Appendix F

Air quality impact assessment

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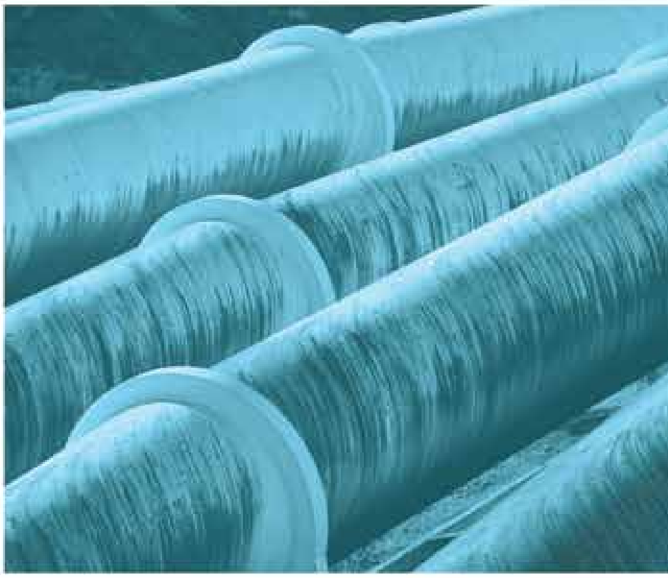
Balranald Mineral Sands Project - Modification of Consent (SSD 5285)

Air quality and greenhouse gas impact assessment

Prepared for Iluka Resources Limited
April 2022



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Balranald Mineral Sands Project - Modification of Consent (SSD 5285)

Air quality and greenhouse gas impact assessment

Report Number

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Client

Iluka Resources Limited

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Version

v3 Final

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1 Introduction

EMM Consulting Pty Limited (EMM) was commissioned by Iluka Resources Limited (Iluka) to undertake an air quality and greenhouse gas assessment (AQGHGA) for the proposed modification (MOD1) to the approved Balranald Mineral Sands Project (the Balranald Project) in south-western New South Wales (NSW).

The purpose of this AQGHGA is to provide a comparison of estimated air quality and GHG impacts related to the proposed modification against the predicted impacts of the approved project. The AQGHGA consists of:

- a description of the proposed modification;
- a summary of the original AQIA prepared for the Balranald Project (ENVIRON 2015, hereafter referred to as the '2015 AQGHGA');
- estimated particulate matter emissions for one worst-case year of the proposed modification;
- a GHG assessment; and
- comparison of particulate matter and GHG emissions between the existing project and the proposed modification.

This report will support a modification report which will be submitted to the NSW Department of Planning and Environment (DPE) under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Project background

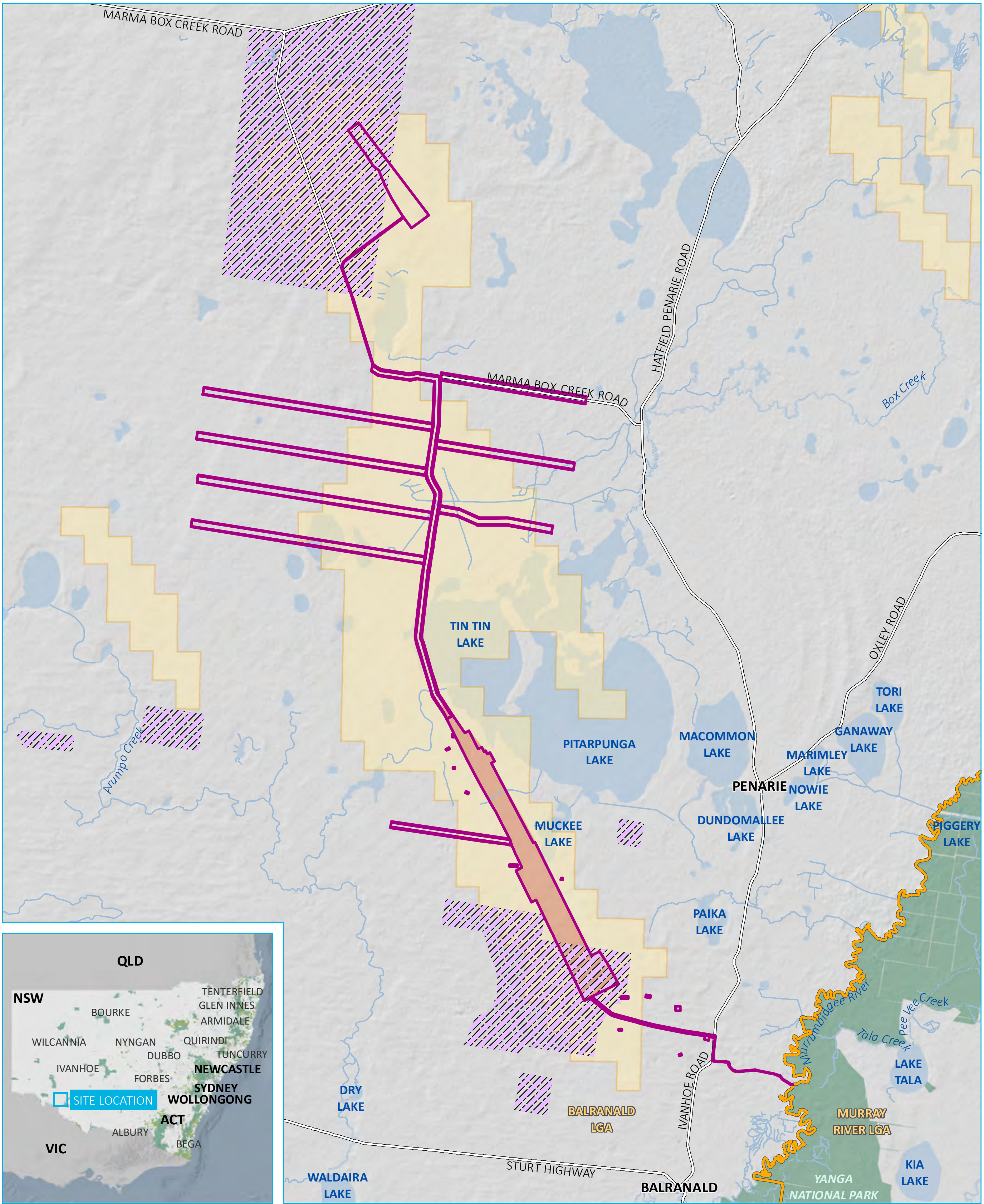
Iluka have approval to develop a mineral sand mine in south-western (NSW), known as the Balranald Project. It includes construction, mining, primary processing and rehabilitation of two linear mineral sand deposits, known as the West Balranald and Nepean deposits, located approximately 12 kilometres (km) and 66 km north-west of the town of Balranald (Balranald town), respectively.

An environmental impact statement (EIS) was prepared and submitted in 2015 to accompany a State significant development (SSD-5285) application under Part 4 of the EP&A Act for an open cut, truck and shovel mining method. Development consent was granted by DPE under Part 4 of the EP&A Act on 5 April 2016. The Balranald Project also included undertaking a bulk sampling activity at the West Balranald mine to test the removal of ore using underground mining methods.

The regional setting and approved EIS project area are shown on Figure 1.1.

Since development consent was granted in April 2016, Iluka has undertaken the approved bulk sampling activity involving the extraction of mineralised material or ore, from depth within the approved disturbance area of the West Balranald mine.

The outcome of the bulk sampling activities confirmed the effectiveness of the underground mining method, validated key elements of the mining unit design and have been used to help guide the proposed modification to inform the potential suitability (ie commerciality and reduced environmental impacts) of underground mining as an alternative method for resource extraction for the Balranald Project.



Source: EMM (2022); GSNSW (2021); Iluka Resources (2018); DFSI (2017); GA (2011); ASGC (2006)

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KEY

- EIS Approved Balranald Project Area (SSD-5285)
- Exploration Licence (EL7450)
- Mining Lease (ML1736)
- Southern Mallee Conservation Area (2015)
- Major road
- Watercourse/drainage line
- Waterbody
- NPWS reserve
- Local government area

INSET KEY

- NPWS reserve
- State forest

Regional Setting and EIS Approved Balranald Project Area (SSD-5285)

Balranald Mineral Sands Project
Air quality impact assessment
Figure 1.1

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1.2 Description of modification

The proposed MOD1 would involve:

- continuing underground mining within a portion of the approved disturbance footprint of the West Balranald deposit pursuant to the consent (ie mining area); and
- development of approved mineral processing infrastructure within a proposed new area of disturbance (ie surface infrastructure).

The construction of infrastructure approved under the development consent would be undertaken to support the construction and operation for proposed underground mining, including mineral processing infrastructure, access roads, upgrade of external roads and intersections, gravel extraction, monitoring infrastructure, accommodation facility, road transport of ore offsite for downstream processing and other infrastructure as required.

The majority of this infrastructure would be required regardless of the mining method (ie open cut as approved under the development consent, or underground). For all other land located outside of the proposed modification area, ie other areas of the West Balranald mine and the Nepean mine, Iluka proposes no change to the currently approved open cut mining method at this stage.

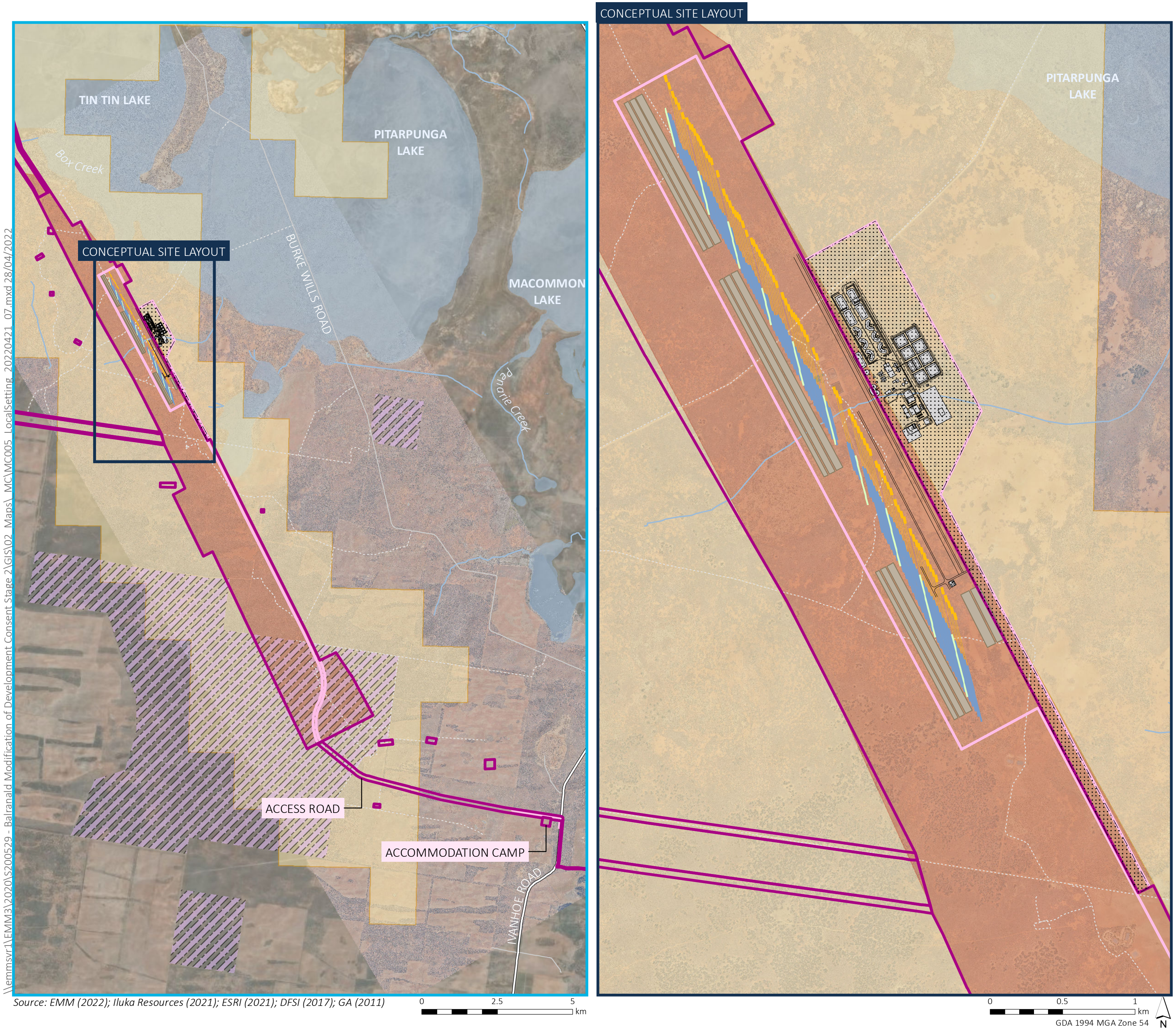
The underground mining process would involve:

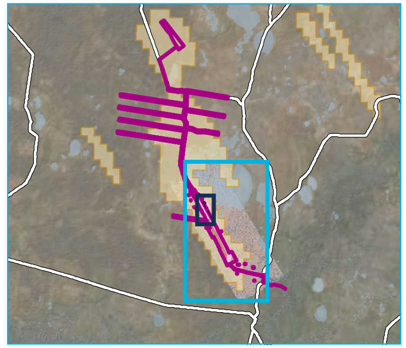
- clearing the footprint directly above the mining area – the area will be stripped of topsoil, subsoil and non-saline overburden to a nominal depth of 2 metres (m);
- surface placement of treated sand tails and overburden/subsoil ahead of mining into the space created by the above stripping;
- underground mining of the ore;
- processing of the mined ore to separate the heavy mineral concentrate (HMC) from sand tails, sand fines and oversize;
- stockpiling of the HMC;
- backfilling of sand fines underground;
- replacement of subsoil and topsoil for rehabilitation and final landform; and
- environmental monitoring activities (including groundwater, geochemistry, subsidence, air quality and noise).

Ore is expected to be produced and processed at a rate no greater than approved under the development consent. The processing plant on site will produce a Heavy Mineral Concentrate (HMC) to generate two primary product streams; magnetic HMC and non-magnetic HMC.

The product would be stockpiled and transported off-site for downstream processing with underground mining operations to be undertaken for a period of 6 years.

The proposed modification study area and conceptual site layout is shown on Figure 1.2.





KEY

- EIS Approved Balranald Project Area (SSD-5285)
- Proposed modification study area
- Proposed modification extension to Balranald Project Area boundary
- Processing area infrastructure
- Subsoil stockpile
- Drill pad and string to underground stope
- Underground stope
- Underground pillar
- Major road
- Minor road
- Existing track
- Watercourse/drainage line
- Waterbody
- Southern Mallee Conservation Area (2015)
- Exploration Licence (EL7450)
- Mining Lease (ML1736)

Source: EMM (2022); Iluka Resources (2021); ESRI (2021); DFSI (2017); GA (2011)

Proposed modification study area and conceptual site layout

Balranald Mineral Sands Project
Air quality impact assessment
Figure 1.2

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2 Summary of the 2015 AQGHGA

The 2015 AQGHGA examined predicted concentrations of airborne particulates, toxic pollutants, and dust deposition and estimated GHG emissions from the approved Balranald Project (SSD-5285).

2.1 Operational dust assessment

The 2015 AQGHGA estimated emissions for three representative years of mining operations (year 1, year 4, and year 8), selected to assess the air quality impacts of worst-case operations. The main activities assessed included soil stripping and handling, overburden handling, open-cut ore mining and handling, product processing, hauling materials and wind erosion from exposed areas.

The estimated particulate matter emissions from the 2015 AQGHGA are replicated in Table 2.1 below. Year 8 was deemed the worst-case year in terms of estimated emissions due to mining operations.

The emission calculations included a range of dust mitigation measures including watering and applying chemical suppressants to unpaved haul routes, and minimising front-end-loader drop heights.

Table 2.1 2015 AQGHGA estimated emissions

Mining year	TSP emissions (kg/y)	PM_{10} emissions (kg/y)	$PM_{2.5}$ emissions (kg/y)
Year 1	1,874,684	587,677	89,269
Year 4	1,941,056	630,969	116,134
Year 8	3,190,476	1,007,639	152,553

The assessment found that the likely intensity of construction emissions would be significantly lower than for operational years. As a result, construction stage emissions were not estimated or modelled.

The predicted ground level concentrations and dust deposition rates associated with the mining years assessed were predicted to be within the EPA impact assessment criteria at all assessment locations and all years. Predicted concentrations of trace metals were also predicted to comply with relevant impact assessment criteria across all years assessed.

2.2 Greenhouse gas assessment

The 2015 AQGHGA estimated Scope 1, 2 and 3 GHG emissions for each of the eight years of mining operations for the Balranald Project.

The key findings of the assessment were:

- annual project GHG emissions calculated from year 1 to year 8 (from direct and indirect emissions) were estimated to be between 0.3 Mt and 0.6 Mt of CO_2-e/yr;
- of the indirect emissions, downstream product transport to the international market on average accounted for 80% of indirect emissions;
- direct emissions represent between 0.04% and 0.055% of total annual NSW emissions, 0.011% to 0.015% of Australian emissions and between 0.00013% and 0.00017% of global emissions; and

- indirect emissions represent between 0.063% and 0.081% of annual NSW emissions, 0.018% to 0.023% of Australian emissions and between 0.0005% and 0.0012% of global emissions.

3 Estimated emissions for the proposed modification

The following sections provide a summary of the emissions estimated for the proposed modification and compares them against those estimated in the 2015 AQGHGA.

It is noted that the focus of the AQGHGA for the proposed modification is the estimation of particulate matter concentrations. As predicted trace metal concentrations were well below the impact assessment criteria in the 2015 AQGHGA (orders of magnitude below for some pollutants), and emissions have decreased as part of the proposed modification, metal concentrations were not re-assessed here.

3.1 Proposed modification emissions summary

The total topsoil/subsoil, overburden and ore handled during the six years of the proposed modification is shown in Figure 3.1. The graph shows that the amount of topsoil/subsoil and overburden handled is highest in year 1. The volume of ore processed is highest in year 2, only higher than year 1 by approximately 50,000 t.

Year 1 was chosen for this assessment given that it includes the maximum amount of topsoil/subsoil and overburden handled. As the proposed modification will not involve open-cut mining, particulate emissions relating to the handling of soil and overburden are the most dominant.

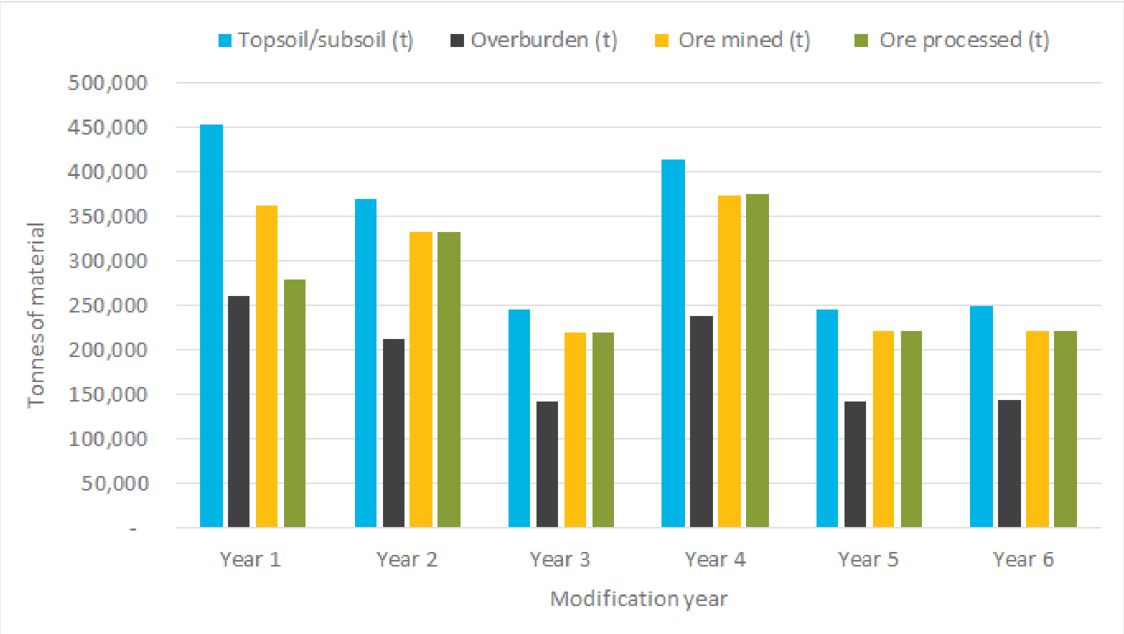

Figure 3.1 Total material handled by year of the proposed modification

Consistent with the 2015 AQGHGA, fugitive dust sources associated with the proposed modification were quantified through the application of US-EPA AP-42 emission factor equations. Particulate matter emissions were quantified for the three size fractions – TSP, PM_{10} and $PM_{2.5}$. Emission rates for coarse particles (PM_{10}) and fine particles ($PM_{2.5}$) were estimated using ratios for the different particle size fractions available in the literature (principally the US-EPA AP-42).

The calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions for each activity in year 1 are shown in Table 3.1. Further detail on the assumptions and emission factors used in the development of the emissions inventory is provided in Appendix A.

A graphical summary of the contribution to annual dust emissions by source type is provided in Figure 3.2. The most significant source of particulate matter emissions from year 1 of the proposed modification's operations is associated with material handling. The next highest emission sources are wheel-generated dust from hauling and stack emissions (associated with the product drying process).

Table 3.1 Estimated emissions (kg/year) – year 1

Activity	TSP emissions (kg/y)	PM_{10} emissions (kg/y)	$PM_{2.5}$ emissions (kg/y)
Soil and overburden stripping and re-handling			
Dozer on soil and OB	17,866	3,838	1,876
Scraper stripping topsoil/subsoil/OB	20,671	12,403	641
Scraper unloading topsoil/subsoil/OB	142,561	85,537	4,419
Excavator loading soil and OB to truck	740	350	53
Trucks hauling soil and OB to stockpiles	16,801	4,731	473
Trucks unloading soil and OB to emplacement area	740	350	53
Product and waste			
HMC - loading stockpiles	131	62	9
HMC - loading trucks	41	20	3
HMC - haul off-site	19,818	3,804	920
WHIMS product drying (baghouse stack)	28,382	28,382	28,382
WHIMS product screening	205	69	5
Tailings - unload to tailings stockpile	113	54	8
Wind erosion			
Topsoil/subsoil/OB stockpile	2,401	1,201	180
HMC stockpile	59	29	4
Rougher head feed stockpile	306	153	23
Sand tails stockpiles	527	264	40
Miscellaneous			
Grader	809	565	50
Other			
Site diesel combustion	543	543	497
Total	**252,715**	**142,353**	**37,638**

Note: OB = overburden, HMC = heavy metal concentrate, WHIMS = wet high intensity magnetic separators

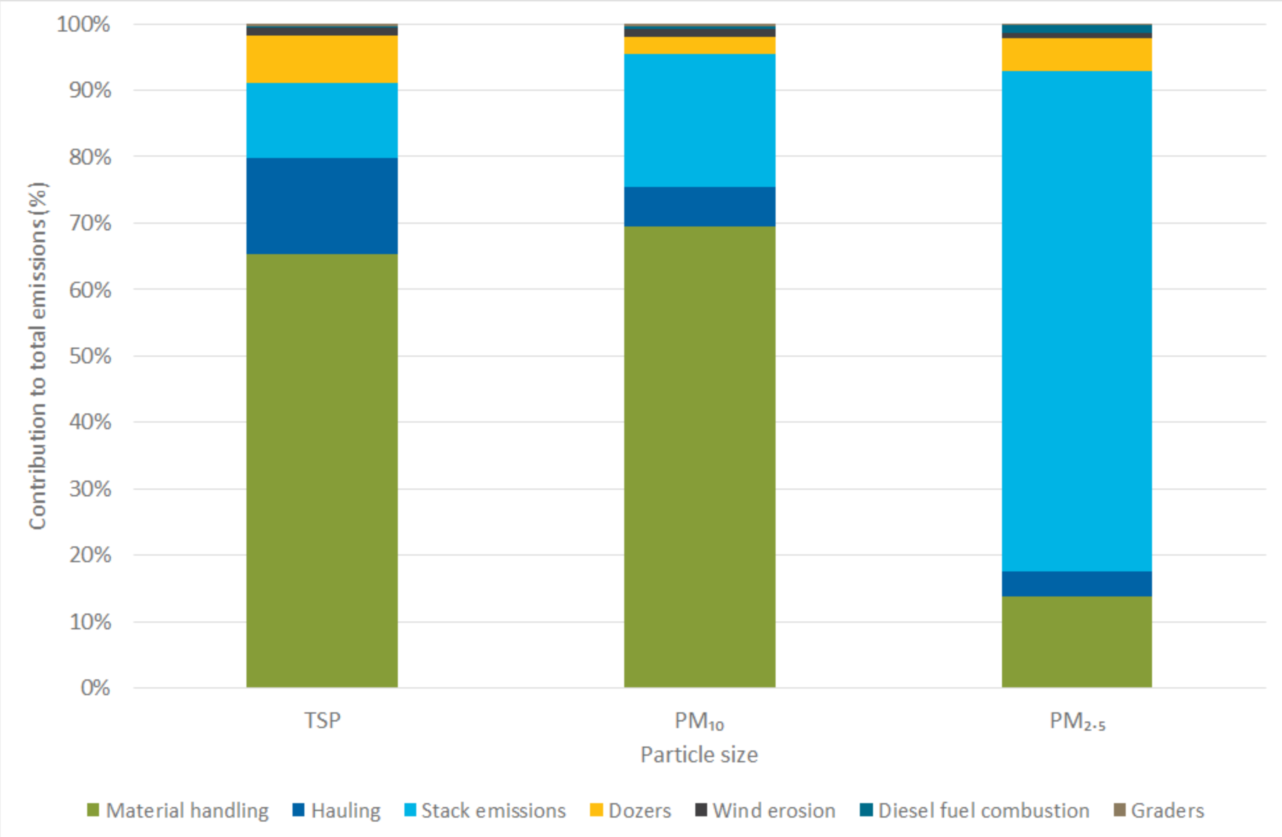

Figure 3.2 Contribution to annual emissions by emissions source type and particle size – year 1

3.2 Comparison of the proposed modification emissions with 2015 AQGHGA

A comparison of emission estimates from the 2015 AQGHGA worst-case year (year 8) and the proposed modification's worst-case year (year 1) is shown in Table 3.2.

The comparison shows that estimated emissions for the proposed modification will be less than the approved Balranald Project by 92%, 86% and 75% in TSP, PM_{10} and $PM_{2.5}$ emissions respectively.

A large proportion of the decrease in emissions is due to the fact that the proposed modification will be completed using underground mining methods as opposed to open-cut mining as assessed in the 2015 AQGHGA. Emission estimates for the proposed modification also include additional dust control measures (discussed in the following section).

Table 3.2 Comparison of estimated particulate matter emissions

	TSP emissions (kg/y)	PM_{10} emissions (kg/y)	$PM_{2.5}$ emissions (kg/y)
2015 AQGHGA – year 8	3,190,476	1,007,639	152,553
Proposed modification emissions – year 1	252,715	142,353	37,638
Decrease with the proposed modification	**92%**	**86%**	**75%**

3.3 Particulate matter emission control measures

To manage particulate matter emissions associated with the proposed modification, a range of mitigation measures and management practices are required.

Control measures have been applied in line with the 2015 AQGHGA and additional measures have also been identified by Iluka and were included in the emissions estimates for the proposed modification based on the *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone 2011).

The control measures incorporated into the emissions calculations and the relevant emission reductions are summarised in Table 3.3.

Table 3.3 Control measures applied in the assessment

Activity	Measure	Control efficiency	Control source
Wheel generated emissions from unsealed on-site haul roads	Water and/or chemical suppressants	84%	Katestone 2011
Wind erosion from topsoil/subsoil/overburden stockpiles	Watering	50%	Katestone 2011
Grading roads	Watering	50%	Katestone 2011

4 Greenhouse gas assessment

4.1 Introduction

The estimation of GHG emissions for the proposed modification was based on the Department of Industry, Science, Energy and Resources (DISER) (2021) National Greenhouse Accounts Factors (NGAF) workbook.

The methodologies in the NGAF workbook follow a simplified approach, equivalent to the 'Method 1' approach outlined in the *National Greenhouse and Energy Reporting (Measurement) Technical Guidelines* (Technical Guidelines) (DoE 2014). The Technical Guidelines are used for the purpose of reporting under the Commonwealth *National Greenhouse and Energy Reporting Act 2007* (the NGER Act).

For accounting and reporting purposes, GHG emissions are defined as 'direct' and 'indirect' emissions. Direct emissions (also referred to as Scope 1 emissions) occur within the boundary of an organisation and as a result of that organisation's activities. Indirect emissions are generated as a consequence of an organisation's activities but are physically produced by the activities of another organisation (DISER 2021). Indirect emissions are further defined as Scope 2 and Scope 3 emissions. Scope 2 emissions occur from the generation of the electricity purchased and consumed by an organisation. Scope 3 emissions occur from all other upstream and downstream activities, for example the downstream extraction and production of raw materials or the upstream use of products and services.

Scope 3 is an optional reporting category (Bhatia et al 2010) and should not be used to make comparisons between organisations, for example in benchmarking the GHG intensity of products or services. Typically, only major sources of Scope 3 emissions are accounted and reported by organisations.

4.2 Emission sources

The GHG emission sources included in this assessment are listed in Table 4.1, representing the most significant sources associated with the proposed modification.

GHG emissions from the proposed modification are estimated using the methodologies outlined in the NGAF workbook, using fuel energy contents and Scope 1, 2 and 3 emission factors for fuel and electricity use in NSW.

Table 4.1 Scope 1, 2 and 3 GHG emission sources

Scope 1	Scope 2	Scope 3
Direct emissions from diesel combustion.	Indirect emissions associated with the consumption of purchased electricity.	Indirect emissions from the extraction, production and transport of diesel.
Direct emissions from LPG use.	-	Indirect emissions from the extraction, production and transport of LPG.
-	-	Indirect emissions from electricity lost in delivery in the transmission and distribution network.
-	-	Indirect emissions associated with the transport of product via truck, rail and ship.
-	-	Indirect emissions from fuel for employee travel.

4.3 Activity data

Estimates of fuel and electricity consumption associated with the proposed modification have been provided by Iluka. The adopted activity data for the emission estimates is presented in Table 4.2.

Table 4.2 Indicative annual activity data

Operational year	Diesel consumption (L)	LPG consumption	Electricity consumption (MWh)
Annual	904,196	446,204	21,900

4.4 Emission estimates

The estimated annual GHG emissions for each emission source in each year, are presented in Table 4.3. Details of the GHG emissions calculations are provided in Appendix B.

The significance of the proposed modification's GHG emissions relative to State and National GHG emissions is made by comparing annual average GHG emissions against the most recent available total GHG emissions inventories (calendar year 2019[1]) for NSW (136,579 kt CO_2-e) and Australia (529,298 kt CO_2-e). The significance of emissions has been calculated for each year of the proposed modification and is shown in Table 4.4.

Annual average GHG emissions (Scope 1) generated by the proposed modification represent 0.0016% of total GHG emissions for NSW and 0.0004% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018. Annual average GHG emissions (Scopes 2 and 3) generated by the proposed modification represent a maximum of 0.0407% of total GHG emissions for NSW and 0.0105% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2019.

Table 4.3 Estimated annual GHG emissions (all scopes)

Operational year	Scope 1 (t CO_2-e/year)	Scope 2 (t CO_2-e/year)	Scope 3 (t CO_2-e/year)	Total
Year 1	2,241	17,301	32,508	**52,050**
Year 2	2,241	17,301	38,343	**57,885**
Year 3	2,241	17,301	25,969	**45,511**
Year 4	2,241	17,301	13,682	**33,224**
Year 5	2,241	17,301	26,043	**45,585**
Year 6	2,241	17,301	26,002	**45,544**

1 https://ageis.climatechange.gov.au/SGGI.aspx

Table 4.4 Significance of emissions

Operational year	NSW		Australia	
	Scope 1	Scope 2 and 3	Scope 1	Scope 2 and 3
Year 1	0.0016%	0.0365%	0.0004%	0.0094%
Year 2	0.0016%	0.0407%	0.0004%	0.0105%
Year 3	0.0016%	0.0317%	0.0004%	0.0082%
Year 4	0.0016%	0.0227%	0.0004%	0.0059%
Year 5	0.0016%	0.0317%	0.0004%	0.0082%
Year 6	0.0016%	0.0317%	0.0004%	0.0082%

4.5 Comparison of GHG emissions for the proposed modification to the 2015 AQGHGA

A comparison of GHG emission estimates from the 2015 AQGHGA worst-case year and the proposed modification's worst-case year is shown in Table 4.5.

The comparison shows that estimated emissions for the proposed modification will be less than the approved Balranald Project by 97% for Scope 1 emissions and 94% for Scope 2 and 3 combined emissions.

Table 4.5 Comparison of GHG emissions estimates

	Scope 1 (t CO_2-e/year)	Scope 2 and 3 (t CO_2-e/year)
2015 AQGHGA	86,813[a]	673,121[b]
Proposed modification emissions	2,364	55,644[c]
Decrease with the proposed modification	**97%**	**92%**

Notes: [a] Year 7 in the 2015 AQIA.
[b] Year 3 in the 2015 AQIA.
[c] Year 2 of proposed modification emissions.

5 Conclusion

An emissions inventory has been prepared for one worst-case operational scenario (year 1) for the Balranald Mineral Sands Project proposed modification. Estimated emissions were then compared to the worst-case emissions scenario presented in the original AQIA for the approved Balranald Mineral Sands Project (SSD-5285) prepared by ENVIRON in 2015.

The comparison of emissions showed that the estimated emissions for the proposed modification will be less than the approved Balranald Project by 90%, 83% and 74% in TSP, PM_{10} and $PM_{2.5}$ emissions respectively. A large proportion of the decrease in emissions is due to the fact that the proposed modification will be completed using underground mining methods as opposed to open-cut mining as assessed in the 2015 AQGHGA.

A GHG assessment has also been completed for the proposed modification and results were compared against those presented in the 2015 AQGHGA. The comparison showed that the estimated GHG emissions for the proposed modification will be less than the approved Balranald Project by 97% for Scope 1 emissions and 92% for Scope 2 and 3 combined emissions.

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US-EPA AP-42 2004, Chapter 11.19.2 – *Crushed stone processing and pulverized mineral processing.*

US-EPA AP-42 2006a, Chapter 13.2.4 – *Aggregate handling and storage piles.*

US-EPA AP-42 2011a, Chapter 13.2.1.3 – *Paved roads.*

US-EPA AP-42 2011b, Chapter 13.2.2 – *Unpaved roads.*

US-EPA AP-42 2016, *Nonroad Compression-Ignition Engines: Exhaust Emission Standards* (EPA-420-B-16-022, March 2016

WRAP 2006, *WRAP Fugitive Dust Handbook*, prepared for Western Governors' Association by Countess Environment, September 2006


Appendix A

Emissions inventory detail




A.1 Introduction

Particulate matter emissions were quantified through the application of accepted published emission estimation factors, collated from a combination of United States Environmental Protection Agency (US-EPA) AP-42 Air Pollutant Emission Factors and US-EPA Exhaust Emissions Standards, including the following:

- US-EPA AP-42 Chapter 13.2.4.4 – *Aggregate handling and storage piles* (US-EPA 2006a).
- US-EPA AP-42 Chapter 13.2.2 – *Unpaved roads* (US-EPA 2011a).
- US-EPA AP-42 Chapter 13.2.1.3 – *Paved roads* (US-EPA 2011b).
- US-EPA AP-42 Chapter 11.9-2 – *Dozers on overburden* (US-EPA 1998).
- US-EPA AP-42 Chapter 11.9-4 – *Topsoil removal by scraper* (US-EPA 1998).
- US-EPA AP-42 Chapter 11, Table 11.19.2-1 – *Screening crushing (uncontrolled)* (US-EPA 2004).
- US-EPA AP-42 Chapter 11, Table 11.9-4 – *Wind erosion of exposed areas* (US-EPA 1998).
- US-EPA Nonroad Compression-Ignition Engines: *Exhaust Emission Standards* (EPA-420-B-16-022, March 2016).

Diesel consumption was provided by Iluka. Assumptions adopted were:

- the proposed construction equipment fleet comprised primarily of equipment with an engine power greater than 130 kW;
- for engines greater than 130 kW, the corresponding USEPA (USEPA 2016) Tier 2 emission standards for PM of 0.2 g/kWh was selected;
- the g/kWh emission standard was converted to g per litre of diesel by applying a scaling factor of 3, as per the notes for Table 35 in *NPI Emission Estimation Technique Manual for Combustion Engines* (NPI 2008); and
- the PM emission standard is assumed to correspond to PM_{10}, with $PM_{2.5}$ emissions derived from the relationship between PM_{10} and $PM_{2.5}$ emission factors presented in Table 35 in NPI, 2008 (91.7%).

Particulate releases were quantified for TSP, PM_{10} and $PM_{2.5}$ as documented in subsequent sections.

A.2 Particulate matter emissions inventory

The emissions inventory developed for year 1 of the proposed modification is presented in Table A.1.

Table A.1 Year 1 emissions inventory

Source name	Emission estimate TSP for Year 1 (kg/year)	Emission estimate PM_{10} for Year 1 (kg/year)	Emission estimate $PM_{2.5}$ for Year 1 (kg/year)	Activity rate	Units	TSP emission factor	PM_{10} emission factor	$PM_{2.5}$ emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Parameter 4	Unit	Reduction factor	Emission control	Emission factor source
Soil and overburden stripping and re-handling																				
Dozer on soil and OB	17,866	3,838	1,876	2,610	h/y	6.85	1.47	0.72	kg/h	3.2	Moisture content (%)	7.9	Silt content (%)							USEPA AP-42 11.9-2 - Dozers on OB
Scraper stripping topsoil/subsoil/OB	20,671	12,403	641	712,806	t/y	0.029	0.0174	0.00090	kg/t											USEPA AP-42 11.9-4 - Topsoil removal by scraper
Scraper unloading topsoil/subsoil/OB	142,561	85,537	4,419	712,806	t/y	0.200	0.1200	0.00620	kg/t											USEPA AP-42 11.9-4 - Scraper unloading
Excavator loading soil and OB to truck	740	350	53	712,806	t/y	0.0010	0.0005	0.00007	kg/t	3.3	Ave wind speed (m/s)	3.2	Moisture content (%)							USEPA AP-42 13.2.4 - Materials handling equation
Trucks hauling soil and OB to stockpiles	9,408	2,649	265	28,538	VKT/year	3.68	1.04	0.10	kg/VKT	7.9	% silt content	1.4	Return haul distance (km)	19,800	Loads/y	46	Ave weight (t)	0.84	Chemical suppression	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading soil and OB to emplacement area	740	350	53	712,806	t/y	0.0010	0.0005	0.00007	kg/t	3.3	Ave wind speed (m/s)	3.2	Moisture content (%)							USEPA AP-42 13.2.4 - Materials handling equation
Product and waste																				
HMC - loading stockpiles	131	62	9	143,470	t/y	0.0009	0.0004	0.00007	kg/t	3.3	Ave wind speed (m/s)	3.5	Moisture content (%)							USEPA AP-42 13.2.4 - Materials handling equation
HMC - loading trucks	41	20	3	143,470	t/y	0.0003	0.0001	0.00002	kg/t	3.3	Ave wind speed (m/s)	8.0	Moisture content (%)							USEPA AP-42 13.2.4 - Materials handling equation
HMC - haul off-site (sealed)	19,818	3,804	920	178,062	VKT/year	0.11	0.02	0.01	kg/VKT	0.6	Road silt loading (g/m^2)	44.7	Return haul distance (km)	3,939	Loads/y	46	Ave weight (t)			USEPA AP-42 13.2.1 - Paved roads
WHIMS product drying (baghouse stack)	28,382	28,382	28,382	18	m^3/s	50.0	50.0	50.0	mg/m^3											
WHIMS product screening	205	69	5	186,511	t/y	0.0011	0.0004	0.00003	kg/t											USEPA AP-42 11.19.2-1 - Screening (controlled)
Tailings - unload to tailings stockpile	113	54	8	203,459	t/y	0.0006	0.0003	0.00004	kg/t	3.3	Ave wind speed (m/s)	5.0	Moisture content (%)							USEPA AP-42 13.2.4 - Materials handling equation
Wind erosion																				
Topsoil/subsoil/OB stockpile	2,401	1,201	180	5.7	Area (ha)	0.1	0.05	0.01	kg/ha/h	8,760	Hours/year							0.5	Watering	USEPA AP-42 11.9-4 - Wind erosion of exposed areas
HMC stockpile	59	29	4	0.1	Area (ha)	0.1	0.05	0.01	kg/ha/h	8,760	Hours/year									USEPA AP-42 11.9-4 - Wind erosion of exposed areas
Rougher head feed stockpile	306	153	23	0.4	Area (ha)	0.1	0.05	0.01	kg/ha/h	8,760	Hours/year									USEPA AP-42 11.9-4 - Wind erosion of exposed areas
Sand tails stockpiles	527	264	40	0.6	Area (ha)	0.1	0.05	0.01	kg/ha/h	8,760	Hours/year									USEPA AP-42 11.9-4 - Wind erosion of exposed areas
Miscellaneous																				
Grader	809	565	50	2,628	km	0.62	0.22	0.02	kg/km	8.0	Speed of grader (km/h)							0.5	Watering routes	USEPA AP-42 11.9-2 - Grading roads
Other																				
Site diesel combustion	543	543	497																	
Total	**245,323**	**140,272**	**37,429**																	

A.3 Input data used for particulate matter emission estimates

The main inputs used in the emission estimates are summarised in Table A.2.

Table A.2 Inputs for emission estimation

Material properties	Value	Source of information
Topsoil/subsoil/overburden moisture (%)	3.2	ENVIRON 2015.
Topsoil/subsoil/overburden silt (%)	7.9	ENVIRON 2015.
HMC moisture (at point of loading/unloading) (%)	3.5	Provided by Iluka.
Tailings moisture (at point of loading/unloading) (%)	5	Provided by Iluka.
Unpaved road silt content (%)	7.9	ENVIRON 2015.
Paved road silt loading (%)	0.6	Site-specific data were not available, therefore 0.6% was taken from USEPA AP-42 Section 13.2.1 (Paved Roads) as 'ubiquitous baseline'.
Diesel consumption for (L/y)	904,196	Provided by Iluka.
Average wind speed (m/s)	3.3	ENVIRON 2015 (calculated from the CALMET extract).
Average truck capacity (t)	46	Calculated from an empty weight of 28 t and a Gross Vehicle Mass (GVM) of 64 t. Truck type (CAT D400) provided by Iluka and specifications taken from: https://www.ritchiespecs.com/model/caterpillar-d400d-articulated-dump-truck


Appendix B

Greenhouse gas calculation data




B.1 Scope 1 emissions

B.1.1 Diesel and LPG

GHG emissions from Scope 1 diesel and LPG consumption were estimated using the following equation:

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of GHG from diesel/LPG combustion	(t CO_2-e)
Q_i	=	Quantity of fuel	(kL)
EC_i	=	Energy content of fuel	(GJ/kL)[2]
EF_{ijoxec}	=	Emission factor for diesel/LPG consumption	(kg CO_2-e/GJ)[3]

GHG emission factors and energy content for diesel and LPG were sourced from the NGAF (DISER 2021). These are presented in Table B.1.

The estimated annual Scope 1 GHG emissions from diesel and LPG are presented in Table B.2. It is noted that diesel consumption related to transport of product off-site is included in Scope 3 emissions in Section B.3.

Table B.1 Diesel GHG emission factors

Fuel type	Energy content (GJ/kL)	Scope 1 Emission factors (kg CO_2-e/GJ)			Scope 3 Emission factor (kg CO_2-e/GJ)
		CO_2	CH_4	N_2O	CO_2
Diesel - stationary energy	38.6	69.9	0.1	0.2	3.6
Diesel - transport energy (post-2004 vehicles)	38.6	69.9	0.01	0.5	3.6
LPG – stationary energy	25.7	60.2	0.2	0.2	3.6

Table B.2 Estimated CO_2-e (tonnes) for diesel and LPG consumption per year

Year	Diesel use (L/annum)	LPG use (L/annum)	Emissions (t CO_2-e)		
			Scope 1 - Diesel	Scope 1 - LPG	Total
Year 1	904,916	446,204	2,241	695	**2,936**
Year 2	904,916	446,204	2,241	695	**2,936**
Year 3	904,916	446,204	2,241	695	**2,936**
Year 4	904,916	446,204	2,241	695	**2,936**
Year 5	904,916	446,204	2,241	695	**2,936**
Year 6	904,916	446,204	2,241	695	**2,936**

[2] GJ = gigajoules

[3] kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

B.2 Scope 2 emissions

B.2.1 Electricity

GHG emissions associated with electricity consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

Where:

$E_{CO2\text{-}e}$	=	Emissions of GHG from electricity consumption	($t\ CO_2$-e)
Q_i	=	Quantity of electricity	(MWh)[4]
EF	=	Emission factor for electricity consumption	(kg CO_2-e/kWh)[5]

GHG emission factors for electricity use were sourced from the NGAF (DISER 2021). These are presented in Table B.3.

The estimated annual Scope 2 GHG emissions from electricity are presented in Table B.4.

Table B.3 Electricity GHG emission factors

Use	Emission factor (kg CO_2-e/kWh)
	Scope 2
Electricity	0.79

Table B.4 Estimated CO_2-e (tonnes) for electricity consumption

Scenario	Electricity use (MWh)	Emissions (t CO_2-e)
		Scope 2
Year 1	21,900	17,301
Year 2	21,900	17,301
Year 3	21,900	17,301
Year 4	21,900	17,301
Year 5	21,900	17,301
Year 6	21,900	17,301

4 MWh = megawatt hours

5 kg CO_2-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

B.3 Scope 3 emissions

B.3.1 Upstream emissions

The upstream activities that contribute to Scope 3 emissions include the production and supply of fuel (diesel and LPG) and emissions from purchased electricity associated with the extraction, production and transport of fuel burned at the point of electricity generation and the indirect emissions attributable to the electricity lost in delivery.

i Diesel and LPG

Scope 3 emissions for diesel and LPG consumption were calculated using the methodology provided in Section B.1.1 using Scope 3 emission factors provided in Table B.5.

Table B.5 Diesel and LPG Scope 3 GHG emission factors

Use	Emission factor (kg CO_2-e/GJ)
	Scope 3
Diesel	3.6
LPG	3.6

The estimated annual Scope 3 GHG emissions from diesel and LPG are presented in Table B.6.

Table B.6 Estimated CO_2-e (tonnes) for diesel and LPG consumption per year

Year	Diesel use (L/annum)	LPG use (L/annum)	Emissions (t CO_2-e)		
			Scope 3 - Diesel	Scope 3 - LPG	Total
Year 1	904,196	446,204	115	41	**156**
Year 2	904,196	446,204	115	41	**156**
Year 3	904,196	446,204	115	41	**156**
Year 4	904,196	446,204	115	41	**156**
Year 5	904,196	446,204	115	41	**156**
Year 6	904,196	446,204	115	41	**156**

ii Electricity

Scope 3 emissions for electricity consumption were calculated using the methodology provided in Section B.1.1 using the Scope 3 emission factor provided in Table B.7. The emission factor used was taken from the latest estimate data for NSW.

Table B.7 Electricity Scope 3 GHG emission factor

Use	Emission factor (kg CO_2-e/kWh)
	Scope 3
Electricity	0.07

The estimated annual Scope 3 GHG emissions from electricity are presented in Table B.8.

Table B.8 Estimated CO_2-e (tonnes) for electricity consumption

Scenario	Electricity use (MWh)	Emissions (t CO_2-e)
		Scope 2
Year 1	21,900	1,533
Year 2	21,900	1,533
Year 3	21,900	1,533
Year 4	21,900	1,533
Year 5	21,900	1,533
Year 6	21,900	1,533

B.3.2 Downstream emissions

Downstream emissions were estimated for the transportation of product to international markets.

i Emissions from road transport

Scope 3 emissions for diesel use related to the transportation of product via truck were calculated using the methodology provided in Section B.1.1 using both the Scope 1 and Scope 3 emission factors combined in order to capture the full fuel life cycle (ie generation and combustion). This is considered a conservative approach. The emission factors used are provided in Table B.9.

Table B.9 Diesel Scope 1 and 3 emission factors

Fuel type	Energy content (GJ/kL)	Scope 1 Emission factors (kg CO_2-e/GJ)			Scope 3 Emission factor (kg CO_2-e/GJ)
		CO_2	CH_4	N_2O	CO_2
Diesel - transport energy (post-2004 vehicles)	38.6	69.9	0.01	0.5	3.6

Diesel used to transport product off-site via trucks per year was estimated using the following information:

- Product ore transported off-site per year (see Table B.10).
- Average truck payload of 46 t.
- Average return trip distance of 389 km (based on trucks travelling from the proposed modification site to Manangatang and Hopetoun consistent with the 2015 AQGHGA).
- Fuel consumption rate of 0.111 L per km (Australian Bureau of Statistics 2021).

The estimated annual Scope 3 GHG emissions from transportation of product via truck are presented in Table B.10.

Table B.10 Estimated CO_2-e (tonnes) for transportation of product via truck per year

Year	Product ore (t/annum)	Diesel use (L/annum)	Emissions (t CO_2-e)
			Scope 3 - Diesel
Year 1	279,080	261,965	748
Year 2	331,650	311,311	889
Year 3	220,164	206,662	590
Year 4	109,457	102,744	294
Year 5	220,828	207,285	592
Year 6	220,461	206,941	591

ii Emissions from rail transport

GHG emissions associated with the transport of product via rail were estimated using the following equation:

$$E_{CO_2-e} = \frac{D \times Q \times EF}{1000}$$

Where:

$E_{CO2\text{-}e}$	=	Emissions of GHG from rail transport	(t CO_2-e)
D	=	Average distance travelled by rail	(km)
Q	=	Quantity of material transported	(t)
EF	=	Emission factor for rail freight movement	(kg CO_2/tonne-km)

GHG emission factors for rail transport are not available in the NGAF. Therefore, the emission factor was adopted from various greenhouse gas assessments for extractive operations which was originally sourced from Australian Greenhouse Office 2007. The emission factor adopted is provided in Table B.11.

Table B.11 Diesel Scope 3 GHG emission factors

Use	Emission factor (kg CO_2-e/tonne-km)
	Scope 3
Rail diesel	0.0054

The average return transport distance was calculated to be 688 km which accounts for transport of product from and to the following locations (as consistent with ENVIRON 2015):

- Manangatang (Victoria) to Port of Melbourne;
- Hopetoun (Victoria) to the Hamilton Mineral Separation Plant (MSP); and
- the MSP to Port of Melbourne.

The estimated annual GHG emissions from transport of product via rail are presented in Table B.12.

Table B.12 Estimated CO_2-e (tonnes) for transportation of product via rail per year

Scenario	Product (t/annum)	Emissions (t CO_2-e)
		Scope 3
Year 1	279,080	1,037
Year 2	331,650	1,232
Year 3	220,164	818
Year 4	109,457	407
Year 5	220,828	820
Year 6	220,461	819

iii Emissions from shipping transport

GHG emissions associated with the transport of product via ship were estimated using the following equation:

$$E_{CO_2-e} = \frac{D \times Q \times EF}{1000}$$

Where:

E_{CO2-e}	=	Emissions of GHG from rail transport	(t CO_2-e)
D	=	Average distance travelled by ship	(km)
Q	=	Quantity of material transported	(t)
EF	=	Emission factor for ship freight movement	(kg CO_2/tonne-km)

GHG emission factors for ship transport are not available in the NGAF. Therefore, the emission factor was adopted from various greenhouse gas assessments for extractive operations which was originally sourced from Australian Greenhouse Office 2007. The emission factor adopted is provided in Table B.13.

Table B.13 Shipping Scope 3 GHG emission factor

Use	Emission factor (kg CO_2-e/tonne-km)
	Scope 3
Shipping diesel	0.0126

The weighted average return transport distance was calculated to be 16,602 km which accounts for transport of product from and to the following locations (as consistent with ENVIRON 2015):

- 30% of product to the UK at a one-way distance of 11,035 km.
- 30% of product to the USA at a one-way distance of 9,464 km.
- 20% of product to India at a one-way distance of 5,626 km.
- 20% of product to China at a one-way distance of 5,131 km.

The estimated annual GHG emissions from transport of product via ship are presented in Table B.14.

Table B.14 Estimated CO_2-e (tonnes) for transportation of product via ship per year

Scenario	Product (t/annum)	Emissions (t CO_2-e)
		Scope 3
Year 1	279,080	29,190
Year 2	331,650	34,689
Year 3	220,164	23,028
Year 4	109,457	11,449
Year 5	220,828	23,097
Year 6	220,461	23,059

B.3.3 Employee travel

GHG emissions from employee travel were estimated using the following equation:

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of GHG from gasoline combustion	(t CO_2-e)
Q_i	=	Quantity of fuel	(kL)
EC_i	=	Energy content of fuel	(GJ/kL)
EF_{ijoxec}	=	Emission factor (scope 3) for gasoline consumption	(kg CO_2-e/GJ)

Scope 3 emissions for employee travel were calculated using the methodology provided in Section B.1.1 using the Scope 3 emission factor provided in Table B.15.

Table B.15 Gasoline Scope 3 GHG emission factor

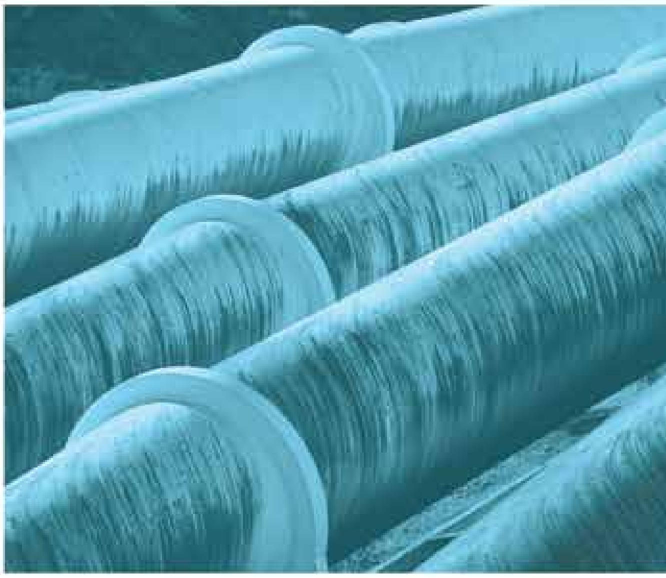
Use	Emission factor (kg CO_2-e/GJ)
	Scope 3
Gasoline	3.6

The estimated annual Scope 3 GHG emissions from employee travel are presented in Table B.16.

Table B.16 Estimated CO_2-e (tonnes) for employee travel per year

Year	Gasoline use (L/annum)	Emissions (t CO_2-e)
		Scope 3 - Gasoline
Year 1	78,000	10
Year 2	78,000	10
Year 3	78,000	10
Year 4	78,000	10
Year 5	78,000	10
Year 6	78,000	10



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