

30 March 2026

Mandana Mazaheri
Team Leader Assessments
Energy, Resources and Industry Assessments
Department of Planning, Housing and Infrastructure

Dear Mandana

**Re: Copi Mineral Sands Project – Further Response to RFI- 102922456
Response to the Department of Planning, Housing and Infrastructure**

I refer Department of Planning, Housing and Infrastructure's (DPHI) request for further information relating to RFI-102922456. On 15 January 2026, R.W. Corkery & Co Pty Ltd (RWC) on behalf of RZ Resources (RZ) submitted a response to RFI- 102922456 addressing the recommendations of the Radiation Expert Review and Recommendations Report. DPHI have since provided RZ with an additional request for information dated 28 January 2026.

RWC and RZ have reviewed the additional information request and have provided a response below.

Management Plans

“Response to recommendation 1 describes that the ‘management plans are not required at this stage of the assessment process and should be included as a post approval matter, to be prepared and approved prior to production of the first heavy mineral concentrate’. Provide further information and justification addressing why the management plans should be provided post determination.”

RZ propose to submit the radiation management plans for approval by DPHI during the post approval period in accordance with DPHI's *Key Guidance on the Post Approval Process*. It is understood that this process allows for completion of detailed design and engineering work post approval and prior to construction and commencement of the activities in question. In this case, mining of ore and operation of the Rare Earth Concentrate Plant is not expected to commence until 2030 at the earliest. During the intervening period, the design and operation of the Rare Earth Concentrate Plant will be refined and optimised. As a result, any *Radiation Management Plan* that would be prepared pre-approval would be substantially out of date and would require revision and re-approval at that time. This would represent an inefficient use of RZ and the Department's resources for no substantive benefit.

As such RZ recommend that these management plans become conditions of Development Consent, with the requirement that these be prepared in consultation with relevant agencies and approved prior to production of the first heavy mineral concentrate. It is noted that this approach is consistent with the Department's approach in relation to other key environmental aspects of SSD projects.

APPENDIX 3

“Update the report responding to the following recommendations and matters raised by the expert report: Appendix 3 – Summary of Mitigations Measure 1.1 and measure 9.3, 12.11”

“Measure 1.1: Groundwater monitoring should include radio analysis for uranium, thorium, radium (Ra-226 and Ra-228), and Pb-210 to establish baseline levels before operations begin.”

RZ agree to adding uranium, thorium, radium (Ra-226 and Ra-228), and Pb-210 to the next round of groundwater monitoring and will establish background groundwater concentrations of these elements prior to mining commencing. This recommendation has already been covered by Section 13.1.3 (Groundwater Quality Monitoring) of the amended Copi Mineral Sands Project—*Groundwater Impact Assessment* submitted to DPHI. The document details that the following parameters will be monitored *“to identify base-line conditions and variations over time”* These parameters include field parameters (pH, Electrical Conductivity), major cations and ions, nitrates, sulphates, trace elements, radionuclides (as appropriate) and hydrocarbons.

“Measure 9.3, 12.11: The ARPANSA Code of Practice for the Safe Transport of Radioactive Material also needs to be adopted for the transport of Class-7 radioactive material. ADGC does not address or license Class-7.”

RZ acknowledges that the ADGC does not address or license Class-7 Radioactive Material. RZ agree to adopt the ARPANSA Code of Practice for the Safe Transport of Radioactive Material.

APPENDIX 14A

“Given the near-surface, short-lived nature of radon/thoron progeny and the project’s configuration, this pathway is likely to contribute less than other pathways; however, the applicant should either (a) provide a screening calculation showing that radon/thoron doses are negligible compared with other modelled pathways, or (b) explicitly include these gases and decay products in the dose assessment.”

DBH Radiation Pty Ltd (DBH) has prepared an updated *Public Radiation Risk Assessment* for the Project (attached). That assessment identifies that radiation exposure pathways include internal exposure from the inhalation of radon and thoron gas released from the minerals during mining or processing operations, or from final products. DBH has included a dose assessment associated with these gases at Section 9.2 and Appendix B of the attached. In summary:

- Multiple emission sources were considered, including
 - Heavy mineral concentrate stockpiles located adjacent to the dredge pond and at the Rare Earth Concentrate Plant; and
 - intermediate and final product located within the Rare Earth Concentrate Plant.
- Dispersion modelling of emitted gasses were estimated by Northstar using the dispersion model for the Project.
- The maximum annual effective dose to a Critical Group adult or child member of the public, as a result of inhalation of both radon and thoron is <0.1 µSv per annum.

When considered against the dose limit applicable for a member of the public of 1000 µSv per annum, risks associated with radon and thoron are considered to be negligible.

APPENDIX 14B

Appendix 14B – “: The applicant should specify the minimum backfill/cover depth required to ensure dose rates do not restrict any future use and describe how this will be verified at closure.”

DBH address this matter in Section 12 of the updated *Public Radiation Risk Assessment*. In summary, the minimum capping of overburden over the returned tailings will be between 10m and 30m. However, there is no ‘minimum depth’ applicable in this instance. This is because the radioactive concentration of the Combined Tailings (0.014 Bq/g) is less than the Topsoil/Overburden (0.041 Bq/g). Considering the non-placement or erosion of the capping, with tailings exposed at the surface, and 100% occupancy of a member of the public on the surface, it is estimated an individual’s terrestrial natural background dose would be reduced by 79µSv.

I trust that this letter provides you with the information that you require at this stage. Please do not hesitate to contact me should you require further information.

Yours sincerely



Matthew Ayre
Senior Environmental Consultant

Attachment 1 - Updated *Public Radiation Risk Assessment*

Attachment 2 – *Environmental Radiation Impacts (non-human biota)*



PUBLIC RADIATION RISK ASSESSMENT

COPI PROJECT

[RZ RESOURCES](#)

Document details	
Document title	Public Radiation Risk Assessment
Document subtitle	Copi Project
Project No.	C24065
Date	30 March 2026
Version	V1.2
Author	Darren Billingsley, Consultant Health Physicist
Client Name	RZ Resources

Document history				
Version	Revision	Author	Date	Comments
V1	1.0	DB	4/5/2025	
V1	1.1	DB	11/6/2025	Table 2 updated
V1	1.2	DB	30/3/2026	Sections 9.2, 12.1, 12.2 updated

© Copyright 2026 DBH Radiation Pty Ltd. The concepts, data and information contained in this document are the property of DBH Radiation Pty Ltd. No part of this document may be reproduced, used, copied, published or adapted for use except in accordance with the provisions of the Copyright Act 1968 or with the consent of DBH Radiation Pty Ltd.

This document has been prepared for RZ Resources. DBH Radiation Pty Ltd accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this document by any third party. Any third party using and/or relying upon this document accepts sole responsibility and all risk for using and/or relying on this document for any purpose.

This document is based on the information available, and the assumptions made, as at the date of the document. For further information, please refer to the assumptions, limitations and uncertainties set out in the methodology section of this document.

This document is to be read in full. No excerpts are to be taken as representative of the findings without appropriate context.

EXECUTIVE SUMMARY

Overview

RZ Resources Pty Ltd plans to develop the Copi Mineral Sands Project approximately 75 km north-west of Wentworth, New South Wales.

The Project will involve open cut mining of the Copi mineral sands orebody over a 17-year period extracting up to 27.1 million tonnes (Mtpa) per year. It will supply rutile, zircon and rare earth element bearing minerals to offshore markets. The heavy minerals are rich in naturally occurring radioactive material, namely uranium and thorium. As such, there is an expectation for consideration of radiological protection issues in relation to operations, and potential exposure to members of the public and the environment.

Scope

A radiation risk assessment of the Project has been undertaken by DBH Radiation Pty Ltd. This report assesses specifically the radiological risk to members of the public as a result of the Project.

Risk assessment approach

In radiation protection the potential for a noticeable health effect is related directly to the total exposure that is received. For biological systems, this is quantified in terms of dose in units of ' μSv '. The greater the μSv received the greater the 'risk' of a health effect. The risk of an effect is the result of the sum of all 'exposure pathways' to an individual. Terminology such as 'significance', 'likelihood' and 'impact' are not conventional terms used in radiation protection as it relates to radiation exposures and have been refrained from use in this report. Changes in environmental conditions are referenced as an 'impact', but it is the resulting exposure and subsequent increased risk (i.e. dose) that has been quantified. For low levels of exposure, there are no threshold values in which 'no' risk can be guaranteed. Instead, potential exposures have been compared to regulatory upper limits for total annual dose (1000 μSv).

Potential doses from exposure pathways relevant to the Project were calculated using internationally and nationally recognised radiation protection documentation. Primary Project-related information such as the radionuclide content of the materials including ore, were used. For environmental conditions, even when specific data on air quality was available from technical studies, overly conservative assumptions were instead assumed for dust resuspension and occupancy factors. Subsequently, the projected doses calculated and considered in the assessment are considered upper 'worst-case' annual doses, rather than realistic potential dose outcomes.

Exposures to Members of Public

All potential exposure pathways for a 'Critical Group' member of the public living near the Project area were considered and evaluated. Consideration was given to the resuspension of dust from site, consumption of locally grown crops, consumption of tank water, emanation of radon gas, and potential exposures arising from the transport of final products on public roadways and by rail.

Annual doses were calculated and summed for an adult and a 5-year-old child using the radionuclide content of the project materials and conservative values related to air quality, occupancy, and food consumption rates. The maximum potential dose to an adult was estimated to be **5.3 μSv** and the dose to a child was **9.4 μSv** . Both doses are considerably less than the regulatory limit for a member of the public of **1000 μSv** .

In regulatory radiation protection, dose 'optimisation' is achieved by keeping annual doses 'as low as reasonably achievable' (ALARA); and is to be achieved by taking a graded approach, balancing risk and benefits. The maximum dose to a 5-yo child member of the public, under worst-case environmental conditions (9.4 μSv) equates to less than 1% of the upper regulatory limit (1000 μSv). Whilst any introduced mitigations will minimise an already low exposure and will be an important component of occupational dose control, they will not have the same significance for environmental exposures to members of the public.

Based on the calculated doses, it was determined that the radiological risk to members of the public was considered negligible as a result of operations, irrespective of any mitigation measures should they be applied.

Concluding Remarks

The radiological risk to members of the public were assessed following calculation of potential radiation doses using internationally and nationally recognised assessment methodologies. Extremely conservative input parameters and assumptions were used for the assessment. In many instances irrespective of any mitigation measures that may be implemented, exposure risks were identified to be negligible.

Irrespective of any prospective radiation doses, RZ Resources will be required to implement sound radiation health physics practices and have an environmental monitoring programme in place to confirm that there are no adverse risks, and to ensure the efficacy of any mitigation measures implemented. The programme will ensure exposures to the Copi Project workforce and members of the public are kept to ALARA in accordance with the 'Optimisation' regulatory principle.

TABLE OF CONTENTS

1	INTRODUCTION	6
1.1	Purpose of this report	6
2	SCOPE OF ASSESSMENT	6
2.1	Scoping requirements	6
2.2	Excluded from Scope	7
2.2.1	Copi mine, processing and transport workers	7
2.2.2	Operations beyond transport to port	7
2.2.3	Non-human biota	7
3	PROJECT OVERVIEW	7
4	NSW RADIATION SAFETY LEGISLATION	8
4.1	Transport	9
5	METHODOLOGY	9
5.1	Risk assessment approach	9
5.2	Dose calculation methodology	10
5.3	Sensitive receptors	11
6	POTENTIAL RISKS RELATED TO THE MINING AND PROCESSING OF MINERAL SANDS	12
6.1	Members of the public	12
7	RADIONUCLIDE CONTENT OF PROJECT MATERIAL	12
8	RADIATION DOSE LIMITS	14
9	MEMBERS OF THE PUBLIC – OPERATIONS & TRANSPORT	14
9.1	Inhalation of airborne dust during operations (EP-01)	15
9.2	Exposure to radon/thoron gas (EP-02)	15
9.3	Consumptions of vegetables or crops grown in impacted soils (EP-03)	16
9.3.1	Baseline exposure	16
9.3.2	During operations	18
9.4	Consumption of contaminated soils (EP-04)	19
9.5	Consumption of personal tank rainwater (EP-05)	19
9.6	Consumption of locally grown livestock (EP-06)	20
9.7	Dust inhalation and ingestion generated from products and ore contamination removed from site (EP-07)	21
9.8	Exposure during transport of products (EP-8 – EP-10)	21
9.8.1	Scenario 1 – Exposure to a passenger vehicle following a truck loaded with product, (EP-08)	22
9.8.2	Scenario 2 – Exposure to a resident living on a trucking route (EP-09)	22
9.8.3	Scenario 3 – Exposure waiting at a rail crossing while a freight train of concentrate passes (EP-10)	22
9.9	Critical Group Assessment	22
9.10	non-Critical Group members of the Public	24
10	MITIGATION MEASURES	24

11	MEMBERS OF THE PUBLIC – BROKEN HILL RAIL SIDING	24
12	POST-REHABILITATION EXPOSURE RISKS	25
12.1	Tailings landform external exposure (EP-11)	25
12.2	Tailings landform radon exposure (EP-12).....	26
12.3	Seepage into groundwater (EP-13)	26
12.4	Seepage into surface waters (EP-14).....	27
13	EMERGENCY SCENARIOS	27
13.1	Major road accident involving truck spill of product	27
14	CONCLUSIONS	28
15	GLOSSARY	29
16	REFERENCES	31
Appendix A:	Site Plan indicating Air Quality receptor locations	34
Appendix B:	Dose estimate parameters	35

LIST OF TABLES

Table 1:	Radionuclide content of ore and products, Copi project – March 2025.....	13
Table 2:	Radionuclide content of tailings, rehabilitation materials, Copi project – March 2025.	13
Table 3:	Average dust concentrations assumed in representative garden, baseline – March 2025. 17	
Table 4:	Estimated annual radiation doses from diet including consumption of vegetables grown in representative garden, baseline – March 2025.	17
Table 5:	Estimated Adult annual radiation doses from consumption of crops grown in soils, years 5 and 17 – March 2025.	18
Table 6:	Estimated annual radiation doses for a Critical Group individual – March 2026.	23
Table B1:	Estimated radon emanation rates – March 2026.	36
Table B2:	Estimated radon concentrations and annual dose – March 2026.	37

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

RZ Resources Pty Ltd (RZR) plans to develop the Copi Mineral Sands Project (the Project), approximately 75 km north-west of Wentworth, New South Wales.

The Project will involve open cut mining of the Copi mineral sands orebody over a ~17-year period extracting up to 27.1 million tonnes per year (Mtpa). It will supply rutile, zircon and rare earth element bearing minerals to domestic and offshore markets.

The Project involves extraction of the ore, processing on site, and transportation to RZR's processing facility at Pinkenba in Brisbane, or direct shipping for commercial use internationally. Some components of the heavy minerals contain naturally occurring radioactive material (NORM), namely uranium and thorium. As such, there is an expectation for consideration of radiological protection issues in relation to operations, and potential exposure to members of the public and the environment. Based on the radioactive concentrations of intermediate and final products, various aspects of operations will be regulated under NSW legislation.

A radiation risk assessment of the Project has been undertaken by DBH Radiation Pty Ltd. This report assesses specifically the radiological risk to members of the public as a result of the project.

2 SCOPE OF ASSESSMENT

2.1 SCOPING REQUIREMENTS

As part of the assessment process required under the NSW *Environmental Planning and Assessment Act 1979 (EP&A Act)*, an Environment Impact Statement (EIS) is necessary for the Project. The Secretary's Environmental Assessment Requirements (SEARs) set out the specific matters to be investigated and documented in the EIS. This includes an assessment of the effects/impacts of the Project, with consideration of nearby sensitive receptors. This includes impacts related to radiological parameters.

To this end, a radiological impact assessment of the Project has been undertaken by DBH Radiation Pty Ltd.

The assessment encompasses:

- Potential radiation exposure to members of the public arising from all aspects of operations; and
- Potential exposure to members of the public post-rehabilitation of the site.

2.2 EXCLUDED FROM SCOPE

The following sections describe matters that have been excluded from assessment in this report.

2.2.1 Copi mine, processing and transport workers

Assessment of radiation exposure to the Project workers from all aspects of operation including mining, processing and rehabilitation. Worksite occupational health and safety is beyond the scope of an 'Environmental' impact assessment. Similarly, the impact to transport workers is beyond the scope of this report.

Potential occupational doses to workers are reported elsewhere (DBH Nov 2024).

2.2.2 Operations beyond transport to port.

Impacts related to operations beyond the transport of product to Port of Adelaide including storage and handling at the port, international export of products, sea transport to Pinkenba, and all Queensland operations are excluded.

2.2.3 Non-human biota

There is now a requirement to demonstrate, rather than assume, that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment as a result of the Project. The potential exposures must be considered.

These impacts are assessed and reported separately (DBH June 2025).

3 PROJECT OVERVIEW

Dredge mining techniques will be utilised within an extraction area approximately 9.6 km long and approximately 3.0 km wide.

Extracted overburden would be stockpiled for later use during rehabilitation operations. Interburden, namely material located below the water table with uneconomic heavy mineral, would be extracted using floating dredges. Ore would then be extracted and transferred to a floating Wet Concentration Plant (WCP) for processing.

Interburden and WCP rejects and slimes would be initially transferred to an Off Path Storage Facility. Once the dredge pond has achieved its full operational size, rejects would be combined with the extracted interburden to backfill completed sections of the extraction area.

Processing operations would involve the following:

- Wet screening and gravity separation of up to approximately 27.1 Mtpa of ore within the WCP.
- Dewatering and transfer of the Heavy Mineral Concentrate (HMC) to the Rare Earth Concentrate Plant (RECP).
- Washing, drying and separation within the RECP to produce the following:

- A primary and secondary ilmenite product.
- A monazite product.
- A non-magnetic concentrate (NM Concentrate).

The monazite will be freighted by road directly to a designated Australian port. All other products will be freighted by road to Broken Hill, before being railed to the port or direct to Pinkenba for further processing.

4 NSW RADIATION SAFETY LEGISLATION

The principal framework for the regulation of radiation protection of people and the environment for the Project is stipulated in NSW legislation. The *Protection from Harmful Radiation Act 1990* (hereafter the *Radiation Act*) and the *Protection of Harmful Radiation Regulation 2013* (hereafter the *Radiation Regulations*) outline the requirements for radiation practices in NSW. Practices are typically managed by the radiation branch of the NSW Environment Protection Agency.

However, the *Radiation Act* does not apply to 'Radioactive ore' (*Radiation Regulations*, Clause 4) while it is being mined or processed. Under Clause 47 of the *Radiation Regulations* the resource regulator (namely NSW Mine Safety) has the power to assess, monitor and enforce compliance with health and safety legislation governing mining of radioactive ores and NORM. It is thus likely Project related occupational radiation safety matters will be regulated under the NSW *Mining Act 1992*. It is assumed the NSW EPA will regulate protection of the environment and members of the public.

For the Project, several products including HMC, monazite and NM Concentrate would be classified as 'Radioactive Ore' (refer Section 7) based on its definition.

A regulatory guidance document exists for newly proposed mineral sands operations that generate radioactive residues (NSW DECC 2009). The document stipulates the *Code of Practice for the Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (RPS 9, 2005) must be complied with (hereafter referred to as the *Mining Code*). This is a national code of practice governing how radiation protection and radioactive waste relevant to the mineral sands industry are managed.

A Project activity that would be regulated under the *Radiation Act* requiring a Radiation Management Licence be issued, includes the possession of fixed on-pipe density gauges likely to be used in the WCP or RECP processing plant.

The *Code for Radiation Protection in Planned Exposure Situations, 2016*, RPS C-1 (RPS C-1 2020) (hereafter the 'Planned Exposure Code') is the principal document in Australia that sets out the requirements for the radiation protection of occupationally exposed persons, the public and the environment. The document is produced by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to promote uniformity of radiation protection in practices across all state jurisdictions, and is based on international best practice. For the purpose of this report, protection philosophies as outlined in the *Planned Exposure Code* will be referred to.

4.1 TRANSPORT

The *Code for the Safe Transport of Radioactive Material* (RPS C-2, 2019) (hereafter referred to as the 'Transport Code') adopts the IAEA's *Specific Safety Requirements No. SSR-6 Regulations for the Safe Transport of Radioactive Material*. The *Transport Code* establishes requirements for adoption by the States and the Territories that will maintain a system for safe transport of radioactive material by road, rail, and inland waterways; and also ensure compliance for international shipment (sea and air) if required. The document outlines specific requirements relating to packaging, labelling and documentation of radioactive material.

Whilst the definition of regulated radioactive material is ultimately defined under the local jurisdictions, criteria for the purposes of transport of natural material is contained in paragraphs 401 - 406 of the *Transport Code*. There is a criterion (Clause 107(e)) that applies to the transport of materials containing natural uranium and thorium, where processing of the material is not for extraction of the respective radioactive element. Under this criterion, heavy mineral sand products or by-products may be exempt from the provisions of the *Transport Code* if they have an activity concentration of Th-232 and U-238 of less than $10 \text{ Bq}\cdot\text{g}^{-1}$.

The NSW DECC guidance document suggests that only material defined as a 'Radioactive Substance' with a concentration exceeding $100 \text{ Bq}\cdot\text{g}^{-1}$ (*Radiation Regulations*, Clause 5) under the *Radiation Act* must comply with *Transport Code*.

However, for the purposes of the Project, the Transport Code criteria ($10 \text{ Bq}\cdot\text{g}^{-1}$) should always be applied to ensure consistency with internationally accepted transport requirements. Monazite is the only product for transport exceeding the $10 \text{ Bq}\cdot\text{g}^{-1}$ criteria (refer Section 7).

It is presumed Monazite transport and consignment activities would be regulated under the *Radiation Act* requiring a Radiation Management Licence be issued by the NSW EPA.

It should be noted; the NSW *Dangerous Goods (Road and Rail Transport) Regulation 2022* and the *Australian Code for the Transport of Dangerous Goods by Road & Rail* does not apply in relation to transport of radioactive materials.

5 METHODOLOGY

5.1 RISK ASSESSMENT APPROACH

In radiation protection, the potential for a noticeable health effect is related directly to the total exposure that is received. For biological systems, this is quantified in terms of ' μSv '. The greater the μSv received the greater the 'risk' of an effect. These 'stochastic effects' apply to low-level exposures associated with the Project, as will be demonstrated in this report.

Importantly there are some key aspects of a radiological risk-based approach that must be considered when conducting a conventional environmental impact assessment:

1. **The risk of an effect, measured in ' μSv ', is the result of the sum of all exposure pathways to an individual.** Thus, whilst individual components are addressed in this report, they cannot be assessed in isolation - it is only the sum of considered 'exposure pathways' that is of importance in determining the risk.

2. **Terminology such as ‘significance’, ‘likelihood’ and ‘impact’** are not conventional terms used in personal radiation protection and have been refrained from use in this report when discussing health risks to an individual. Changes in environmental conditions are referred to in this report as an impact, but it is the resulting exposure and subsequent increased risk (i.e. dose) that has been quantified.
3. **For low levels of exposure, there are no threshold values in which ‘no’ risk can be guaranteed.** The effects of low-level exposure to radiation and upper dose limits are based on a linear-no-threshold (LNT) model. Rating exposure components with a graded significance level is contrary to international and national radiation protection philosophy.

There are regulatory dose limits that apply to occupational workers and members of the public. The limit for a member of the public (1000 μSv) is set conservatively low, and considerably less than the annual dose limit to an occupational worker (20,000 μSv averaged over 5 consecutive years) in the interest of keeping doses as low as reasonably achievable (ALARA). Dose limits are discussed further in Section 8.

In relation to the Project radiation assessment, individual exposure components have been assessed and summed (Section 9.9) to enable a total annual dose received to be estimated, allowing direct comparison with the regulatory limits. Importantly, the regulatory limits are considered administrative and not a threshold value for a health effect. It is important to recognise that exposure to any level of radiation represents a potential risk (refer Section 8). Likewise, even in the event an individual was to receive an annual dose exceeding any annual dose limit, in one calendar year, it does not necessarily constitute a significant additional risk of a biological effect.

The majority of projected doses calculated and used for the assessment are considered upper ‘worst-case’ annual doses, rather than realistic potential dose outcomes. No mitigation measures have been considered in the calculated doses. However, they have been discussed, in the context of keeping doses to members of the public to ALARA and are discussed in Section 10.

5.2 DOSE CALCULATION METHODOLOGY

Potential doses were calculated using internationally recognised radiation protection documentation. Australia has adopted the International Commission of Radiological Protection (ICRP) protection framework, with many of the approved dose assessment methodologies also outlined in Australian ARPANSA guideline documents. ARPANSA guidelines were considered in calculating potential annual doses provided in this report. Additionally, the International Atomic Energy Agency (IAEA) is the world’s central intergovernmental forum for scientific and technical co-operation in radiation safety. Where required, international ICRP and IAEA documentation was referred to.

In identifying suitable parameters for dose calculations, there has been some reference to site specific data collected from other project-related technical studies. However, every attempt has been made to apply overly conservative assumptions, irrespective of any Project specific data that is available.

Wherever possible, only primary information such as the maximum radionuclide content of the project materials (ore, products and tailings) as identified from laboratory analysis results have been used, in conjunction with extremely conservative dust resuspension and occupancy assumptions.

The majority of projected doses calculated and used for the assessment are considered upper 'worst-case' annual doses, rather than realistic potential dose outcomes.

5.3 SENSITIVE RECEPTORS

The *Mining Code* recommends that in evaluating compliance with the limit on effective dose to members of the public, the dose to a Critical Group of individuals most likely to be impacted from the Project, should be assessed (RPS 9 2005, p.23).

For the purpose of this assessment, a residential property positioned directly west of the Project Area, at 'Huntingfield', has been considered as the critical group, based on its close proximity to the proposed operations, for the duration of the Project. The area incorporates receptor R1 included in the air quality assessment for the Project (as depicted in Appendix A). Modelling predicts this location to receive the greatest dust concentrations, of all the receptors located off-lease, as a result of the Project (Northstar 2025). It is noted the Mine Camp is located closest to the process plant (<1 km), however predicted dust concentrations are lower at this location.

In addition to considerations of an adult male, the dose received by a 5-year-old child has been included. Children have different anatomical features to adults, and dose conversion factors will differ dependant on the exposure pathway.

Residual doses to the Critical Group are discussed in Sections 9.1 to 9.8 of this report and are summarised in Section 9.9.

Applicability of the impacts to members of the public that are not included in the considered Critical Group is addressed in Section 9.10.

6 POTENTIAL RISKS RELATED TO THE MINING AND PROCESSING OF MINERAL SANDS

6.1 MEMBERS OF THE PUBLIC

In general, radiation hazards to members of the public arise from the mining and processing of heavy minerals through three principal pathways: external irradiation, inhalation, and ingestion. The potential contribution of each exposure pathway will depend on many factors and will differ for each operation.

The specific exposure pathways for consideration are as follows:

- External exposure from the ore body during the mining of ores, and during handling of heavy minerals, or bulk quantities of mineral concentrate;
- Internal exposure from the inhalation of dusts containing elevated levels of radioactive materials;
- Internal exposure from the inhalation of radon gas released from the minerals during mining or processing operations, or from final products;
- Direct ingestion of material during handling of ores, products and tailings; and
- External and internal exposures resulting from the transport of ore or mineral concentrates.

Potential exposure pathways to members of the public include off-site releases of dust or radon gas, as well as the contamination of food and water supplies due to the migration of radionuclides from the mine site during mining operations or following the disposal of tailings. Radioactive material associated with the various heavy minerals or tailings may also have the potential to be dispersed in the environment during processing operations if mitigation measures are not implemented.

7 RADIONUCLIDE CONTENT OF PROJECT MATERIAL

RZ Resources has undertaken detailed metallurgical process development test work and studies on several bulk samples representative of the ore to be extracted at Copi. These studies have produced process streams and a mineral balance for uranium and thorium content in ppm. Using specific activities of 12,440 kBq·kg⁻¹ and 4,070 kBq·kg⁻¹ for uranium-238 and thorium-232 respectively, the equivalent radionuclide concentrations (Bq·g⁻¹) can be determined from the uranium and thorium mass concentrations in ore, products and tailings assumed to be in natural equilibrium and ratios (relative abundance by weight of U-238 in ore is 99.28%).

The radioactive concentration for each source material, including ore, products and waste streams, were identified for each area of the WCP and the RECP, and are presented in Table 1.

A process flow chart for the Copi operations indicating radionuclides of intermediate process streams is discussed further in the occupational assessment report (DBH Nov 2024).

Table 1: Radionuclide content of ore and products, Copi project – March 2025.

Description	tph	Concentrations				
		Uranium mass conc. (ppm)	Thorium mass conc. (ppm)	U-238 (Bq·g ⁻¹)	Th-232 (Bq·g ⁻¹)	Total (Bq·g ⁻¹)
Ore	3000	2-3	10-12	0.031*	0.045*	0.076
Heavy Mineral Concentrate (HMC)	39	146	629	1.80	2.55	4.36
Primary Ilmenite	6.5	24	28	0.30	0.11	0.41
Secondary Ilmenite	13.7	42	96	0.52	0.39	0.91
Monazite	0.3	3094	51400	38.2	208.6	246.9
Non-magnetic concentrate	16.4	187	311	2.31	1.26	3.57

* Average concentrations shown.

Radioactivity concentrations of the tailings, overburden and other materials are represented in Table 2. Tailings consist predominantly of rejects from the WCP, but also RECP rejects originating from the Monazite circuit. These have been combined to provide an average radioactive content (Combined Tailings).

Table 2: Radionuclide content of tailings, rehabilitation materials, Copi project – March 2025.

Description	tph	Concentrations				
		Uranium mass conc. (ppm)	Thorium mass conc. (ppm)	U-238 (Bq·g ⁻¹)	Th-232 (Bq·g ⁻¹)	Total (Bq·g ⁻¹)
Topsoils, overburden	-	0.6 – 2.3	3.7 – 8.6	0.021	0.020	0.041
Interburden [#]	-	0.10	0.83	0.0012	0.0034	0.0046
WCP co-disposed rejects	2960	0.10	0.83	0.0012	0.0034	0.0046
RECP rejects	2.2	371	2080	4.62	8.44	13.1
Combined tailings	2962	0.38	2.4	0.0047	0.0097	0.014

[#] Interburden values assumed from concentrations of WCP co-disposed rejects.

Although most uranium and thorium bearing minerals will be removed as part of the heavy mineral concentrate, there will still be trace amounts in the tailings consisting of the smaller size fraction that is returned to the mine pit for disposal.

Radionuclide concentrations of the combined tailings will be considerably less than that of the natural ore body.

The radioactive content of overburden and topsoils have been obtained from a laboratory analysis of collected samples. Concentrations vary as would be expected dependent on the soil type and its depth and position in relation to the ore body.

8 RADIATION DOSE LIMITS

In relation to radiation protection, Section 2 of the *Planned Exposure Code* stipulates that persons and the environment must be protected from unnecessary exposure to radiation through the process of 'justification', 'optimisation' and 'limitation'. Optimisation is achieved by keeping individual doses 'as low as reasonably achievable' commonly known as the ALARA principle.

Additionally, the Schedules A and B stipulates the following 'limitation' for an individual's annual whole-body radiation exposures in terms of 'effective dose':

- for occupational exposure – 20 mSv per year, averaged over 5 years; and
- for members of the public – 1 mSv (1000 µSv) per year.

The dose limit of 20 mSv per year for occupational exposure would apply to those persons who are exposed as a result of working directly with radiation or radioactive materials (termed 'designated employees'). This annual limit comprises the sum of all exposures, both from external radiation and the intake of radioactive materials. Exposure of employees, who have no direct involvement in the mining, processing, or transport, should be limited in exposure in the same manner as members of the public and subject to the respective annual dose limit of 1 mSv per year.

9 MEMBERS OF THE PUBLIC – OPERATIONS & TRANSPORT

As a result of mining, processing and transport operations, potential sources of exposure to members of the public are the off-site dispersal of airborne dusts or radon, the migration of contaminated groundwater into other water stocks, and post-rehabilitation exposure pathways arising from tailings disposal.

Key risks requiring specific explanation including methodologies and assumptions, outlined within this section include:

- Inhalation of airborne dust arising from operations;
- Exposure to radon gas from operations;
- Consumption of crops and vegetables grown in impacted soils;
- Consumption of contaminated soils;
- Consumption of personal tank rainwater;
- Consumption of locally grown livestock; and
- Exposure resulting from transport of products on roadways and by rail.

Doses for each respective environmental pathway (EP) related to member of the public exposures are summed and presented in Section 9.9 for comparison with the regulatory annual dose limits.

9.1 INHALATION OF AIRBORNE DUST DURING OPERATIONS (EP-01)

It is suspected that any off-site releases of dust during mining or processing operations would lead to negligible doses to members of the public, including residents of neighbouring properties, given the nature of the material, and the substantial dilution with atmospheric dispersion off-site.

However, using available data, the annual dose to a member of the public can be estimated as a result of inhalation of the resuspension of dust arising from the Project. A 'worst case' inhalation dose been calculated.

Several assumptions were considered for the dose assessment of an adult. In situations where a parameter could be considered subjective, a conservative 'worst case' value was used. Full details of assumptions considered for the dose assessment are outlined in Appendix B.

Based on assumed parameters, the maximum annual effective dose to a Critical Group adult member of the public, as a result of inhalation of Project related dust (EP-01) is **1.2 µSv**.

For completeness, exposure to a 5-year-old child was also assessed. An annual effective dose of **0.8 µSv** was calculated.

Calculated doses are less than the annual limit (1000 µSv) but must be considered in summation with all exposure components (Section 9.9).

Potential exposures resulting from the deposition of resuspended dust on crops, and subsequent consumption is addressed separately in Section 9.4.

9.2 EXPOSURE TO RADON/THORON GAS (EP-02)

Inert radioactive gases are released from minerals containing uranium and thorium. The radioactive gases of interest are radon-222 and radon-220. From the perspective of potential radiation exposures from these radioisotopes, the most important radionuclide is radon-222 (commonly termed 'radon' gas), being a decay product of radium-226. Radon-222 has a relatively longer half-life (3.8 days) compared with radon-220 (55 secs). Radon-220 is a member of the thorium-232 natural series and is commonly termed 'thoron' gas.

The inhalation of radon and thoron at significantly high concentrations can lead to radiation doses to lung tissue from their respective short-lived decay products. The potential levels of radon and thoron gases in mineral sand mining and primary separation will depend on the rate at which it emanates, or escapes, from the ore or mineral product, and the level of ventilation in the area where these materials are handled, produced, or stored.

In mineral sands operations, the physical structure of the heavy minerals mitigates the quantities of radon escaping or emanating from the sand grains. Radon emanation coefficients for minerals have been reported (IAEA 2007 p.32, IAEA 2013 p.13) to be, on average, an order of magnitude below that of rocks and soil. The low radon emanation coefficient in heavy minerals is attributable to the fact that the escape of radon is inhibited due to radium-226, like its parent uranium-238, being incorporated within the crystal lattice of the mineral.

The same reasoning could be applicable to thoron emanation. However, it would be expected that the emanation rate would be even more diminished because of the very short half-life of thoron. This fact

has been supported by thoron measurements in other studies of mineral sand processing plants (PIL 2003).

Additionally, emanation rates for radon are inversely proportional to the grain size (UNSCEAR 2000, p.97). An important consideration, as the ore undergoing processing has a median (P50) particle size of approximately 130 μm . The minimum average particle size (d50) of final products is expected to be at least 70 μm (RZR 2022).

Modelling was undertaken (Northstar 2026) to identify concentrations of radon-220 and radon-222 at receptor R1 based on the emission from considered sources, and air quality. Multiple emission sources were considered namely the HMC stockpile located at the mine dredge, the HMC stockpile located at the processing plant, and intermediate and final product located within the processing plant. Annual averages concentrations were estimated. For completeness, concentrations were estimated for multiple receptors. Using recognised conversion factors, annual doses were estimated based on the exposure to the airborne concentrations that were modelled. Full details of assumptions and parameters considered for the dose assessment are outlined in Appendix B.

Based on assumed parameters, the maximum annual effective dose to a Critical Group adult or child member of the public, as a result of inhalation of both Rn-222 and Rn-220 (EP-02) is **<0.1 μSv** . (the calculated dose at R1 is 0.034 μSv , and the highest dose calculated for any off-project receptor).

Calculated doses are less than the annual limit (1000 μSv) but must be considered in summation with all exposure components (Section 9.9).

9.3 CONSUMPTIONS OF VEGETABLES OR CROPS GROWN IN IMPACTED SOILS (EP-03)

The exposure pathway was considered in relation to an individual receiving a radiation dose as a result of the ingestion of locally grown produce which may have been impacted by the Project. The scenario considered a member of the public growing vegetables in their personal garden.

Production cropping is primarily undertaken in close proximity to major water sources and not in the vicinity of the Project site (EIS Copi, p6-211). Thus, whilst the assessment of any mass-produced product grown locally is not warranted, it was included in the scenario for completeness.

Based on internationally recognised models for predicting radionuclide transfer rates in terrestrial and freshwater environments (IAEA 2010), the annual dose to a member of the public can be estimated as a result of the consumption of the vegetables containing radioactive material. Assumptions can be made on the quantity of vegetables consumed by an individual in a year to enable an annual dose to be estimated.

The consumption of soils directly arising from airborne dust resettling as a result of general farming activities has been considered separately (Section 9.4).

9.3.1 Baseline exposure

Prior to considering potential doses as a result of the Project, baseline doses were calculated based on an individual consuming vegetables assumed to be grown in the region.

Estimates of natural uptake of radionuclides in representative vegetables was calculated. There are internationally recognised models for estimating radionuclide transfer rates in terrestrial and freshwater environments (IAEA 2010). Soil-to-plant transfer factors are available for temperate environments and enable uptakes to be estimated. The factors vary considerably depending on the plant group, the soil type and the radionuclides present in the soil.

The uptake of key radionuclides was calculated for a designated farming area (Table 3). In the absence of specific farming region soils, nine topsoil samples collected from the environmental monitoring station locations (EM1-EM9) were used as representative samples. Locations are depicted in Appendix A. Average topsoil radionuclide concentrations were determined from samples analysed. Results are typical of radioactivity normally encountered in soils in Australia

Table 3: Average dust concentrations assumed in representative garden, baseline – March 2025.

Farming Area	Average Radioactive content (ppm)	
	Uranium	Thorium
General	0.60 ± 0.08	3.7 ± 0.6

Estimated doses to an adult and a 5-year-old child as a result of consumption of these crops were calculated and are shown in Table 4.

Assumed parameters used for the calculations are outline in Appendix B.

Table 4: Estimated annual radiation doses from diet including consumption of vegetables grown in representative garden, baseline – March 2025.

Farming Area	Vegetable type assumed	Prospective Annual Dose (mSv)	
		Adult	5 yo child
Central	Leafy vegetables	0.1295	0.220
Central	Cereals/grains	0.0349	0.083

For comparison purposes, the world average annual radiation dose as a result of the ingestion of any radioactive material varies considerably from 0.2 mSv – 1.0 mSv (ARPANSA 2015).

It is not plausible that an individual's entire annual diet of vegetable would originate entirely from one vegetable garden, or farming area (particularly once in an arid area with poor soils such as that surrounding the Mine Site), and is more likely to originate from around Australia, where the naturally occurring radioactive material within soil types will differ considerably. The natural radioactivity content within a cultivated crop may vary by orders of magnitude dependant on the soil type, cultivation methods,

addition of fertilisers, etc. Some super phosphogypsum fertilisers contain significantly elevated concentrations of radioactivity in the form of radium (RPS 15, 2008, p. 105) and in concentrations far in excess of those encountered in dust associated with the Project.

It must be stressed, the baseline doses reported in Table 4 are indicative only, intended for the purposes of estimating an additional risk due to the Project - calculated in Section 9.3.2. Local uptake factors may differ from those used for this assessment.

The uptake of naturally occurring radioactive potassium-40 in crops and resulting doses have not been considered in the assessment.

9.3.2 During operations

Firstly, considering the effects of contaminated soil on vegetable uptake, the dust modelling conducted (Northstar 2025, Tables 19, 24) provides estimates of gross dust concentrations deposited at various receptor locations within and outside the Project area. Using conservative average annual deposition rate, the impact on soil concentrations in which vegetables or crops may be grown can be estimated. Resulting doses can be calculated for comparison with the baseline doses already calculated.

Assumed parameters used for the calculations are outlined in Appendix B.

Calculated doses are shown in Table 5. Doses have been calculated for different annual periods from commissioning, namely Year 5 and Year 17. The results calculated for each annual period can be compared with the baseline dose estimates, which have been reproduced in column 3 of Table 5.

Table 5: Estimated Adult annual radiation doses from consumption of crops grown in soils, years 5 and 17 – March 2025.

Soil Sample Location	Vegetable type assumed	Annual Dose Baseline (mSv)	Annual Dose Year 5 - adult (mSv)	Annual Dose Year 17 - adult (mSv)
Central	Leafy vegetables	0.1295	0.1299	0.1308
Central	Cereal/grains	0.0349	0.0350	0.0353

Of the vegetable types chosen, 'leafy vegetables' represented the greatest incremental dose.

Even after the 17 years of exposure of soils to deposited radionuclides, and assuming the very conservative assumptions, the annual doses calculated are only marginally greater than the calculated baseline doses. The additional, project-related, dose to an adult as a result of ingestion of leafy vegetables would be **1.3 µSv**.

A similar dose can be calculated for a 5-year-old child considering age-related food consumption rates and dose conversion factors. The expected annual dose would be **2.4 µSv**.

The additional dose equates to less than 1% of the dose that would be received anyway, by an adult or a child, as a result of vegetable uptake of naturally occurring radionuclides already present in the soils. Considering the variation in natural radioactivity encountered in soils worldwide (UNSCEAR 2000,

p.116) the impact of dust deposition on existing soil concentrations as result of the Project is considered of inconsequential statistical significance.

In summary, the maximum annual effective dose to a Critical Group member of the public, as a result of consumption of vegetable in local soils (EP-03) is **1.3 μSv** for an adult, and **2.4 μSv** for a child.

Calculated doses are less than the annual limit (1000 μSv) but must be considered in summation with all exposure components (Section 9.9).

9.4 CONSUMPTION OF CONTAMINATED SOILS (EP-04)

The inadvertent ingestion (swallowing) of soil is an important human exposure pathway to consider. Possible pathways include:

- The ingestion of soil containing radioactive material as a result of farming activities. In the outdoor environment, this will be of importance to local farmers who are likely to come into regular direct contact with surface soils.
- The inadvertent consumption of soils by children during daily activities. Young children are particularly prone to ingest soil as they have greater contact with soil during play and have not developed avoidance strategies of older children and adults (enHealth 2012, p.124).

Assumed parameters used for the calculations are outlined in Appendix B.

Using these conservative assumptions, the maximum annual effective dose to a Critical Group member of the public, as a result of ingestion of soils and settled dusts (EP-04) is **0.5 μSv** for an adult, and **3.1 μSv** for a child.

Calculated doses are less than the annual limit (1000 μSv) but must be considered in summation with all exposure components (Section 9.9).

9.5 CONSUMPTION OF PERSONAL TANK RAINWATER (EP-05)

Tank water collected from roofing rainwater run-off has been considered. Resuspended dust from the Project that settles on a household roof could be washed directly into a tank during a rain event. If a member of the public relies on this water as a primary drinking source, consumption could potentially result in an uptake of radionuclides and a dose being received.

When considering the exposure pathways of resuspended project dust, we need to consider two components – the soluble and insoluble fractions once the dust enters the tank.

Soluble component

The ore is a medium-fine sized sand, with a high specific gravity. The ore would preferentially sink to the base of the tank rather than remain suspended.

The soluble fraction is of most interest from a drinking water perspective. The minerals are naturally highly insoluble, particularly the uranium. If any component of the dust is of interest from a radiological

health perspective, it is the radium content, which is a by-product of uranium and thorium decay series (ARPANSA 2008, p17).

The solubility of radium in water is highly variable. A suitable leachability test for radionuclides ASTM Standard Test Method, D4319-93 is used for radionuclides. The leachability factor, k_d , varies by a factor of 12 – 950,000 and dependent on the soil type (IAEA 2010, pp 33-36). This leachability property is a naturally occurring phenomenon. It is identified groundwater in varying concentrations in Australia (ARPANSA 2008). Often groundwater samples demonstrated gross alpha and beta radioactivity concentrations exceeding the 0.5 Bq.L^{-1} drinking water guidance value (ADWG 2011). The leachability of the Copi ore into groundwater, and water generally, is likely to be consistent with other heavy mineral deposits in the Murray Basin (WIM 2024).

However it must be considered, the radioactive content of any project related airborne dust settling on a rooftop will be considerably less than that of the ore (Northstar 2025, p 107,109). Subsequently, the impact of the deposited dust on the soluble radioactive component of collected rainwater will be less than that of the buried ore body on groundwater.

In conclusion, the dust collected in rainwater tanks is expected to not contribute to the existing soluble radioactive component and is unlikely to be identifiable from any natural occurring variability.

Insoluble component

Consumption of the insoluble dust component settled at the base of the rainwater tank, in a drinking water supply is considered unlikely. Any household water filtration system would remove any insoluble fraction should it resuspend in the tank.

However, for the purposes of the radiation assessment a worst-case dose can be calculated.

Several assumptions were considered for the dose assessment and are outlined in Appendix B.

As a result of the consumption of an insoluble radioactive component, the maximum annual dose to an adult would be **0.9 μSv** , and for a 5-year-old child the maximum estimated dose is **1.7 μSv** .

Sum of soluble and insoluble components

Both fractions considered, the total annual dose to an adult would be **0.9 μSv** , and for a 5-year-old child the estimated dose is **1.7 μSv** . For the purposes of the risk assessment this can be considered a reasonable maximum projected dose from the consumption of drinking water from rainwater tank supply, both soluble and insoluble components considered.

Calculated doses are less than the annual limit (1000 μSv) but must be considered in summation with all exposure components (Section 9.9).

9.6 CONSUMPTION OF LOCALLY GROWN LIVESTOCK (EP-06)

It is noted that local land use is predominantly used for grazing including sheep and lambs, meat cattle and goats (EIS Copi, p6-211).

Internationally recognised literature (IAEA 2010, Part 6) discusses the transfer of radionuclides to livestock in the natural environment. It is recognised the ingestion of contaminated feed is the major

pathway for livestock, and the ingestion of contaminated feed and the absorption and retention of that feed, that will ultimately determine radionuclide content in animals. Absorption values differ only slightly for ruminants (cattle) in comparison with monogastric animals (pigs, hens, and humans). Transfer to tissue and milk products will be largely dependent on an animal's diet including feeding strategies, agricultural practices, and local seasonal conditions.

The human consumption of any grazing animals and related produce is seen as an inconsequential exposure pathway relative to other pathways assessed. This decision was based on the low radioactive content of the dust, and the estimated doses to a member of the public as result of crop consumption (Section 9.3) already being of inconsequential value.

The consumption of locally produced livestock (EP-06) is considered a negligible exposure pathway to a member of the public and has not been considered further.

9.7 DUST INHALATION AND INGESTION GENERATED FROM PRODUCTS AND ORE CONTAMINATION REMOVED FROM SITE (EP-07)

For consideration is the partner of a worker responsible for the regular handling of potential contaminated work clothing for the purpose of laundering. There is the potential for the inhalation of dried ore or related product dust that has accumulated on clothing, or the direct ingestion of soils from poor hygiene practices in the home. The Project will be a drive-in drive-out operation, with workers leaving work clothing on site for laundering, however the scenario has still been considered.

Prolonged exposure to resuspended airborne dust has been considered in Section 9.1 (EP-01). Prolonged daily ingestion of radioactive particulate was considered in Section 9.4 (EP-04). Both scenarios considered continuous exposure at elevated airborne concentrations to ore material over a calendar year. Laundering operations, and other periods of exposure to family members of workers, will be of considerably less duration, and subsequently the potential dose will be considerably less.

The exposure pathway as result of dust inhalation and ingestion from ore and products transferred off-site on clothing (EP-07) is considered negligible and has not been considered further.

Suitable controls will be established at the site exit point to minimise contaminated vehicles, equipment, and workers clothing leaving site.

9.8 EXPOSURE DURING TRANSPORT OF PRODUCTS (EP-8 – EP-10)

Dose estimates are calculated as a result of exposure of a member of the public due to external gamma radiation under certain conditions during the transport of products. Estimates for members of the public have been assessed for several scenarios involving the transport of products from the Copi site to Broken Hill and the Port of Adelaide.

Products will be contained at all times during transport, therefore, radiation exposure arising from the inhalation, ingestion or resuspension of product into the air has not been considered in the scenarios.

9.8.1 Scenario 1 – Exposure to a passenger vehicle following a truck loaded with product, (EP-08)

With respect to the scenario in which an individual in a passenger vehicle is following a truck loaded with any product, gamma radiation dose rates in the passenger vehicle would be indiscernible from natural background levels. This conclusion is based on a separation distance between the passenger vehicle and truck of 25 metres. This is considered a conservative assumption given that, on an open road at speeds of 100 km/h, the minimum separation distance is recommended to be 60 metres (NSW Transport 2025).

In an extreme case, a passenger vehicle may follow behind a truck at an average separation distance of only 5 metres (typical perhaps in a busy rural township with traffic lights), on multiple occasions totalling 1 hour per year. Even with separation distances reduced, the estimated maximum dose would be less than **0.8 µSv** per year for monazite.

Considering the same scenario for a load of NM Concentrate or Ilmenite, the annual dose is <0.1 µSv.

9.8.2 Scenario 2 – Exposure to a resident living on a trucking route (EP-09)

This scenario relates to a resident living on a trucking route and receiving a gamma radiation exposure as a result of the proximity of trucks loaded with products regularly passing by their property. Conservatively a 2-second exposure time has been considered per passing truck, and an average separation distance of 10 metres between the truck and a resident of the property. 60 trucks of Monazite, 2,800 truckloads of NM Concentrate, and 2,400 truckloads of Secondary Ilmenite have been assumed to pass in one year resulting in a total exposure time of 3.0 hours per annum. The scenario assumes an individual is residing 24/7, 365 days per year, and does not leave the property during this period. Under this scenario, the estimated maximum dose would be less than **0.1 µSv** per year.

9.8.3 Scenario 3 – Exposure waiting at a rail crossing while a freight train of concentrate passes (EP-10)

This scenario relates to a passenger vehicle stationary at a railway crossing whilst a train loaded with NM Concentrate or Ilmenite is passing by. Assumptions for the calculations include exposure to a bulk quantity of material (IAEA 2006, Appendix III) with a separation distance of 2 metres between the occupant of the passenger vehicle and the passing train, and an exposure period over the year totalling 2 hours. Under this scenario, the estimated maximum dose would be less than **0.4 µSv** per year.

9.9 CRITICAL GROUP ASSESSMENT

As discussed in Section 5.3, for the purpose of this risk assessment, residents residing located directly west of the Project area at the 'Huntingfield' residence have been chosen as a representative Critical Group. The area is represented as Receptor R1 in Appendix B.

The total annual dose has been estimated for an adult resident. For completeness, the potential dose received by a 5-year-old child has also been calculated.

Summarising the various exposure pathways assessed in Sections 9.1 - 9.8 of this report, the estimated doses and associated assumptions are reproduced in Table 6. Dose components have been summed to provide a total annual dose in 'µSv'.

Table 6: Estimated annual radiation doses for a Critical Group individual – March 2026.

ID	Exposure pathway	Annual Dose (μSv)	
		Adult	Child (5 yo)
EP-01	Airborne dust inhalation, 20% ore, 1 μm AMAD, 50% outdoor occupancy at residence, age-related breathing rates	1.2	0.8
EP-02	Radon and thoron inhalation dose, 50% outdoor occupancy at residence.	<0.1	<0.1
EP-03	50% of annual leafy vegetable consumption grown locally. Ore deposition at 1 $\text{g}/\text{m}^2/\text{month}$, distributed evenly through top 20 cm of soil.	1.3 ^a	2.4 ^a
EP-04	Ingestion of soils impacted by dust deposition; 20% ore fraction assumed.	0.5	3.1
EP-05	Drinking tank rainwater water impacted by runoff from a roof, 50% ore, soluble and insoluble considered.	0.9	1.7
EP-06	Consumption of locally grown livestock	negligible	negligible
EP-07	Inhalation and ingestion of dust during laundering of contaminated clothing	negligible	negligible
EP-08	Following truck loaded with monazite, 5 metre separation distance, 1 hr/year	0.8	0.8
EP-09	Resident on trucking route, 24/7 occupancy, 10-metre separation.	0.1	0.1
EP-10	Passenger at a rail crossing while a freight train of product passes, 2 hrs/year	0.4	0.4
Total:		5.3 μSv	9.4 μSv

a: For Year 17 of operations only, after 17 years of dust deposition. Prior years the dose will be less.

The calculated maximum annual doses of **5.3 μSv** for an adult, and **9.4 μSv** for a child, are both considerably less than the dose limit applicable for a member of the public of **1000 μSv** per annum.

The calculated doses should be considered upper ‘worst-case’ annual doses that are unlikely to be exceeded even in the worst possible meteorological conditions.

The estimates and limits do not include dose contributions from natural background radiation of approximately 1,500 μSv per year (ARPANSA 2015).

9.10 NON-CRITICAL GROUP MEMBERS OF THE PUBLIC

The Critical Group assessment assumes occupancy at a residence located at Receptor R1. This assessment resulted in an extremely conservative dose being estimated for the Critical Group.

It can be concluded that other members of the public, irrespective of the location of residence, workplace or schooling in relation to the distance from Project operations would receive a radiation dose most likely less than, but no more than **5.3 μSv** per year for an adult and **9.4 μSv** for a child, as a result of operations.

The calculated maximum annual doses are considerably less than the dose limit applicable for a member of the public of **1000 μSv** per annum.

10 MITIGATION MEASURES

Section 2 of the *Planned Exposure Code* stipulates that persons and the environment must be protected from unnecessary exposure to radiation through the process of 'justification', 'optimisation' and 'limitation'. Optimisation is achieved by keeping individual doses 'as low as reasonably achievable' (ALARA) considering all potential exposure pathways. However, the concept of Optimisation, and ALARA is to be achieved by taking a graded approach, balancing risk and benefits, and considering both economic and social effects. One of the methods of Optimisation is to implement suitable mitigations to minimise exposures to an acceptable level.

As demonstrated in Section 9.9, the maximum dose recorded, that being for a 5-yo member of the public, under worst-case environmental conditions is **9.4 μSv** - or <1% of the upper regulatory limit of 1000 μSv . The implementation of any mitigations is likely to reduce the possible public dose received, despite the exposure risk already being low.

Irrespective of any decision to introduce mitigations for the purposes of reducing the radiation doses to a member of the public, mitigations will be implemented on the project for other reasons, which are likely have a direct impact on reducing doses to a member of the public.

Mitigations will be applied for:

- **Minimising radiation doses to occupational workers.** Workers on the Project will receive a greater radiation dose than members of the public as they will be directly handling the ore, intermediate and final products, and tailings. Introduced mitigations to minimise the resuspension in air of Project-related particulates in the mining pit and processing plant for workers, will also result in minimising airborne concentrations in the environment outside the Project area.
- **Improving general air quality.** Mitigation to minimise airborne silica, heavy metals and any other airborne contaminants will also mitigate airborne radionuclide dust exposures. Proposed mitigations are outlined in detail in the EIS (EIS Copi, Table A4.1, 8.1-8.5).

11 MEMBERS OF THE PUBLIC – BROKEN HILL RAIL SIDING

Estimated doses have been considered for members of the public as a result of product handling operations at the Broken Hill Rail siding.

Products will be contained at all times during transport, therefore, radiation exposure arising from the inhalation, ingestion or resuspension of product into the air does not need to be considered.

Potential external exposures would be possible if there is direct access to products in storage or transit at the siding. Product will need to be stored in restricted areas such that a member of the public does not receive an elevated radiation dose.

It is reasonable to assume that personnel directly handling the products will receive a radiation exposure. This dose will be largely dependent on the handling techniques adopted. However, these individuals would be considered occupationally exposed persons and not 'members of the public' and their doses will be monitored accordingly. Expected doses to workers at the siding are reported elsewhere (DBH Nov 2024).

12 POST-REHABILITATION EXPOSURE RISKS

The potential risk on members of the public as a result of the disposal of tailings post rehabilitation were assessed.

12.1 TAILINGS LANDFORM EXTERNAL EXPOSURE (EP-11)

The gamma radiation dose at ground level directly above any rehabilitated tailings landform has been considered, with respect to the existing ambient background radiation levels in the region.

The radionuclide concentration of the combined tailings disposed of into the mine pit will be $0.014 \text{ Bq}\cdot\text{g}^{-1}$ (refer Table 2), and less than that of the topsoil/overburden of $0.041 \text{ Bq}\cdot\text{g}^{-1}$. (Note that periodic sampling and analysis for radioactive content of tailings will be required during operations to ensure the higher activity RECP rejects, and WCP co-disposed rejects are adequately blended within the pit).

The overburden placed as capping over the returned tailings is proposed to vary between 10 and 30 metres in thickness across the rehabilitated landform. Using international recognised methods (ICRU 1994), surface air kerma rates can be estimated based on the radioactivity concentrations of soils at the surface.

Considering a member of the public residing on the landform, and 100% occupancy outdoors as a worst-case scenario. Using a calculated air kerma rate of $0.021 \mu\text{Gy}\cdot\text{h}^{-1}$ (excluding potassium-40 contributions), this would result in a total annual dose from terrestrial contributions of approximately $128 \mu\text{Sv}$. *Note, this dose is considered inclusive of background contributions and differs from project-only related doses referenced elsewhere in this report.*

If we consider an alternative scenario where the capping is totally eroded and a member of the public resides on the exposed tailings. Using the same occupancy parameters, an individual's total annual dose from terrestrial contributions would be $49 \mu\text{Sv}$.

So, in summary, if a member of the public resided on exposed tailings, then their natural background dose from terrestrial gamma radiation would be reduced by $79 \mu\text{Sv}$, compared to if they resided on undisturbed soils natural to the area.

In summary, the proposed capping will be sufficient in ensuring the gamma radiation dose rates and thus external exposure from the rehabilitated tailings landform is inconsequential compared to natural background contributions.

12.2 TAILINGS LANDFORM RADON EXPOSURE (EP-12)

The source of airborne radon will be largely dependent on the radioactive concentration of surface soils, among other factors. The exposure to an individual residing on the landform will be dependant on the fraction of time spent indoors vs outdoor, and the thickness of any concrete flooring if present.

Irrespective of any residence construction and occupancy factors, the airborne radon concentration thus resulting in an exposure, will be directly proportional to the radionuclide concentration of the surface materials. As discussed in Section 12.1, the radionuclide concentration of the combined tailings disposed of into the mine pit will be $0.014 \text{ Bq}\cdot\text{g}^{-1}$, and less than that of the topsoil/overburden of $0.041 \text{ Bq}\cdot\text{g}^{-1}$ that will be used as capping over the tailings.

Subsequently, if a member of the public resided on exposed tailings, then their natural background dose from radon exposure would be reduced, compared to if they resided on undisturbed soils natural to the area.

The radon exposure from the rehabilitated tailings landform is considered inconsequential compared to natural background contributions.

12.3 SEEPAGE INTO GROUNDWATER (EP-13)

The Loxton-Parilla Sands hosts the Copi orebody and therefore the Upper Aquifer is the principal groundwater system of interest for the Project (EIS Copi, p6-14). Seven registered bores have been identified within 15km of the area of disturbance with records identifying them being historically for the purpose of stock, domestic water and monitoring purposes. It is reported that several bores could not be located.

The migration of radionuclides from the rehabilitated tailings site into a groundwater aquifer that might be used for drinking, for stock use, or crop irrigation has still been considered in this assessment.

It can be concluded that there will not be any long-term impact on radioactivity levels in groundwater (and subsequently an increased exposure risk) arising from mining, mineral processing and the disposal of tailings. The reasoning for this is as follows:

- *The potential for migration of radionuclides into the groundwater in the area would be similar to the existing situation with the presence of the heavy mineral ore deposits.* The Copi WCP and RECP utilises purely mechanical and gravimetric processes, with no chemical or thermal alteration of the mineral. Consequently, the leachability properties of key radionuclides of U, Th and Ra will not be altered.
- *The overall radionuclide levels in tailings disposed of into the mine void will be lower than that of the original ore.* As reported in Section 7 the activity concentrations of combined tailings ($0.01 \text{ Bq}\cdot\text{g}^{-1}$) is considerably less than the ore ($0.06 \text{ Bq}\cdot\text{g}^{-1}$).

- *Groundwater is already impacted by radionuclides naturally present in the buried ore body. The groundwater is likely to already expected to have a radioactive component (ARPANSA 2008) and as reported for other deposits in the Murray Basin (WIM 2024). Radioactivity analysis of local groundwater will be undertaken to confirm this.*

In summary, based on the characteristic of the tailings waste stream including its radioactive content, the potential for seepage of radionuclides from the rehabilitated site into the existing groundwater system, will be identical to the existing pre-mining conditions. Subsequently there is deemed to be negligible risk as a result of an increased exposure from any effected pathways.

12.4 SEEPAGE INTO SURFACE WATERS (EP-14)

Migration of radionuclides from the rehabilitated tailings landforms site into any local surface water was considered.

There are no major surface water bodies in the vicinity of the mine site. The closest is Lake Victoria located 30km to the south of the Project site and forms an integral component of the regulated Murray River system.

The only local water bodies are dams used potentially for stock and are not used for human consumption. The dams are understood to only contain water seasonally, and only after a major rain event.

The arguments related to the potential impacts on groundwater are similar to the impacts on any surface waters. Any leaching will be dominated by radioactivity already naturally present in topsoils and overburden. The introduction of any tailing's material to the soils, will only dilute existing radioactivity concentrations further.

13 EMERGENCY SCENARIOS

13.1 MAJOR ROAD ACCIDENT INVOLVING TRUCK SPILL OF PRODUCT

A scenario is considered where there is a road accident involving a haulage truck. This accident could result in the spill of a significant quantity of concentrate.

Under this scenario, a member of the public could be near the spill and/or the bulk shipment with an average separation distance of 3 metres for a 1-hour period, perhaps as sentry assisting the driver until clean-up crews arrive. It is assumed for the scenario the concentrate is dry for the entire exposure period, resulting in an airborne dust concentration of $1 \text{ mg}\cdot\text{m}^{-3}$. Also, it is assumed that the product is not covered to minimise resuspension in the air, the individual remains downwind, and no respiratory protection is worn.

Considering a monazite shipment, the estimated maximum dose for the member of the public, using conservative assumptions, is **49 μSv** from a single exposure. The exposure would be considered a 'one-off' exposure is could not be considered a regular annual dose component for a member of the public. The estimated dose is considerably less than the 1000 μSv annual limit.

Expected doses in the event of a spill of NM Concentrate or Ilmenite, considering similar assumptions are **< 1 μ Sv**.

In reality, in the event of an accidental spill of product during road transport, an emergency response plan would be implemented to mitigate the dispersion of material from the accident site and also minimise inadvertent exposure to the driver and other persons. In addition to the RZR emergency response plan, any relevant municipal emergency management plan would likely be implemented.

14 CONCLUSIONS

A radiation impact assessment of the Project has been undertaken by DBH Radiation Pty Ltd.

The radiological risk to members of the public were assessed following calculation of potential radiation doses using internationally and nationally recognised assessment methodologies. Extremely conservative input parameters and assumptions were used for the assessment. In many instances irrespective of any mitigation measures that may be implemented, exposure risks were identified to be negligible.

Irrespective of any prospective radiation doses, RZR will be required to implement sound radiation health physics practices and have an environmental monitoring programme in place to confirm that there are no adverse risks, and to ensure the efficacy of any mitigation measures implemented. The programme will ensure exposures to the Copi Project workforce and members of the public are kept to ALARA in accordance with the 'Optimisation' regulatory principle.

15 GLOSSARY

Absorbed dose (Gy) - the energy absorbed per unit mass by matter (or air) from ionising radiation which impinges on it. The unit of gray.

Activity (Bq) - the measure of quantity of radioactive materials. The unit of becquerel.

ALARA - an acronym for 'as low as reasonably achievable', used in the context of optimization.

Annual Limit on Intake (Bq) - that quantity of a radionuclide which, taken into the body during one year, would lead to a committed effective dose equal to the occupational annual limit on effective dose.

Code of Practice for radiation protection - a document prescribing specific requirements for radiation protection in a particular application.

Collective effective dose (man.Sv) - a measure of the total radiation exposure of a group of people which is obtained by summing their individual effective doses.

Committed effective dose (Sv) - the effective dose which a person is committed to receive from an intake of radioactive material. The unit of sievert.

Controlled area - an area to which access is subject to control and in which employees are required to follow specific procedures aimed at controlling exposure to radiation.

Dose - a generic term which may mean absorbed dose, equivalent dose or effective dose depending on context.

Dose constraint - a prospective restriction on anticipated dose, primarily intended to be used to discard undesirable options in an optimization calculation. In occupational exposure, a dose constraint may be used to restrict the options considered in the design of the working environment for a particular category of employee.

Effective dose (Sv) - a measure of dose which takes into account both the type of radiation involved and the radiological sensitivities of the organs and tissues irradiated. The unit of sievert.

Equivalent dose (Sv) - a measure of dose in organs and tissues which takes into account the type of radiation involved.

Exposure - the circumstance of being exposed to radiation.

Half-life - a unique property of a radioactive substance and is the time taken for half of the radioactive atoms initially present to decay. Half-lives can range from a tiny fraction of a second to millions of years depending on the particular radioactive element.

Ionizing radiation - radiation which is capable of causing ionization, (the process by which one or more electrons are removed from, or sometimes added to, an atom leaving the atom in a charged state).

Minimum detection level (MDL) - the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is indistinguishable from method blank results.

NORM (Naturally Occurring Radioactive Material) - radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides.

Occupational exposure - exposure of a person to radiation which occurs in the course of that person's work and which is not excluded exposure.

Public exposure - exposure of a person, or persons, to radiation which is neither occupational or medical exposure.

Radiation - electromagnetic waves or quanta, and atomic or sub-atomic particles, propagated through space or through a material medium.

Radiation Management Plan (RMP) - a document that includes a description of operations to which it applies, and the measures that are intended to be taken to control the exposure of employees and members of the public to radiation.

Radioactive decay - the spontaneous transformation of the nucleus of an atom into another state, accompanied by the emission of radiation; for a quantity of such atoms, the expectation value of the number of atoms present decreases exponentially with time.

Radioactivity units - the rate at which a radioactive atom disintegrates is used to express the amount of radioactive material. The unit of measurement used is the **becquerel** (Bq) where 1 Bq equals one disintegration per second.

Radioactive waste - radioactive waste means material that contains or is contaminated with radionuclides at concentrations or activities greater than prescribed levels as established by the relevant regulatory authority, and for which no use is foreseen.

Radioactive waste management plan (RWMP) - a document that describes all the facilities and procedures involved in the handling, treatment, storage and disposal of wastes.

Radionuclide - a species of atomic nucleus which undergoes radioactive decay.

Radon - used generically, all isotopes of the element radon, having atomic number 86, but typically used to refer to the radioactive gas radon-222.

Radon progeny - the short-lived products of the radioactive decay of radon-222, namely polonium-218, lead-214, bismuth-214, and polonium-214.

Specific activity - the activity of a radionuclide per unit mass of the element, or the activity of a radioactive material per unit mass of that material.

Supervised area - an area in which working conditions are kept under review but in which special procedures to control exposure to radiation are not normally necessary.

16 REFERENCES

- ADWG 2011. *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*, National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra, 2011 (updated Jan 2022).
- DBH Nov 2024. *Occupational Radiation Dose Estimates, Copi Project*, DBH Radiation, November 2024.
- DBH Jun 2025. *Environmental Radiation Impacts (non-human biota), Copi Project*, DBH Radiation, June 2025.
- ARPANSA 2008. *The Radioactive Content of Some Australian Drinking Waters*, S. Long, S. Sdraulig, L. Hardege, J. McLeish, Australian Radiation Protection and Nuclear Safety Agency Technical Report 148, August 2008.
- ARPANSA 2015. *Ionising Radiation and Health*, ARPANSA, May 2015.
- EIS Copi. *Environmental Impact Assessment*, Copi Mineral Sands Project.
- enHealth 2012. *Australian Exposure Factor Guidance – Guidelines for assessing human health risks from environmental hazards*, Commonwealth of Australia (2012)
- IAEA 1996. International Atomic Energy Agency, *International Basic Safety Standards for Protection against Ionising Radiation and the Safety of Radiation Sources*, Safety Series No. 115, IAEA, Vienna (1996).
- IAEA 2006. International Atomic Energy Agency, *Assessing the need for Radiation Protection Measures in Work Involving Minerals and Raw Materials*, Safety Report Series No. 49, IAEA, Vienna (2006).
- IAEA 2007. International Atomic Energy Agency, *Radiation Protection and NORM Residue Management in the Zircon and Zirconia Industries*, Safety Report Series No. 51, IAEA, Vienna (2007).
- IAEA 2010. International Atomic Energy Agency, *Handbook of Parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments*, Technical Report Series No. 472, 2010.
- IAEA 2013. International Atomic Energy Agency, *Measurement and Calculation of Radon Releases from NORM Materials*, Technical Report Series No. 474, IAEA, Vienna (2013).
- IAEA 2014. International Atomic Energy Agency, *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards*, No. GSR Part 3, IAEA, Vienna (2014).
- ICRP 1994. International Commission on Radiological Protection, *Human Respiratory Tract Model for Radiation Protection*, ICRP Publication 66, Pergamon Press, Oxford, 1994.

ICRP 1995. International Commission on Radiological Protection, *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation dose Coefficients*, ICRP Publication 71, Pergamon Press, Oxford, 1995.

ICRU 1994. International Commission on Radiation Units and Measurements, *Gamma-Ray Spectrometry in the Environment*, ICRU Report 53, 1994.

Northstar 2025. *Air Quality Impact Assessment, Copi Project*, Northstar Air Quality Pty Ltd, Apr. 2025.

Northstar 2026. *Radiation Modelling, Copi Mineral Sands*, Northstar Air Quality Pty Ltd, Mar. 2026.

NSW DECC 2009. *Guidance for Licensing of Mineral-sand Mining that Generates Radioactive Residues*, NSW Department of Environment & Climate Change, June 2009.

NWQMS 2009. *Australian Guidelines for Water Recycling: managing health and environmental risks (Phase 2) – Stormwater harvesting and use*, Natural Resource Management Ministerial Council. July 2009.

PIL 2003. Pillai, P.M.B., Khan, A.H., *Radiological safety and environmental surveillance during the mining and milling of beach minerals and processing of monazite*. Radiat. Prot. Environ. 26 3–4 (2003) 523-532.

NSW Transport 2025. weblink: <https://www.transport.nsw.gov.au/roadsafety/topics-tips/roadrules>

Radiation Act. *Protection from Harmful Radiation Act*, NSW, 1990.

Radiation Regulation. *Protection from Harmful Radiation Regulation*, NSW, 2013.

RPS 9, 2005. Australian Radiation Protection and Nuclear Safety Agency, *Code of Practice and Safety Guide – Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*, Radiation Protection Series No. 9, Commonwealth of Australia, 2005.

RPS 9.1, 2011. Australian Radiation Protection and Nuclear Safety Agency, *Safety Guide – Monitoring, Assessing and Recording Occupational Radiation Doses in Mining and Mineral Processing*, Radiation Protection Series No. 9.1, Commonwealth of Australia, 2011.

RPS 15, 2008. Australian Radiation Protection and Nuclear Safety Agency, *Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM)*, Radiation Protection Series No. 15, Commonwealth of Australia, 2008.

RPS C-1 2020. Australian Radiation Protection and Nuclear Safety Agency, *Code for Radiation Protection in Planned Exposure Situations*, Radiation Protection Series No. C-1, Commonwealth of Australia, 2020.

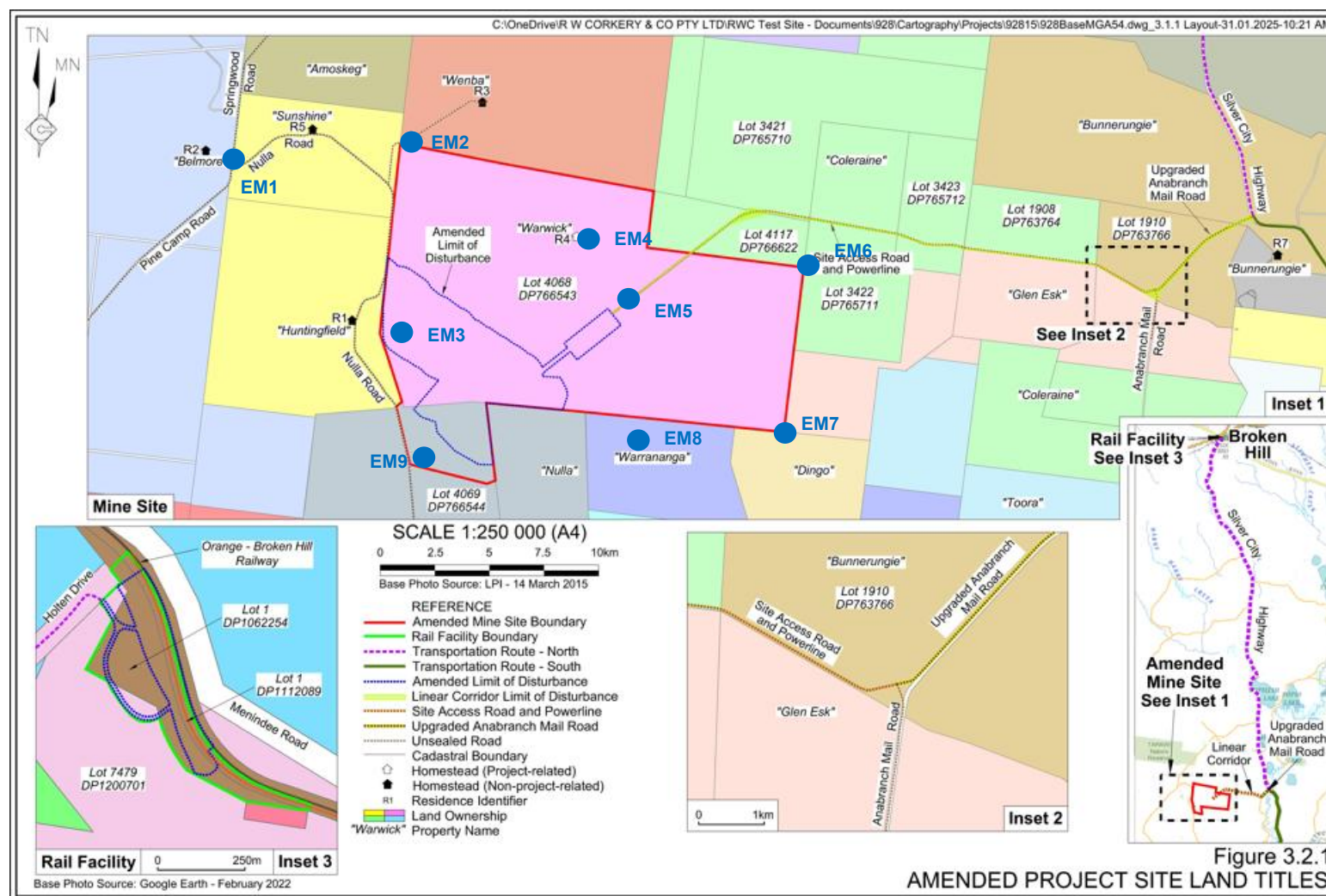
RPS C-2 2019. Australian Radiation Protection and Nuclear Safety Agency, *Code for the Safe Transport of Radioactive Material*, Radiation Protection Series C-2, Commonwealth of Australia, 2019.

RZ Resources 2022. *Product Data Sheets 2022*.

UNSCEAR 2000. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionising Radiation, UNSCEAR 2000 Report to the General Assembly*, United Nations, New York 2000.

WIM 2024. *Environment Effects Statement, Avonbank Project, Chapter 14*, WIM Resource, 2024.

APPENDIX A: SITE PLAN INDICATING AIR QUALITY RECEPTOR LOCATIONS



APPENDIX B: DOSE ESTIMATE PARAMETERS

Inhalation of airborne dust during operations (EP-01)

Assumptions for an adult exposure, including reasonings for the assumptions, are as follows:

- **Dust has an AMAD particle size of 1 μm .** A recommended assumed particle size for dose estimates to a member of the public (ICRP 1994, p.49).
- **Dust concentration of 50 $\mu\text{g}/\text{m}^3$ continuously, corresponding to the predicted maximum 24-hr criterion for concentrations of PM_{10} as outlined in the Northstar report.** For comparison purposes, Northstar predict dust concentrations are not expected to exceed 8.0 $\mu\text{g}/\text{m}^3$ at any Receptors in Year 5 or Year 16 of operations including R1 (corresponding to the location of the Critical Group). An average annual dust concentration of 50 $\mu\text{g}/\text{m}^3$, attributable to the Project is extremely conservative.
- **20% of the dust resuspended to air is Ore.** Project dust will be composed of a blend of overburden, topsoil, and road dust, or any other material resuspended as a result of operations, all with activity concentrations considerably less than the ore itself. It has been identified that ore and mineral concentrates combined would comprise <0.3% of all dust emissions (Northstar 2025, Appendix C).

The non-magnetic products will be stored in a 3-sided enclosure. The Ilmenite and monazite products will remain sealed. All final products are not considered a potential airborne source based on the particle size of >70 μm (RZR 2022).

- **Dose coefficient factor is $1.1 \times 10^{-2} \text{ mSv} \cdot \text{Bq}^{-1}$.** Calculated from consideration of individual Th-232 series radionuclides for a member of the public exposure, 17-year-old adult, (IAEA 1996, Table III.2E). Assumed solubility types as per the ARPANSA Safety Guide (RPS 9.1 2011, Table A2) for occupational exposures.
- **Breathing rate of 0.93 m^3/h .** Breathing rate for an adult male for member of the public dose assessment (ICRP 1995, p.11).
- **Outdoor exposure of 4380 hours.** Equates to 12 hours, 365 days per year, i.e. 50% of an individual's occupancy is outdoors. It can be expected that dust concentrations outdoors will be considerably higher than indoors. 50% outdoor occupancy is considered a conservative estimate, as typically the outdoor occupancy of an individual is assumed to be 20% (UNSCEAR 2000, p.92).

For a child, assumptions on characteristics of the airborne dust are identical to those assumed for an adult male. Those assumptions that differ are:

- **Dose coefficient factor is $1.9 \times 10^{-2} \text{ mSv} \cdot \text{Bq}^{-1}$.** Calculated from consideration of individual Th-232 series radionuclides for a member of the public exposure, 2–7-year-old child, (IAEA 1996, Table III.2E). Assumed solubility types as per the ARPANSA Safety Guide (RPS 9.1 2011, Table A2) for occupational exposures.

- **Breathing rate of 0.36 m³/h.** Breathing rate for 5-year-old child (ICRP 1995, p.11).

Exposure to radon/thoron (EP-02)

airborne concentrations Radon 222 and Radon-220 were modelled (Northstar 2026) at receptors based on estimated emanation rates from key on site sources. Annual average airborne concentrations (Bq·m⁻³) were calculated. Annual doses were estimated based on the concentrations. The following assumptions were considered for the calculations:

- **Three potential sources considered.** Emission sources considered were the HMC stockpile located at the mining dredge (400 m²), and the HMC stockpile located at the processing plant (400 m²). Intermediate and final product located within the processing plant was considered the third source, assuming one week of processed material to be present on site at any one time. Ore within the mining pit was not considered a source as it will be submerged in groundwater.
- **Variations in location of the Dredge HMC Stockpile.** Two modelling scenarios were run with consideration of the dredge stockpile located at either the NW or the SE of the mining footprint.
- **The entire volume is a potential source.** It was assumed that the entire stockpiles and process material is a source and not just shallow material located near the air interface.
- **Decay constants.** For Rn-222: 2.1 x 10⁻⁶ s⁻¹, for Rn-220: 1.24 x 10⁻² s⁻¹.
- **Emanation rates for the mineral.** For Rn-222 a rate of 0.2 (IAEA 2013, Figure 8) and for Rn-220 a rate of 0.02 (IAEA 2013, Table 3). The rates used are considered conservative.

Table B1: Estimated radon emanation rates – March 2026.

Source	Emanation Rate (Bq/s)	
	Rn-220	Rn-222
Dredge HMC Stockpile	8.36E+05	9.99E+02
Plant HMC Stockpile	8.36E+05	9.99E+02
Process HMC material	4.15E+06	4.96E+03

- **Outdoor exposure of 4380 hours.** Equates to 12 hours, 365 days per year, i.e. 50% of an individual's occupancy is outdoors. Considered a conservative estimate, as typically the outdoor occupancy of an individual is assumed to be 20% (UNSCEAR 2000, p.92).
- **Dose conversion factor for Rn-222.** For conversions from radon concentration to effective dose: 6.7 x 10⁻⁶ mSv/Bq.h.m⁻³, assuming an equilibrium factor of 0.4 (RPS 9.1 2011, Table A1 Amended).
- **Dose conversion factor for Rn-220.** For conversions from radon concentration to effective dose: 1.1 x 10⁻⁴ mSv/Bq.h.m⁻³, assuming an equilibrium factor of 1 (RPS 9.1 2011, Table A1 Amended).

Table B2: Estimated radon concentrations and annual doses – March 2026.

Receptor	Rn-220		Rn-222		Total Dose (μSv)
	Concentration ^a (Bq/m ³)	Dose (μSv)	Concentration ^a (Bq/m ³)	Dose (μSv)	
R1	0.00002	0.012	0.0008	0.023	0.034

Note: Maximum concentrations, Scenarios 1 and 2.

Consumptions of vegetables or crops grown in impacted soils (EP-03)

For **baseline calculations**, the following assumptions were considered for the calculations:

- Radionuclide concentrations for U-238 and Th-232 decay chain are assumed to be in equilibrium with their parent. This was confirmed from gamma ray spectrometry and alpha spectrometry of multiple representative samples. Pb-210 concentrations in soils can be greater as a due to washout in the atmosphere and have been assumed directly from gamma spectrometry results.
- 50% of an individual's annual consumption of a particular vegetable of crop type originates from locally grown produce.
- An adult consumes, in total, 238.9 g/day of leafy vegetables (enHealth 2012, p.108). Consumption data is for the average of males and females combined, aged 16-18 years.
- A 5-year-old child consumes, in total, 108.0 g/day of leafy vegetables (enHealth 2012, p.108).
- The estimated annual dose to a member of the public, is calculated assuming absorption of a soluble radioactive species and the corresponding dose conversion factors (IAEA 2014, pp. 224-268).

For **operational impacts**, several assumptions were considered for the dose assessment. In situations where a parameter could be considered subjective, a conservative 'worst case' value was used. Assumptions, including reasonings for the assumptions, are follows:

- **Dust deposition rate of 1 g/m².month.** This dust deposition rate far exceeds the maximum predicted value of corresponds to the maximum predicted value of '< 0.1' g/m².month identified for any of the Receptors, including R1.
- **Ore contributes 20% of the deposited dust.** Project dust will be composed of a blend of overburden, topsoil, and road dust, or any other material resuspended as a result of operations, all with activity concentrations considerably less than the ore itself (Northstar 2025, p 107,109).
- **The deposited dust is homogenously distributed through the top 2 cm of soil.** Consideration has been made that the dust is mixed homogenously through the top 2 cm of natural soil. Mixing could occur as the result of cultivation, seepage following rainfall, or an ore deposition event being interspersed by the deposition of windblown localised dust or soil.

Conservatively, soil in the top 2 cm layer is assumed to be in direct contact with the applicable root system (which could be to a depth of 20 cm).

- **Dust deposition occurs for a 11-year period of mining operations.** It is assumed in the first-year dust is deposited and mixed as per the assumptions above. In the second year, ore is deposited and distributed through the same 2 cm of topsoil, thus contributing to the contamination already deposited in previous years. This process continues for 17 years, essentially resulting in an additive effect to the existing radioactivity present in the soil.
- **None of the vegetables are protected from the weather** (e.g. no shade cloth or greenhouses are in use protecting crops or soils from dust deposition).

Consumption of contaminated soils (EP-04)

Several assumptions were considered for the dose assessment:

- **A soil consumption of 50 mg/day for adults.** Based on recommended values for individuals greater than 15 years of age (enHealth 2012, p.129).
- **A soil consumption of 100 mg/day for a 5-year-old child.** Based on recommended values for children aged 1-15 years of age (enHealth 2012, p.129).
- **20% of the ingested soil has a radioactive content equivalent to that of the Project Ore.** Even considering existing natural radioactivity in surface soils and considering 17 years of dust deposition, activity concentrations of surface soils will still not approach concentrations comparable to ore. Additionally, it would be reasonable to assume an individual's soil uptake will not solely consist of surface soils and could originate from introduced fills, building materials, pollens, etc.

Consumption of personal tank rainwater (EP-05)

Several assumptions were considered for the assessment of the soluble component, and assumed for the calculations:

- **50% of the deposited material is Ore.** Project dust will be composed of a blend of overburden, topsoil, and road dust, or any other material resuspended as a result of operations, all with activity concentrations considerably less than the ore itself (Northstar 2025, p 107,109).
- **A suspended solid concentration of 20 mg/L.** Australian Guidelines for Water Recycling provide collated data of roof water quality in Australia (NWQMS 2009, p.47). Table A2.1 provides summary data for identified suspended solids in roof water, and reports a mean concentration of 17.7 mg/L.
- **A water consumption of 2 litres/day for adults.** Based on recommended values for an adult (enHealth 2012, p.52).

- ***A water consumption of 1.1 litres/day for a 5-year-old child.*** Based on recommended values for a 3- to 6-year-old child (enHealth 2012, p.50).
- An individual's entire annual water consumption originates from the water tank.



ENVIRONMENTAL RADIATION IMPACTS (NON-HUMAN BIOTA)

COPI PROJECT

RZ RESOURCES

Document details	
Document title	Environmental Radiation Impacts (non-human biota)
Document subtitle	Copi Project
Project No.	C24065
Date	30 March 2026
Version	V1
Author	Darren Billingsley, Consultant Health Physicist
Client Name	RZ Resources

Document history				
Version	Revision	Author	Date	Comments
V1	1.1	DB	16/6/2025	Updated following client review
V1	1.2	DB	30/3/2025	Dose quantities clarified further

© Copyright 2026 DBH Radiation Pty Ltd. The concepts, data and information contained in this document are the property of DBH Radiation Pty Ltd. No part of this document may be reproduced, used, copied, published or adapted for use except in accordance with the provisions of the Copyright Act 1968 or with the written consent of DBH Radiation Pty Ltd.

This document has been prepared for RZ Resources to satisfy the scope of work. DBH Radiation Pty Ltd accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this document by any third party. Any third party using and/or relying upon this document accepts sole responsibility and all risk for using and/or relying on this document for any purpose.

This document is based on the information provided, and the assumptions made, as at the date of the document. This document is to be read in full. No excerpts are to be taken as representative of the findings without appropriate context.

EXECUTIVE SUMMARY

RZ Resources Pty Ltd (RZR) plans to develop the Copi Mineral Sands Project (the Project), approximately 75 km north-west of Wentworth, New South Wales.

The Project will involve open cut mining of the Copi mineral sands orebody over a 17.2-year period extracting up to 27.1 million tonnes per year (Mtpa). It will supply rutile, zircon and rare earth element bearing minerals to domestic and offshore markets.

There is a requirement to demonstrate that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human actions such as the Copi Project.

A Tier 2 assessment was undertaken for the Project to identify if an Environmental Reference Level (ERL) was exceeded. Using the ERICA software tool, a site scenario was considered. Namely exposure to biota, in a terrestrial ecosystem within the Project area following 17 years of dust deposition arising from operations. Species of flora and fauna native to the area, and/or referenced in the *Biodiversity Development Assessment Report* for the Project were considered.

The results of the modelling have identified that dose rate values, for all species assessed, are considerably less than ERL values.

It was concluded that even using extremely conservative criteria, the radiological risk on any non-human biota identified in the Project area will be negligible.

TABLE OF CONTENTS

1	INTRODUCTION	4
1.1	Purpose of this report	4
2	REGULATORY REQUIREMENT	4
2.1	Non-human biota (NHB)	4
3	OVERVIEW & SCOPE.....	4
3.1	Scope exclusions	5
4	ENVIRONMENT PROTECTION CONCEPTS.....	5
4.1	Dosimetric quantities for wildlife protection	5
4.2	Reference organisms.....	5
4.3	Environmental Reference Levels.....	6
4.4	Concentration ratios.....	6
4.5	Erica assessment tool and tiered approach	7
5	PROJECT EXPOSURE SETTINGS.....	7
5.1	Natural background	7
5.2	Radioactive concentrations in media.....	8
5.3	Environmental transport.....	8
5.4	Time scales.....	9
5.5	Organisms and pathways	10
5.5.1	Reference organisms	10
5.5.2	Site-specific organisms.....	10
6	RESULTS	12
7	CONCLUSIONS	13
8	REFERENCES	13
	Appendix A – Concentration Ratios for organisms	15

LIST OF TABLES

Table 1:	Radionuclide content of ore, tailings, rehabilitation materials, Copi project – May 2025..	8
Table 2:	ERICA Reference Organisms including default parameters - May 2025.....	10
Table 3:	Site specific organisms – Copi Project, May 2025.	11
Table 4:	ERICA Environmental assessment – Copi Project, May 2025.	12

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

RZ Resources Pty Ltd (RZR) plans to develop the Copi Mineral Sands Project (the Project), approximately 75 km north-west of Wentworth, New South Wales.

The Project will involve open cut mining of the Copi mineral sands orebody over a 17.2-year period extracting up to 27.1 million tonnes per year (Mtpa). It will supply rutile, zircon and rare earth element bearing minerals to domestic and offshore markets.

This report outlines the radiological impact to the natural environment associated with the proposed mine, and processing plant.

2 REGULATORY REQUIREMENT

2.1 NON-HUMAN BIOTA (NHB)

It is generally accepted that there is a need to demonstrate, rather than assume, that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human actions. For the uranium and mineral sands industry, protection should be based on world's best practice standards.

One of the principal objectives of the NSW *Protection from Harmful Radiation Act 1990* is to 'secure the protection of persons and the **environment** from exposure to ionising radiation to the maximum extent that is reasonably practicable'.

3 OVERVIEW & SCOPE

Australia's system for managing radiation risks from ionising radiation is closely aligned with international best practice as stipulated by the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). Protection of the environment from the harmful effects of radiation is integral to these recognised systems.

It is generally accepted that there is a need to demonstrate, rather than assume, that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human actions. In Australia, this is recognized through a regulatory guidance document – the *Guide for Radiation Protection of the Environment* (2015) (RPS G-1, 2015). The Guide outlines the framework for protection of the environment from the harmful effects of ionising radiation and the practical aspects of the process through which protection can be demonstrated. The Guide was used as the basis for the Copi Project assessment.

An Australian 'top-tier' radiation protection document, *Fundamentals for Protection Against Ionising Radiation* (RPS F-1 2014) includes environmental considerations as one of the exposure categories. The document defines environmental exposure as:

“the exposure of wildlife to all additional radiation sources resulting from human activities. Wildlife may require protection in order to maintain biological diversity, conservation of species, or the health and status of natural habitats, communities or ecosystems, or anything that may be otherwise required from a conservation point of view in accordance with relevant legislation.”

The protection objective is to ensure maintenance of robust wildlife populations. This involves demonstrating that radiation exposures are of no regulatory concern in relation to the maintenance of biological diversity, the conservation of species, or on the health of natural ecosystems.

This assessment considers the wildlife inhabiting and potentially impacted within the Copi Project mining footprint.

3.1 SCOPE EXCLUSIONS

The assessment excludes consideration of protection of the environment for recreational food gathering, or the protection of livestock. Land within the Copi Project footprint is currently used for low intensity grazing, including sheep and the harvesting of feral goats (EIS Copi, 3.12.2.2).

Technically, wild goats could be considered as ‘livestock’, however due to their abundance, they have been considered as a wildlife species for the purposes of this assessment.

Potential radiological impacts relating to human exposures are considered elsewhere (DBH 2025).

4 ENVIRONMENT PROTECTION CONCEPTS

4.1 DOSIMETRIC QUANTITIES FOR WILDLIFE PROTECTION

The fundamental dosimetric quantity is the absorbed dose, i.e. the energy absorbed per unit mass of the material with which the radiation interacts. Absorbed dose is measured in the unit ‘gray’ (Gy).

It is relevant to relate the likelihood of occurrence of radiation effects on wildlife to the absorbed ‘dose rate’ resulting from long-term chronic exposures in units of ‘microgray per hour’ ($\mu\text{Gy}\cdot\text{h}^{-1}$).

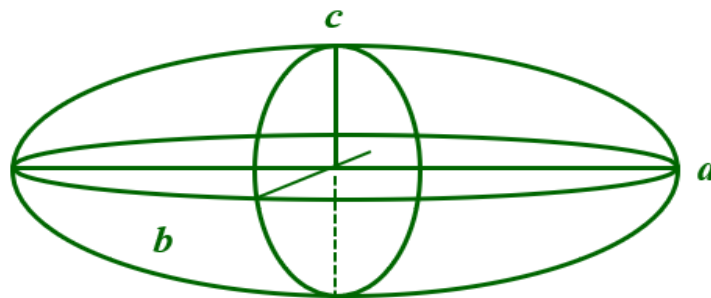
It should be noted the quantity equivalent dose in ‘sievert’ (Sv) as referenced in the public risk assessment (DBH 2025) is only relevant for human exposure and is not referenced in this report.

4.2 REFERENCE ORGANISMS

Among the organisms that inhabit a particular environment where radiation exposures are elevated, it is practical to identify representative organisms, which are typical of that environment or necessary for the structural or functional integrity of an ecosystem exposed to radiation.

As an approximation, and to facilitate assessments with a reasonable degree of confidence, the assessment and decision-making can be built around reference organisms. These are hypothetical representations of wildlife using a simplified (ellipsoid) geometry (Figure 1), and broadly representative of a group of wildlife.

Figure 1: An ellipsoid geometry representative of an assessed organism.



4.3 ENVIRONMENTAL REFERENCE LEVELS

Environmental reference levels (ERLs) are dose rates (in $\mu\text{Gy}\cdot\text{h}^{-1}$) to wildlife, in addition to those incurred from exposure to 'background' radiation, at which a more considered evaluation of the situation and the potential detriment to wildlife might be reasonable, and which should be considered in the overall optimisation process. Calculated dose rates from the assessment are compared to these levels.

Chosen ERLs are defined with different considerations. ICRP considers Derived Consideration Reference Level (DCRL) values, in which stipulated dose rates are a band of dose rates within which there is likely to be some chance of deleterious effect of ionising radiation to individuals of an organism type (ICRP, 2009). IAEA and UNSCEAR instead stipulate dose rates which apply to an organisation population as a whole (IAEA, 1992 and UNSCEAR, 2011).

These ERL's are not dose limits, and do not imply that higher dose rates are environmentally damaging but rather considered a dose rate increment to wildlife above the natural and normal background level, which might result in detrimental health effects in the environment.

4.4 CONCENTRATION RATIOS

The whole-organism concentration ratio ($\text{CR}_{\text{WO-media}}$) is an important value used to quantify the equilibrium activity concentration between an environmental medium and the whole living organism.

For terrestrial biota, as considered for this assessment, the $\text{CR}_{\text{WO-media}}$ value is defined as the ratio of activity concentration whole-body ($\text{Bq}\cdot\text{kg}^{-1}$ fresh weight) to activity concentration in soils ($\text{Bq}\cdot\text{kg}^{-1}$ dry weight).

Where values do not exist, it is deemed acceptable to adopt values from comparable species.

4.5 ERICA ASSESSMENT TOOL AND TIERED APPROACH

The RPS G-1 Guide recommends a graded approach to the assessment of the environment. Whilst radiation protection of the environment has to be clearly demonstrated, it is important a graded approach is applied, commensurate with the actual radiation risks from the Project.

The ERICA software is an internationally recognised assessment tool and allows for the estimation of dose rates from both external and internal exposures based on radioactivity concentrations in wildlife and environmental media. The latest version (2.0.228) was used for this assessment.

The software allows for preliminary Tier 1 assessments of an environment, through to more complex Tier 3 assessments if warranted.

- A **Tier 1** assessment is a basic assessment using conservative radioactivity and site deposition assumptions. It enables 'Risk Quotients' to be calculated and enables sites to be screened out where there is a negligible radiological risk of the populations of non-human species being affected by the presence of the ionising radiation.

A screening dose rate of $10 \mu\text{Gy}\cdot\text{h}^{-1}$ is considered – the value at which 95% of the species in an ecosystem are expected to be protected.

- A **Tier 2** assessment is undertaken if results of a Tier 1 indicate it is warranted. A Tier 2 assessment also allows selection of site-specific reference organisms, modification of default input parameters, and allows selection on how contaminants are distributed in the environment.

ERL's are defined as dose rates in which it is proposed that chronic exposure below these values would result in no measurable population effect ($40 \mu\text{Gy}\cdot\text{h}^{-1}$ for terrestrial animals, birds and amphibians, and $400 \mu\text{Gy}\cdot\text{h}^{-1}$ for plants and other organisms).

- A **Tier 3** is a more complex probabilistic risk assessment in which uncertainties associated with the results may be determined using sensitivity analysis. A Tier 3 assessment is likely only warranted on rare occasions.

A Tier 2 assessment was undertaken for the Project as it allows for the consideration of site-specific organisms.

5 PROJECT EXPOSURE SETTINGS

Project specific data use for the assessment was defined as follows.

5.1 NATURAL BACKGROUND

A detailed assessment of natural background radiation levels is currently underway for the site. This includes measurement of terrestrial radiation levels, airborne radioactive dust, ambient radon concentrations, radioactivity in groundwater, and surface waters.

Identification of the radioactive concentrations of surface soils for the Project areas has been completed.

5.2 RADIOACTIVE CONCENTRATIONS IN MEDIA

Radioactivity concentrations of the ore, topsoil/overburden, and tailings are represented in Table 1. The radioactive concentration of each material is discussed in detail within the public impact assessment report (DBH, 2025).

Table 1: Radionuclide content of ore, tailings, rehabilitation materials, Copi project – May 2025.

Description	tph	Concentrations				
		Uranium mass conc. (ppm)	Thorium mass conc. (ppm)	U-238 (Bq·g ⁻¹)	Th-232 (Bq·g ⁻¹)	Total (Bq·g ⁻¹)
Ore	3000	2 - 3	10 - 12	0.031	0.045	0.076
Topsoils, overburden	-	0.6 – 2.3	3.7 – 8.6	0.021	0.020	0.041
Interburden [#]	-	0.10	0.83	0.0012	0.0034	0.0046
WCP co-disposed rejects	2960	0.10	0.83	0.0012	0.0034	0.0046
RECP rejects	2.2	371	2080	4.62	8.44	13.1
Combined tailings	2962	0.38	2.4	0.0047	0.0097	0.014

[#] Interburden values assumed from concentrations of WCP co-disposed rejects.

Radioactivity concentrations of the ore, topsoil/overburden, and tailings are represented in Table 1, and where applicable used for the assessment. (The radioactive concentration of each material is discussed in detail within the public impact assessment report (DBH, 2025)).

Only long-lived progeny associated with the U-238 and Th-232 decay chain require consideration for the assessment. Progeny with physical half-lives less than 10 days are accounted for accordingly within the ERICA modelling if considered to be in equilibrium with the parent nuclide – as is the case for Copi Project material.

For the purpose of the assessment U-235 and its progeny have been excluded from consideration. The ratio of U-238 to U-235 in the natural environment (and thus the ore) is 0.9928 / 0.0072. If a Tier 2 assessment identified an ERL being exceeded, then U-235 contributions to a species would need to be considered further.

5.3 ENVIRONMENTAL TRANSPORT

Two scenarios were considered, that could result in a potential exposure:

- The resuspension of radioactive material from operations, dispersing and depositing outside the Project footprint; and
- Occupancy of organisms on rehabilitated landforms.

Scenario 1 - Resuspension of airborne radioactivity from operations

RZ Resources | June 2025

The parameters used for the assessment, and the justification for their use is as follows:

- **Dust deposition rate of 1 g/m².month, every month.** This dust deposition rate far exceeds the maximum predicted value of '< 0.1' g/m².month identified for any of the Receptors as outlined in the air quality report (Northstar, 2025). This includes Receptor R1, the position of the receptor representative of the 'Critical Group' for the member of the public assessment.
- **Ore contributes 100% of the deposited dust.** Values used are outlined in Table 1.

In reality, Project dust will be composed of a blend of overburden, topsoil, and road dust, or any other material resuspended as a result of operations, all with activity concentrations considerably less than the ore itself. It has been identified that ore and mineral concentrates combined would comprise <0.3% of all dust emissions for the Project (Northstar 2025, Appendix C).

- **The deposited dust is homogenously distributed through the top 2 cm of soil.** Consideration has been made that the dust is mixed homogenously through the top 2 cm of natural soil. Mixing could occur as the result of cultivation, seepage following rainfall, or an ore deposition event being interspersed by the deposition of windblown localised dust or soil. Conservatively, soil in the top 2 cm layer is assumed to be in direct contact with the applicable root system (which could be to a depth of 20 cm).

Scenario 2 – No environmental transfer, residency on/in rehabilitated landform

Occupancy of an organism on rehabilitated landforms incorporating tailings, including the Off Path Storage Facility will be a likely scenario following rehabilitation. This could include burrowing animals, and vegetation grown on the surface of the landform.

However, this scenario has not been considered further as:

- Tailings are buried at sufficient depth below an overburden cap and are considered inaccessible,
- The tailings have an activity concentration less than the overburden cap; and
- Soil concentrations of the overburden cap are within the range of concentrations identified in topsoils for the area. Surface concentrations will be comparable to identified background levels, and less than that considered as a result of dust deposition considered in Scenario 1.

5.4 TIME SCALES

The assumption is that dust deposition occurs for a 17.2-year period of mining operations.

It is assumed in the first-year dust is deposited and mixed as per the assumptions outlined in 5.3. In the second year, ore is deposited and distributed through the same 2 cm of topsoil, thus contributing to the contamination already deposited in previous years. This process continues for 17 years, essentially resulting in an additive effect to the existing radioactivity present in the soil.

As a result, the activity concentrations assumed for the U-238 decay series radionuclides (including U-238, U-234, Th-234, U-234, Th-230, Ra-226, Pb-210 and Po-210) is 0.210 Bq·kg⁻¹. For the Th-232 series (Th-232, Ra-228, and Th-228) an activity concentration of 0.304 Bq·kg⁻¹ is assumed.

Contributions from 'background' radioactivity already present in topsoil are not included, as per the requirements of the assessment.

5.5 ORGANISMS AND PATHWAYS

5.5.1 Reference organisms

Various terrestrial reference organisms in the ERICA software (Table 2) were included in the assessment.

Table 2: ERICA Reference Organisms including default parameters - May 2025.

Reference Organism	Mass (kg)	Default ellipsoid dimensions		
		a (cm)	b (cm)	c (cm)
Amphibian (ICRP Frog)	0.031	8	3	3
Annelid (ICRP Earthworm)	0.0052	10	1	1
Arthropod	0.00017	1.7	0.61	0.31
Bird (ICRP Duck)	1.26	30	10	8
Flying insects (ICRP Bee)	0.00059	2	0.75	0.75
Grasses & Herbs (ICRP Wild grass)	0.0026	5	1	1.0
Lichen & Bryophytes (ICRP Bryophyte)	0.00017	4	0.23	0.23
Mammal - large (ICRP Deer)	245	130	60	60
Mammal - small-burrowing (ICRP Rat)	0.31	20	6	5
Mollusc - gastropod (ICRP Snail)	0.0014	2	1.5	0.9
Reptile	0.75	116	3.5	3.5
Shrub (ICRP Wild grass)	0.0026	5	1	1
Tree (ICRP Pine tree)	471	1000	30	30

NB: Bracketed text relates to the Reference Animal and Plants (RAP) – a suite of organisms recommended as models by ICRP.

5.5.2 Site-specific organisms

The transfer of radionuclides from the environment to non-human biota is dependent on environmental conditions. Often values used are appropriate for a temperate environment (e.g. a European deer) and may not be as applicable in arid Australian conditions. Thus, in addition to Reference organisms, it is important that consideration is given to species unique to the Australian environment.

It is also important to consider any species that may be directly impacted by the Copi Project, or subject to interest from a biodiversity perspective. Potentially impacted species are discussed in the Project *Biodiversity Development Assessment Report* (EIS Copi, Appendix 6).

For the Copi Project, the following additional species were considered:

- Red Kangaroo (*Osphranter rufus*);

- Emu (*Dromaius novaehollandiae*);
- Feral Goat;
- Rainbow bee-eater (*Merops ornatus*) listed under the EPBC Act.
- Mallee birds – listed under the EPBC Act (specifically the Chestnut Quail-thrush (*Cinclosoma castanotum*) and the Splendid Fairy Wren (*Malurus splendens*);
- Pink cockatoo (*Cacatua leadbeateri*);
- Little eagle (*Hieraaetus morphnoides*);
- Spear grass (*Austrostipa nullanulla*); and
- White Cypress Pine (*Callitris columellaris*).

The considered organisms are outlined in Table 3. Concentration ratios used for the assessment are outlined in Appendix A.

Occupancy Factors have been assigned, as it is important that consideration is given to the habitat of the organism which will dictate the dose received.

The two Mallee birds chosen (Chestnut Quail-thrush and the Splendid Fairy Wren) have been chosen based on their differing habitat (the Chestnut Quail-thrush is more ground dwelling while the Splendid Fairy Wren forages in the lower branches of vegetation as well as on open ground near shelter).

The occupancy rate for the emu of 100% in the air does not reflect the species being in-flight, rather, it is considered to have an axial centre 60 cm above ground level.

Table 3: Site specific organisms – Copi Project, May 2025.

Organism	Mass ¹ (kg)	Default ellipsoid dimensions ¹			Occupancy Factor
		a (cm)	b (cm)	c (cm)	
Red Kangaroo (<i>Osphranter rufus</i>)	36	120	40	40	1.0 on soil
Emu (<i>Dromaius novaehollandiae</i>)	40	80	80	50	1.0 in air
Feral Goat	60	100	100	30	1.0 on soil
Rainbow bee-eater (<i>Merops ornatus</i>)	0.027	20	3	3	1.0 in air
Chestnut quail-thrush (<i>Cinclosoma castanotum</i>)	0.075	24	5	5	1.0 on soil
Splendid fairy wren (<i>malurus splendens</i>)	0.01	13	2.5	2.5	0.5 in air, 0.5 on soil
Pink Cockatoo (<i>Cacatua leadbeateri</i>)	0.37	40	10	10	0.5 in air, 0.5 on soil
Little Eagle (<i>Hieraaetus morphnoides</i>)	0.8	50	20	20	1.0 in air
White Cypress Pine (<i>Callitris columellaris</i>)	471	1000	30	30	1.0 on soil
Spear grass (<i>Austrostipa nullanulla</i>)	0.2	50	50	50	1.0 on soil

Note 1: Various on-line sources were utilised to identify representative weights and dimensions.

6 RESULTS

Using the exposure settings as outlined in Section 5, a Tier 2 assessment in ERICA was undertaken. Results are shown in Table 4.

Table 4: ERICA Environmental assessment – Copi Project, May 2025.

Organism	Dose rate per organism ($\mu\text{Gy}\cdot\text{h}^{-1}$)	Tier 1 Screening value ($\mu\text{Gy}\cdot\text{h}^{-1}$)	Tier 2 Environmental Reference Level ¹ ($\mu\text{Gy}\cdot\text{h}^{-1}$)
Fauna			
Amphibian	0.010	10	40
Annelid	0.013	10	40
Arthropod - detritivores	0.014	10	40
Bird	0.0021	10	40
Flying insects	0.0033	10	40
Mammal - large	0.005	10	40
Mammal - small-burrowing	0.0052	10	40
Mollusc - gastropod	0.0030	10	40
Reptile	0.010	10	40
Red Kangaroo (<i>Osphranter rufus</i>)	0.040	10	40
Emu (<i>Dromaius novaehollandiae</i>)	0.0020	10	40
Feral Goat	0.0048	10	40
Rainbow bee-eater (<i>Merops ornatus</i>)	0.0021	10	40
Chestnut quail-thrush (<i>Cinclosoma castanotum</i>)	0.0021	10	40
Splendid fairy wren (<i>malurus splendens</i>)	0.0021	10	40
Pink Cockatoo (<i>Cacatua leadbeateri</i>)	0.0021	10	40
Little Eagle (<i>Hieraaetus morphnoides</i>)	0.0021	10	40
Flora			
Grasses & Herbs	0.023	10	400
Lichen & Bryophytes	0.091	10	400
Shrub	0.026	10	400
Tree	0.0017	10	400
White Cypress Pine (<i>Callitris columellaris</i>)	0.18	10	400
Spear grass (<i>Austrostipa nullanulla</i>)	0.091	10	400

Note 1: Dose rates in which it is proposed that exposure below these values (of chronic exposure), no measurable population effect would occur (IAEA 1992, UNSCEAR 1996).

The results of the modelling have identified that dose rate values are at least two orders of magnitude less than the $10 \mu\text{Gy}\cdot\text{h}^{-1}$ screening value applicable to Tier 1 assessments.

For completeness a Tier 2 assessment was conducted to allow assessment of Project specific species potentially at risk. Estimated dose rates are less than the respective Tier 2 Environmental Reference Level ($40 \mu\text{Gy}\cdot\text{h}^{-1}$ or $400 \mu\text{Gy}\cdot\text{h}^{-1}$) by several orders of magnitude. The highest dose rate was $0.18 \mu\text{Gy}\cdot\text{h}^{-1}$ calculated for the White Cypress Pine.

7 CONCLUSIONS

It can be concluded that even using extremely conservative criteria, the radiological risk on any non-human biota identified in the Copi Project area will be negligible as a result of proposed operations.

8 REFERENCES

DBH, 2025. *Public Radiation Risk Assessment, Copi Project*, V1.1 2025.

ARPANSA, 2014. *A Review of existing Australian radionuclide activity concentration data in non-human biota inhabiting uranium mining environments*, Technical Report 167, Commonwealth of Australia, 2014.

EIS Copi. *Environmental Impact Assessment*, Copi Mineral Sands Project.

Hirth, G.A., Carpenter, J.G., Bollhöfer, A., Johansen, M.P., Beresford, N.A., 2014. Whole-organism concentration ratios in wildlife inhabiting Australian uranium mining environments. In: (Third) International Conference on Radioecology & Environmental Radioactivity: Conference Programme: 7-12 September 2014, Barcelona, Spain.

IAEA, 1992. Effects of ionizing radiation on plants and animals at levels implied by current radiation protection standards, Technical Reports Series No. 332, IAEA, Vienna.

ICRP, 2009. Environmental Protection: Transfer Parameters for Reference Animals and Plants, vol. 114. ICRP Publication. Ann ICRP 39(6).

Northstar 2025. *Air Quality Impact Assessment, Copi Project*, Northstar Air Quality Pty Ltd, Apr. 2025.

Radiation Act. *Protection from Harmful Radiation Act*, NSW, 1990.

Radiation Regulation. *Protection from Harmful Radiation Regulation*, NSW, 2013.

RPS F-1, 2014. Australian Radiation Protection and Nuclear Safety Agency, *Fundamentals for Protection Against Ionising Radiation*, Radiation Protection Series F-1, Commonwealth of Australia, 2014.

RPS G-1, 2015. *Guide for Radiation Protection of the Environment* (2015) Radiation Protection Series No. G-1, Commonwealth of Australia, 2015.

UNSCEAR 2011. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionising Radiation, UNSCEAR 2008 Report to the General Assembly*, Scientific Annexes C, D and E.

APPENDIX A – CONCENTRATION RATIOS FOR ORGANISMS

Nuclide	Concentration ratio CR ^{wo-soil} (Bq·kg ⁻¹ fw whole organism / Bq·kg ⁻¹ dw soil)					Reference
	U	Th	Ra	Pb	Po	
Amphibian	4.52E-04	5.70E-04	2.00E-01	4.60E-02	8.72E-02	ERICA library
Annelid	3.41E-02	1.12E-02	2.05E-01	4.36E-01	7.63E-02	ERICA library
Arthropod - detritivores	9.55E-02	1.12E-02	2.05E-01	7.02E-01	7.63E-02	ERICA library
Bird	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Flying insects	5.20E-03	2.96E-03	5.31E-02	1.73E-02	7.63E-02	ERICA library
Grasses & Herbs	1.16E-01	1.50E-01	1.66E-01	1.15E-01	2.76E-01	ERICA library
Lichen & Bryophytes	9.11E-01	3.77E-01	7.10E-01	2.60E+00	2.65E+00	ERICA library
Mammal - large	2.84E-03	1.11E-03	8.93E-02	3.85E-02	8.72E-02	ERICA library
Mammal - small-burrowing	2.84E-03	1.11E-03	8.93E-02	3.85E-02	8.72E-02	ERICA library
Mollusc - gastropod	3.41E-02	1.12E-02	2.74E-02	6.89E-03	7.63E-02	ERICA library
Reptile	3.07E-03	9.55E-04	2.00E-01	4.74E-02	9.85E-02	ERICA library
Shrub	5.99E-02	5.97E-02	3.34E-01	3.29E-01	3.50E-01	ERICA library
Tree	6.47E-03	1.15E-03	1.65E-02	4.95E-02	4.18E-02	ERICA library
Red Kangaroo	2.12E-02	1.11E-03	7.60E-01	2.22E-02	1.06E+00	ARPANSA 2014
Emu	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Feral goat	2.84E-03	1.11E-03	8.93E-02	3.85E-02	8.72E-02	ERICA library
Rainbow Bee-Eater	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Chestnut Quail Thrush	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Splendid Fairy Wren	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Pink Cockatoo	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Little Eagle	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
White Cypress Pine	6.47E-03	4.00E-02	1.70E-01	3.90E+01	6.00E-01	Grasses (Hirth et.al 2014)
Spear grass	2.70E-01	2.10E-01	1.30E+00	8.40E-01	4.90E-01	Grasses (Hirth et.al 2014)