

Exploration for Naturally Occurring Radioactive Materials in the Northern Territory

1 Introduction

Exploration for minerals containing naturally occurring radioactive materials (NORM) (e.g. uranium) involves specific risks to health, safety and the environment that must be addressed in addition to the other risks associated with exploration activities.

The contents of this Advisory Note are largely based on the Guideline for Radiation Protection for Mineral Exploration in South Australia and the Radiation Protection Division of the SA Environmental Protection Agency is gratefully acknowledged for their assistance.

1.1 Scope

This Advisory Note covers radiation protection and radioactive waste management issues arising from exploration drilling, mining, sample handling, analysis, transport, storage and site rehabilitation in areas of known radioactive mineralisation.

This advisory note does not cover the use or storage of instruments that emit gamma or neutron sources, Prompt Fission Neutron (PFN) logging tools or other devices that emit ionising radiation. These sources or devices must be registered and the operators licensed in accordance with the *NT Radiation Protection Act*, which is administered by the Department of Health.

2 Applicable Legislation, Codes and Standards

Radiation exposures may arise where activities of an exploration program involve contact with radioactive ores through drilling, mining, sample handling, analysis, transport, storage and associated waste disposal practices.

All exploration and mining in the Northern Territory is administered by the Department of Primary Industry and Resources which regulates the *Mining Management Act* (MMA). Under the MMA, operators are required to establish, implement and maintain an appropriate environmental protection system for the site and submit a Mining Management Plan (MMP) on an annual basis. The MMP must include details of the implementation of the management system to address environmental issues, including radiation.

NT Worksafe maintains the responsibility for all workplace health and safety matters, and regulates the *Radioactive Ores and Concentrates (Packaging and Transport) Act*. The transport of / or storage of radioactive material may require a licence from NT Worksafe.

The Department of Health regulates the *Radiation Protection Act* which applies to the control and use of all radiation sources (radiation apparatus or radioactive material), not relating to uranium mining or exploration activity.

Companies undertaking exploration for radioactive materials are advised to contact the relevant agency for information on the requirements of the Acts regulating the activity.

To avoid unnecessary regulation of the low radiation risk activities arising from exploration, this advisory note describes what measures should be applied to activities currently managed on a mining interest (i.e. tenements for mineral exploration, mining etc.) which includes areas of known radioactive mineralisation.

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Compliance with this advisory note will demonstrate sufficient and effective procedures are in place to minimise radiation exposures associated with an exploration program on an Exploration Licence (EL).

The advisory note also incorporates the approach to radiation safety in the following Commonwealth documents published by Australian Radiation Protection and Nuclear Safety Agency (ARPANSA):

- Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)
- Code of Practice for the Transport of Radioactive Material (2014)
- Code of practice for the near surface disposal of radioactive waste in Australia (1992).

3 Radiation Management Plan

Exposure to radioactive samples and wastes during exploration activities in areas of known radioactive mineralisation is generally small and correspondingly the radiation doses are low. However; a Radiation Management Plan (RMP) must be developed to ensure that risks of radioactive materials are recognised and controlled during exploration activities.

The basic risk principle is to achieve radiation levels which are “as low as reasonably achievable” – commonly referred to as ALARA. Implementation of the RMP will ensure that radiation doses to workers and the environment are as low as reasonably achievable. The following section outlines the information that should be provided in a RMP. The purpose of the RMP is to:

- identify all radiation risks associated with the exploration program
- outline procedures to control the risks to people and the environment, as required under the MMA
- outline methods of monitoring and recording of doses to workers
- outline procedures for managing incidents and spills involving radioactive samples, waste or drilling fluids
- outline the program of disposal of radioactive waste generated on site or returned to site from laboratory testing
- outline the processes to ensure all contaminated equipment is cleaned before leaving site
- outline the processes to ensure that drill sites are free from contamination following rehabilitation
- outline procedures to suitably record and report information as necessary
- outline the roles of the Radiation Safety Officer¹ and the availability of resources to implement the RMP
- document the induction and training programme for all workers and contractors on site.

NOTE: An RMP is required for MMP approval to conduct drilling in an area known to contain or is likely to intersect radioactive minerals.

Companies should therefore develop a RMP prior to undertaking exploration drilling activities so that radiation protection measures can be implemented if mineralisation is encountered.

¹ A person who has received radiation safety training should be identified as the Radiation Safety Officer (RSO) to implement the RMP and advise on radiation safety matters.

3.1 Sources of Radiation Exposure

3.1.1 Pathways

The RMP should describe the significant radiation exposure sources and exposure pathways as well as the form, quantity and concentration of radioactive samples and wastes that may be encountered during exploration activities.

External Exposure of workers (or members of the public) to radiation during exploration activities can occur by being close to radioactive samples. For example by:

- sampling of surface mineralisation
- handling of radioactive core samples and drill cuttings
- working or residing near stored samples
- transporting radioactive samples for storage or analysis off-site.

Internal Exposure to radiation can arise from radioactive materials entering the body via inhalation or ingestion. This can include:

- inhalation of dust created from drilling through radioactive ore zones or cutting of cores
- ingestion of radioactive materials or inhalation of dust through handling core samples and drill cuttings
- ingestion of radioactive materials through poor personal hygiene (not washing hands after handling radioactive samples)
- inhalation of radon decay products where large quantities of samples are kept in enclosed and poorly ventilated storage areas.

3.2 Control of Radiation Exposures

The RMP should describe the measures and procedures that will be implemented to control the sources of radiation exposures identified above.

3.2.1 External Gamma Radiation Exposure

A portable gamma survey meter should be used to identify any radioactive samples. An ore grade scintillometer or spectrometer would be suitable for this purpose.

A gamma dose rate meter is required to determine the radiation dose from exposure to any radioactive samples.

Instruments must be properly calibrated on a yearly basis.

Basic principles for radiation protection from external sources should be applied to minimise exposure to workers by:

- minimising the time spent working with radioactive samples
- locating radioactive samples away from occupied area
- use of non-active samples or other materials as shielding for radioactive samples, if necessary.

3.2.2 Internal Exposures

The use of appropriate PPE and hygiene procedures are an important part of radiation management. Procedures must be developed to minimise the spread of radioactive material when handling core samples and drill cuttings. Examples of these include:

- the use of P2 dust masks if there is potential for exposure to dust when intersecting radioactive ore or cutting core samples
- wearing gloves and appropriate work clothing when handling radioactive samples or using drilling equipment to minimise transfer of contamination
- washing hands before eating or smoking
- regular cleaning of work areas where there is potential for build-up of dust or mud
- showering and changing out of work clothing at end of shift or before leaving site
- regular laundering of clothes.

3.2.3 On-site Sample Storage

Radioactive samples should be stored away from normally occupied areas and be well ventilated if held in an enclosed space. Highly active samples should be stored in a clearly sign-posted, designated area. All radioactive samples must be clearly labelled as such. Radioactive samples which have a tendency to flake or degrade must be stored in plastic sample bags which are sealed and in good condition to prevent release of radioactive dust.

3.3 Monitoring

Summary details of the personnel and area radiation monitoring plan needs to be provided in the RMP. Monitoring radiation levels in the workplace and in the environment is performed to:

- identify the presence and activity levels of radioactive material
- provide information on the effectiveness of the control measures at the site
- determine the radiation exposure of workers and demonstrate compliance with regulatory radiation dose limits
- assess the impact of the project on the local environment and confirm that rehabilitation of the site has been successful.

3.3.1 Monitoring for Site Controls

A gamma survey should be conducted of samples, drill core and cuttings to determine the presence of radioactive materials and develop controls necessary to minimise exposure to workers. The RMP should specify the instrument used for monitoring, and relevant calibration information.

3.3.2 Monitoring of Workers

Average radiation doses received by workers during exploration activities are typically well below the recommended annual limit for members of the public (1 mSv/a). Notwithstanding, it is recommended that the radiation dose continues to be assessed for those work groups most at risk of exposure to radiation by routine contact with radioactive samples. This is best achieved by issuing a personal dosimeter e.g. thermoluminescent dosimeter (TLD) badge, to those workers with routine exposure to radioactive samples.

The dose results should be recorded and reported to the relevant workers on a regular basis (e.g. quarterly) and at the end of the exploration program.

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Monitoring for airborne radioactive dusts should be considered if workers are exposed to significant levels of dust involving radioactive ores. In this case, monitoring should be undertaken in accordance with the appropriate Australian Standards.

The requirements for radiation safety monitoring of an exploration program are specific to the site and will depend on several factors such as the duration of the drilling program, drilling methods, and the radioactivity of the materials being drilled e.g. resource definition drilling may pose a higher radiation exposure risk than regional exploration. A radiation specialist must be consulted prior to commencement of exploration activities to determine the level of monitoring required.

3.3.3 Monitoring of the Environment

For rehabilitation purposes, the area of the drillhole, drill sump and bulk disposal pit should be surveyed to determine background gamma dose rates (or scintillometer count rate) before disturbance and after site rehabilitation. The site cannot be considered rehabilitated or closed until background gamma dose rates are similar to initial pre-disturbance background levels. The measurement methods must be defined in the RMP and records of the results must be kept.

3.4 Incidents

The RMP must describe procedures to manage and report incidents involving radioactive samples; radioactive wastes on site; radioactive samples during transport; or radioactive material stored off-site. Licensed users of radioactive sources must have incident procedures in place to ensure reporting of damaged, stuck or lost logging sources e.g. density probe lost downhole.

3.5 Disposal of Radioactive Waste Materials

The RMP must detail the methods that will be implemented to safely dispose of radioactive liquid and solid wastes generated during exploration. Radioactive waste is defined as any radioactive substance in the form of a solid, liquid or gas (or combination thereof) that is left over, surplus or an unwanted by-product of any business or domestic activity, whether of value or not. This excludes material containing activities or activity concentrations of radioactive elements below the exemption levels specified in the National Directory of Radiation Protection published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Radioactive wastes must not be disposed off-site or near permanently occupied areas.

3.5.1 Liquid wastes

Liquid wastes can include:

- drilling muds
- slurry from core cutting
- vehicle and equipment wash-down water
- groundwater containing elevated natural levels of radionuclides (such as radium).

Where radioactive mud, cuttings or samples are present in drill sumps, the sumps should be allowed to dry, and be covered by a minimum of 1.0 m of compacted clean soil. If core cutting of radioactive samples is conducted on-site, the waste slurry should be directed to a sump for disposal as above.

Vehicle or equipment wash-down should be conducted on site and waste-water should be directed to a sump or similar, allowed to dry, and be covered by a minimum of 1.0 m of compacted clean soil.

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Care should be taken to minimise the surface spread of groundwater. Groundwater should be directed to a drill sump or similar, allowed to dry, and be covered by a minimum of 1.0 m of compacted clean soil.

3.5.2 Solid wastes

Solid waste material generated during exploration activities can include surplus radioactive samples and returned analytical samples as well as contaminated PPE, equipment and containers.

Samples

All samples should be removed from sample bags for disposal, unless they are made from biodegradable material.

It is preferred that radioactive drilling samples are returned to the drillhole (ie. before other cuttings). Where this is not possible, radioactive samples from individual drillholes should be buried in adjacent drill sumps with at least 1.0 m of compacted clean soil cover. The drillhole can then be rehabilitated in accordance with procedures approved by the Department.

Bulk Samples

In the situation where radioactive samples cannot be backfilled down the hole and no drill sump is available, the samples should be removed from their sample bags, mixed with barren cuttings or clean soil to reduce any artificial concentration of the material, and be buried in a purpose built disposal pit as outlined below.

The disposal pit for bulk samples should:

- only hold samples removed from their sample bags and containers, and should not be used to dispose of other wastes generated on site
- be located in a stable area that does not compromise its future use, and on ground not subject to flooding or erosion which may re-expose the material
- be constructed so as to ensure the material has at least 2m of clean and compacted soil cover
- be located within the exploration licence associated with the authorised exploration program.

Analytical Sample Returns

It is common practice for off-site analytical laboratories to return reject sample material and laboratory pulps to the operator once analysis is completed. Radioactive sample returns must be stored or disposed in the same manner as solid wastes.

Other wastes (empty bags, PPE, etc), should be drummed and disposed of in a licensed landfill as un-contaminated waste (in respect to radioactivity), provided they are not radioactively contaminated. Radioactive waste is not permitted for disposal in general landfill.

Sample returns from barren intervals (i.e. not radioactive samples) can also be disposed of in a licensed landfill.

Potentially Contaminated Waste Materials

Empty sample bags, used PPE, and other miscellaneous waste are unlikely to be contaminated to the extent that they are considered a 'radioactive waste' material requiring special disposal arrangements. These wastes can be disposed of in a licensed landfill after consultation with the appropriate authority.

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If radiation monitoring indicates that materials are contaminated to the extent they are considered 'radioactive waste'; the waste items should be drummed, labelled and stored securely on site for further assessment. The Department should be contacted for advice on the assessment required.

3.6 Disposal Pit Closure Report

A 'closure report' must be completed for each pit providing:

- the location (GPS coordinates) and dimensions of the pit
- a list of contents
- photographic confirmation of the construction of the pit
- photographic confirmation of the pre-closure waste location within the pit indicating depth
- photographic confirmation of closure and surface remediation
- measured gamma dose rates (or scintillometer rates) before construction and after closure.

The disposal pit closure report must be forwarded to the Department within 1 month of pit closure. Photographs should be taken from the same point, in the same direction and include an identifying feature or reference point for comparison.

3.7 Decontamination of Machinery and Equipment

It is possible that some machinery and other equipment may become contaminated through significant or prolonged contact with radioactive material. Operators should ensure that all equipment has been thoroughly cleaned to remove loose material before leaving the site. Cleaning should be undertaken in a designated area where any contaminated material is contained (e.g. so that it runs into a sump). Fixed surface contamination not removed by washing may need abrasive cleaning methods such as abrasive blasting. Any radioactive waste material removed during this process should be disposed of as outlined above.

The target level for decontamination should be to background levels.

3.8 Spills Management

Spills of drilling or cuttings fluids, and any groundwater returns must be contained e.g. through the use of earth bunds or by directing fluids into drill sumps. If there is obvious soil contamination resulting from these spills, the soil should be removed for burial in a drill sump or bulk sample disposal pit.

Where drill sumps have been used for this purpose these should be allowed to dry out before covering with at least 1.0 m of compacted clean soil.

3.9 Personnel and resources

A person who has received training in radiation safety should be identified to act as Radiation Safety Officer (RSO). The RMP should outline their role and those of any other responsible persons, and also the resources available to properly implement the plan.

3.10 Induction and Training of Workers

All workers and contractors working with or handling radioactive samples must be appropriately inducted and trained regarding the radiation aspects of their work and in the precautions necessary to control their exposure to radiation. The induction must cover all site safety and environmental issues associated with radiation and the management of radioactive samples and wastes.

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The RMP must document the induction and training undertaken.

3.11 Records

Records of the following information or events must be kept:

- details of radiation safety training provided to employees
- results of all employee radiation monitoring undertaken
- estimates of dose received by employees/contractors and if applicable, members of the public
- incidents involving exposure to radiation and the corrective actions
- any measurements related to soil contamination caused by exploration activities (for rehabilitation purposes)
- bulk sample disposal pit closure reports as described above. The survey method used to establish gamma levels (or scintillometer count rates) before construction and after closure of the pit should be defined in the RMP and records kept of the results
- annual calibration of radiation monitoring equipment.

4 Transport and Storage

The majority of exploration samples collected are likely to be either non-radioactive or low level radioactive and can usually be transported as an “Exempted Package”. It is recommended that operators refer to relevant legislation, guidelines or NT Worksafe for information on requirements for the packaging, labelling and transport of radioactive materials.

Transport of radioactive materials outside of the Northern Territory may be subject to different regulatory requirements and it is the responsibility of the operator to determine what requirements may be necessary. The relevant authority within the receiving state or territory should be consulted prior to transportation.

5 Further Information

- Recommendations for Limiting Exposure to Ionizing Radiation (1995) and National Standard for Limiting Occupational Exposure to Ionizing Radiation (republished 2002)
ARPANSA RPS No1.
<http://www.arpansa.gov.au/Publications/codes/rps1.cfm>
- Code of Practice for the Safe Transport of Radioactive Material (2014),
ARPANSA, RPS No 2.1
<http://www.arpansa.gov.au/Publications/codes/rps2.cfm>
- National Directory for Radiation Protection (Edition2)
ARPANSA, RPS No 6.
<http://www.arpansa.gov.au/Publications/codes/rps6.cfm>
- Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005),
ARPANSA, RPS No 9.
<http://www.arpansa.gov.au/Publications/codes/rps9.cfm>
- Code of practice for the near surface disposal of radioactive waste in Australia (1992),
NHMRC RHS No. 35
<http://www.arpansa.gov.au/pubs/rhs/rhs35.pdf>
- Safety Guide – Management of Naturally Occurring Radioactive Material (NORM) (2008)
ARPANSA, RPS No 15.
<http://www.arpansa.gov.au/pubs/rps/rps15.pdf>
- Radiation Protection Guidelines on Mining in South Australia – EPA
www.epa.sa.gov.au/files/4771294_guidelines_mineral.pdf
- Guide to Uranium in Western Australia – Department of Mines and Energy
www.dmp.wa.gov.au/documents/Guide_to_Uranium_in_Western_Australia.pdf
- Best Practice Guidelines for Uranium Exploration - Minerals Council Australia
http://www.minerals.org.au/file_upload/files/resources/uranium/aua_history/Best_practice_guidelines/Best_practice_uranium_exploration_guidelines_December_2009.pdf