Appendix 14a

Public Radiation Risk Assessment

prepared by

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PUBLIC RADIATION RISK ASSESSMENT

COPI PROJECT

RZ RESOURCES

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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’ or ‘negligible’ 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. No mitigations were considered in the calculated doses.

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 **5.2 µSv** and the dose to a child was **9.3 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 (9.3 µSv) equates to 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.

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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.

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 $Bq{\cdot}g^{-1}$.

The NSW DECC guidance document suggests that only material defined as a 'Radioactive Substance' with a concentration exceeding 100 $Bq{\cdot}g^{-1}$ (*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 $Bq{\cdot}g^{-1}$) should always be applied to ensure consistency with internationally accepted transport requirements. Monazite is the only product for transport exceeding the 10 $Bq{\cdot}g^{-1}$ 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’ or ‘negligible’ 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 ($Bq \cdot g^{-1}$)	Th-232 ($Bq \cdot g^{-1}$)	Total ($Bq \cdot g^{-1}$)
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 ($Bq \cdot g^{-1}$)	Th-232 ($Bq \cdot g^{-1}$)	Total ($Bq \cdot g^{-1}$)
Topsoils, overburden	-	0.6 – 2.3	3.7 – 8.6	0.021	0.020	0.037
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).

Furthermore, any radon or thoron gas released to the atmosphere from an ore body or stockpile will be rapidly diluted and dispersed. Therefore, it is likely that in an open pit during mining, radon and thoron concentrations will be close to ambient levels and this exposure pathway will not be of significance.

Consequently, further dilution and atmospheric dispersion of any radon or thoron released will mean that off-site concentrations in the air will not be discernible from ambient levels due to release of natural radon from the surface soils in the area.

Based on the characteristics of the ore, products and tailings, the potential exposure pathway to a member of the public as a result of radon gas emanation (EP-02) is considered negligible.

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, ‘leavy 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, an argument can be made 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 an 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 2025.

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 as a result of Project	negligible	negligible
EP-03	50% of annual leafy vegetable consumption grown locally. Ore deposition at 1 g/m^2/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:	**5.2 μSv**	**9.3 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 **5.2 μSv** for an adult, and **9.3 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 **5.2 μSv** per year for an adult and **9.3 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 **9.3 µSv** - or <1% of the upper regulatory limit of 1000 µSv. An argument could be made that no additional mitigations are warranted for the Project to minimise an already low exposure risk, even though the implementation of mitigations is likely to reduce the possible dose received.

Irrespective of any decision to introduce mitigations, purely 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 concentrations in tailings, disposed of into the mine pit from the primary processing of the mineral sand ore will be less than the original ore (refer Table 1 and Table 2). The concentrations of interburden and overburden will remain unchanged.

Therefore, it is likely that the gamma radiation levels arising from the disposed material would be comparable or less than that currently associated with the undisturbed mineral resource.

Furthermore, rehabilitation of the pit area after disposal will mean that the overburden and subsoil cover will attenuate the gamma radiation field. The radioactivity concentrations in the topsoil, and overburden are less than that of the combined tailings. Consequently, the external radiation dose at ground level will not be significantly different to the ambient background radiation levels that currently exist.

In summary, the proposed capping will be sufficient in ensuring the gamma radiation dose rates and thus external exposure from the rehabilitated tailings landform could be comparable, but most likely less than the current natural pre-mining conditions.

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. In section 9.2 it was explained how the ore body, if exposed at the ground surface, would result in airborne radon concentrations indiscernible from natural ambient levels. For the rehabilitated landform, the topsoil, overburden and subsoils capping, will only further inhibit the release of radon emanating from the underlying tailings into the air.

The proposed overburden and subsoil capping will be sufficient in ensuring the radon emanation from the rehabilitated tailings landform will be comparable to the current natural pre-mining conditions.

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 $Bq{\cdot}g^{-1}$) is considerably less than the ore (0.06 $Bq{\cdot}g^{-1}$).

- *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 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 $mg \cdot m^{-3}$. 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 µSv.**

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.

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APPENDIX A: SITE PLAN INDICATING AIR QUALITY RECEPTOR LOCATIONS

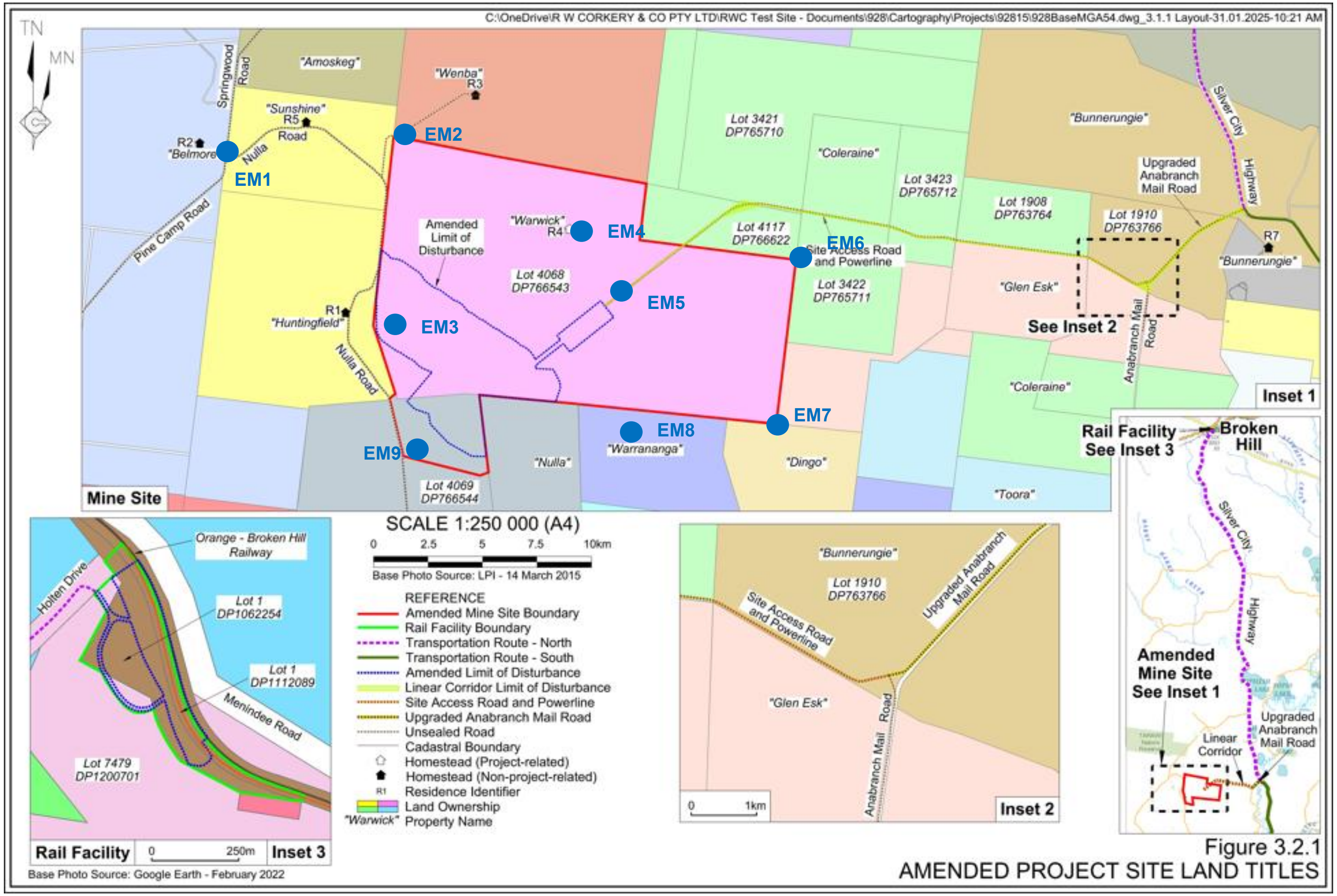

Figure 3.2.1
AMENDED PROJECT SITE LAND TITLES

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 µg/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 µg/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 µg/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 in a 3-sided enclosure. The Ilmenite and monazite products will remain sealed. All final products are not considered a potential are not considered a potential airborne source based on the particle size of >70 µm (RZR 2022).
- ***Dose coefficient factor is 1.1 x 10^{-2} mSv·Bq$_{\alpha}^{-1}$.*** 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 x 10^{-2} mSv·Bq$_{\alpha}^{-1}$***. 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 m^3/h***. Breathing rate for 5-year-old child (ICRP 1995, p.11).

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/m^2.month***. This dust deposition rate far exceeds the maximum predicted value of corresponds to the maximum predicted value of '< 0.1' g/m^2.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.