TORO ENERGY LIMITED

WILUNA URANIUM PROJECT

RADIATION MANAGEMENT PLAN

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DOCUMENT REF	REVISION	DATE	PREPARED BY	CHECKED	AUTHORIZED	AUTHORIZED FOR USE
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1 INTRODUCTION

This Radiation Management Plan describes the radiation management systems that would be implemented during the construction and operational phases of the Wiluna Uranium Project (the Project). This document provides an overview of the key radiation management strategies and systems based on the discussions provided in the PER. A more detailed plan would be submitted for approval to the appropriate authority, prior to operations commencing.

This RMP describes how Toro would –

- Comply with relevant legislation and standards for radiation management;
- Manage potential radiation exposure to the workers and the public; and
- Implement management measures, methods and reporting, auditing and review.

This RMP is part of a suite of plans that deal with impacts and aspects of the Project. It is designed to assist Toro employees and contractors to manage radiation exposure in a manner that is compliant with relevant legislation, safe and environmentally responsible. All management strategies would be periodically reviewed as part of Toro's commitment to continuous improvement, and for their continued application to the Project, particularly during the operational phase.

1.1 Project Overview

The Wiluna Project is in the Murchison region of Western Australia, approximately 960km north-east of Perth. It is based on mining four deposits: Centipede, Millipede, Lake Maitland and Lake Way. The Centipede and Millipede deposits are approximately 30km south of the town of Wiluna, and the Lake Way deposit is approximately 15km south of Wiluna. The Lake Maitland deposit is some 90km to the south east at another salt lake, Lake Maitland.

The principal activities planned for the Project include:

- Development and operation of a uranium mine encompassing the Centipede, Millipede, Lake Maitland and Lake Way deposits;
- Construction and operation of a uranium ore processing, packing and handling facility at Centipede/Millipede;
- Development of the Lake Maitland and West Creek borefields to supply water to the Project;
- Support facilities including an accommodation village, mine administration buildings and workshops, haul roads, power generation and transmission facilities, communications systems and water and waste management;
- Transport of uranium product within Australia for export; and
- Rehabilitation and closure of the mine and other areas disturbed by the Project.

The proposed total area of disturbance required for the development of the Project over the planned 20-year-life-span is approximately 3120 hectares (ha) including infrastructure.

Across the four deposits the grade of the ore remains relatively consistent with the Centipede, Lake Maitland and Lake Way deposits having average grades of between 545 to 566 parts per million (ppm). The Millipede deposit is the lowest grade deposit, with an average grade of 486 ppm. Table 1.1 shows how the grades of the deposits compare to the tonnes of ore in each deposit and the pounds of uranium metal available from each deposit.

Table 1.1: Comparison of Deposits in the Wiluna Uranium Project

	Total		
	Ore	Grade	Metal
	Mt	PPM	Mlb's
Centipede	10.4	566	13.0
Lake Way	10.3	545	12.3
Millipede	6.4	486	6.9
Lake Maitland	19.9	555	24.3

2 Scope

This RMP provides a reference for monitoring, reporting and auditing as necessary to minimise identified and potential environmental impacts of the Project.

This RMP is being submitted to the Environmental Protection Authority (EPA) with the Public Environmental Review (PER) as part of the environmental assessment and approvals process for the Project.

This RMP has been prepared based on:
- Toro's Environment Policy;
- Toro's Indigenous Relations Policy;
- Toro's Occupational Health and Safety Policy;
- Relevant Commonwealth and Western Australian legislation;
- Other legal obligations;
- Identified potential direct and indirect environmental impacts from risk assessments;
- Consultants' reports;
- Relevant permits and standards; and
- Toro's commitment to continuous improvement.

This RMP has been developed to:
- Provide an overview of the system for radiological protection;
- Identify and assess potential radiological impacts of the Project;
- Describe proposed management and monitoring strategies for radiation protection;
- Describe the general radiological control mechanisms;
- Outline reporting, auditing and review mechanisms; and
- Guide the development of other site specific plans and procedures relevant to the Project.

This RMP covers the following phases of the Project:
- Construction at and mining of the Centipede, Millipede, Lake Maitland and Lake Way deposits;
- Construction and operation of a processing, packing and handling facility;
- Development of the Lake Maitland Borefield and refurbishment of the West Creek borefield; and
- General infrastructure including an accommodation village, mine administration buildings and workshops, haul roads, power generation and transmission facilities, communications systems and water and waste management.

3 LEGISLATIVE REQUIREMENTS

This section lists the legislation, regulations and standards that apply to the radiation protection aspects of the construction and operational phases of the Project.

3.1 Commonwealth Legislation and Standards

- *Environment Protection and Biodiversity Conservation Act 1999*;
- Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2003. *RPS No. 1 – Recommendations for Limiting Exposure to Ionizing Radiation (1995) and National Standard for Limiting Occupational Exposure to Ionizing Radiation (2002)*;
- ARPANSA, 2005. *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*;
- ARPANSA, 2008. *Code of Practice for the Safe Transport of Radioactive Material* (2008 Edition); and
- ARPANSA, 2011. *Safety Guide for Monitoring, Assessing and Recording Occupational Radiation Doses in Mining and Mineral Processing*.

3.2 Western Australian Legislation

- *Radiation Safety Act 1975*;
- *Radiation Safety (General Regulations) 1983*;
- *Radiation Safety (Transport of Radioactive Substances) Regulations 2002*;
- *Mining Act 1978*;
- *Mines, Safety and Inspection Act 1994* and Regulations 1995;
- *Nuclear Waste Storage (Prohibitions) Act 1999;*
- Department of Mines and Petroleum (DMP), 2010. *Managing naturally occurring radioactive material (NORM) in mining and mineral processing*; and
- *Occupational Safety and Health Act 1984.*

Toro would construct and operate the Project facilities utilising best practicable technology, as defined by Part 16 of the DMP's *Mine Safety and Inspection Regulations 1995.*

4 OVERVIEW OF POTENTIAL IMPACTS

4.1 Radiological Dose Assessment

The overall radiological impacts of the Project are related directly to workers, members of the public and the environment.

The human radiation exposure pathways that have been identified for the construction and operational phases of the Project are:

- Irradiation by gamma radiation;
- Inhalation of decay products of radon;
- Inhalation of radionuclides in airborne dust; and
- Ingestion of radionuclides.

Occupational exposure to radiation would be assessed by determining doses to the different work groups (miners, plant workers, transport workers and final product handlers). For the public, critical groups have been identified as people living in the following locations:

- Wiluna Township;
- Bondini Reserve;
- Nganganawili Community;
- Millbillillie Station;
- Lake Way Station;
- Toro Camp; and
- Barwidgee Station.

4.2 Radiation Doses to Workers

4.2.1 Radionuclides in Airborne Dust

There are a number of radiological dust sources that result from the mining and processing of uranium ores.

The following sources of dust from the mining operations have been identified:

- Dust from mining of ore; and
- Dust from ore stockpiles, ore transfer processes, crushing, road haulage and conveyor systems.

Processing of ore generates dust from the following sources:

- Fugitive dust from tailings deposits;
- Transport systems in mill area (conveyors etc.); and
- Uranium oxide drier and packaging area.

Mining would generate low levels of dust, because the mined material would generally be damp, and dust suppression would be used when necessary to keep dust levels low. Dust levels in the processing plant would be low due to the process material being mainly wet or damp and the operational and engineering controls put in place.

The impacts from radionuclides in dusts have been calculated from air quality modelling and experiences at other operating uranium mines and shown to be low due to design controls and management practices. An annual dust dose of 0.32 mSv/y may be expected for mine workers, and the average dust dose for process plant workers is estimated to be 0.64 mSv/y.

4.2.2 Decay Products of Radon (RnDP)

The RnDP impact is determined directly from the radon impact modelling. RnDP doses have been determined by modelling the mine as an open pit and estimating the release rate of radon into the mine. The ventilation rate of the open pit is then predicted by atmospheric modelling.

Radon sources include:

- Mining of ore;
- Stockpiles;
- Ore processing; and
- Tailings management and disposal.

The impacts from radon arise from the decay products, which are generally directly proportional to the radon concentrations. Modelling has shown that the incremental radon concentrations at the closest permanently occupied communities to the Project would be low. Based on conservative modelling assumptions, the estimated average RDP dose for a miner would be 3.8mSv/y, and for workers in the processing plant the calculated occupational RDP dose is expected to be 0.05mSv/y.

4.2.3 Gamma Radiation

The main sources of gamma radiation from the Project are:

- Stockpiles;
- Tailings;
- Uranium; and
- Process materials.

All materials would be contained within the Project area. Accordingly, gamma radiation from the Project is not expected to be detectable beyond the Project boundary.

Estimates of gamma radiation exposure have been based on two sources; information from other operational uranium mines and estimates from first principles. For a full work year the theoretical maximum exposure would be 3.9mSv/y. However, this figure does not take into account the shielding afforded by the mining equipment. Based on gamma radiation levels observed in other open-cut uranium mines, it is estimated that miners would on average receive 1mSv/y from gamma radiation.

4.2.4 Radionuclides in Soil

The radionuclide concentrations in soils may change through spillages or through long term dust deposition.

Spills have not been considered in the assessment of environmental impact, as operational procedures would ensure that all spillages would be immediately cleaned up and therefore would not contribute to long term changes in soil concentrations.

Over time, dust deposited from emissions from the Project would accumulate in the local soil, leading to increases in the pre-existing radionuclide concentrations. The impact of long term dust deposition from the Project on soils was estimated from the air quality modelling and showed that changes in natural levels would be approximately 3% after 15 years.

4.2.5 Waterborne Emissions

Radionuclides in water can lead to radiation exposure to the environment or to humans when consumed.

The regional groundwater is unsuitable for human or stock consumption due to its relatively high salinity and therefore human and animal exposure to radionuclides in the groundwater is highly unlikely.

Additional radionuclides may enter the groundwater from various sources including seepage from tailings storage facilities, seepage from the pit and water infiltration through the stockpiles into groundwater.

Groundwater modelling shows that movement of groundwater from the mine area is limited. During mining there would be an induced and natural groundwater flow towards the mine as a result of active dewatering. Groundwater would also tend to flow back towards the lake systems, thereby preventing groundwater to flow away from the mining areas.

Testwork has shown that the radionuclides have low solubility and do not migrate with seepage.

Overall, the limited spread of seepage, the direction of groundwater flow, the low solubility of the radionuclides and the limited exposure pathways from groundwater indicate that the impacts would be low.

4.2.6 Emissions during Transport of Uranium Oxide Concentrate

The transport of uranium oxide concentrate (UOC) is a closely regulated activity with strict requirements for packaging, labelling, emergency response and management. Airborne emissions from the routine transport of the material are non-existent although low levels of gamma radiation would be detected close to the containers. The gamma levels are reported externally on all containers. Finished product would be trucked interstate for export either through the Port of Adelaide or Darwin Port. Truck drivers would be exposed to low levels of gamma radiation for the duration of the trip.

Final product uranium would be trucked interstate for export either through the Port of Adelaide or Darwin. Truck drivers would be exposed to low levels of gamma radiation for the duration of the trip. Gamma radiation measurements in truck cabins transporting uranium oxide would be on average, 1µSv/h. For a 36 hour trip between Wiluna and Port Adelaide, this equates to 36µSv. A driver may make up to 12 of these trips per year giving a total dose of approximately 0.5mSv/y.

4.2.7 Radiation doses to the Public

The most exposed public group are residents of the Toro accommodation camp. People living full time at this location could be exposed to up to 0.033 mSv/a. Residents of Wiluna are expected to receive less than 0.022 mSv/a when mining is occurring at Lake Way, the nearest deposit to the town.

4.3 Summary of Radiological Impacts

Radiation doses to both workers and members of the public from the operation are expected to be well below internationally accepted limits, as shown in Table 4.1.

Table 4.1: Summary of Radiological Impact

	Expected Impact	Limit/Standard
Workers Doses	5 mSv/a	20 mSv/a
Member of Public Doses	<0.1 mSv/a	1 mSv/a

5 OBJECTIVES, TARGETS AND INDICATORS

Toro's objectives for radiation management are to ensure that doses to workers and the public never exceed the recognised annual radiation limits (as outlined in ARPANSA, 2005) as follows:

- Radiation doses to designated workers less than 20 mSv/a above natural background; and
- Radiation doses to members of the public less than 1 mSv/a above natural background.

Toro bases its radiation protection philosophy and approach on the internationally-accepted guidelines of the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) (ICRP, 2007; IAEA, 1996) which have been adopted in Australia, either through state/territory based legislation or through the ARPANSA series of radiation-related codes of practices.

The ICRP is recognised as the pre-eminent international authority on radiation protection and has recommended a 'system of dose limitation' that has been widely adopted overseas and in Australia. The system has three key elements:

- Justification – A practice involving exposure to radiation should only be adopted if the benefits of the practice outweigh the risks associated with the radiation exposure;
- Optimisation – Radiation doses received should be as low as reasonably achievable, taking into account economic and social factors (the ALARA principle); and
- Limitation – Individuals should not receive radiation doses greater than the recommended limits.

Optimisation is generally considered to be the most effective means of radiological control.

6 MANAGEMENT STRATEGIES AND ACTIONS

6.1 Overall Approach

Radiation emissions and exposures are potential hazards associated with the mining and processing of radioactive ores. Like all other hazards, radiation can be effectively managed in both the design stage and in operations. Hazards are primarily controlled through design and then further reduced through operational management systems.

The overall approach by Toro towards the management of radiation is consistent with the recommendations of the ICRP, in particular, the principle of as low as reasonably achievable (ALARA). Proper and appropriate implementation of the ALARA principle is an important means of managing radiation. In this section, the management and control of radiation is described within the broader context of ALARA.

6.2 ALARA in Design

Toro considered radiation protection at an early stage of Project planning in two primary ways:

- The establishment of radiation design criteria for the Project; and
- A preliminary radiation risk assessment.

The design criteria are fundamental instructions to design engineers that require final verification by appropriately qualified radiation protection personnel, and include such measures as:

- All tanks and process vessels that contain radioactive process material must be concrete-bunded with hose-down facilities and sumps;
- All liquid spillages must be able to be cleaned up when wet, water outlets must be provided to ensure this;
- Where there is the possibility for large spillages, access must be provided to allow bobcats or similar to enable clean-up;
- Where there is dry process material that cannot be cleaned up with hoses and water, vacuum systems will be installed to enable clean-up;
- All process materials transfer points must be covered and active ventilation should be utilised;
- Dust extraction systems will be designed to ensure ease of maintenance (to minimise exposures);
- Wet scrubbing systems should be used; and
- For uranium product there must be specific design requirements developed in consultation with a qualified Radiation Safety Officer.

Toro additionally undertook a radiation risk review of design of the Project, which resulted in a set of mandatory control measures. The work is summarised in Table 6.1.

Table 6.1: Radiological Risk Review

Area and Process	Radiological risk Considerations	Mandatory Control/Mitigation
Mining – Ore Removal/Movements	Generation of dust from loading or haul roads	Provision of water sprays to minimise dust and regular watering of haul roads
Mining – Mining	Build-up of RDP concentration during still or inversion conditions	Real time RDP monitoring equipment fitted to all mining equipment fitted with filtered air conditioners.
		Air conditioned vehicles would be required to operate with windows closed at all times.
		Routine maintenance program for air conditioning units.
Mining – Stockpiles	Dusting of stockpiles	Adequate water sprays or chemical suppressants.
		Use of a water cart to control dust.
		Design limits for stockpile heights.
Transport of Material	Dust generation	Covering of haul trucks when trucking from the Lake Way and Lake Maitland deposits to the processing plant
Processing – Tanks	Spillage leading to loss of control materials	All tanks bunded with adequate clean-up systems (i.e. sloped floors to sump, concrete, access for bobcat)
Crushing and Screening	Dust generation	Installation of a dust enclosure and water sprays for tipping to grizzly.
		Dust extraction on conveyors and transfer points.
Processing – Product Packing	Exposure to UOC	Dedicated best practice control system based on automation, containment, dust control and ease of clean-up.
Processing – Laboratory	Radioactive water and waste	Appropriate nominated area for disposal.
Processing – Workforce etc	Spread of contamination	Clean/dirty change-rooms to be installed.
		Wheel wash for all vehicles leaving the site.
		Certain vehicles to remain on site at all times (mining).

Within the broader Project area, radiation controls would include:

- Controlled access to the site, and around the site, through security swipe cards;
- Vehicle wheel wash at main gate;
- Change rooms for all radiation workers at the site, requiring workers to change into overalls when entering the site and to shower and change prior to leaving the site;
- Lunch and control rooms would have wash facilities;
- A decontamination facility would be installed, including high pressure hose and sump with wash water recycled to the mill;
- Plant would be designed with multiple hose mounts, sumps for spillage collection and concrete bunding;

- The tailings pipeline would have leak detection and be bunded its entire length to contain any spillages; and
- All equipment and materials leaving site would be required to be tested for radioactive contamination and issued a radiation clearance before they could be removed from site.

An on-site laboratory would undertake sample preparation, analytical and metallurgical work with all the wastes recycled to the process plant or disposed to tailings.

6.3 ALARA in Operation

The application of ALARA during the operational phase would include:

- Training of all workers (including inductions and regular retraining);
- Additional specialised training for product handlers, supervisors and others;
- Controlled access to the whole of the working area with additional controls for certain areas of the plant;
- Review of design modifications from a radiological perspective; and
- Operational procedures:
  - Use of clean/dirty procedures;
  - Establishment of Radiation Work Procedures (RWP) for specific tasks, such as any work in the final product shed;
  - Strict procedures for equipment or materials leaving the designated radiation areas; and
  - Investigative monitoring to identify anomalies, and implement remedial measures as required.

7 OPERATIONAL AND ADMINISTRATIVE CONTROL

7.1 Overarching Systems

Toro would implement a series of controls for radiation protection. The Project would be divided into designated and non-designated areas for the administrative control of radiation exposure to staff. Designated areas would be those where workers had contact with radioactive ores as part of their everyday work; these workers would be monitored regularly.

As required under relevant legislation, all workers would receive a pre-employment medical, and then regular medical check-ups throughout their employment with Toro. Workers' dose and radiation monitoring records would be collected and maintained in accordance with relevant requirements. Dose records would be made available to the Australian National Dose Register. In addition, Toro would make dose and monitoring records available to the Western Australian Boswell system.

7.2 Training

Training of all personnel in the principles of radiation protection would be undertaken as part of the site induction with refresher training conducted annually.

Signed records of inductions would be kept by Toro. Additional radiation safety briefings would be given as toolbox meeting topics, to reinforce personal monitoring, dust control, spillage control and site clearance control measures. The dates of these safety briefings would be recorded along with identifying information on attendees.

The employee induction program would cover:

- Ionising radiation—types, quantities and units;
- Biological effects of radiation exposures;
- Natural background radiation—terrestrial gamma radiation, cosmic radiation, natural radionuclides in water and food, and radon and radon daughters;
- Radiation protection standards and regulations, including employee responsibilities;
- Basic concepts of radiation monitors used on mine sites;
- Potential health risks associated with ionising radiation;
- Safe working methods and techniques;
- Use of protective equipment and clothing;
- Importance and means of dust suppression;
- Reporting of unusual occurrences;
- Proper use, operation and care of personal monitoring equipment;
- Importance of personal hygiene in limiting intake of radioactive materials;
- Need for notification of any health problem; and
- Procedures for handling spills of radioactive materials.

7.3 Records Management and Reporting

Radiation records collated as part of the operation of the RMP would include:

- Results of monitoring conducted;
- Induction and other training records;
- Radiation dose records;
- Abnormal events;
- Records of any inspections or audits;
- Quality assurance calibrations and checks; and
- Personnel details.

Radiation monitoring results and any radiation dose assessments would be recorded and reported to the individual, management and to the relevant regulatory agency at the required intervals and at completion of the Project. Radiation dose records for each worker would be kept for the duration of employment and for as long as required by relevant legislation.

8 MONITORING AND MANAGEMENT

8.1 Radiation Monitoring

8.1.1 Introduction

Occupational and environmental radiation monitoring is undertaken to fulfil a number of functions:

- Provision of data and information to assess the adequacy and effectiveness of radiation protection systems;
- Provision of information for radiation dose assessment;
- Identification of trends or changes in conditions; and
- Investigation of possible exposure situations.

This section outlines the methods and systems for effective radiation monitoring and provides an indicative monitoring program that would be subject to approval by the appropriate authorities.

8.1.2 Methods

Table 8.1 provides an outline of the aspects to be monitored and the methods of monitoring.

Table 8.1: Methods of Monitoring

Radiation	Method	Primary Purpose
Gamma	Personal TLDs	Dose assessment
	Locational dose rate measurements using hand held gamma radiation monitors	Operational control
	Environmental gamma monitor	To identify changes
Radon	Continuous real time environmental sampling	To identify changes
	Passive radon detectors for radon concentrations	
	Charcoal cups for radon emanation	
RnDP	Continuous real time samplers	Dose assessment
	Spot sampling	
Dust	Personal dust pumps	Dose assessment
	Microvol dust pumps	To identify changes
	High volume dust pumps	To determine changes in radiation levels
		Public Dose assessment
	Dust deposition gauges	To determine changes in radiation levels

Radiation	Method	Primary Purpose
		Dose assessment and impacts on non-human biota
Radionuclides in Water	Grab sampling opportunistically following rainfall events, then radionuclide analysis	To determine changes in radiation levels
		Public Dose assessment
	Borehole sampling, then radionuclide analysis	To determine changes in radiation levels
		Public Dose assessment and doses to non-human biota

The support system for the monitoring program would also include:

- Recognised sampling methodologies that were documented and regularly reviewed;
- Routine instrument calibration programs, including auditing of calibration sources;
- Instrument maintenance and repair programs;
- The purchase and use of appropriate monitoring equipment;
- Provision of appropriately trained and qualified monitoring personnel;
- Review of new equipment; and
- Regular external audits of the monitoring program and system.

8.1.3 Generic Environmental Radiation Monitoring Program

The environmental radiation monitoring program implemented to collect background and baseline information to support the government assessment of the Project would continue during the operational phase. Continuing environmental monitoring would include:

- Meteorological data collection;
- Radon concentrations, including real time continuous radon concentration monitoring at the environmental monitoring sites;
- RnDP concentrations; real time monitoring at the environmental monitoring sites;
- Flora and fauna:
  - Vegetation would be sampled every five years and analysed for radionuclides using the same species and the same general locations as those used in pre-mining studies; and
  - Fauna sampling and analysis would occur and the program would be maintained in consultation with Traditional Owners.
- Airborne dust sampling:
  - Environmental dust would be measured using high-volume and low-volume samplers and passive dust deposition gauges;
  - Dust filters would be weighed to provide monthly trends of dust levels and filters would be composited for radionuclide analysis; and
  - Low-volume filters would be analysed to provide an indication of total long-lived alpha radiation in air; passive dust would be analysed for radionuclides on a quarterly basis.
- Water sampling:
  - A network of monitoring bores would be sampled quarterly and analysed for radionuclides and other constituents; and

- Opportunistic surface water sampling would occur following significant rainfall events.

- Gamma radiation:
  - Annual environmental gamma surveys would be conducted, focussing on the localities of critical groups.

8.1.4 Generic Occupational Radiation Monitoring Program

Radiation monitoring would have two main objectives: dose assessment monitoring and operational control monitoring. The proposed radiation measurements and frequency of sampling are shown in Table 8.2 and Table 8.3.

Table 8.2: Proposed Radiation Monitoring Program A – Dose Assessment Monitoring Program

Radiation Exposure Pathway	Mine area	Mill Area	Product Packers	Admin
Gamma Radiation	Quarterly TLD badges	Quarterly TLD badges	Quarterly TLD badges	Area TLD badge
Airborne Dust	Weekly sampling in mine area Fortnightly personal samples for all occupation groups (e.g. drillers, geologists)	Fortnightly personal samples in each plant area	Personal samples each packing session	Fortnightly area samples
Radon Decay Products	Continuous RDP sampling in work areas each month Consideration given to back shift	Weekly grab samples in each plant area	(included in general mill area sampling)	Monthly grab sample

Table 8.3: Proposed Radiation Monitoring Program B – Operational Management Monitoring Program

Radiation Exposure Pathway	Mine area	Mill Area	Product Packers	Admin
Gamma Radiation	Weekly gamma spot samples in each work area	Monthly gamma survey of mill area	(as part of Mill area survey)	N/A
Surface Contamination	Weekly survey in change rooms and crib rooms	Weekly survey in change rooms and crib rooms	(as part of Mill area survey) Weekly survey of U_3O_8 area	Monthly survey in office

Radiation Exposure Pathway	Mine area	Mill Area	Product Packers	Admin
Airborne Dust	Weekly samples on mining equipment	Weekly samples in: • crushing/grinding • leach • tailings	Area dust sampling during all drumming operations	N/A
Radon Decay Products	Real time continuous RDP monitoring in pit	Real time continuous RDP monitoring at various locations	N/A	N/A

8.1.5 Calculating Doses

There are standardised methods for calculating occupational radiation doses, which are based on the recommendations of the ICRP.

In general, 'dose' is a standardised measure of radiation detriment or harm, and is usually measured in Sieverts (Sv). The recognised occupational dose limit is 20 mSv/a. As noted, there are different ways that radiation doses can be received, such as gamma irradiation, dust inhalation and ingestion. The dose depends upon a number of factors (such as solubility class of the dust through to type of radiation and chemical characteristics of the material). The dose incorporates all these factors to produce one measure of radiation detriment.

A simplified model of assessment for radiation exposure is as follows:

- Radiation is emitted;
- A receptor (human or non-human) is exposed to the radiation;
- A measurement of exposure is made;
- The mechanism of exposure (inhalation, ingestion, etc.) and the form of exposure is factored; and
- Standardised conversion factors are utilised to determine a dose.

Toro's method for calculating doses for workers would be consistent with the national mining code (ARPANSA, 2005) and the internationally-accepted methods defined by the ICRP.

8.2 Radiation Management

8.2.1 Radiation Protection Resources

Toro would employ an appropriately qualified Radiation Safety Officer (RSO) who would be part of the operational management team and directly influence the day-to-day operation of the mine site.

The RSO would be provided with support staff and sufficient resources to achieve the requirements of the RMP including monitoring. The RSO would also have opportunities to obtain higher qualifications and remain abreast of the latest developments in radiation safety.

8.2.2 Action Levels

Toro has established an operational control management system based on the results of the routine monitoring results, as shown in Table 8.4.

Table 8.4: Exposure Action Levels and Actions

Radiation	Action Level	Actions
Gamma	10 µSv/h	Investigate. Remove personnel from area if necessary and placement of inert material to shield or clean-up; if spillage is present, then re-monitor.
RnDP	7 µJ/m^3	Monitor inside of equipment. If above action level, consider removal of personnel from area.
Dust	10 mg/m^3	Identify source and suppress (e.g. water suppression).
TLD (quarterly result)	1 mSv	Investigate and identify source. Redesign workplace to reduce exposure.

9 REFERENCES

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