactivity analysis only do not require refrigeration. If the sample will also be analyzed for chemical constituents, it will be cooled to 4°C immediately after packaging.

Samples will be transported to the laboratory as soon after acquisition as practicable, particularly if the samples will be used for any chemical analysis. Samples for radioactivity analysis only can be accumulated on site at the direction of the project manager. Transportation to the laboratory will be performed by project personnel or by licensed commercial carrier.

All samples transported to the laboratory for analysis will be accompanied by a Chain of Custody (COC) form as required in the QAPP.

4.6 Sample Analytical Requirements

Samples for radiological analysis will be analyzed for total uranium, radium, and thorium. If other radionuclides were indicated by ISOCS analysis, those radionuclides will also be analyzed. Additional radionuclides or chemical analysis may be specified by the project manager. Analytical requirements will be included on the COC as required in the QAPP.

4.7 Decontamination

Reusable sampling equipment will be decontaminated between samples. For radionuclide analysis, decontamination will consist of washing the sampler with detergent and water, followed by a water rinse, acid rinse, and a final water rinse. If samples will be analyzed for chemical constituents, the decontamination procedure may be expanded to include a suitable solvent rinse and deionized water final rinse to remove suspected contaminants.

5.0 CORE SAMPLING SUBSURFACE SOILS

A number of subsurface core samples will be obtained to characterize subsurface conditions at the site and to define the vertical extent of contamination if present.

5.1 Sample Site Selection Criteria

Core samples will be obtained from radiological anomalies and areas of generally elevated radioactivity as selected by the project manager. In addition, a number of core samples (not less than 25% of the total) will be obtained from areas that did not exhibit elevated surface soil radioactivity during the surface soil survey in order to evaluate the possibility of subsurface radioactivity that was not detectable with surface scanning instruments.

A map will be prepared under the guidance of the project manager to locate core-sampling sites. Non-impacted area samples will be distributed over the site to provide general information on the presence of subsurface radioactivity.

5.2 Sample Location Instrumental Survey

Each subsurface soil sample location will be surveyed using gamma radiation instruments. The following measurements will be obtained:

- Uncollimated gamma radiation at the surface of the soil,
- Uncollimated gamma radiation at a distance of one meter above the soil surface,
- Terrestrial gamma radiation, and
- ISOCS measurement.

Additional survey instrument measurements adjacent to the selected surface soil sample location may also be obtained at the direction of the project manager.

Subsurface soil sample locations may be examined using ISOCS to identify the radionuclides present and their activity. Additional ISOCS measurements may be specified by the project manager to delineate the approximate depth of the radioactive material using angled and offset measurements.

The results of all subsurface soil sample location radiation survey measurements, including a hard copy of the ISOCS spectra will be included in the sampling records.

5.3 Core Sampling Methodology

Cores will be advanced using a 3-inch split spoon core sampler. Cores will be advanced to a total depth of 10 feet below the ground surface. If refusal is met within this column, the core rig will be relocated proximate to the original location and another attempt will be made to recover a core sample. No more than three attempts will be made to recover a core sample.

After the third refusal the sampling location will be abandoned or the project manager may direct that the best available recovery be used for subsurface sampling.

5.4 Downhole Gamma Radiation Survey

Each boring to be sampled will be surveyed. A downhole survey will be performed using a NaI gamma detector. The detector will be lowered into the hole at one-foot increments. At each increment, a timed one-minute gamma count will be acquired. This survey will be used to select sampling intervals if identifiable zones of subsurface radioactive materials are apparent.

A record of the downhole gamma survey will be prepared and included in the project records.

5.5 Sample Interval Selection

If the downhole gamma radiation survey shows a specific horizon that contains elevated radioactivity, this horizon will be selected for sampling. If there were no horizons showing elevated radioactivity from the downhole gamma radiation survey, the core will be sampled at the top, bottom, and middle. If the core sample is closely associated with a surface soil sample, the surface fraction can be eliminated from the sampling and analysis program for the core.

Optionally, the core can be examined using ISOCS. If the optional ISOCS measurement shows a zone of elevated radioactivity, this zone will be sampled for laboratory analysis.

A core sample for analysis will consist of the entire selected interval. Unless field measurements such as the downhole gamma survey indicate otherwise, the sample interval will be six inches in thickness.

One duplicate sample will be obtained for every twenty (20) core samples submitted for analysis. Field duplicates from core samples will consist of a longitudinal split of the sample through the entire length of the sampled interval.

5.6 Sample Documentation

Each sample obtained for laboratory analysis will be documented. Sample documentation includes the following:

- Sample location, referencing the site-wide grid together with GPS reading,
- Depth below ground surface,
- Physical description,
- Sample number,
- Results of radioactivity survey conducted in accordance with section 6.2,
- Date,
- Name of sampler, and

- Any other information relevant to the sample or the use of the analytical data.

Sample documentation will be retained as part of the project record.

5.7 Sample Packaging and Transportation

Samples for radioactive analysis will be double bagged using zipper sealed plastic bags. If chemical analysis will also be performed on the sample, it will be placed in a wide-mouth glass jar with a chemically inert seal or gasket. Each sample should be labeled as specified in the QAPP.

Samples for radioactivity analysis only do not require refrigeration. If the sample will also be analyzed for chemical constituents, it will be cooled to 4°C immediately after packaging.

Samples will be transported to the laboratory as soon after acquisition as practicable, particularly if the samples will be used for any chemical analysis. Samples for radioactivity analysis only can be accumulated on site at the direction of the project manager. Transportation to the laboratory will be performed by project personnel or by licensed commercial carrier.

All samples transported to the laboratory for analysis will be accompanied by a COC form as required in the QAPP.

5.8 Sample Analytical Requirements

Samples for radiological analysis will be analyzed for total uranium, radium, and thorium. If other radionuclides were indicated by ISOCS analysis, those radionuclides will also be analyzed. Additional radionuclides or chemical analysis may be specified by the project manager. Analytical requirements will be included on the COC as required in the QAPP.

5.9 Decontamination

Split spoon samplers will be decontaminated between samples. For radionuclide analysis, decontamination will consist of washing the sampler with a pressure washer with detergent, followed by a water rinse.

6.0 OTHER SUBSURFACE SAMPLES

Other subsurface samples may also be obtained. Areas of interest that cannot be sampled by split spoon sampler because of subsurface obstructions will be sampled using conventional trenching and excavating methods. Under the direction of the project manager, the SAP provisions of Chapter 5.0 will apply to other subsurface sampling applications.

7.0 EXPOSURE MONITORING

Exposure of employees to airborne and ionizing radiation will be monitored throughout the project. Specific measurements and procedures are identified in the following sections.

7.1 Dosimetry

Exposure to external ionizing radiation will be measured using thermoluminescent dosimeters. Each site employee will be provided with a dosimeter which will be worn between the knees and shoulders whenever the employee is on site. Dosimeters will be analyzed on a quarterly basis. A designated secure storage location removed from sources of site radiation will be used to store dosimeters when not in use.

Dosimetry results will be presented to the site employees, and posted in a prominent location on the site for review. The site RSO will be available to interpret the dosimetry results to the employees on request.

7.2 Personal Air Monitoring

Personal air monitoring will be performed during the first 10 days of site work and periodically thereafter. During the 10-day baseline period (personnel will utilize Level C PPE during this period), personal air samples will be collected on appropriate sampling media. Personal air samples will be monitored for total α and β radioactivity after a 72-hour holding time to allow for radon daughter decay. Total α radioactivity will be compared to the Derived Air Concentration (DAC) for Thorium-230, the site radionuclide with the most restrictive exposure limitation. The sample media will then be submitted to an accredited laboratory for isotopic analysis. The isotopic analyses will identify the isotope(s) of concern. The identified isotopes will be used for the remainder of project for anticipated air contaminants expected. All subsequent air samples will be counted on-site, air concentrations calculated, and compared to the appropriate standard. The derived air concentrations will be used to determine the appropriate level of respiratory protection.

At the start of project activities, at least one employee in each work area will be provided with a personal sampling pump and dust collection cassette. The pump will be operated for the entire shift. If the measured α activity is less than the DAC for Thorium-230, no further action is necessary. If the measured α indicates that a potential exposure to Thorium-230 above the DAC may have occurred, the air sample filter will be submitted for laboratory analysis and a radionuclide-specific exposure will be determined.

This procedure will be repeated for each new work activity. During continuing work activities, at least one employee will be monitored each week to maintain a continuing record of potential employee exposure to airborne radioactivity.

7.3 Work Area Air Monitoring

Each work area will be monitored for airborne radioactivity on a weekly basis. A nominal 20 liters per minute air sampler will be located in each work area and operated throughout the shift. The air sampler will be provided with a dust collection cassette. A 10-day baseline area exposure assessment will be performed as detailed in Section 7.2.

After the holding time for radon daughter decay, each work area air monitor will be analyzed for total α and β activity. As with the personal air monitor, if the work area air monitor indicates that the DAC for Thorium-230 may have been exceeded, the filter will be submitted for laboratory analysis and radionuclide-specific exposures will be calculated.

7.4 Work Area Dose Rate Monitoring

In addition to personal dosimetry measurements, a regular program of work area dose rate monitoring will be performed. Each day that work activities are carried out on the site, work areas will be monitored for ionizing radiation. Monitoring will be performed using a pressurized ion chamber (PIC) or a gamma scintillation detector such as the Ludlum model 19 or equivalent that has been correlated to a PIC.

Any work area with an exposure rate equal to or greater than 5 millirads per hour will be designated as a radiation area. Radiation areas will be clearly marked with warning signs and flagging tape. Entry into the radiation area and duration of work in the radiation area will be controlled by and documented by the RSO. Based on previous experience with the site, no radiation areas are anticipated.

A written record of work area dose rate monitoring will be prepared and maintained to calculate potential employee exposure to ionizing radiation.

7.5 Dose Calculation and Recording

Total employee exposure to ionizing radiation will be calculated on a quarterly basis. Employee exposure will consist of external ionizing radiation exposure as measured by the dosimetry program and internal exposures. Internal exposure will be determined on the basis of the air monitoring results and radon exposure monitoring results. The internal and external exposure will be combined to yield a total radiation dose exposure value for each employee.

7.6 Dose Reporting

Employees will be informed of their dose exposure record as the values are obtained. Employee dose exposure records will be generated and maintained indefinitely for communication to future employers or the employee.

7.7 Monitoring for Chemical Contaminants

Chemical contaminant exposure is not anticipated at this site based on previous experience. However, work area surveys will be conducted daily using a photoionization detector (PID) for airborne organic vapors. If airborne organic vapors or other potential chemical exposures are suspected, additional monitoring of employees at the site for chemical constituents will be performed.