Sampling, Analysis and Quality Plan
Koongarra Radiological Baseline Survey

Brayden Miller

Supervising Scientist
GPO Box 461, Darwin NT 0801

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Contents

1 Introduction

1.1 Background

In December 2020, it was determined that *Australian Radiation and Nuclear Safety Act* (1998) (the Act) and subsequent *Regulations* (2018) require the [approximate 200 t of] drill core (the Source) stored at the historic Koongarra exploration camp to be licenced by the Australian Radiation and Nuclear Safety Agency (ARPANSA). After consultation between ARPANSA and the Supervising Scientist Branch, a source licence (S0340) was issued to the Director of National Parks (DNP) in February 2022. The Supervising Scientist is tasked with the role of licence nominee for the source licence – responsible for safe management of the source on behalf of the licence holder.

Schedule 2 of source licence S0340 comprises a list of conditions required under the Act, including the requirement to report to ARPANSA. Although there are no current licence conditions requiring radiation monitoring at the Koongarra source, consultation with ERISS's radiation team highlighted the benefit of a large-scale radiation survey to provide a contemporary radiation baseline that can be used as a point of reference and comparison for: (i) a significant natural event (e.g. cyclone, bushfire) causing a loss of containment of the Source; and (ii) future disposal of the Source and remediation of the site.

1.2 Monitoring Objectives

The specific objectives of this radiation survey are as follows:

- Establish a contemporary radiological baseline for the area surrounding the Source, the Koongarra camp and the Koongarra ore body;
- Increased knowledge of radiological risks associated with accessing the Koongarra camp and the Source;
- Provide crucial information required for planning the disposal of the Source and any associated site remediation.

1.3 SAQP Objectives

The general aim of this sampling, analysis and quality plan (SAQP) is to ensure high quality and consistent methods are used for sampling radon-222 exhalation flux densities, soil radionuclide activity concentrations and gamma dose rates at the Koongarra source and surrounding area.

The specific objectives of this SAQP are to:

- Describe the sampling and data analysis methods for gamma dose rates, soil radionuclide activity concentrations and radon-222 exhalation flux densities at the Koongarra source, orebody and surrounding area.
- Describe the quality assurance and quality control (QA/QC) methods applied to the sampling and analysis of gamma dose rates, soil radionuclide activity concentrations and radon-222 exhalation flux densities at the Koongarra source and surrounding area.

2 Sampling

2.1 Frequency of sampling

The survey will be conducted in early May, as this is the period in which the post-wet site inspection will commonly be undertaken. The survey therefore provides information on the radiological risk to personnel accessing the Koongarra site and source at this time. An additional survey of radon-222 exhalation flux will be conducted in the late dry season (August or September) due to the known seasonality in exhalation flux associated with changes in soil moisture content (radon-222 exhalation fluxes will likely be lower in May due to higher soil moisture content at the end of the wet season).

2.2 Methods for sampling radon-222 exhalation flux density

Brass canisters containing approximately 0.025 kg of activated charcoal will be used for sampling radon-222 exhalation flux densities as follows:

- The canisters will be heated in an oven at 110°C for no less than 48 hours to drive out residual radon-222 adsorbed on the surface of the charcoal.
- The canisters will be removed from the oven and allowed to cool to room temperature, then immediately sealed with a lid for transport to the field.
- The lid of the canister will be removed and the canister embedded into the ground surface to a depth of approximately 1 cm to trap exhaling radon-222. In cases where the sampling point is wholly or partly on rocks, then a plasticine compound (e.g. play dough) will be used to seal the whole circumference of the brass canister opening with the rock and soil to ensure that all radon emanating from the rock and soil surfaces are trapped on the charcoal.
- The time and date that each canister is deployed and the GPS coordinates of the sampling point will be recorded.
- No less than 40 canisters will be deployed at selected points in the camp area and ore body (Appendix A).
- At least three ‘control’ canisters will be prepared and carried into the field as part of the batch but will remain sealed at all times to provide a measure of the background radon-222 activity of the charcoal.
- Canisters will remain deployed in the field for a minimum of three days to passively sample radon-222 exhalation flux density.
- At the end of the sampling period, the canisters will be removed from the ground surface, and, while holding the canister opening pointing to the ground, carefully wiped around the open edge of the canister with a cloth (e.g. daily wipe), to remove any attached soil or plasticine compound, and then immediately sealed with a lid for transport back to the laboratory.
- In the laboratory, each canister including the ‘control’ canisters will be measured by gamma spectrometry using high purity germanium (HPGe) detectors for a period of 600 seconds. Prior to counting, all canisters will be thoroughly cleaned by wiping with a damp cloth to remove and dust which could contaminate the HPGe detectors.
- A canister spiked with a known activity of radium-226, which is the parent radionuclide of radon-222, will also be measured for 600 seconds to determine detector efficiency.
- For each canister, the total counts under the photopeaks of the radon-222 decay products of lead-214 (242 keV, 295 keV and 352 keV) and bismuth-214 (609 keV) will be summed and then divided by the counting period (i.e. 600 seconds) to determine the gross count rate.
- The average count rate determined from the control canisters will be subtracted from the gross count rate determined for each field-deployed canister to determine the net count rate of each field-deployed canister.
- The detector efficiency will be determined by dividing the count rate of the spiked canister by the activity of radium-226 with which it was spiked.
- The radon-222 exhalation flux density sampled by each field-deployed canister will be calculated as:

$$J = \frac{R \cdot t_c \cdot \lambda^2 \cdot \exp(\lambda \cdot t_d)}{\varepsilon \cdot a \cdot [1 - \exp(-\lambda \cdot t_s)] \cdot [1 - \exp(-\lambda \cdot t_c)]}$$

Where:

- J (Bq m^{-2} s^{-1}) is the radon-222 exhalation flux density
- R (s^{-1}) is the net count rate of the field-deployed canister
- t_c (s) is the counting period
- λ (s^{-1}) is the radon-222 decay constant
- t_d (s) is the delay period from the end of sampling to the beginning of counting
- ε (s^{-1} Bq^{-1}) is the counting efficiency of the detector
- a (m^2) is the area of the open face of the canister when embedded in the ground
- t_s (s) is the duration of the sampling period

2.3 Methods for sampling gamma dose rates

Gridded gamma dose rate surveys will be conducted across the camp area and the ore body (Appendix A). The grid spacing across the camp area will be approximately 10 m x 10 m and that across the ore body will be approximately 20 m x 20 m. Additional spot measurements will also be taken at features of interest such as any rock piles on the surface of the ore body (i.e. remnants of past drilling activities) and inside the sheds where some core samples (not thought to be mineralised) are present.

At each survey point:

- The GPS coordinates (easting and northing) will be recorded.
- A RadEye GX meter with an attached Mini Instrument MC70 Geiger Muller tube will be used to measure the total counts over 60 seconds at a height of 1 m above the ground surface.
- The meter/tube combination will be calibrated by an external service provider against a certified radiation source during the preceding 12-month period.
- The gamma dose rate will be calculated from the measured count rate using conversion factors given in the calibration report.

2.4 Method for soil sampling

At each point where a canister for radon-222 exhalation flux density is deployed, a soil sample of approximately 500 g will be collected using the following method:

- Soil will be collected from approximately 0-10 cm using a clean, plastic hand trowel.
- Soil will be scooped into a plastic zip-lock bag, before being sealed shut.
- After collection, the trowel will be rinsed with deionised water (DI) and wiped dry with paper towel to ensure soil is not stuck to the tool between sites.
- A mark will be recorded on the GPS, with a specific code given to the location (i.e. KO-01 for Koongarra ore body sample 1; KC-04 for Koongarra camp location 4).
- The location code will be recorded on the zip-lock bag.
- Any comments (moisture content, changes in colour etc) will be recorded in a field sheet, noting the location code.
- Soils will be returned to the laboratory, oven dried and ground in a ring mill before being pressed and sealed in standard containers for gamma spectrometry analysis using HPGe detectors.

- The pressed and sealed samples will be left for at least 1 month before counting to allow secular equilibrium to be achieved between radium-226, radon-222 and its short-lived decay products.
- Radionuclides that will be measured in the samples include radium-226 (based on lead-214 and bismuth-214), radium-228 (based on actinium-228), lead-210 and potassium-40.

3 Analysis

3.1 Statistical analysis of data

The same analysis methods will be applied to radon-222 exhalation flux density, gamma dose rate and soil radionuclide activity concentration data as follows:

- The data for each sampling point will be plotted on an image of Koongarra to provide a spatial representation of the data, including any ‘hotspots’ of higher radiation levels.
- Statistical summaries including mean (arithmetic and geometric), standard deviation and minimum and maximum values will be produced.

4 Quality

4.1 Field QA/QC Procedures

The QA/QC procedures that will be applied to field measurements of radon-222 exhalation flux densities, soil sample collection and gamma dose rates at Koongarra include:

- Control canisters will be prepared and carried into the field but remain sealed at all times to provide assurance that the charcoal in the canisters has been properly ‘activated’ and has low background activity of radon-222.
- The meter and probe used to measure gamma dose rates will be calibrated by an external service provider against a certified radiation source during the preceding 12-month period to provide assurance that it is accurate.
- The hand trowel used for soil collection will be cleaned between sites using the method described above.

4.2 Laboratory QA/QC Procedures

The laboratory QA/QC procedures that will be applied to the gamma spectrometry measurement of canisters and soil samples are detailed in the gamma spectrometry procedures manual developed and maintained by the ERISS Radiation Team and include:

- Routine detector calibration checks using certified standards and reference materials to provide assurance that measurements are accurate, and that detector efficiency does not change significantly over time.
- Routine measurement of detector backgrounds to provide assurance that detector background is low and does not change significantly over time.
- Validation (i.e. double-checking) of results by a second person.

4.3 Data, Reporting and Review

Data and results will be presented in Supervising Scientist internal reports or technical advices including:

- Sampling date(s)
- Coordinates of sampling points

- Radon-222 exhalation flux density, gamma dose rate and soil radionuclide activity concentration for each sampling point
- Statistical summaries of radon-222 exhalation flux density, gamma dose rate and soil radionuclide activity concentration

Data will also be stored in both the Koongarra folder of the *ERISS Shared drive* and within the ESdat database (for applicable analytes).