Appendix C

Impact assessment studies

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Atacama Surface Water Assessment

Prepared for Iluka

November 2022

Atacama Surface Water Assessment

Iluka

E220426 RP#1

November 2022

Version	Date	Prepared by	Approved by	Comments
1	12 September 2022	Anya Jones-Gill	Jarrah Muller	Draft for comment
2	4 November 2022	Anya Jones-Gill	Jarrah Muller	Final
3	17 November 2022	Anya Jones-Gill	Jarrah Muller	Final

Approved by

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17 November 2022

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1 Introduction

1.1 Background

In 2009, Iluka Resources Limited (Iluka) commenced mining operations of the Jacinth-Ambrosia (J-A) mineral sand deposit in the Eucla Basin, approximately 200 kilometres (km) north-west of Ceduna in South Australia. The Atacama satellite mineral deposit is located approximately 5 km north-east of the existing J-A site (Figure 1.1).

This document describes the potential surface water effects associated with development of the Atacama deposit (referred to in this document as the project).

1.2 Project elements

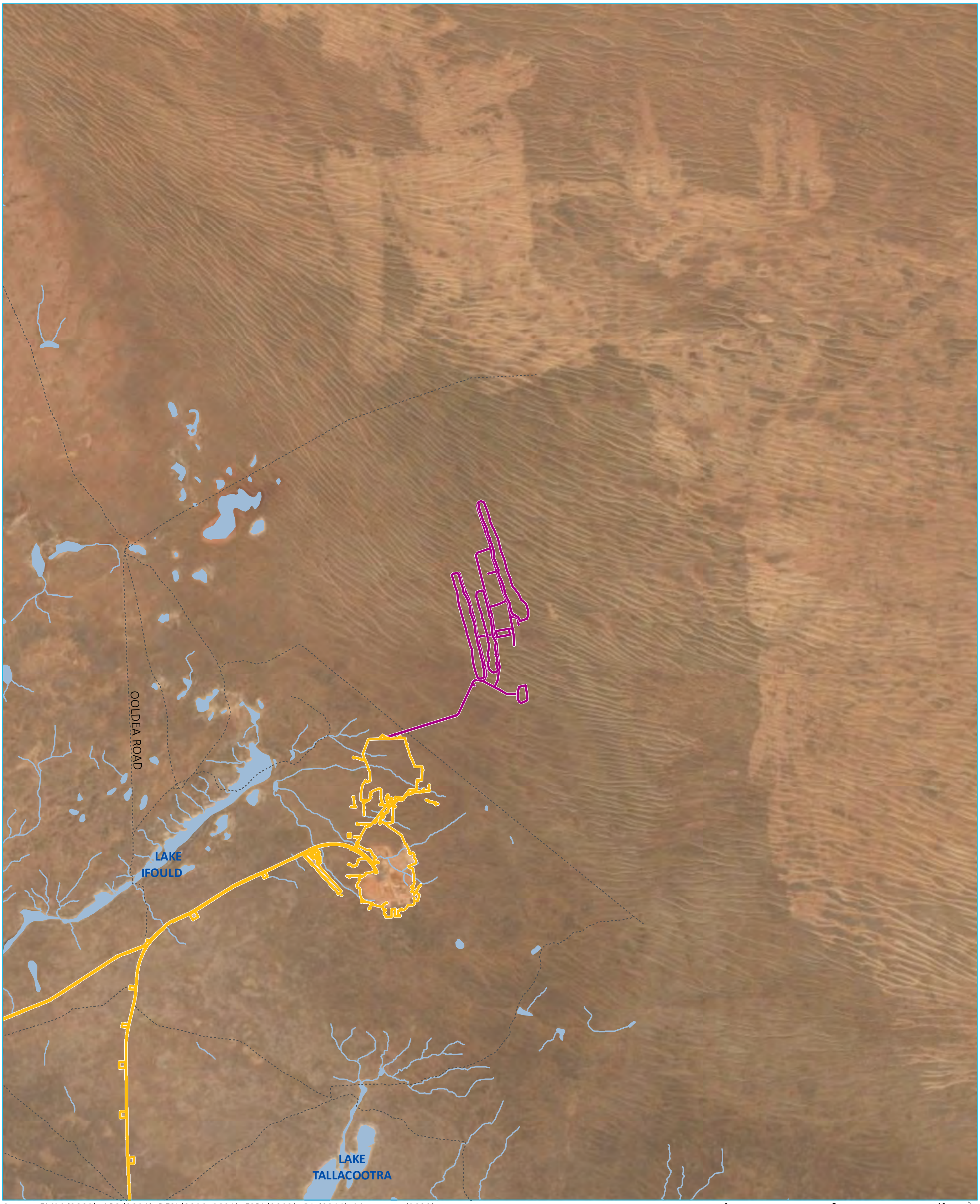
The Atacama development (the project) has the following elements (Table 1.1):

Table 1.1 Project elements

Element	Description
Mining method	Three open pits: 1. Western pit: approximately 5,000 metres (m) long, 350 m wide, 60 m deep. 2. Central pit: approximately 3,700 m long, 290 m wide, 45 m deep. 3. Eastern pit: approximately 5,800 m long, 460 m wide, 75 m deep.
Mine life	7 years
Processing	Transport via truck or slurry pipe to J-A for processing in the existing plant.
Tails storage facility	A sand tails stockpile will be constructed at the existing J-A mine site. Fine tails would be placed in J-A voids.

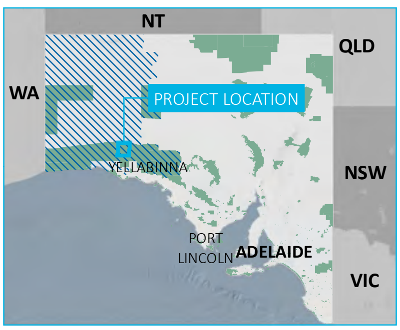
The sand tails stockpile constructed at the existing J-A mine site will be fully contained within the J-A disturbance footprint. J-A approvals require that during closure of the J-A site, water ways will be rehabilitated to pre-mining conditions. The location of the sand tails stockpile would be selected with an appropriate waterway set-back to allow the required watercourse rehabilitation to be carried out.

This surface water assessment describes changes to the surface water environment at the Atacama site. It is assumed that no meaningful change to the surface water environment will occur at the J-A site.



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 5 10 km
GDA 1994 MGA Zone 53
N



KEY

- Project layout
- J-A mine disturbance footprint

Existing environment

- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody

INSET KEY

- Public protected area
- Alinytjara Wilurara NRM Zone

Project layout and regional location

Atacama surface water assessment
Figure 1.1

creating opportunities

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1.3 Report structure

The regulatory framework is described in chapter 2.

A baseline surface water assessment was conducted by Alluvium in 2014, included as Appendix A. That document comprehensively describes the existing landscape and surface water features. A brief summary of elements relevant to the effects assessment is provided in this document in chapter 3.

Baseline flood modelling contained in Appendix A has been superseded. *Australian Rainfall and Runoff*, the main guideline for undertaking flood studies in Australia was updated in 2016 after the baseline was completed. Newer methods and data have been incorporated into the revised flood model described in Appendix B and summarised in chapter 4.

The J-A and Atacama proposed water balance is described in chapter 5.

Existing water quality is described in chapter 6, followed by a discussion of potential water quality effects due to development of the Atacama deposit.

Identified surface water risks and mitigation measures are presented in chapter 7.

A surface water monitoring plan is proposed in chapter 78.

2 Regulatory framework and context

Relevant legislation related to environmentally relevant activities are outlined in Section 2 of the Alluvium (2014) *Atacama Surface Water Study*. That study predates current legislation and as such references to the *Natural Resources Management Act 2004* are no longer relevant, with this legislation being superseded by *The Landscape South Australia Act 2019*. State legislation relevant to the protection of the environment and approval/regulation of a mine in South Australia are listed below, inclusive of any relevant federal legislation:

- *Environment Protection and Biodiversity Conservation Act 1999* – Commonwealth;
- *National Parks and Wildlife Act 1972* – Commonwealth;
- *Environmental Protection Act 2003* – SA;
- *Landscape South Australia Act 2019* – SA; and
- *Mining Act* 1971, with associated Mining Regulations 2020.

In addition to the legislation listed above, additional information pertaining to the impact on the environment required as part of a mining proposal are outlined by terms of reference (TOR) by the Department for Energy and Mining (DEM) in the following documents:

- Terms of Reference 006 (TOR006) (formerly MD006); and
- Minerals Regulatory Guidelines MG2a: Preparing a mining application Metallic and industrial minerals (2020).

TOR006 requires that the following information be provided to support applications for mining leases (Table 2.1).

Table 2.1 TOR006 surface water assessment requirements

Requirement	Addressed
Location of watercourses, drains and dams.	Appendix A
Surface water catchment boundaries.	Appendix A and Appendix B, noting that sand dune catchments are complex, and that boundaries may be interpreted differently at different scales.
Direction of drainage and discharge from the application area.	Appendix A
A statement describing if the application area is within an area where the water resources are prescribed under the Natural Resource Management Act 2004.	The project is not with a prescribed water resources area.
A statement if the application area is within a water protection area including areas under the River Murray Act 2003.	The project is not within a water protection area.
Groundwater-surface water interactions.	Section 3.4
Water quality data for identified watercourses, where there is potential for discharge into that watercourse from the proposed mining operation.	Chapter 6

Table 2.1 TOR006 surface water assessment requirements

Requirement	Addressed
If there is potential for changing the flow regime, including change in flow volume, or discharge into these watercourses from the proposed mining operations, an assessment of the use of this water by the landowner, downstream users, and water dependent ecosystems.	No discharges are proposed. No change in flow regime of creeks flowing to Lake Ifould is expected to occur (chapter 4).

3 Existing environment

The existing surface water environment is comprehensively described within the surface water baseline included as Appendix A. Appendix A includes a description of:

- Project Area characteristics;
- Hydrology;
- Geomorphology; and
- Surface water dependent ecosystems.

A summary of pertinent existing environment characteristics is provided below.

Due to the passage of time, hydrology data provided in Appendix A has been superseded by newer data. Where this document and Appendix A provide conflicting information, this document supersedes Appendix A.

3.1 Topography and landscape

The Atacama site lies within the Yellabinna dune field, with most dunes oriented in a north-west-south-east direction. Dunes can be hundreds of meters in length, with swale drains lying in the troughs at the base of dunes. Dunes can be up to 20 m high with parallel peaks spaced between 250 and 500 m apart (Alluvium, 2014). The local landscape context is presented in Figure 3 in Section 3 of the Alluvium (2014) *Atacama Surface Water Study* which is included in Appendix A (Alluvium, 2014).

Drainage within the Atacama site consists of flow through the swales that run alongside dunes, which predominantly drain to a terminal pan. In some cases, the ends of dune crests have eroded over time to connect two terminal pans into a single, larger terminal pan or in some cases multiple dune crests have eroded over time to form a larger terminal pan fed by multiple swales (Alluvium, 2014). Photograph 3.1 shows the dune field and associated swales in the Atacama Project Area.

Photograph 3.1 Yellabinna dune field; linear sand dunes with associated swale drains (Alluvium, 2014)

The Yellabinna dune system comprised of dunes with associated swale drainage into terminal pans is distinctly different from the landforms present at the J-A site, which is characterised by a dendritic network of drainage lines (Alluvium, 2014). Because of the topographical features at the Atacama site, namely terminal pans, the distance that runoff from disturbed areas can travel is typically in the order of 2 to 3 km.

Generally, the elevation of the Atacama main disturbance footprint is 150-200 m AHD. A detailed description of the topography and geomorphology of the region is included in Section 3 of the Alluvium (2013) *Atacama Surface Water Study*.

3.2 Regional hydrologic context

The Project Area lies to the north-east of the J-A catchment as defined by the Alluvium (2014) *Atacama Surface Water Study*, which drains west towards various unnamed salt pans and Lake Ifould. Lake Tallacootra lies approximately 25 km to the south of the Atacama site, however, drainage to Lake Tallacootra is not affected by the Atacama site or the J-A mine site.

The Project Area consists of dunes and swales and contains no named watercourses or official hydrolines. In the project site itself drainage occurs between dunes towards terminal pans in both north-west and south-east directions. Other than within terminal pans which intersect mining activities, runoff in the dune field is unaffected by mining activities.

Apart from the water management infrastructure related to the mining activities associated with the J-A mine, there are no constructed surface water features such as dams, weirs or irrigation channels in the vicinity of the project.

3.3 Climate

The Atacama site is situated in the arid climate zone, receiving between 200 and 300 mm of annual rainfall (refer Figure 3.1) (BoM, 2022). The climate is drier to the north-west, and wetter to the south near the coast.

The annual evaporation rate for the Atacama site is between 2,400 mm and 2,800 mm per year (Figure 3.2), and monthly evaporation exceeds monthly rainfall rates in all months of the year (Figure 3.3).

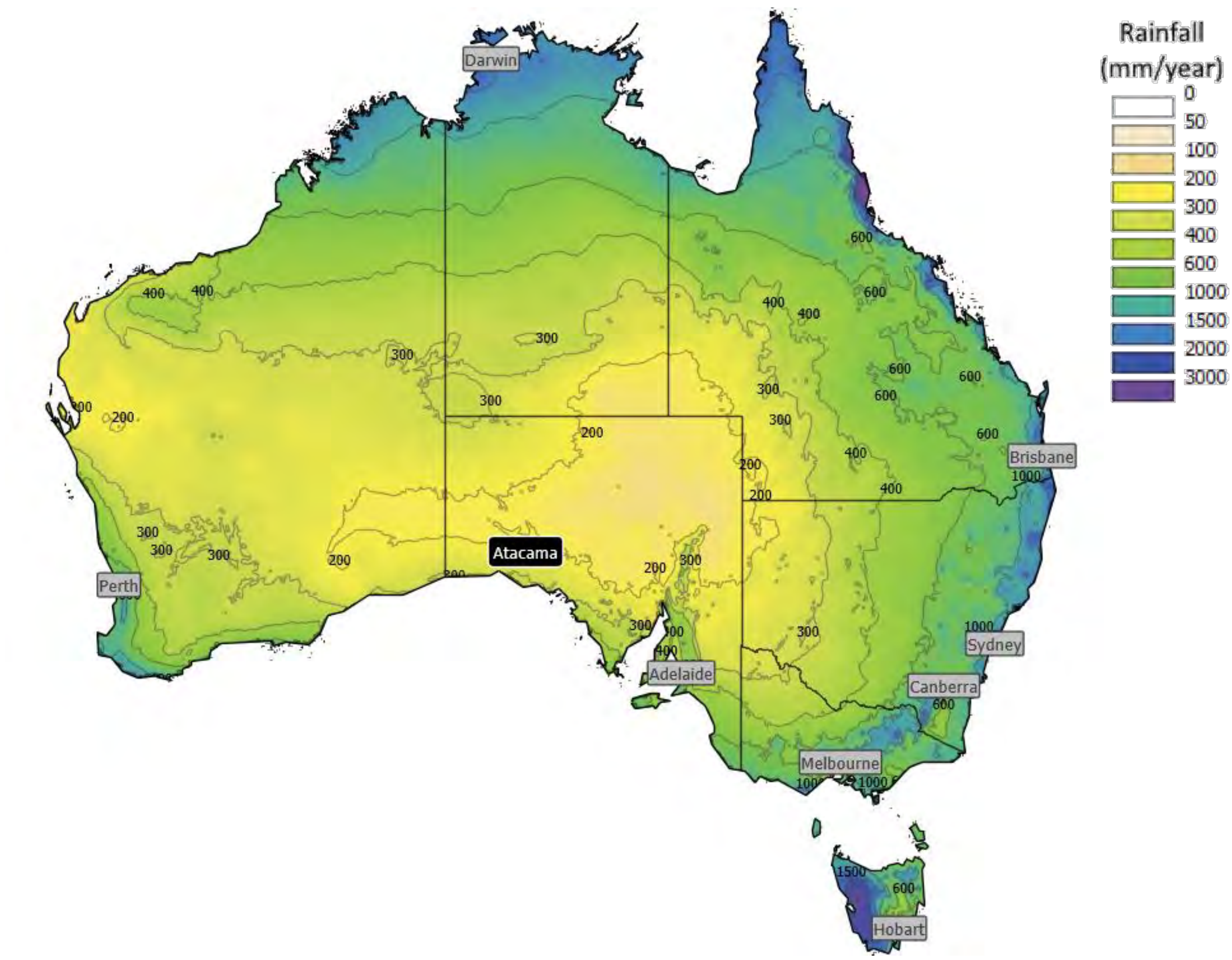


Figure 3.1 Annual average rainfall for Australia (Bureau of Meteorology, 2020)

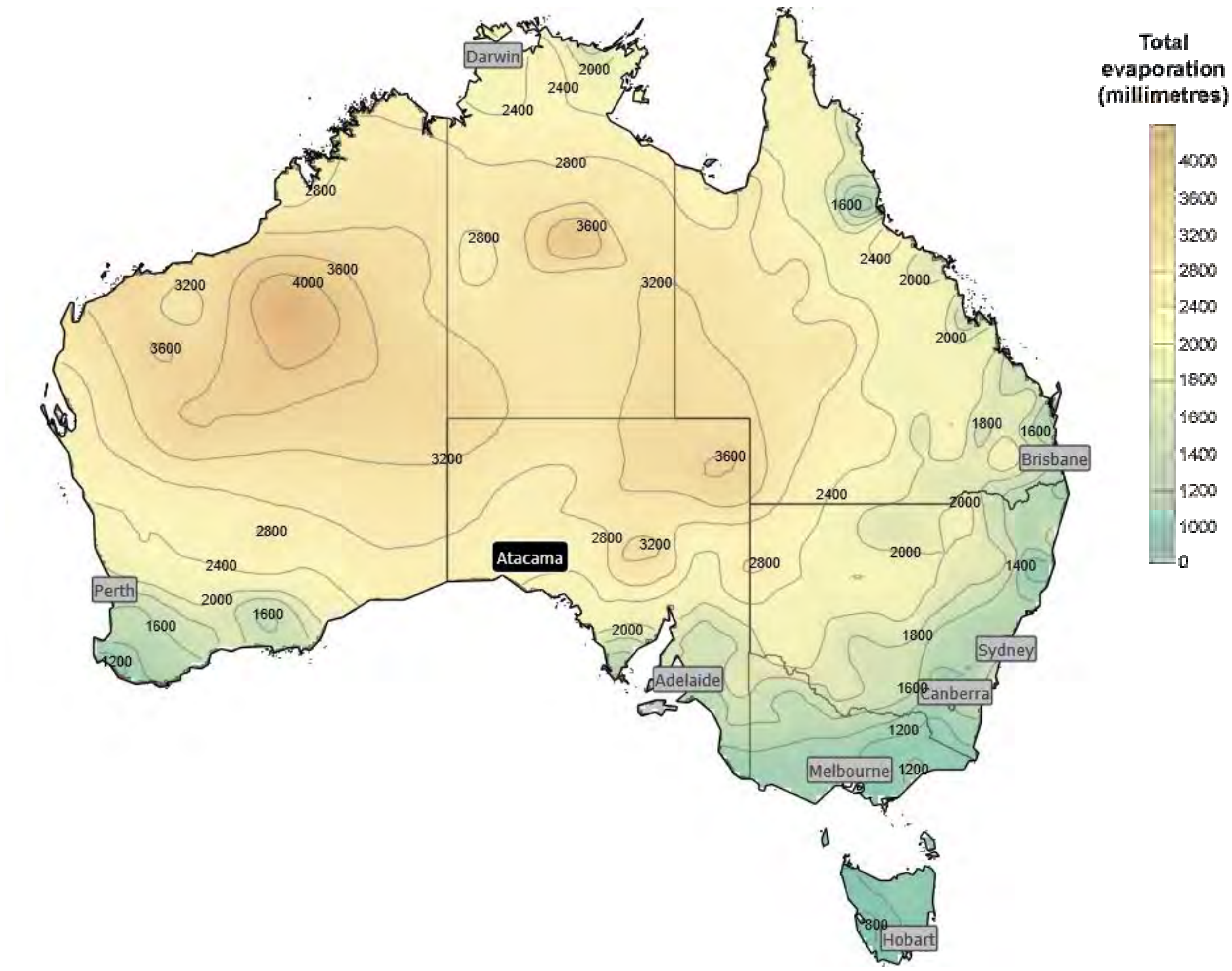


Figure 3.2 Annual average pan evaporation for Australia (Bureau of Meteorology, 2008)

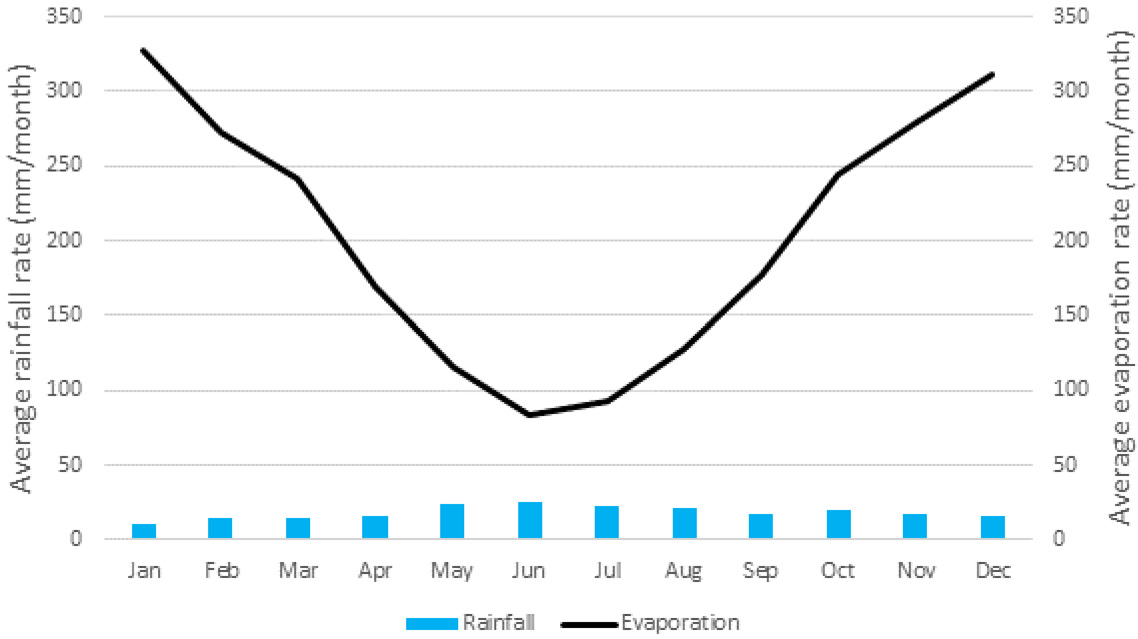


Figure 3.3 Average monthly rainfall and evaporation rates for the Atacama site

Rainfall data has been collected at the J-A weather station at the site from January 2013 to present, and is compared in Figure 3.4 with rainfall data interpolated from Bureau of Meteorology gauges by the Scientific Information for Land Owners (SILO) database hosted by the Queensland Government.

Between these data trends in annual rainfall over the active period of 2013-2021 are similar, with the difference in mean annual rainfall measured at the J-A site and predicted for the Atacama site being in the order of 10 mm. Average annual rainfall for the Atacama site over the reference period of 1981-2010 is approximately 240 mm, aligning with data presented in Figure 3.1.

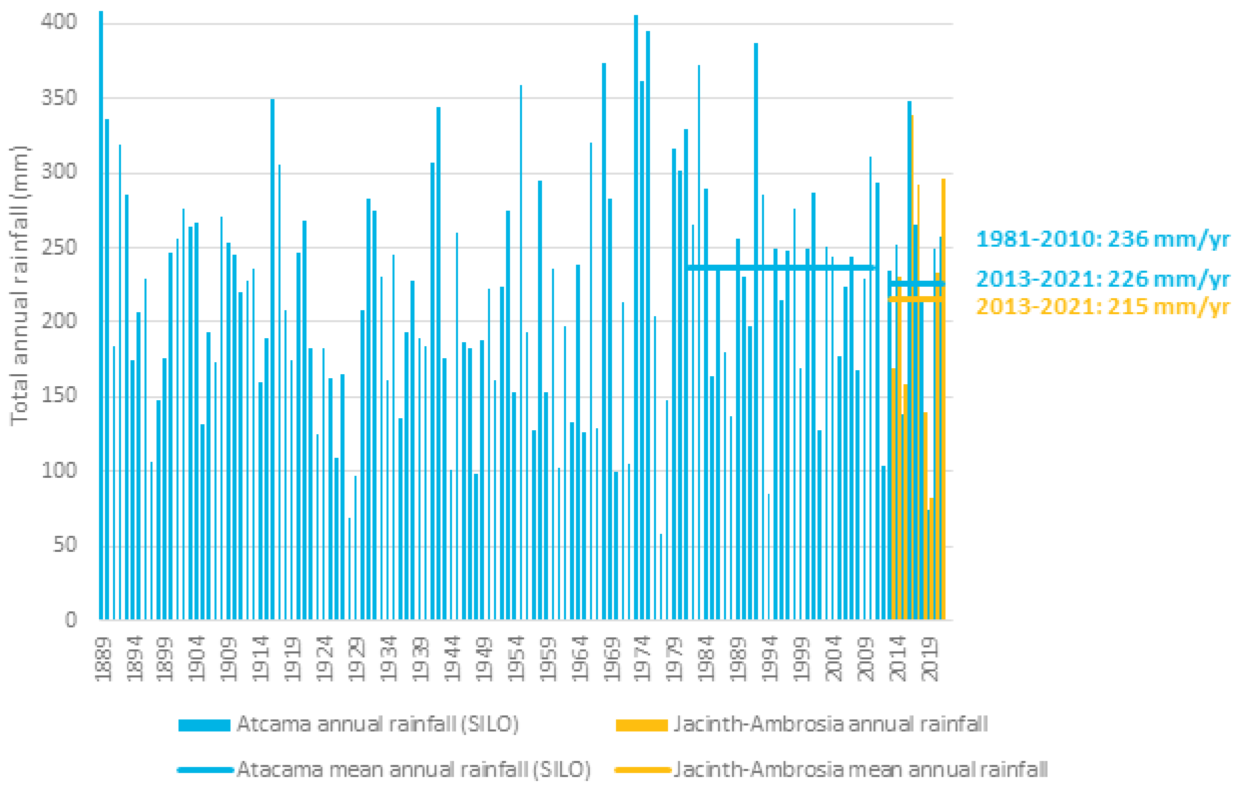


Figure 3.4 Comparison of SILO rainfall data for Atacama site with site rainfall data collected at the J-A mine site

3.4 Surface water–groundwater interactions

Creeks in the Project Area are ephemeral, flowing only in response to rainfall, and do not receive groundwater discharges. Groundwater is known to discharge at Lake Ifould, a terminal salina which lies approximately 10 km south-west of the project.

Groundwater recharge is inferred to be minimal (<1 mm/year) due to low rainfall in the area, high evapotranspiration rates and the large depth to groundwater (EMM, 2022).

4 Flooding

The potential for flooding at the site was assessed for the following annual exceedance probability (AEP) storms:

- 1% AEP (1 in 100 AEP);
- 2% AEP (1 in 50 AEP); and
- 0.5% AEP (1 in 200 AEP).

Three scenarios were assessed: baseline (pre-mining), during mining and post closure. Details of these scenarios are given in Table 4.1.

Table 4.1 Flood model scenarios

Scenario name	Description
Baseline (pre-mining)	The existing, pre-development landscape
During mining	Maximum development[1], including all proposed mine site infrastructure:
	• mine pits (bunded to their full extent): – NOTE: pit excavation will cross multiple dune swales, and bund walls would be required to exclude ponding flood waters from the pit;
	• roads, pads;
	• topsoil, ponds, stockpiles (bunded); and
	• culverts.
Post closure	Mine site rehabilitated:
	• mine pits backfilled;
	• roads, pad and culverts removed; and
	• topsoil, ponds, stockpiles removed.

The mine plan describes progressive rehabilitation, and so the entire footprint of each pit will not be open at any one time. However, to model multiple mine plan stages would have required many more model simulations and maps for little additional clarity regarding impacts, as the pits cross many individual swale catchments which are discretely impacted. The presented results for this scenario may thus be viewed as a composite effects map illustrating how each swale catchment will be affected when mining occurs in that area.

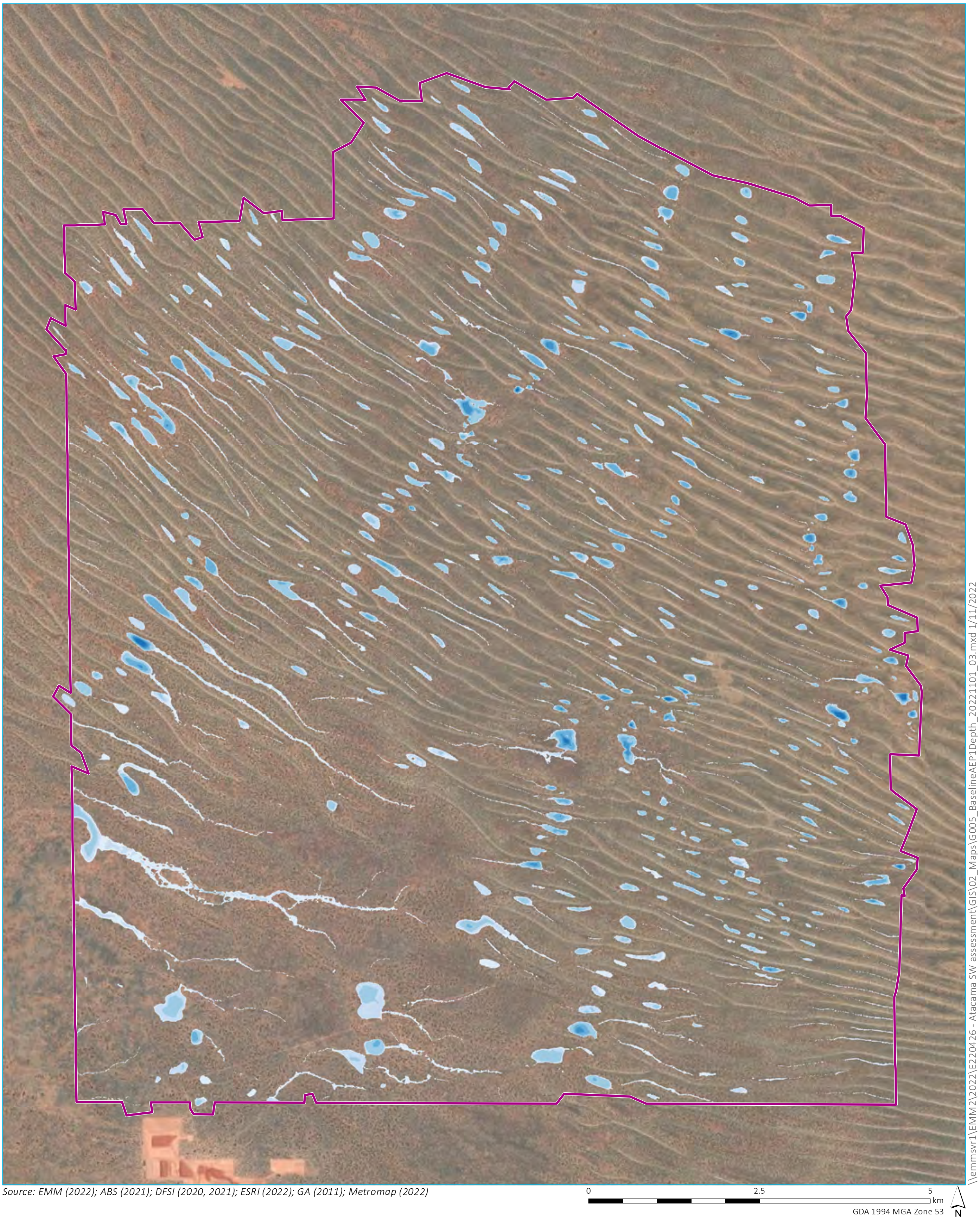
The model domain was chosen to include sufficient catchment area around the mine site to capture larger drainage pathways away from the site during large flood events, and such that model boundaries were not located near proposed disturbance areas. A description of the modelling method and full set of results is provided in Appendix B, with a summary presented here.

Modelling illustrated that at the proposed Atacama mine site, flooding is restricted to ponding in swales between dunes (Figure 4.1). There are no waterways in the vicinity of the pits, pads, or contractor facilities.

Pit excavation will cross a number of dune swales, and bund walls would be required to exclude ponding flood waters from the pit (Figure 4.2). The peak modelled depth adjacent to a pit bund in the 1% AEP storm was modelled as 2.5 m. Following mine closure, bund walls would be removed, and the pits surfaces would be remediated to become low points within the dune system (Figure 4.3).

Several unnamed ephemeral creeks lie between the proposed Atacama site and the existing J-A site, which flow from east to west after rain, terminating at Lake Ifould. These creeks would be crossed by the proposed haul road between Atacama and existing J-A. At crossing points, flows are expected to be relatively minor, with depths of less than 0.2 m (Figure 4.2) and peak velocities of around 0.6 m/s (Figure 4.4) reported by the model. Design of culverts for these crossing locations would be undertaken according to published guidelines utilising the design flow results extracted from the flood model.

During mining and post closure, changes to the flood regime would be restricted to the dune swales in which excavation or construction occurs (Figure 4.5 and Figure 4.6).



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Maximum water depth (m)

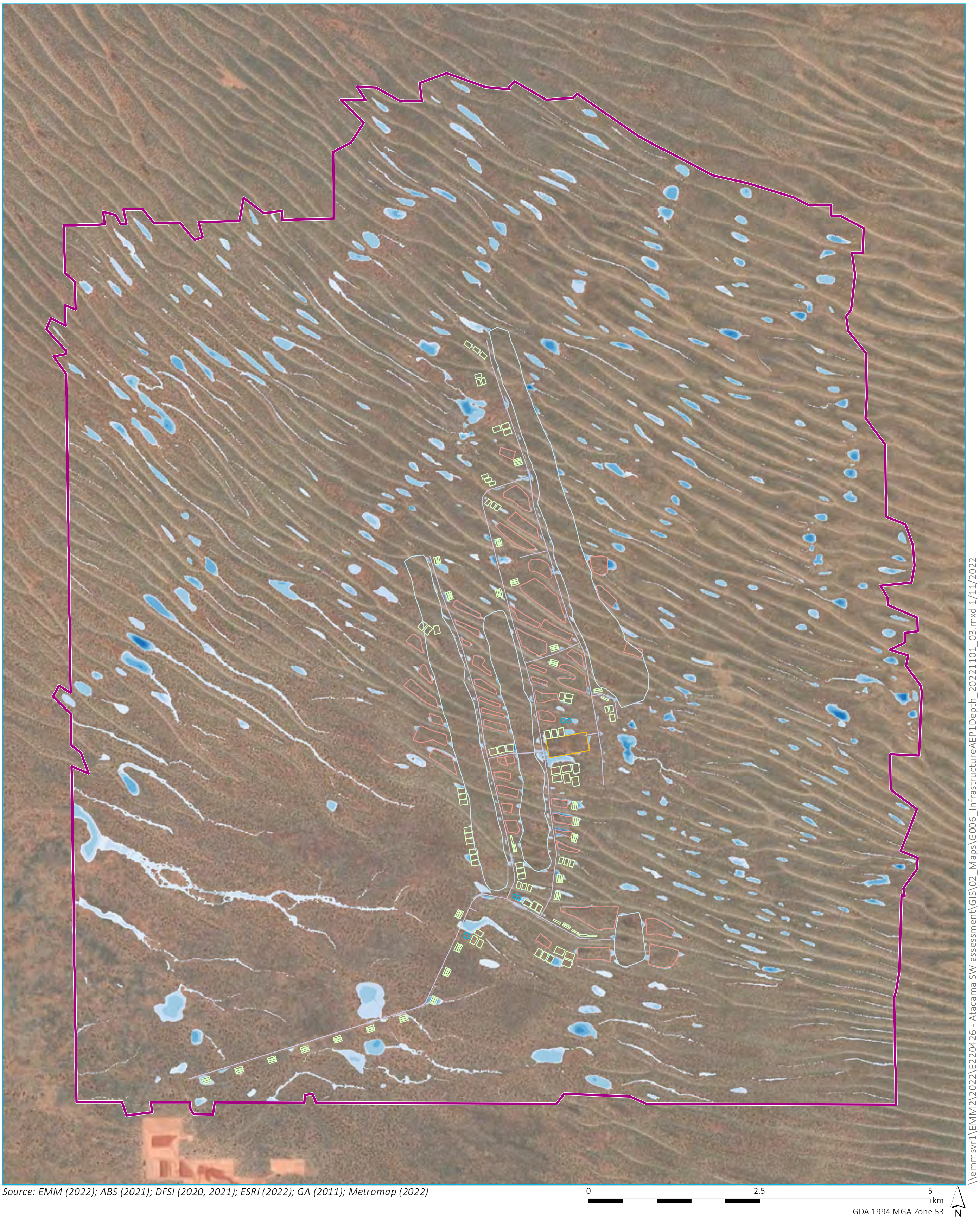
- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 1% AEP - baseline (pre mining)

Atacama surface water assessment

Figure 4.1

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

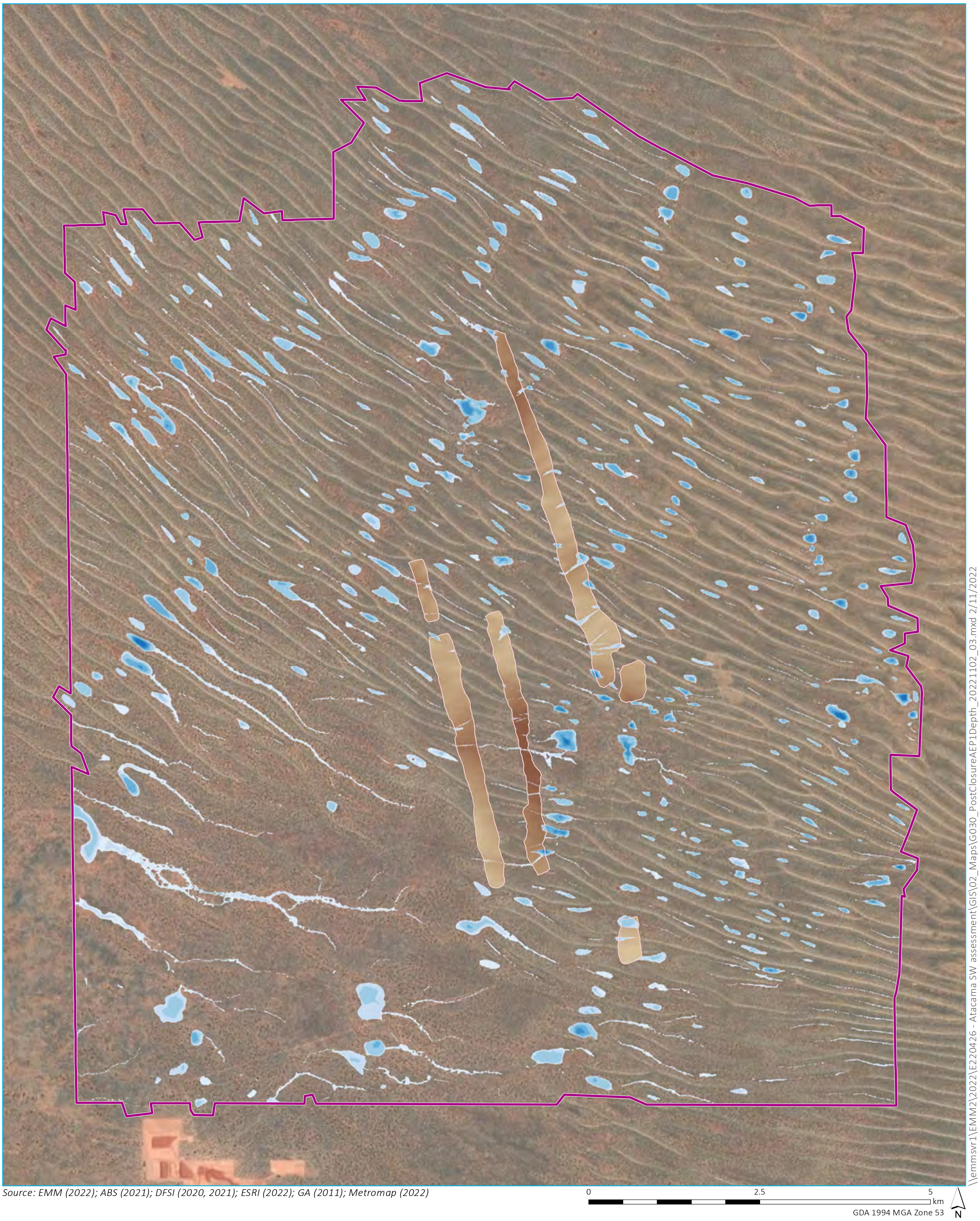
Maximum water depth (m)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 1% AEP - during mining

Atacama surface water assessment
Figure 4.2

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Backfilled pit changed elevation

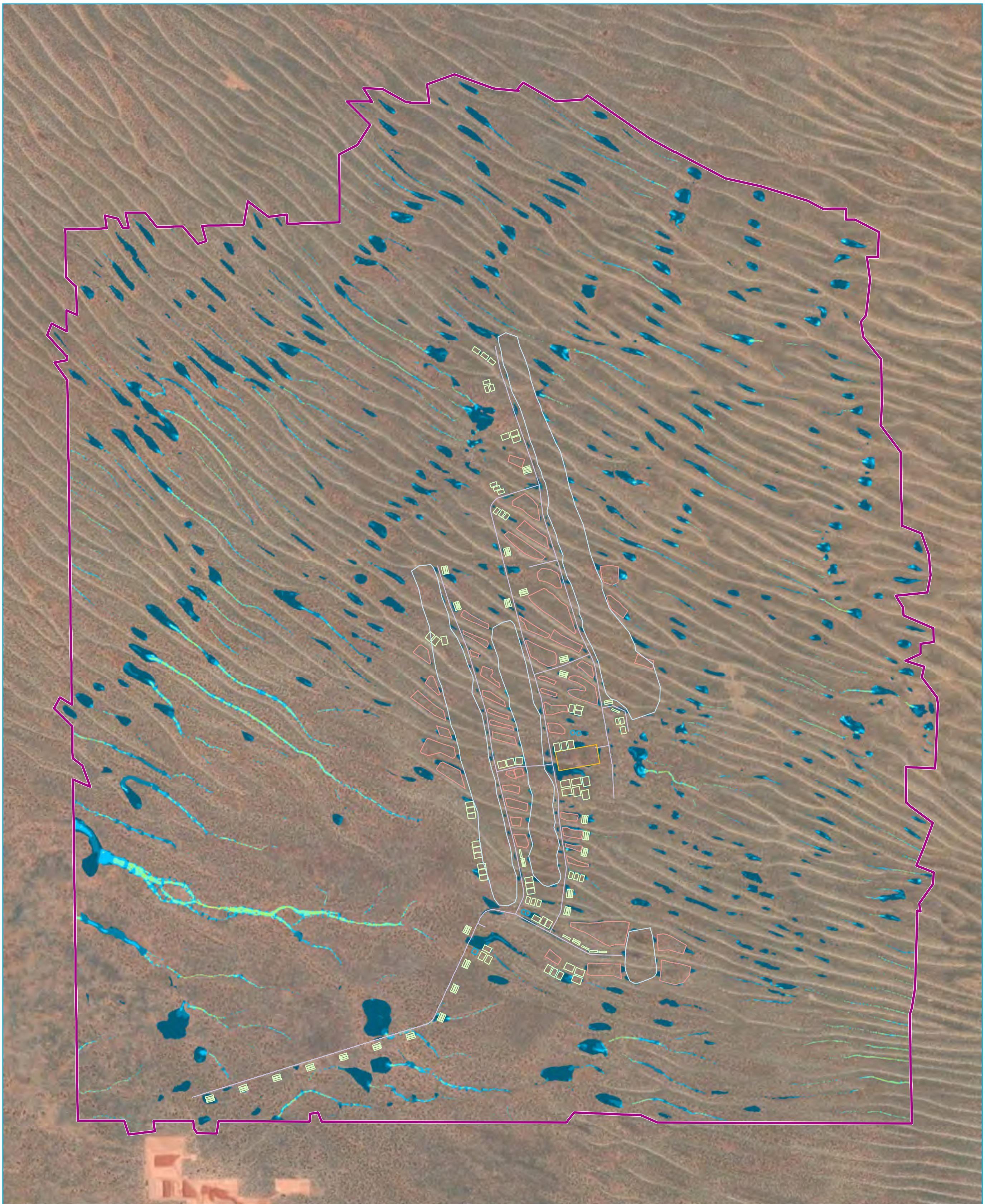
Maximum water depth (m)

- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 1% AEP - post closure

Atacama surface water assessment
Figure 4.3

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

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KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

Maximum water velocity (m/s)

- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5

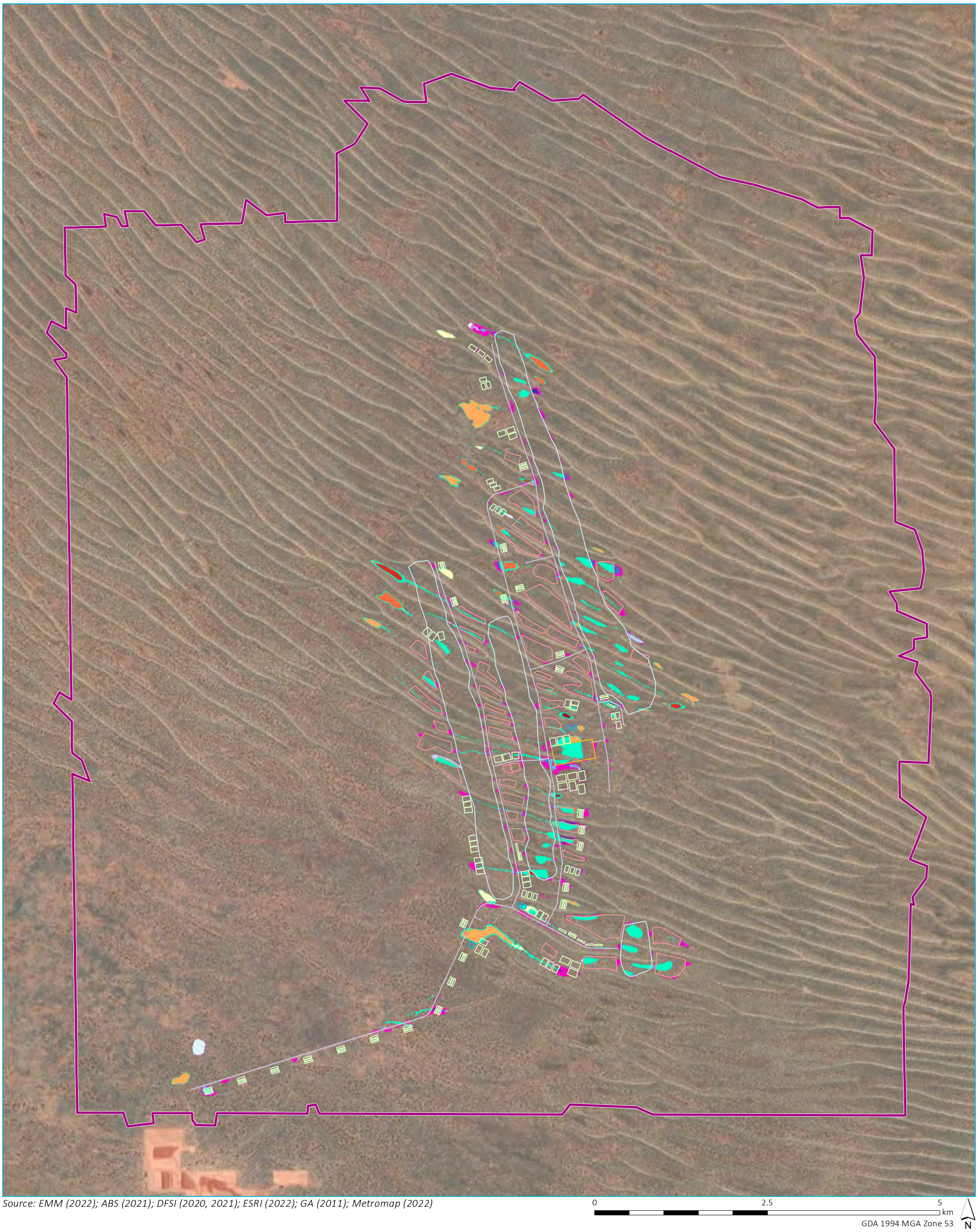
Peak design velocity 1% AEP - during mining

Atacama surface water assessment

Figure 4.4

EMM

creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

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KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Was wet now dry
- Was dry now wet

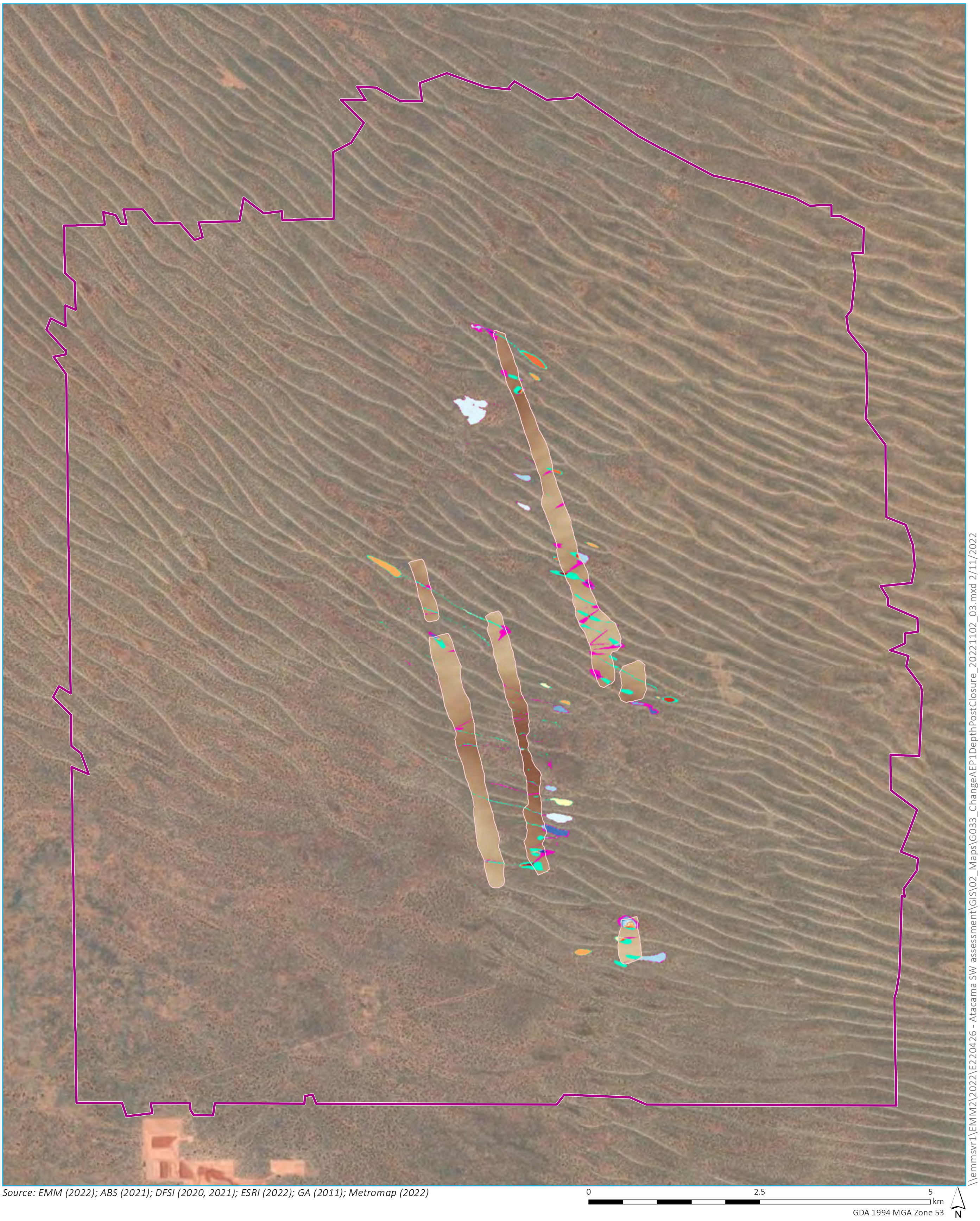
Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 1% AEP - during mining

Atacama surface water assessment
Figure 4.5

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Backfilled pit changed elevation
- Was wet now dry
- Was dry now wet

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 1% AEP - post closure

Atacama surface water assessment
Figure 4.6

EMM creating opportunities

5 Water balance

Water for the J-A mine site is currently sourced from an approved wellfield (miscellaneous purpose licence MPL 110) which is located approximately 40 km from the J-A site. It is proposed that water for the Atacama project will be sourced from the existing wellfield.

Water use requirements of the Atacama project include:

- water required within the process circuit to replace water lost to evaporation and entrainment within tails; and
- dust suppression.

Where potable water is required, this will be produced via modification to an existing Reverse Osmosis (RO) plant at the J-A site, with feed water supplied from the existing wellfield.

Due to the current ongoing operations at J-A, the process and dust suppression water requirements are well known by Iluka. The existing wellfield capacity significantly exceeds the anticipated water demands (Table 5.1).

Mining at Atacama is expected to take place above the water table, such that there will be no groundwater take associated with pit dewatering.

Table 5.1 Estimated water balance

Item	Water supply (ML/year)	Water demand (ML/year)
Existing wellfield capacity	11,000	
Existing J-A operations		3,200
Atacama project water use		1,900
	11,000	5,100

6 Water quality

TOR006 recommends that where surface water sampling is not possible due to the ephemeral nature of watercourses and frequent drying, as is the case at the Atacama site, soil sampling may provide a representative characterisation of water quality parameters. In line with this recommendation, sediment sampling was undertaken at the Atacama site. Details of sampling, laboratory testing and the full suite of results are included in CDM Smith (2022).

This chapter presents a representative sub-set of sediment testing results from the Atacama site, along with surface water quality data collected at the J-A site. High-level comparison of the two datasets indicates that the water quality of surface water runoff is likely to be similar across the two sites.

6.1 Guidelines

Relevant water quality guidelines for the Atacama site include both national and state government guidelines, which provide default guideline values (DGVs) for water quality objectives relevant to the receiving environment:

- Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018), using DGVs for the benchmark of protection of 95% of aquatic species; and

- South Australian (SA) Environment Protection (Water Quality) Policy (2003), using DGVs assigned to aquatic freshwater receiving environments. NOTE: Where this document provides guidance, it supersedes the national guidance.

DGVs are summarised in Table 6.1. The guidelines recommend that site-specific water quality thresholds should be developed where possible with regard to the existing environment and receptors. This is of particular relevance at the J-A and Atacama sites, as surface water and sediment sampling shows that the region is naturally mineral rich, and runoff contains elevated metals concentrations.

Table 6.1 Default guideline values (DGVs)

Parameter	Units	SA Water Quality (2003) DGV	ANZG (2018) DGV
Field parameters			
Turbidity	NTU	20	-
pH	-	6.5 – 9.0	-
Nutrients			
Total phosphorus	mg/L	0.1	-
Total nitrogen	mg/L	5	-
Metals			
Aluminium	mg/L	0.1	0.055
Arsenic	mg/L	0.05	-
Cadmium	mg/L	0.002	0.0002
Chromium (III)	mg/L	-	0.0033
Chromium (VI)	mg/L	0.001	0.001

Table 6.1 Default guideline values (DGVs)

Parameter	Units	SA Water Quality (2003) DGV	ANZG (2018) DGV
Cobalt	mg/L	-	0.0014
Copper	mg/L	0.01	0.0014
Iron	mg/L	1	-
Lead	mg/L	0.005	0.0034
Manganese	mg/L	-	1.9
Mercury	mg/L	0.0001	0.0006
Nickel	mg/L	0.15	0.011
Zinc	mg/L	0.05	0.008

6.2 Baseline water quality records

Available water quality records to characterise baseline water quality at the project site include:

- surface water monitoring at the existing J-A site; and
- sediment leachate testing at the Atacama site.

While the results of sediment leachate testing are not directly comparable to the results of surface water testing due to differing test methods, inferences may be made based on the relative concentration of metals in each sample.

6.2.1 J-A surface water monitoring data

i Monitoring sites and sample dates

Surface water monitoring at the existing J-A site consists of three water quality sampling sites as illustrated in Figure 6.2 and described in Table 6.2**Error! Reference source not found.**.

Table 6.2 Monitoring locations

Location ID	Date sampled	Description	Monitoring type
SW1	25/03/2016	Upstream of J-A mine workings	In situ monitoring and grab sampling
SW3	2/11/2021	Downstream of J-A mine workings	Rising stage sampler (RSS)
SWM16	16/11/2021	Within J-A mine workings, downstream of SW1	In situ monitoring and grab sampling

A short description of the rainfall events preceding sampling is provided:

- SW1 – sampled during March 2016, which was the wettest month of 2016 (refer Figure 6.1). Due to the depth of rain recorded in March 2016, it assumed that this sample was taken as a grab sample from on-site ponded water on the date of sample;

- SW3 – RSS sample taken on the 2nd of November 2021 and would have sampled runoff from the largest rainfall event of this month (refer Figure 6.2). November 2021 was the wettest month on record at the J-A rain gauge site, with 127.6 mm of rain falling over the entire month; and

- SWM16 – was sampled on the 16th of November 2021. It is assumed this was a grab sample from ponded water accumulated over several rainfall events prior to the sample date.

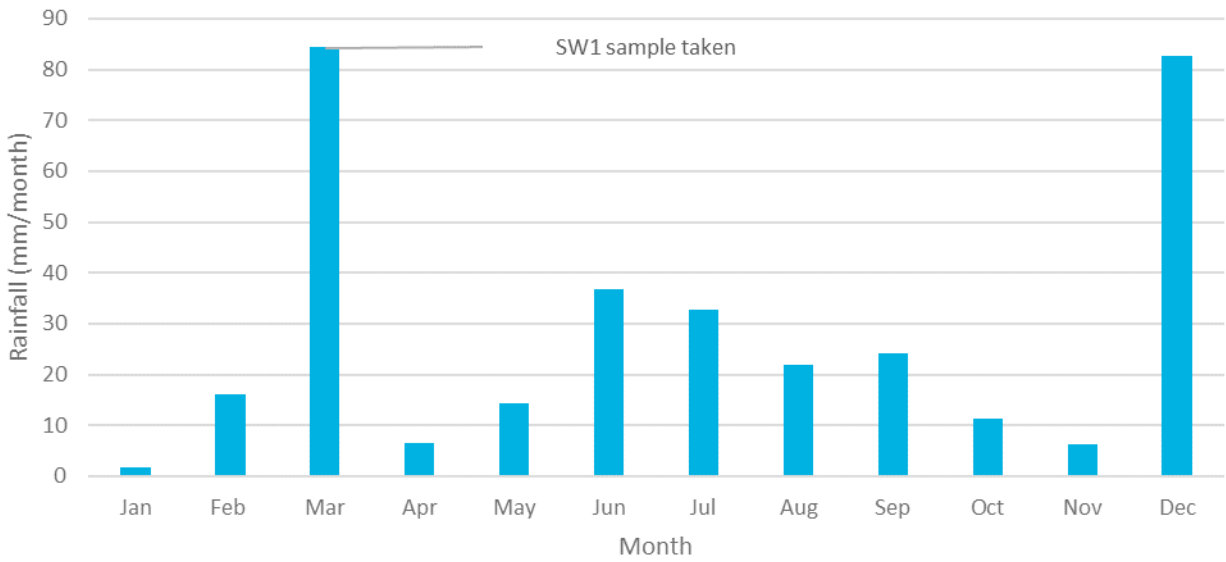


Figure 6.1 2016 rainfall at the J-A site

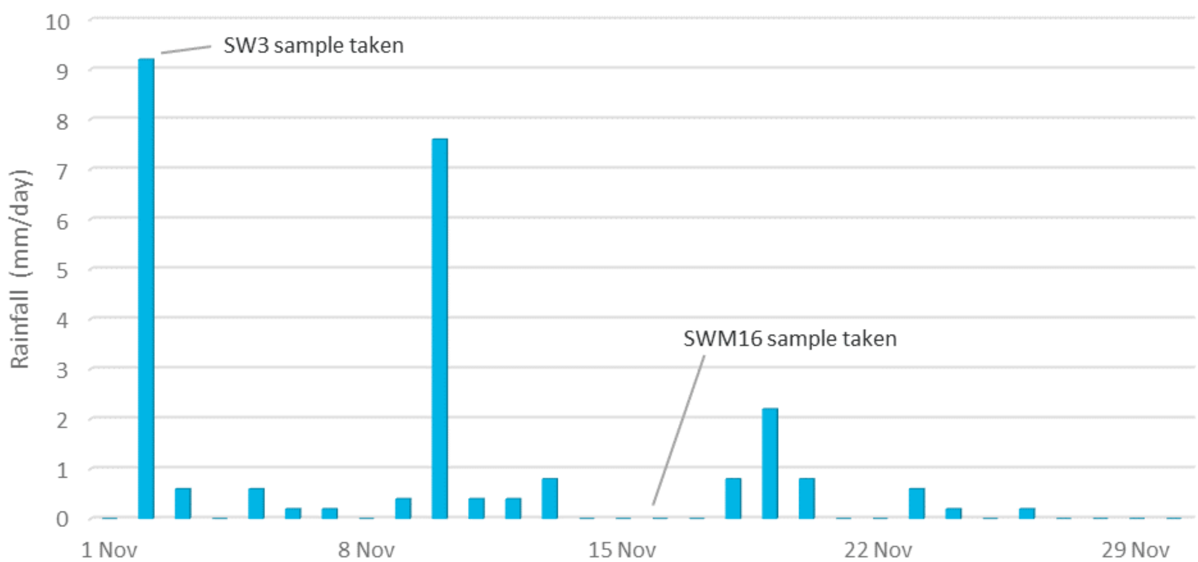


Figure 6.2 November 2021 rainfall at the J-A site

ii Water quality record

Water quality records for the J-A sites are presented in Table 6.3. These records illustrate elevated turbidity, nitrogen, phosphorus, aluminium, cadmium, chromium, cobalt, copper, and iron, at each of the sites including SW1 upstream from the mine.

The quantum of rain occurring and timing of when SW1 was sampled in 2016 (see section 6.2.1i) would indicate that it is likely representative of runoff from the upstream catchment; any dust from the mine would have been flushed from the catchment during the first flush, and would be outweighed by the stream sediment load.

The SW3 and SWM16 samples could potentially be affected by mining activities. Of the tested parameters, only the physicochemical parameters salinity (EC), turbidity and TDS are noticeably different to the SW3 sample. These parameters are expected to vary significantly between runoff events depending on the intensity of rainfall, so no conclusions can be made regarding whether the samples were affected by mining activity.

The relationship between surface water quality data from J-A and expected runoff water quality at Atacama is discussed in Section 6.2.1.

Table 6.3 Water quality results

			SW1 (upstream)	SW3 (downstream)	SWM16 (within J-A)
Group	**Units**	**Adopted DGV**	**25/03/2016**	**2/11/2021**	**16/11/2021**
Physicochemical parameters					
pH	-	**6.5-9**	7.6	7.9	8.4
EC (field)	uS/cm	-	260	2,710	2,450
Turbidity	NTU	**20**	**>1,000**	**220**	-
Total Dissolved Solids	mg/L	-	164	1,840	1,530
Total Suspended Solids (@ 105°C)	mg/L	-	3,830	-	-
Nutrients					
Nitrogen (Total)	mg/L	**5**	**14**	**6.8**	-
Phosphorus	mg/L	**0.1**	**0.7**	0.09	-
Metals					
Thorium	mg/L	-	0.0016	<0.005	-
Thorium (filtered)	mg/L	-	-	-	<0.005
Aluminium	mg/L	**0.1**	**24**	**2.3**	-
Aluminium (filtered)	mg/L	**0.1**	-	-	0.01
Arsenic	mg/L	**0.05**	0.003	0.001	-
Zirconium	mg/L	-	0.009	0.0016	-
Uranium	mg/L	-	0.0006	0.0021	-
Uranium (filtered)	mg/L	-	-	-	0.0007
Titanium	mg/L	-	0.054	0.02	-

Table 6.3 Water quality results

Group	Units	Adopted DGV	SW1 (upstream)	SW3 (downstream)	SWM16 (within J-A)
			25/03/2016	2/11/2021	16/11/2021
Cadmium	mg/L	**0.002**	0.0003	<0.0005	-
Cadmium (filtered)	mg/L	**0.002**	-	-	<0.0005
Chromium (III+VI)	mg/L	**0.001**	**0.027**	<0.005	-
Cobalt	mg/L	**0.0014**	**0.009**	**0.002**	-
Copper	mg/L	**0.01**	**0.039**	**0.013**	-
Copper (filtered)	mg/L	**0.01**	-	-	<0.005
Strontium	mg/L	**-**	0.51	0.85	-
Iron	mg/L	**1**	**15**	**1.4**	-
Iron (filtered)	mg/L	**1**	-	-	<0.05
Lead	mg/L	**0.005**	**0.015**	0.001	-
Manganese	mg/L	**1.9**	0.63	0.048	-
Manganese (filtered)	mg/L	**-**	-	-	<0.005
Mercury	mg/L	**0.0001**	<0.00005	0.0001	-
Nickel	mg/L	**0.15**	-	0.005	-
Nickel (filtered)	mg/L	**0.15**	-	-	<0.001
Zinc	mg/L	**0.05**	**0.07**	**0.09**	-

1. Bold indicates the DGV of SA Water Quality 2003, Aquatic Freshwater has been exceeded for that analyte.
2. Italics indicates the DGV of ANZG (2018) for protection of 95% of Freshwater species has been exceeded for that analyte.
3. Watermarked values indicate a non-detect, that is the analyte was below the limit of reporting (LOR)

6.2.2 Atacama sediment sampling data

i Monitoring sites and sample dates

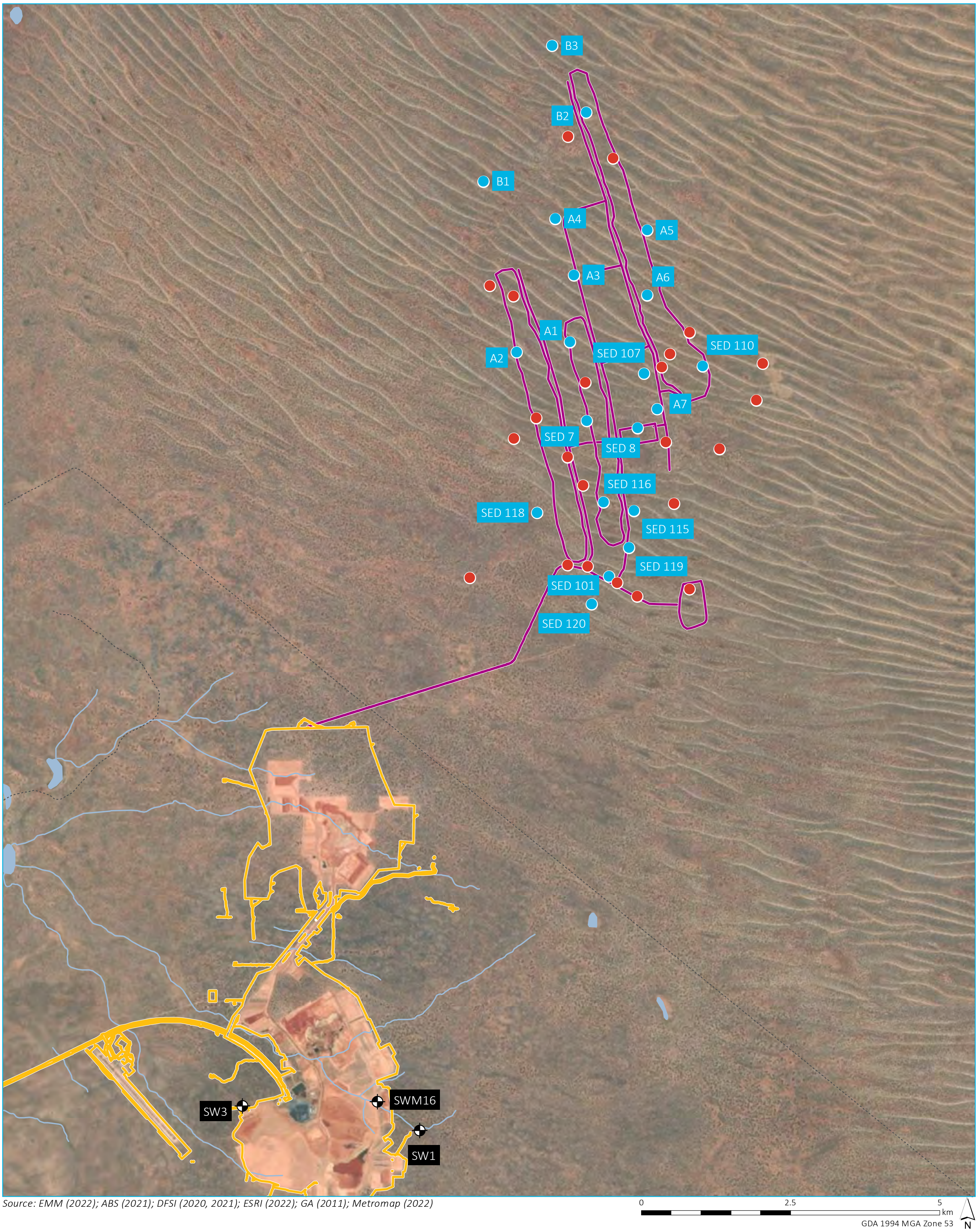
Three sediment sampling rounds were conducted at the Atacama site between September 2019 and May 2022. This is further described in CDM Smith (2022). Sampling sites (shown in Figure 6.3) were located within flow pathways and within the dune swales.

Table 6.4 outlines the sub-set of samples that were submitted for laboratory analysis, and summarises the sample date, topography and the type of testing carried out on the sediment samples.

Table 6.4 Sediment sample locations

Location ID	Date sampled	Description	Method
Sed 7	September 2019	Gently undulating plains, obvious drainage	ASLP Leachate
Sed 8	September 2019	Gently undulating plains, obvious drainage	ASLP Leachate
Sed 101	October 2019	Swale 300 m wide, no obvious drainage line	ASLP Leachate
Sed 107	October 2019	Swale 100 m wide, erosion gully 50 cm deep, active	ASLP Leachate
Sed 110	October 2019	Swale 25 m wide, no obvious drainage	ASLP Leachate
Sed 115	October 2019	Swale 100 m wide, no obvious drainage	ASLP Leachate
Sed 116	October 2019	Swale 150 m wide, no obvious drainage	ASLP Leachate
Sed 118	October 2019	Gently undulating plains, no obvious drainage	ASLP Leachate
Sed 119	October 2019	Swale 250 m wide, shallow drainage line around type 4 mounds	ASLP Leachate
Sed 120	October 2019	Swale flat and broad, 400 m wide, no obvious drainage	ASLP Leachate
A1	April/May 2022	Swale 100 m wide, no obvious drainage	DI Water Leachate
A2	April/May 2022	Swale 150 m wide, no obvious drainage	DI Water Leachate
A3	April/May 2022	Swale 200 m wide, minor drainage line, 5 cm deep	DI Water Leachate
A4	April/May 2022	Swale 200 m wide, no obvious drainage	DI Water Leachate
A5	April/May 2022	Swale 100 m wide, minor drainage lines and signs of run off	DI Water Leachate
A6	April/May 2022	Swale 200 m wide, drainage line 5 cm deep	DI Water Leachate
A7	April/May 2022	Gently undulating plains, obvious drainage line, 30 cm deep	DI Water Leachate
B1	April/May 2022	Swale 200 m wide, no obvious drainage	DI Water Leachate
B2	April/May 2022	Swale 150 m wide, no obvious drainage	DI Water Leachate
B3	April/May 2022	Swale 100 m wide, no obvious drainage	DI Water Leachate

1. Australian Standard Leaching Procedures (ASLP), Deionised (DI) Water



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Project layout (pits, roads)
- J-A mine disturbance footprint
- Water quality sampling location

Sediment sampling location

- Submitted for laboratory analysis
- Not submitted for laboratory analysis

Existing environment

- Vehicular track
- Watercourse/drainage line
- Waterbody

Water quality and sediment sampling locations

Atacama surface water assessment
Figure 6.3

EMM creating opportunities

ii Water quality record

Leachate test results indicated that run off generated at Atacama would be slightly alkaline and of low salinity (CDM Smith, 2022).

Leachate test results for representative sediment sample sites at Atacama (Sed 120, Sed 7 and Sed 8) have been compared to the surface water sampling from J-A (SW1) (Figure 6.4 and Figure 6.5). The soil leachate test results are representative of metals accumulated in the sediment for that location over geological time periods, whilst water quality grab samples will vary based on the rainfall and runoff intensity and the extent that soil particles are mobilised in the runoff event. Absolute metals concentrations in the soil sample leachate are thus not expected to be representative of the concentration that would occur in a surface water sample from a waterway, but the relative ratios of metals and major ions illuminate whether the sites have similar properties.

The soil and water samples have similar metals and major ion signatures. Each sample has:

- elevated aluminium, iron, manganese and strontium (Figure 6.4);
- lower concentrations of chromium, cobalt, lead and zinc (Figure 6.4); and
- similar ratios of calcium, sodium, magnesium and potassium (Figure 6.5).

Based on the similarities in metals and major ion signatures it is reasonable to assume that runoff from the Atacama site would be similar to that from the J-A site, and that the surface water samples described in Table 6.3 are indicative of Atacama runoff.

The higher chloride concentration for SW1 could indicate the J-A catchment has more sodium chloride (NaCl) salt than the Atacama region, or may be an analysis artefact. Low chloride concentrations in water used to perform the ASLP leachate tests can lead to overall lower mobility of other ions in sediment leachate test results and so skew the ratio of ions reported (Soilwater Consultants, 2015).

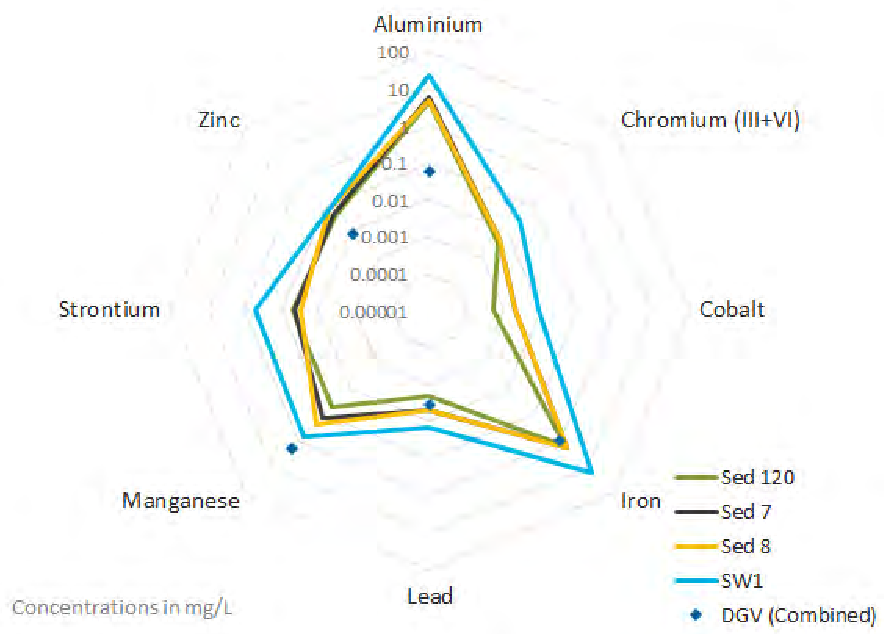


Figure 6.4 Metal signatures for J-A and Atacama sites

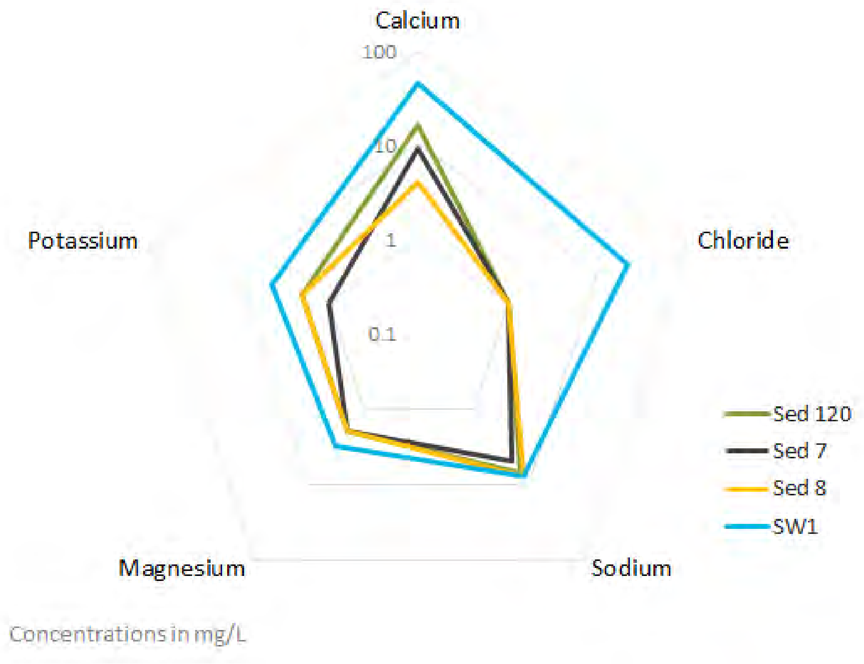


Figure 6.5 Salt signatures for J-A and Atacama sites

6.3 Risks to surface water quality

6.3.1 Receptors

Surface water receptors near to the project area include:

- dune swales at Atacama, where runoff may pool following rainfall;
- unnamed creeks, which cross the haul road from east to west and flow towards Lake Ifould; and
- Lake Ifould, an ephemeral salina.

There are no townships downstream of the mine site, and no water users are reliant on water from the dune swales that would be affected by the project.

Investigations into the level of reliance on surface water by ecosystems in the project area are described in Appendix A, with the conclusion that 'vegetation species within the Atacama study area are not reliant on collection of surface water or periods of inundation to survive'.

The proposed mine layout is primarily contained within the dune land scape. When rainfall runoff occurs, mining influences on runoff would be contained to dune swales in the immediate vicinity of the activity. The unnamed creeks and Lake Ifould are not connected to mining activity by overland flow paths (Figure 4.1, and Figure 2 of Appendix A), other than where the proposed haul road crosses drainage paths.

6.3.2 Construction

Development of the Atacama site would involve significant earth moving and vehicle movements and will disturb the soil surface crust and create areas with increased erosion potential. Mining pit backfill and rehabilitation will be progressive during the life of the mine, but nevertheless surface soil disruption will be significant.

During construction, erosion would be managed via an Erosion and Sediment Control Plan (ESCP), which would detail erosion control measures. Erosion control is standard practice in mining and construction, and standard methods are expected to be suitable at the Atacama site. Erosion control measures during construction may include:

- installation of silt barriers;
- bunding; and
- minimising disturbance areas on a spatial and temporal basis.

The majority of construction effects would take place within the dunes. Any local erosion would be contained to the immediate dune swale and would not affect water quality within creeks which flow to Lake Ifould (chapter 4).

At locations where the haul road crosses drainage paths, there is an increased risk of erosion on the downstream side of the haul road due to locally changed flow patterns. For example, water flowing over road embankments may locally be shallower with higher velocity, while culverts concentrate flow and can create higher velocity jets at the outlet. Civil road design guidelines such as *Austroads* describe these effects and provide standard guidance for the design of effective erosion protection measures. It is anticipated that erosion risk at waterway crossings can be entirely mitigated through appropriate design.

It is proposed that soil stripped from the pits would be stored in soil stockpiles until needed for rehabilitation. These stockpiles would be located out of waterway flood inundation areas, would be bunded to prevent mobilisation and transport of soil material during rainfall events, and would typically be located within dune swale catchments rather than waterway catchments.

During construction, equipment would utilise diesel fuel and would be lubricated with oils. There is a low likelihood risk of oil/fuel spill from vehicles, for example in the case of mechanical failure. Spill kits would be available at contractor facilities. Due to the arid environment, the likelihood of fuel/oil transport by surface water prior to clean up is very low. Heavy vehicles would primarily be used and parked within the dune system, where any transport of spilled material would be contained within the local dune swale.

Any fuel stores located at the Atacama site would be constructed on bunded pads in accordance with appropriate guidelines, outside of areas identified to be at risk from flooding. Spill clean-up procedures would be developed, and spill kits would be available.

6.3.3 Operation

During operation, earth moving would occur within the pits. The pits would be bunded for flood protection, and any erosion of exposed material within the pits during rainfall would remain within the pits. Progressive closure and rehabilitation of pits would minimise the area of pit open at any one time.

During operation, equipment would utilise diesel fuel and would be lubricated with oils. There is a low likelihood risk of oil/fuel spill from vehicles, for example in the case of mechanical failure. Spill kits would be available at contractor facilities.

Due to the arid environment, the likelihood of fuel/oil transport by surface water prior to clean up is very low. Heavy vehicles would primarily be used and parked within the dune system, where any transport of spilled material would be contained within the local dune swale.

There would be no tails storage facility at Atacama. Tails would be stored at J-A within the existing approved disturbance area utilising tailing methods currently employed at the J-A site. The continuation of tailing at J-A with material from Atacama is not expected to increase the risk to surface water at that site.

6.3.4 Closure

Closure activities would closely resemble construction activities. During closure, earth moving would occur within the pits to create a final landform. Colonisation of the final landform by vegetation and the formation of a soil crust would likely take a period of years, during which time there would be elevated risk of erosion. Material eroded from the disturbed surfaces would be contained within the rehabilitated pits, which would remain the lowest points in the landscape.

Progressive closure and rehabilitation of pits would allow the effectiveness of closure and rehabilitation practices to be seen during the period of operations, and potentially improved over time. ESCPs would be modified as the mine progresses to allow for ever changes in water holding capacity as pits are backfilled and the final land surface graded to meet the existing surface levels.

7 Surface water risk assessment

Risks to water quality during the development, operation, and closure of mining the Atacama deposit have been assessed using the risk matrix illustrated in Table 7.1, with descriptors as per Table 7.2 and Table 7.3.

Table 7.1 Risk matrix

Likelihood	Significance				
	Negligible	Minor	Moderate	High	Severe
Rare	Low	Low	Low	Medium	Significant
Unlikely	Low	Low	Medium	Significant	High
Possible	Low	Medium	Significant	High	High
Likely	Low	Medium	Significant	High	Extreme
Almost Certain	Medium	Significant	High	Extreme	Extreme

Table 7.2 Classification of significance

Significance category	Description
Severe	The impact is considered critical to the decision-making process. Impacts tend to be permanent or irreversible or otherwise long-term and can occur over large areas. Very high sensitivity of environmental receptors to impact.
High	The impact is considered likely to be important to decision-making. Impacts tend to be permanent or irreversible or otherwise long-term (>5 year recovery period). Impacts can occur over large or medium size areas. High to moderate sensitivity of environmental receptors to impact.
Moderate	The effects of the impact are relevant to decision-making including the development of environmental mitigation measures. Impacts can range from long-term to short-term in duration (1 to 4 year recovery period). Impacts occur mostly near the source, which is apparent and requires mitigation to be within limits of acceptability. Moderate sensitivity of environmental receptors to impact.
Minor	Impacts are recognisable/detectable but acceptable and may be contained on-site. These impacts are unlikely to be of importance in the decision-making process but are relevant in the consideration of standard mitigation measures. Impacts tend to be short-term (<12 month recovery period) or temporary and/or occur at a local scale.
Negligible	Minimal change to the existing situation. This could include for example impacts which are beneath the levels of detection, impacts that are within the normal bounds of variation or impacts that are within the margin of forecasting error.

Table 7.3 Classification of likelihood

Likelihood category	Description	Annual probability of occurrence
Almost Certain	A recurring event during the lifetime of an operation or project	More than two occurrences per year
Likely	An event that will probably occur during the lifetime of an operation or project	Around one occurrence per year
Possible	An event that may occur during the lifetime of an operation or project	More than 10% annual probability of occurrence
Unlikely	An event that is unlikely to occur during the lifetime of an operation or project	More than 1% annual probability of occurrence
Rare	An event with a low probability to occur during the lifetime of an operation or project	Less than 1% annual probability of occurrence

An assessment of risks to surface water is provided in Table 7.4. Residual risks considering proposed mitigation measures are each classified as 'low', indicating that appropriate controls have been identified and that the surface water environment is not expected to be impacted outside the immediate construction and mining footprint.

Table 7.4 Risk assessment

Hazard					Unmitigated risk			Mitigation measures	Mitigated risk		
Description	**Type**	**Source**	**Pathway**	**Receptor**	**Likelihood**	**Significance**	**Risk**		**Likelihood**	**Significance**	**Risk**
Construction											
Changed waterway flow regime due to ponding upstream from the haul road	Flow regime	Haul road construction	Waterways along the haul road	Waterways crossed by the haul road	Unlikely	Minor	Low	Culverts at waterway crossings	Rare	Negligible	Low
Faster creek head-cut migration	Water quality	Soils and landscape	Increased runoff velocity/flow magnitude	Waterway geomorphology	Rare	Minor	Low	None required; the current design is not expected to increase flow to waterways	Rare	Minor	Low
Deposition of road material in waterways due to erosion	Water quality	Haul road	Rainfall runoff	Waterways crossed by the haul road	Possible	Moderate	Significant	Culvert design at waterway crossings Design haul road to allow overtopping in larger rainfall events without failure	Unlikely	Minor	Low
Erosion downstream from waterway crossings	Water quality	Haul road	Rainfall runoff	Waterways crossed by the haul road	Likely	Moderate	Significant	Standard erosion control measures included in design	Unlikely	Minor	Low
Fluvial transport of soil stockpiles	Water quality	Soil stockpiles	Rainfall runoff	Dune swales within the area of disturbance	Likely	Minor	Medium	Locate stockpiles outside of waterway floodplains Bunding of stockpiles/Stockpile toe protection	Unlikely	Minor	Low
Fuel or oil spill contamination	Water quality	Vehicle fuel/oil	Rainfall runoff	Dune swales within the area of disturbance	Unlikely	Minor	Low	Spill kits Spill management plan Bunded fuel stores	Rare	Negligible	Low
Erosion of areas disturbed by earth moving equipment	Water quality	Construction activities	Rainfall runoff	Dune swales within the area of disturbance	Likely	Minor	Medium	Minimise the area of disturbance Erosion and sediment control plan Standard construction erosion and sediment control measures	Unlikely	Minor	Low
Operation											
Fuel or oil spill contamination	Water quality	Vehicle fuel / oil	Rainfall runoff	Dune swales within the area of disturbance	Unlikely	Minor	Low	Spill kits Spill management plan Bunded fuel stores	Rare	Negligible	Low
Fluvial transport of soil stockpiles	Water quality	Soil stockpiles	Rainfall runoff	Dune swales within the area of disturbance	Likely	Minor	Medium	Locate stockpiles outside of identified areas at risk of flooding Stockpile toe protection	Unlikely	Minor	Low
Closure											
Erosion of closed pit areas prior to rehabilitation completion	Water quality	Exposed soils	Rainfall runoff	Rehabilitated dune swales	Likely	Minor	Medium	Progressive rehabilitation, with potential improvements over time Dynamic ESCPs	Possible	Negligible	Low

8. Water quality monitoring

A water quality monitoring plan will be developed as part of the Program for Environment Protection and Rehabilitation (PEPR), describing sampling locations, frequency, method and analytes. Given the ephemeral nature of streamflow in the project area, the monitoring plan would include both:

- surface water sampling, which would take place opportunistically following rainfall; and
- sediment sampling from the waterway/swale bed, which would be undertaken on a regular basis (eg yearly).

Table 8.1 gives an example water quality monitoring plan and example sampling locations are illustrated in Figure 6.3**Error! Reference source not found.**. These locations were selected via desktop study to meet the intent of the description provided in Table 8.1, and may not be ideal (eg due to convenience of access following rain).

Water and sediment sampling would be undertaken as per relevant guidelines and to align with baseline sampling and monitoring already undertaken at the Atacama and J-A sites (see Chapter 6). Similarly, water and sediment samples would be analysed for analytes recommended in guidelines and for those detected in water samples at the J-A site and in sediment samples at the Atacama site.

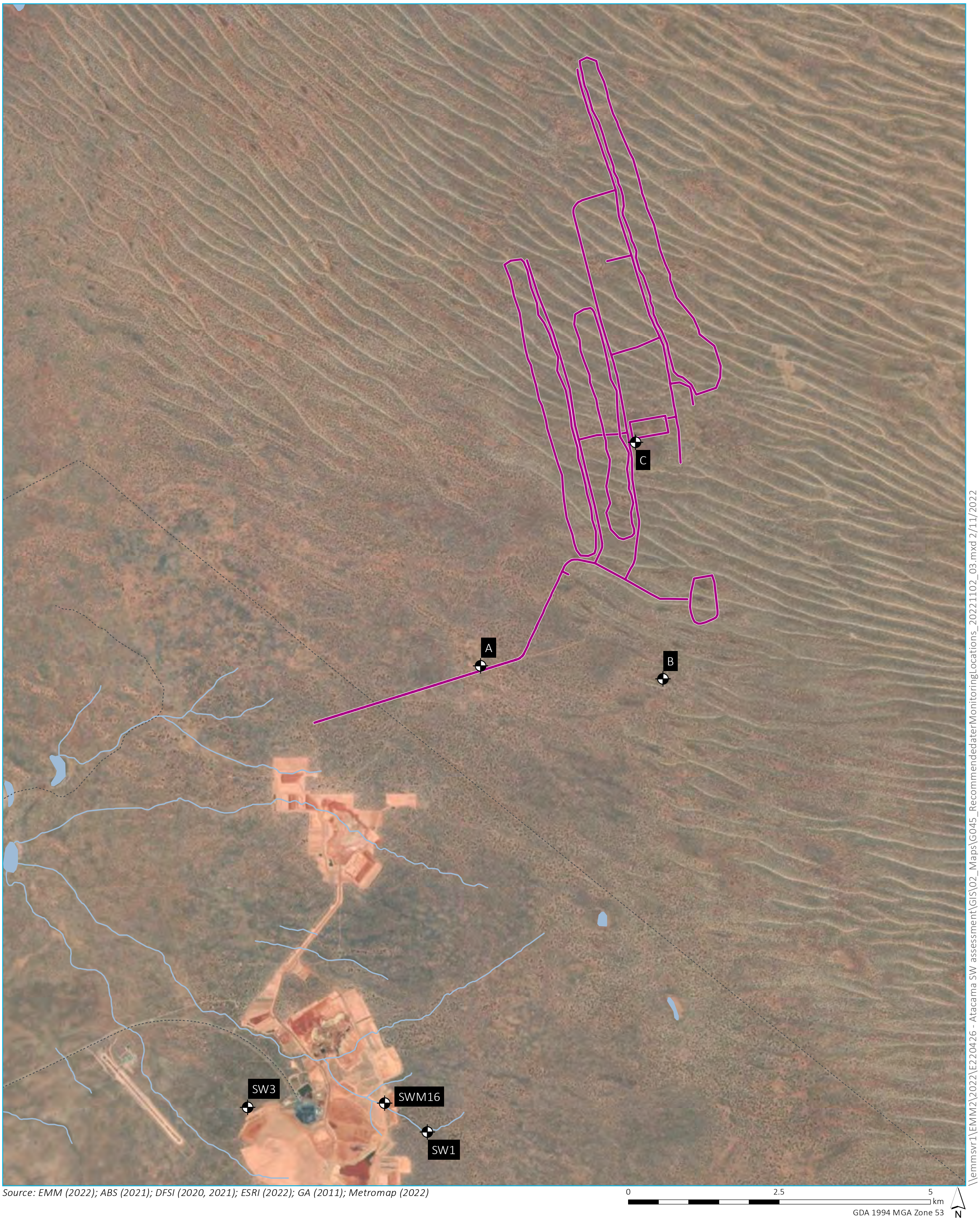
Table 8.1 Example water quality monitoring plan

Location	Sampling frequency	Sample method	Analytes
• Within one waterway crossed by the haul road at the culvert outlet	Following significant rainfall	Rising stage sampler bottle installed 0.3 - 0.5 m above the ground.	Metals (eg aluminium, chromium, cobalt, iron, lead, manganese, strontium, zinc) Physicochemical parameters (pH, EC, turbidity, TDS, TSS)
• One dune swale within the disturbance footprint • One dune swale outside the disturbance footprint	Yearly	Soil sample from waterway/ swale bed	

A trigger-action-response plan would be developed as part of the PEPR, describing actions to be taken if water samples indicate contamination due to mining activities.

Trigger levels would be site-specific and would not necessarily refer to the DGVs. Site-specific trigger values would be developed following the initiation of monitoring, once at least three sample events have occurred.

The response plan would likely include actions such as an investigation into possible sources of contamination, measures to clean up residual contaminant sources, and increased monitoring frequency.



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Project layout (pits, roads)

Proposed monitoring location

Existing environment

Vehicular track

Watercourse/drainage line

Waterbody

Proposed monitoring location

Atacama surface water assessment

Figure 8.1

EMM
creating opportunities

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Appendix A

Atacama Surface Water Study - Alluvium baseline study (2014)

ATACAMA DEVELOPMENT PROJECT:

Atacama Surface Water Study

Final Report

December 2014

Document history

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Author/s	Clare Ferguson Karen White Hamid Ghajarnia
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Author/s	Clare Ferguson Karen White Hamid Ghajarnia
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Contents

Figures

Tables

Abbreviations

Alluvium	Alluvium Consulting Australia Pty Ltd
ARI	Average Recurrence Interval
BSC	Biological Soil Crust
DEWNR	Department of Environmental, Water and Natural Resources
DMITRE	Department of Manufacturing, Innovation, Trade, Resources and Energy
J-A	Jacinth Ambrosia
PEPR	Program for Environmental Protection and Rehabilitation
PMP	Probable Maximum Precipitation

1 Introduction

1.1 Project background

In 2009, Iluka Resources Limited (Iluka) commenced mining operations of the Jacinth mineral sand deposit in the Eucla Basin, approximately 200 km north west of Ceduna in South Australia. Several satellite resource deposits (Atacama, Sonoran and Typhoon) have subsequently been identified approximately 10 km northeast and 9 km south east respectively of Iluka's Jacinth-Ambrosia Operation (J-A) as shown in Figure 1. The development of these resources will allow the J-A operation to combine zircon rich and ilmenite rich feed stocks allowing Iluka the flexibility to supply changing markets and manage changing economic conditions.

The Atacama resource (collectively referred to as the Atacama deposit) falls within Exploration Licence 5198 which is located within the Yellabinna Regional Reserve. Activities within the reserve require specific approvals from the South Australian Department of Environmental, Water and Natural Resources (DEWNR), Department of State Development (DSD) and the Environmental Protection Authority. A pre-feasibility study is currently underway to determine the most economic method to develop the Sonoran deposit.

Alluvium Consulting Australia (Alluvium) was engaged by Iluka to identify and characterise watercourses within the Atacama deposit region to provide an understanding of existing conditions of surface water drainage and identify potential environmental impacts to inform mine planning. The work will underpin impact assessment predictions and commitments in any mining proposal under the South Australian *Mining Act 1971*.

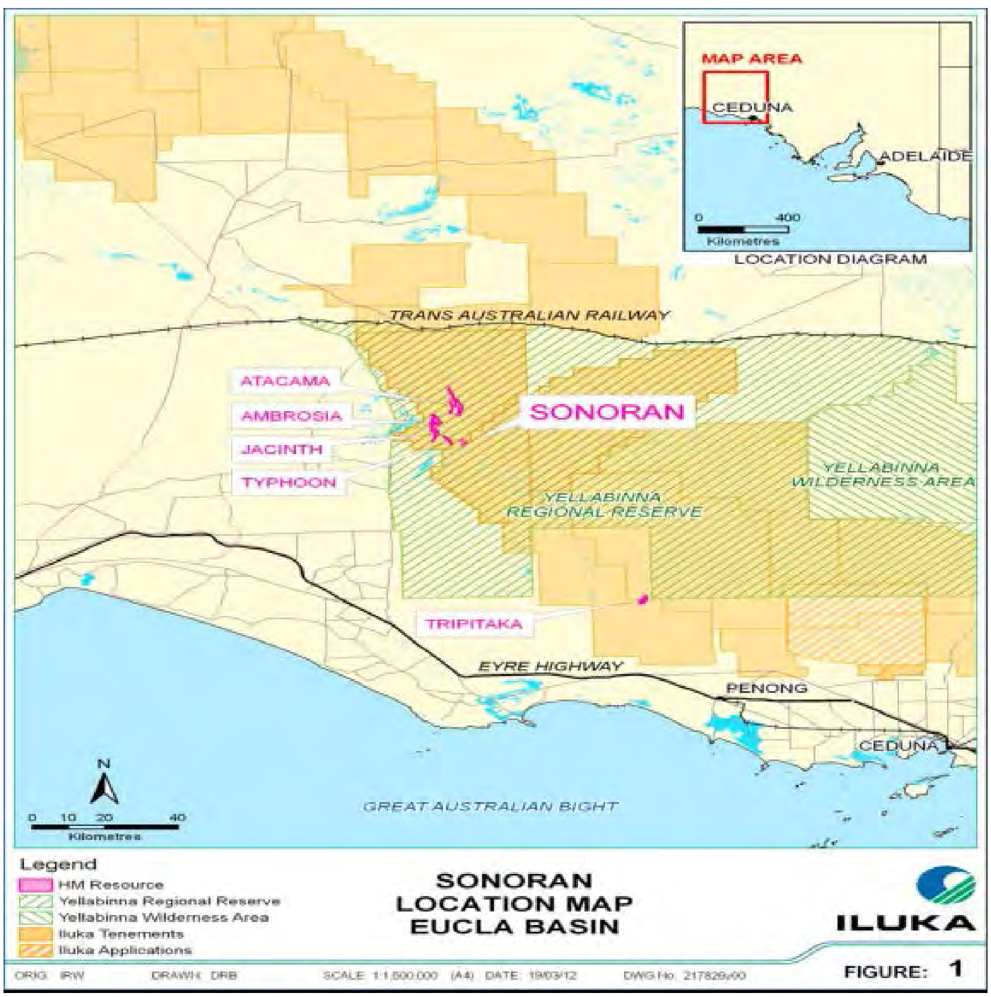

Figure 1. *Location of the different resource deposits in the Eucla Basin, South Australia (Iluka, 2014)*

1.2 Objectives

The purpose of this surface water study is to:

- Determine relevant legislative requirements that apply to surface water management
- Describe the current surface water environment including:
    - Characterisation of the surface water hydrology (rainfall and runoff)
    - Hydraulics, including flood inundations
    - Stream geomorphology, including stream type and processes at work.

The objectives of this study include:

1. Develop key data sets to describe the surface water drainage across the deposit which will underpin impact assessment predictions and commitments in any Mining Lease Proposal under the SA *Mining Act 1971*;
2. Characterise pre disturbance land condition for use in mine restoration planning, including basis for rehabilitation commitments in any Mining Lease Proposal and Program for Environmental Protection and Rehabilitation (PEPR);
3. Develop flood mapping in order to inform infrastructure design and placement.

A surface water study was recently completed for the Jacinth Ambrosia catchment (Alluvium, 2013) and the Sonoran Typhoon study area (Alluvium, 2014). The Atacama surface water study will build on this existing knowledge to develop a regional understanding of surface water conditions in the local region.

1.3 Scope and method

The project scope includes watercourses and associated catchments that may potentially be impacted by developing the Atacama deposit (Figure 2). This includes watercourses and their sub-catchments upstream of the Atacama resource deposits and adjacent to the Ambrosia resource deposit. Collectively, this is referred to as the Atacama study area in this report. The use of the term 'watercourse' in this document is not necessarily reflective of the definition of 'watercourse' under the *Natural Resources Management Act 2004* (refer to Section 2).

The method for this study has been developed to provide datasets comprising:

- A description of the current surface water environment including:
    - definition of relevant legislative requirements in relation to surface water
    - characterisation of the surface water hydrology (rainfall and runoff)
    - hydraulics, including flood depths
    - stream geomorphology, including stream type and processes at work.

This study consisted of a desktop assessment, fieldwork and development of a 2 dimensional hydrodynamic model to identify flood extents within the complex parallel dune system that exists through much of the study area. Details of the method for each discipline area are provided in Section 3. A list of the data used is provided in Table 1.

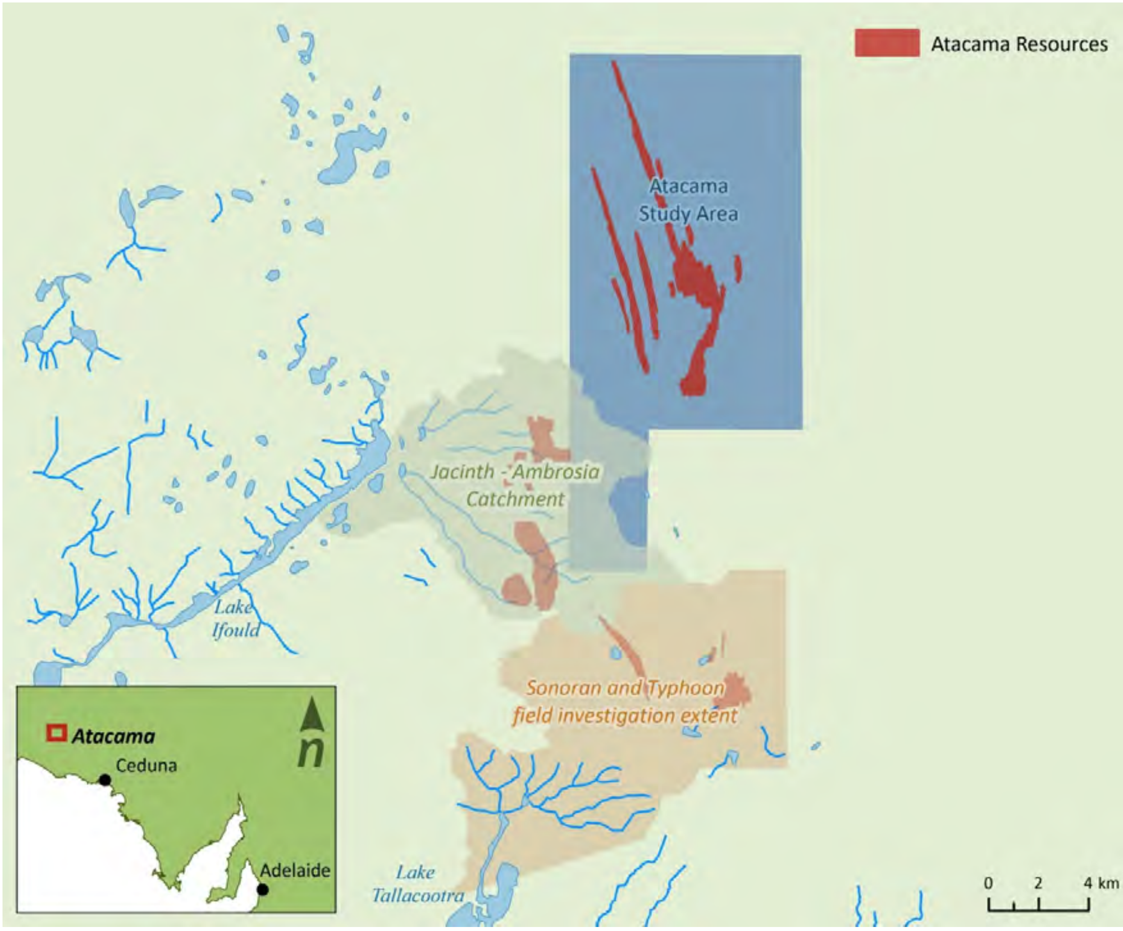

Figure 2. *Location map of Atacama study area*

Table 1. Summary of data used during the study

Data list
• Previous reports and GIS layers • 10cm resolution RGB outline imagery of Atacama (2013) • 1m grid DEM of Atacama study area • Rainfall records (Tarcoola, Jacinth Ambrosia) • BOM IFD data • 2005/10/11/12/13 aerial photos of Jacinth Ambrosia catchment • Vegetation and fauna survey (EBS 2014) • Arid zone literature • New 2D hydrodynamic model built using XPSWMM • Flow heights based on measurements taken during fieldwork at J-A mine (4 – 7 March 2014) • Watercourse characterisation based on observations during field work (September 2014)

1.4 Report structure

This report outlines the baseline condition of watercourses and associated surface water drainage within the Atacama study area. The report is divided into the following sections:

Report section	Description
1. Introduction (this section)	Introduces the project background and outlines the project objectives and scope.
2. Legislative summary	Summarises relevant legislation related to surface water drainage as part of the proposed mine development.
3. Baseline information	Provides a summary of baseline environment, review of relevant previous studies and description of surface water drainage, geomorphology and vegetation.
4. Conclusions and recommendations	Short summary of the main outcomes and recommendations for future rehabilitation.

2 Legislative summary

In addition to the primary approval and regulation of mining projects by the *Mining Act 1971*, there are a number of South Australian and Commonwealth Acts and regulatory processes that need to be taken into account for the Atacama mine development.

The two main pieces of legislation relating to surface water are the *Environmental Protection Act 1993* (and Water Policy 2003) and the *Natural Resources Management Act 2004*. The study area is covered by the Alinytjara Wilurara Regional Natural Resources Management Plan (2006) which provides an assessment of condition and proposes priorities for the management of natural resources, including water.

The *Natural Resources Management Act 2004* provides for the protection of water resources, including the requirements for permits to undertake Water Affecting Activities as detailed in Section 127 (5) as follows.

(a) the erection, construction or enlargement of a dam, wall or other structure that will collect or divert water flowing in a watercourse that is not in the Mount Lofty Ranges Watershed and that is not prescribed or flowing over any other land that is not in a surface water prescribed area or in the Mount Lofty Ranges Watershed;

(b) the erection, construction or placement of any building or structure in a watercourse or lake or on the floodplain of a watercourse;

(c) draining or discharging water directly or indirectly into a watercourse or lake;

(d) depositing or placing an object or solid material in a watercourse or lake;

(e) obstructing a watercourse or lake in any other manner;

(f) depositing or placing an object or solid material on the floodplain of a watercourse or near the bank or shore of a lake to control flooding from the watercourse or lake;

(g) destroying vegetation growing in a watercourse or lake or growing on the floodplain of a watercourse;

(h) excavating or removing rock, sand or soil from—

(i) a watercourse or lake or the floodplain of a watercourse; or

(ii) an area near to the banks of a lake so as to damage, or create the likelihood of damage to, the banks of the lake;

(i) using water in the course of carrying on a business in an NRM region at a rate that exceeds the rate prescribed by an NRM plan if the water has been brought into the region by means of a pipe or other channel;

(j) using effluent in the course of carrying on a business in an NRM region at a rate that exceeds a rate prescribed by an NRM plan;

(k) an activity prescribed by the regulations.

It is possible that (b), (d), (f) and (h)(i) would be triggered by the project and that a Water Affecting Activities permit under the *Natural Resources Management Act 2004* would be required. This should be discussed with the Department of State Development (DSD) and Natural Resources Alinytjara Wilurara during the Detailed Feasibility Study (DFS) phase. The use of the term 'watercourse' in this document is not necessarily reflective of the definition of 'watercourse' under the *Natural Resources Management Act 2004.*

A summary of key legislation relating to surface water and their relevance to the study area is provided in Table 2. This has been used to guide the collation of baseline condition for surface water and associated elements such as flora and fauna and to assess potential impacts of the proposed mine.

Table 2. Summary of legislation relating to surface water

Legislation	Description	Relevance
Environmental	Provides the regulatory framework to protect South	General environmental duty (Part

Legislation	Description	Relevance
Protection Act 2003	Australia's environment, including land, air and water. It states that a person must not undertake an activity that pollutes, or might pollute, the environment unless the person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm.	4) and environment and development authorisations (Part 6).
Environmental protection (Water quality policy) 2003 Under section 28 of the Environmental Protection Act 1993	The principal object of this policy is to achieve the sustainable management of waters, by protecting or enhancing water quality while allowing economic and social development. The policy aims to achieve this objective by: • setting environmental values and water quality objectives for streams, rivers, oceans and groundwater • establishing obligations for industry and the community to manage and control different forms of pollution • encouraging better use of wastewater by: o avoiding its production o eliminating, or reducing it o recycling and re-using it o treating it to reduce potential harm to the environment • promoting best practice environmental management • promoting within the community environmental responsibility and involvement in environmental issues • setting discharge limits for particular activities.	Setting of water quality objectives (Part 3) and management and control of point source pollution (Part 4).
Natural Resources Management Act 2004	Promotes and facilitates integrated and sustainable management of all natural resources (water, soil, biodiversity etc); and provides for their protection.	Management and protection of water resources (Chapter 7) Section 127 (Water affecting activities) A person must not undertake a Water Affecting Activities unless it is in accordance with the relevant Natural Resources Management Plan or Water Allocation Plan.
National Parks and Wildlife Act 1972	Provides for the establishment and management of reserves for public benefit and enjoyment; to provide for the conservation of wildlife in a natural environment.	The study area is located within Yellabinna Regional Reserve and Jacinth and Ambrosia mine is regulated under the National Parks and Wildlife Act. While the act refers to plants and animals there is mention of surface water management requirements.
The Commonwealth Environment Protection and Biodiversity Conservation Act 1999	Provides protection for matters of national environmental significance. Any action that has, will have or is likely to have a significant impact on matters of national environmental significance requires referral	Not directly relevant to surface water however, the water requirements of threatened species and ecological

Legislation	Description	Relevance
(EPBC Act)	under the EPBC Act. The EPBC Act identifies the follow as matters of national environmental significance: • World Heritage properties • National Heritage properties • Wetlands of international importance (Ramsar wetlands) • Listed threatened species and ecological communities • Migratory species • Commonwealth marine areas • The Great Barrier Reef Marine Park • Nuclear actions (including uranium mining).	communities may need to be considered under this act. Where an activity may trigger requirements of the EPBC Act, this legislation must be taken into account. Any action that has, will have, or is likely to have a significant impact on a matter of national environmental significance requires referral and approval.

3 Baseline environment

3.1 Overview

The Atacama resource deposits lie in the Eucla Basin where the Nullarbor Plain meets the Yellabinna Dunefield. The deposits are located approximately 10 km to the north of the Jacinth-Ambrosia operation and extend approximately 14 km northward. A number of environmental surveys and investigations have been completed in the region, both prior to and following the granting of the Jacinth-Ambrosia mining lease.

Although the Atacama deposits are located in relatively close proximity to the Ambrosia deposit, there are some important landscape differences between the two areas. This section details the baseline environment in the Atacama study area in relation to surface water and watercourses. It also outlines the application of the River Styles® framework to characterise the geomorphology of the study area and compares this to the Jacinth Ambrosia and Sonoran and Typhoon study areas to develop a regional understanding of surface water and geomorphology.

3.2 Study area characteristics

The characteristics of the Atacama study area are summarised below (Table 3), while key characteristics such as rainfall, flow, geomorphology and vegetation that are relevant to surface water are discussed in more detail in the following sections.

Table 3. Summary of characteristics for the Atacama study area

Characteristic	Summary
Climate	The study site is located in an arid environment (<250 mm annual rainfall). Rainfall records from Tarcoola (230 km north east from study site) show an average annual rainfall of 175 mm since 1904, varying from 50 to 430 mm per annum. On average between 10 and 20 mm of rainfall occurs each month with no distinct seasonal trends. Winter and spring tend to receive more days with rainfall events > 1mm compared to autumn and summer. This data indicates that winter and spring rainfall is composed of more frequent and smaller rainfall events whereas summer and autumn receive less frequent and larger rainfall events. The hottest months are from November to March, with an average maximum close to 30°C and an average annual evaporation of 2,483 mm (Doudle and Ekert, 2013).
Geology	The study site is located in the Eucla Basin at the inland extent of ocean transgression (Hou and Warland 2005). The Eucla Basin consists of Cainozoic marine limestone deposits overlying the crystalline basement of the Gawler Craton. Sea-level lowering and continental uplift during the middle Miocene exposed the Nullarbor plain. This plain was subjected to weathering, resulting in silcrete and ferricates duricrusts. The upper stratum consists of quaternary sands of the Great Victoria desert.
Topography	The Atacama study area is located on the western fringe of the Yellabinna Dunefield. The Atacama deposits lie within parallel dunes running predominantly in a northwest – southeast direction. These dunes can be hundreds of metres long and up to 20 m high. The distance between parallel crests can be 250 m to 500 m. The morphology of this landscape is dominated by aeolian (wind) processes. Fluvial (water) processes have relatively minimal impact on the landscape. Fluvial impacts are best seen in the pans located throughout the area. The dunes have formed a number of terminal catchments (i.e. small, isolated catchments that are typically delineated by dunes). These are typically bounded by a dune crest to the north and south of the catchment and low, rounded, often barely distinguishable ridgelines that are perpendicular to the dunes. Almost all catchments contain a terminal pan. In several places, the dune crest ends have lowered over time enabling the troughs (dune swales) on either side of the crest to connect, effectively joining two formerly parallel catchments. There are examples where multiple parallel catchments have connected in this way, forming a larger, complex terminal catchment. The dune system transitions into an interdunal landscape towards the south western corner of the study area, where the access corridor extends to the south (see Figure 3). The topography of this southern corridor, through which access roads will be constructed to connect the Atacama deposits to the existing infrastructure at the Jacinth deposit, is markedly different to that

Characteristic	Summary
	topography surrounding the Atacama deposits. The topography here reflects the dendritic network found throughout the Jacinth and Ambrosia catchments. Fluvial processes dominate here while aeolian processes have a minor influence. The southern corridor lies to the east of the Ambrosia and northern end of the Jacinth deposits and is largely within the upper Jacinth and Ambrosia catchments. The landscape gently slopes to the west, with the exception of a single terminal catchment located on the eastern side of the corridor. This drains inwards towards a terminal pan.
Watercourses	There are no large watercourses in the Atacama study area. Drainage occurs along dune swales, with no defined watercourses throughout much of the Atacama area. Small incised gullies have formed in the base of some dune swales through which the spine track has been cut. These gullies have formed in response to the hydrologic impacts caused by development and maintenance of the track. The southern corridor lies in the upper Jacinth – Ambrosia catchments. These upland watercourses form part of a dendritic network, but are largely undefined in these upper reaches. Several defined reaches of Jacinth North Creek Ambrosia South Creek lie within the southern corridor.
Flow characteristics	Stream flow is ephemeral and there is no gauged flow data available in the area. Stream flow has occurred twice since mining operations commenced in the region, in 2008 and in February 2014. Smaller, intermittent flow events were reported in 2009 and 2011. High initial and continuous transmission losses characterise rainfall and flow events. Flow typically occurs in response to high intensity, short duration rainfall events.
Soil	Soils across the region are very fine sands. In the Atacama study area, these sands are of aeolian origin, while in the southern corridor sands are of both fluvial and aeolian origin. A baseline soil survey of the Jacinth – Ambrosia region (through which the southern corridor passes) conducted by SKM (2014) reported that surface soils were similar across the Ambrosia area and are classified as Calcarosols with the upper 1.5 m consisting of a gradational increase in texture from sandy loam in the topsoil to clay loam in the subsoil. Soil texture was found to follow a characteristic profile with depth of increasing clay content from the surface to the pedogenic clays and then decreasing through the Pidinga Formation and into the Aeolian sand (SKM 2014). Water retention curves reveal that the soil materials have a high water storage capacity to support vegetation.
Vegetation	Vegetation structure is significantly influenced by soil type and depth in the study area (EBS, 2014). Dune crests are dominated by *Eucalyptus* spp. and *Callitris verrucosa* (Native Pine) over low shrubs and small trees such as *Grevillea stenobotrya* and *Hakea francisiana*. These species are very tolerant of the harsh conditions present in these landforms and are reliant on rainfall events only. Moderate depth loams in swales and flanks of dunes are dominated by a mix of species, primarily *Eucalyptus yumbarrana / E. pimpiniana* over *Triodia*. These are neither reliant nor tolerant of excessive moisture and require excellent drainage to persist in these areas. Areas of low to mid elevation and clay loams over fragmented calcrete are typified by stands of *Acacia papyrocarpa* (Western Myall). The understorey is commonly dominated by *Maireana sedifolia* (Bluebush), *Cratystylis conocephala* (Daisy Bluebush), *Senna* spp. *Santalum acuminatum* (Quandong) and various other shrub and herbaceous species. The lowest elevation sites are typified by extensive areas of dead Myall with an often dense stand of Senna spp.

Figure 3. *Landscape regions in the Atacama study area*

3.3 Surface water hydrology

Surface water hydrology in the arid zone is a function of rainfall (intensity and duration), soils (sandy soils), vegetation and topography. While the relationship between these elements and runoff is complex, the process can be analysed with current generation modelling software. Previous studies have modelled surface hydrology at the J-A operation (SKM, 2005; PB, 2008; Alluvium, 2013) and the proposed Sonoran and Typhoon development (Alluvium, 2014). This study has reviewed these models and applied the lessons learned to modelling surface water in the Atacama study area. The following section summarises the method and outcomes from the surface hydrology modelling which will be used to inform the flood inundation and geomorphic assessments. Further information regarding the surface hydrology analysis method and assumptions is provided in Attachment A.

Rainfall

Rainfall at the study area is infrequent and irregular both spatially and temporally across the broader region. Rainfall records from Tarcoola (230 km north east from study site) show an average annual rainfall of 175 mm since 1904, varying from 50 to 430 mm per annum (Figure 4).

A weather station was installed at the J-A operation in March 2006 approximately 12 km south west of the Atacama study area, however technical difficulties have resulted in periodic and possibly unreliable data (Doudle and Eckert 2013). Anecdotal reports indicate that rainfall at the J-A operation is localised and small events (less than 10 mm) may not generate sufficient runoff for the watercourses to flow. Furthermore, flow in one part of a catchment often does not continue to reaches further downstream.

In the absence of long-term data at the J-A station, nearby weather stations can be used for modelling surface hydrology providing that the nearby catchments are located in same climate classification zone. Based on our investigations there are 11 stations in nearby regions, however, all nearby weather stations, including Tarcoola, are in different climate zones (Figure 5). This means that application of this method is not recommended by Australian Rainfall and Runoff guidelines (AR&R) (Institute of Engineers, 2001).

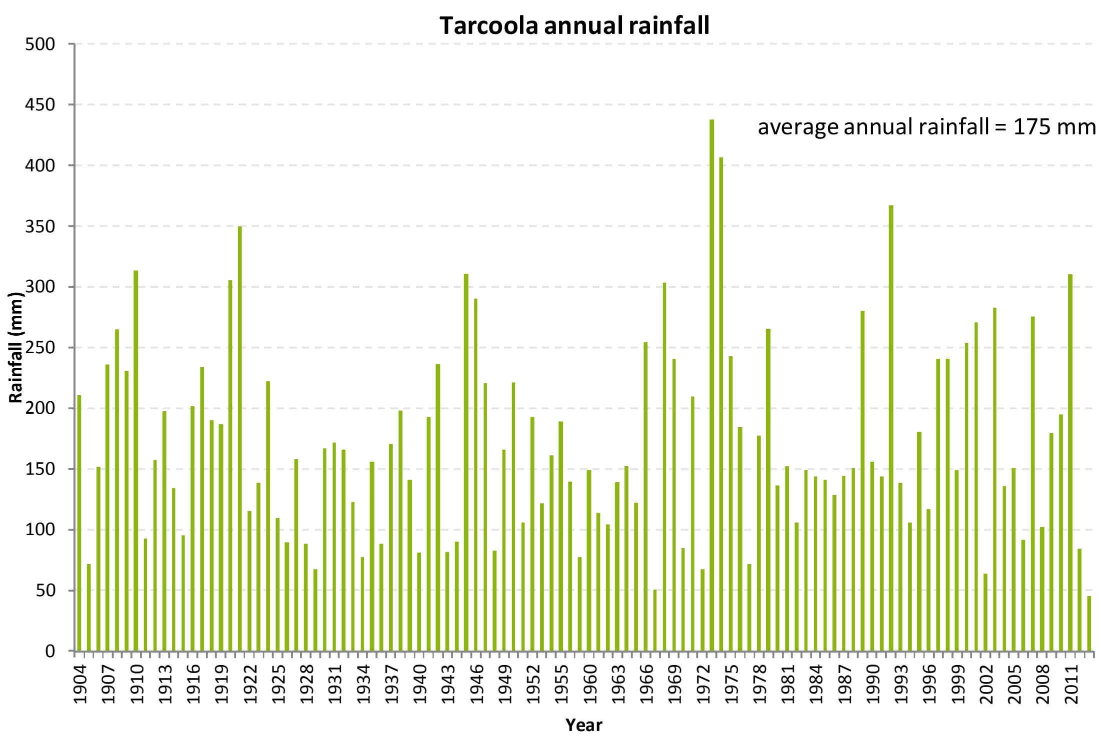

Figure 4. *Annual rainfall recorded at Tarcoola from 1904 to 2013*

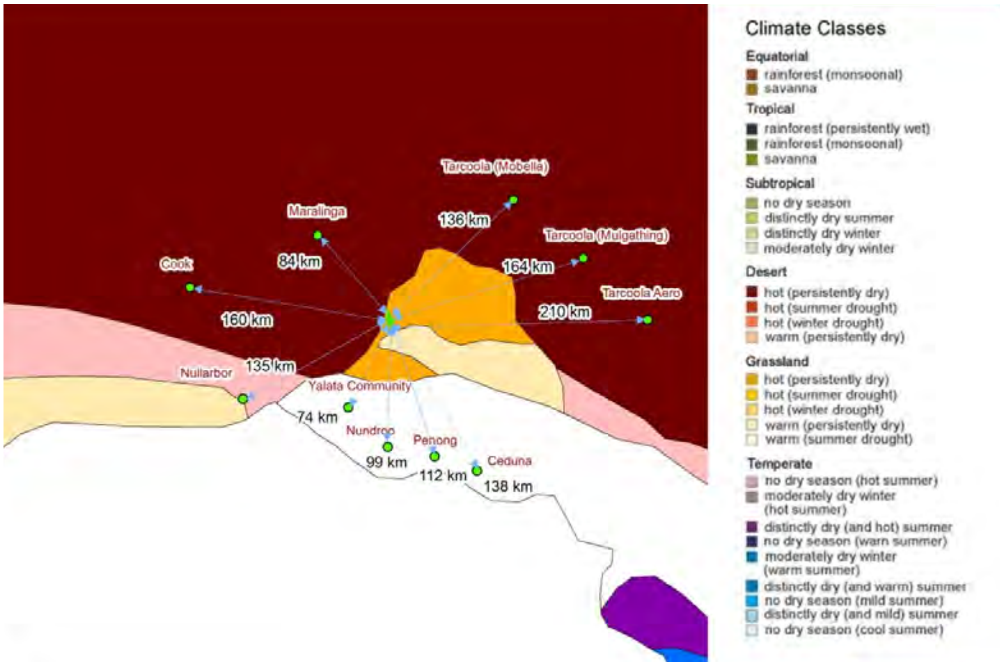

Figure 5. *Climate classification for nearby weather stations*

In the absence of suitable rainfall data, surface water flows can be derived by using Intensity Frequency Duration (IFD) curves developed by the Bureau of Meteorology (BOM). These curves provide a relationship between rainfall intensity for storms with different durations for the study area region. The 1987 IFD curves were applied to the hydrology analysis for this study (Figure 6). The IFD curves are currently in the process of being reviewed by BOM and although a revised IFD curve (2013) for the study region has been developed, it could not be used for this study as the temporal distribution pattern has not been developed and officially published. The magnitude of rainfall depth, intensity and temporal pattern for 2, 5, 10, 20 and 100 year storms were derived from the 1987 IFD curves.

The initial and continuous losses for rainfall events were set to recommended values for arid zones in South Australia (initial loss (IL) = 15 mm and continuous loss (CL) = 4 mm/h), as outlined in AR&R. In the future, these values can be revised and calibrated using site data from three significant rainfall events. One such event occurred on 15 February 2014 when 52 mm was recorded during a 2 hour period (Figure 7). See Attachment A for further discussion on data requirements for future calibration.

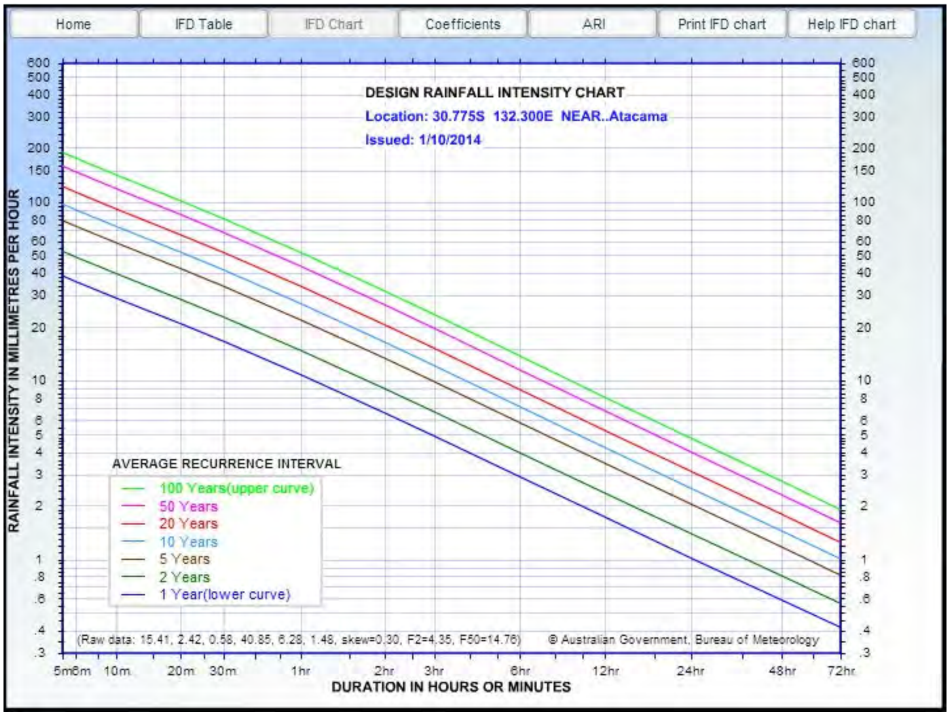

Figure 6. *IFD curve derived for Atacama Mine site (Bureau of Meteorology - BOM website)*

Figure 7. *Photo of Jacinth North Creek on 15 February 2014 following 52 mm of rain (equivalent to the 1 in 50 year ARI(event).*

Hydrology

The process of converting rainfall into surface water runoff was simulated using XPSWMM hydrodynamic model. XPSWMM is a two-dimensional hydrodynamic model that undertakes advanced calculations to simulate rainfall-runoff process. This model was developed for rainfall with different durations from 30 minutes to 6 hour and for extreme events such as 1000 year average recurrence interval (ARI) to small events such as 5 year ARI to recognise catchment boundaries and most critical duration for each flow.

To estimate flows, catchment boundaries need to be clearly defined. The challenge for the Atacama study area is that some catchments are defined by dune ridges and there is a possibility that these catchments may merge during rare, extreme flow events. The merging of catchments under these circumstances would indicate whether the watercourses that dissect the Atacama deposit are part of a large catchment that drains to playa lakes to the west or are in separate catchments.

The hydrodynamic model was run for the 1000 year ARI storm event to define catchment boundaries and the results indicated that catchments remain separated with surface water terminating in pans. Figure 8 shows water depth and delineation of catchments at 1000 year ARI storm event and clearly demonstrates that the watercourses in the vicinity of the Atacama resource deposits are in separate catchments, demonstrating that surface water runoff is highly localised.

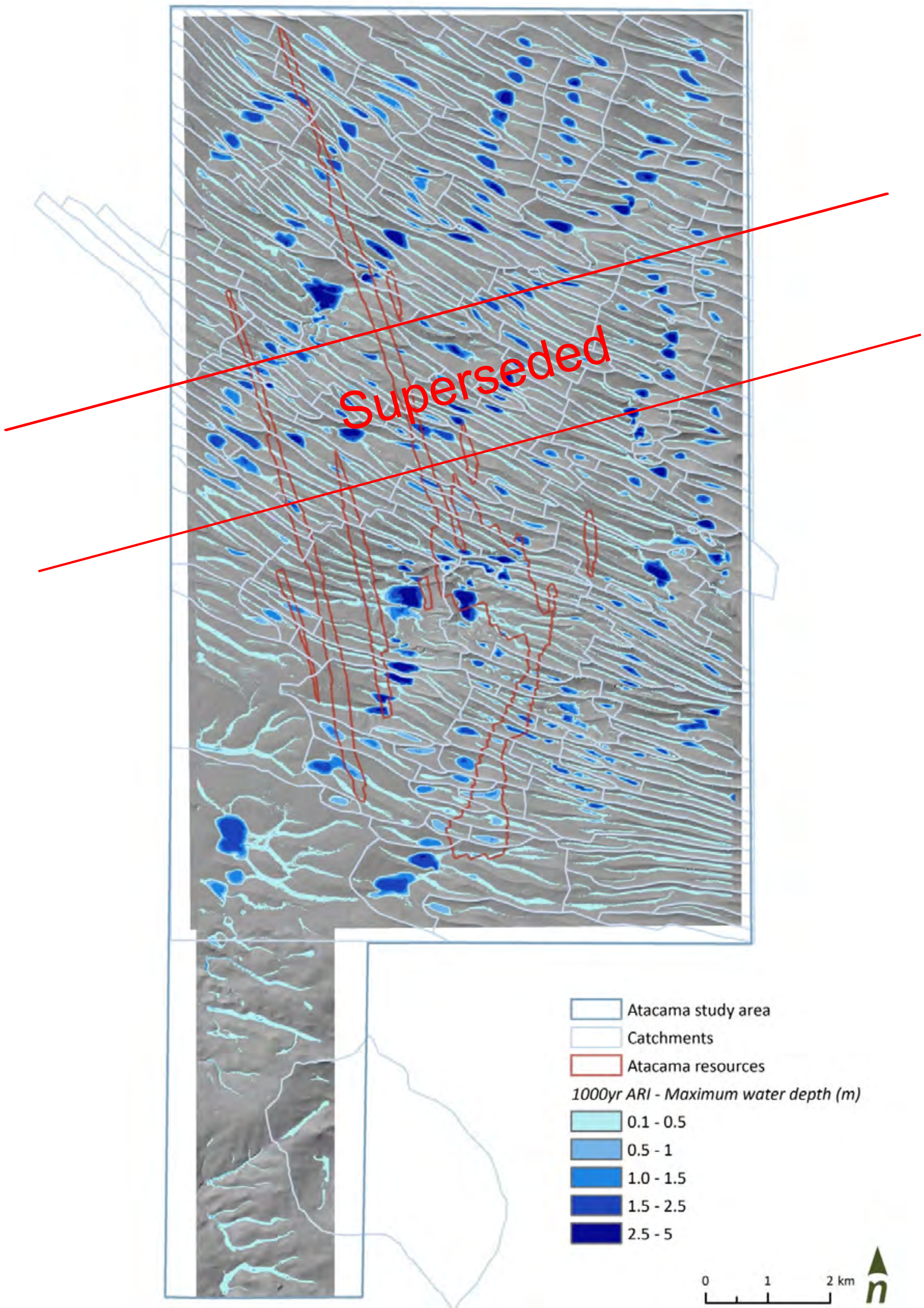

Figure 8. *Maximum water depth at 1000 year ARI storm event*

Once catchment boundaries were defined, the XPSWMM model was run using a coarse mesh (15 m grid size) for 1000 year ARI using different storm durations to determine the critical rainfall duration. Initial investigations revealed that unlike nearby deposits / mine sites (Sonoran, Jacinth and Ambrosia) the critical rainfall duration not only varies for different sub-catchments but also it is varies for different hydraulic parameters such as water depth (maximum volume of water produced in each storm event) and flow discharge. This is because surface water runoff in sub-catchments in the Atacama study area is affected by sub-catchment size and the terminal nature of the watercourses.

Therefore, in order to recognise the maximum water depth and flow discharge, all storm durations were run in fine mesh model. The investigated rainfall durations in this study were 15 min, 30 min, 45 min, 1 hour, 1.5 hour, 2 hour, 3 hour and 6 hour[1]. As shown in Table 4, there is no single unique critical storm duration across all sub-catchments. Consequently, we have extracted the maximum value of the water depth and discharge parameters from each of the storm durations for each rainfall ARI. The results are presented in Figure 9 to Figure 11.

Table 4. Critical storm duration for water depth and flow discharge with different ARIs

	2 year ARI	5 year ARI	10 year ARI	20 year ARI	100 year ARI	1000 year ARI
Critical storm duration for unit flow discharge (m^3/s.m)	No runoff	45 min – 1.5 hour	45 min – 1.5 hour	45 min – 1.5 hour	45 min – 1.5 hour	45 min – 1.5 hour
Critical storm duration for water depth (m)	No runoff	6 hour	6 hour	6 hour	6 hour	6 hour
6 hour Rainfall depth (mm)	23.76	34.98	43.02	53.58	82.51	158.9

The results indicate that there is no runoff during the 2 year ARI as the soil absorbs the entire rainfall. Runoff occurs during the 5yr ARI and starts to accumulate in individual pans. Flood water depths increase in larger rainfall events to the maximum of up to 3 m during the 1 in 100 year ARI event (i.e. 82.51 mm of rain over 1 hour produces a flood depth of up to 3 m) in the pans within and in the vicinity of the Atacama deposits.

[1] We would expect that storm events with longer durations than those adopted for the investigation may become the critical events for the depth of ponded water in the terminal pans. We have not rerun the analysis to identify the extent to which longer duration storm events change the depth of inundation in the terminal pans. This may be of some value. However we are also aware of the many other assumptions that have a greater influence on the rainfall runoff estimations for the site and have assumed that the critical storm duration adopted for the assessment will have a lower order of impact on inundation depths than the other assumptions such as the initial and continuing losses and the estimates of rainfall intensities adopted for the analysis.

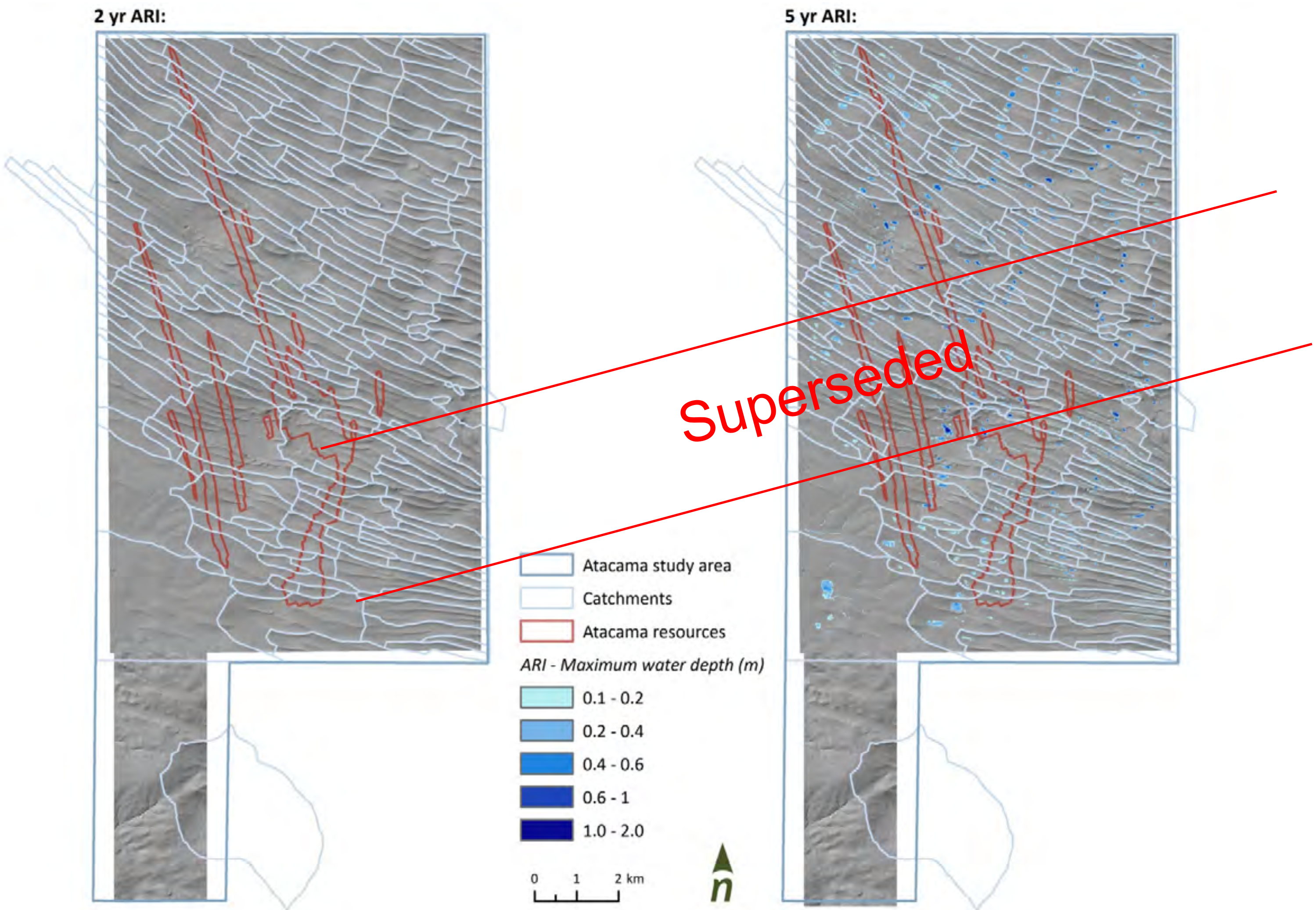

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Figure 9. *Maximum water depth distribution for 2 and 5 year ARI rainfall events*

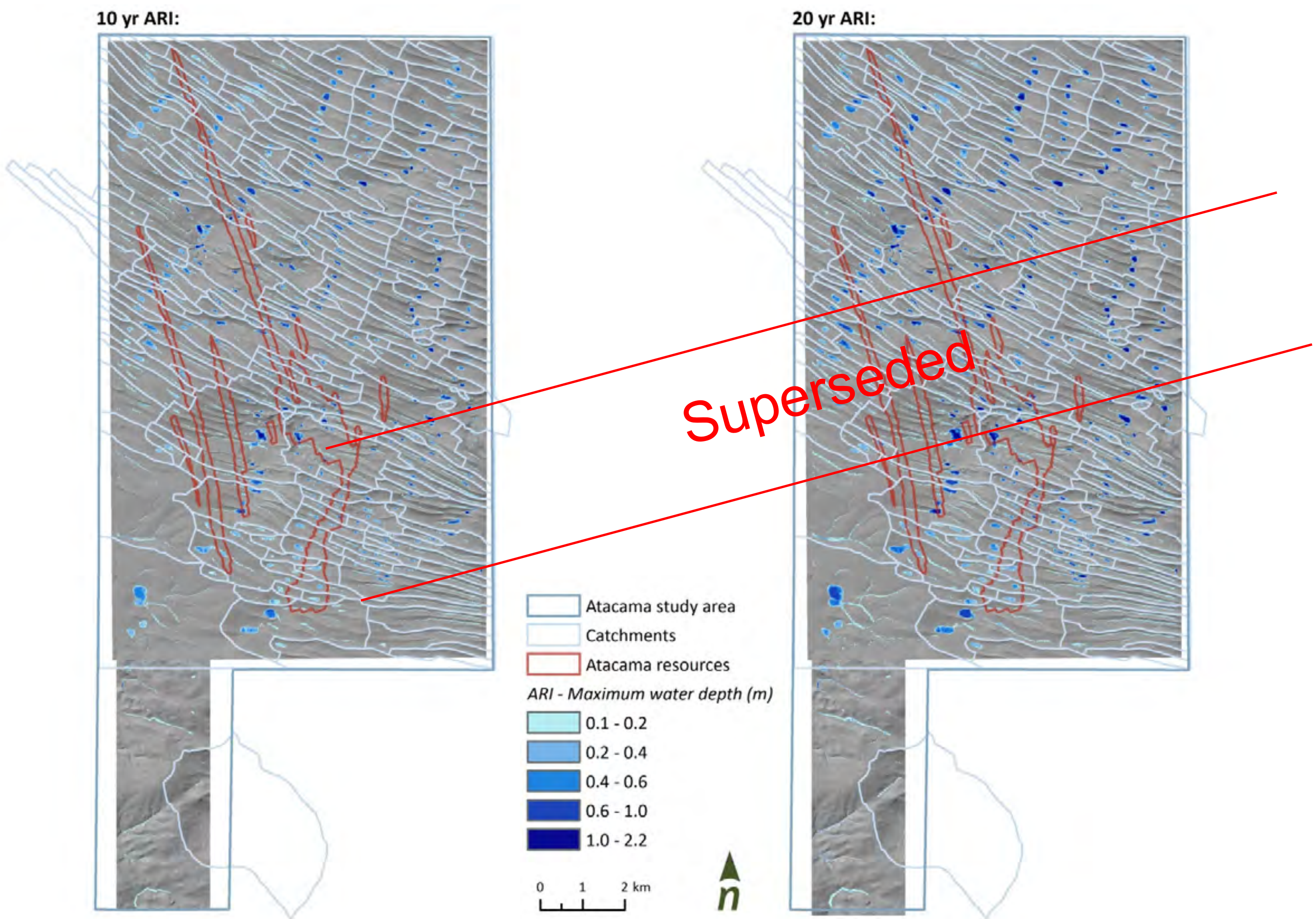


Figure 10. *Maximum water depth distribution for 10 and 20 year ARI rainfall events*

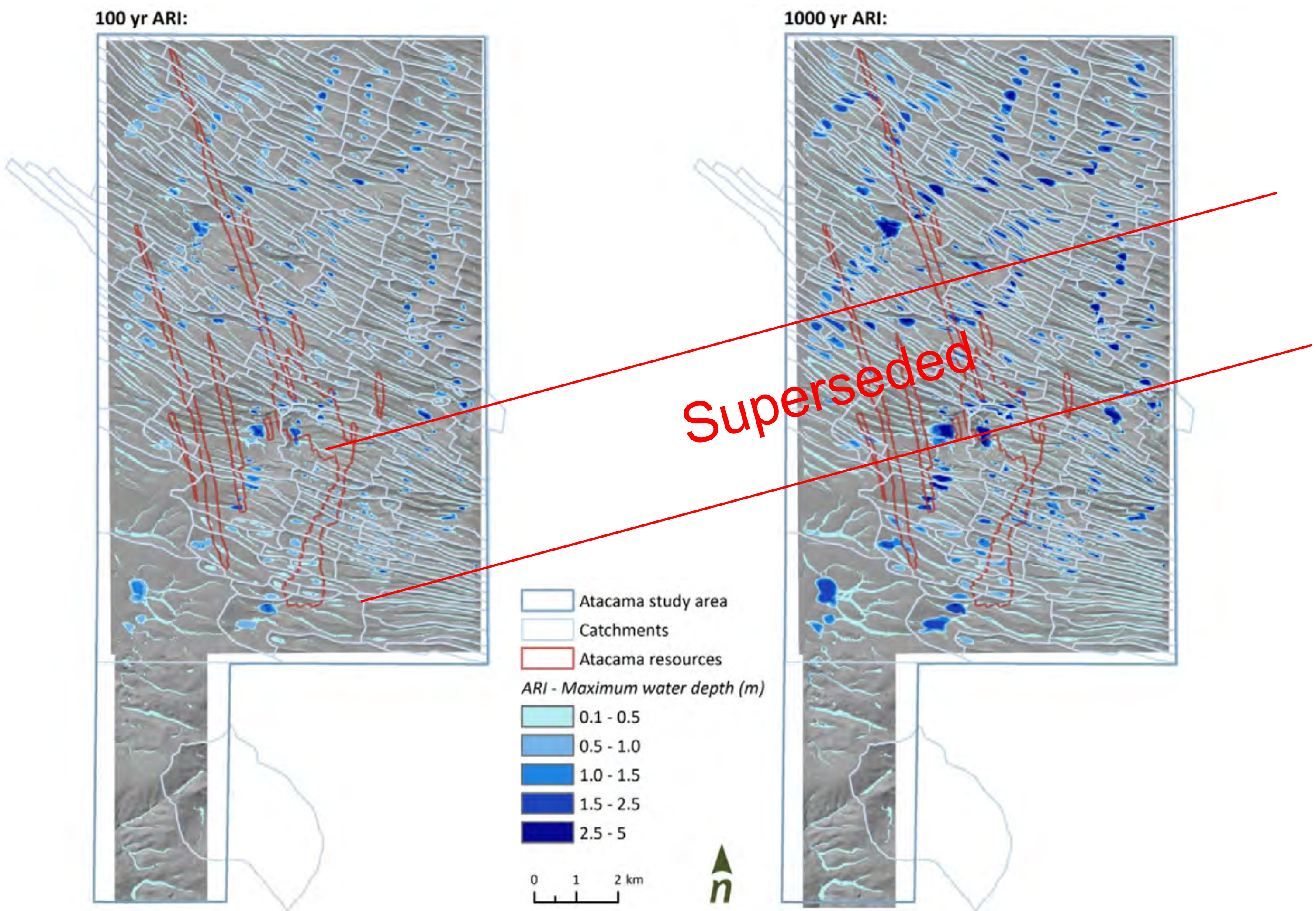


Figure 11. *Maximum water depth distribution for 100 and 100 year ARI rainfall event*

3.4 Arid surface water geomorphology

Geomorphology is the identification and interpretation of relationships between process and form in the landscape. An important application of geomorphic assessment is to help understand how human activities may interfere with this relationship and how this is likely to impact future processes and form. A geomorphic assessment often follows the principles of describing the landscape and its features, interpreting the landscape through the processes that have shaped it and predicting the future form of the landscape.

This section begins by providing an overview of general arid surface water geomorphology and the River Styles® framework before discussing the specific geomorphic characteristics of the Atacama study area.

Surface water and sand dunes

The Atacama study area is dominated by dune fields which control surface water morphology. Desert dunes are a type of self-organised aeolian bedform. There are a range of different types of dunes, each with a range of heights, widths and spacing. Dunes form and evolve through interacting processes of sand transport rates, dune topography and airflow. While dunes evolve over time, their morphology continues to reflect past climate and wind regimes.

Dune initiation is not well understood, but is likely to involve localised reductions in sand transport, potentially due to changes in surface roughness, surface particle size or microtopography. Key controls on dune morphology include wind regime (especially directional variability), sand supply and vegetation cover. As winds approach the base of the dune, velocities reduce. As the air moves up the dune slope, velocity increases in magnitude in relation to dune height and steepness. In theory, wind shear stress increases in a similar manner to velocity, however, in practice, changes in wind shear stress are also subject to the shape of the dune slope (such as concave verses convex). On the lee side of the dune crest, wind velocity and sand transport rates decrease rapidly, resulting in sediment deposition (Figure 12).

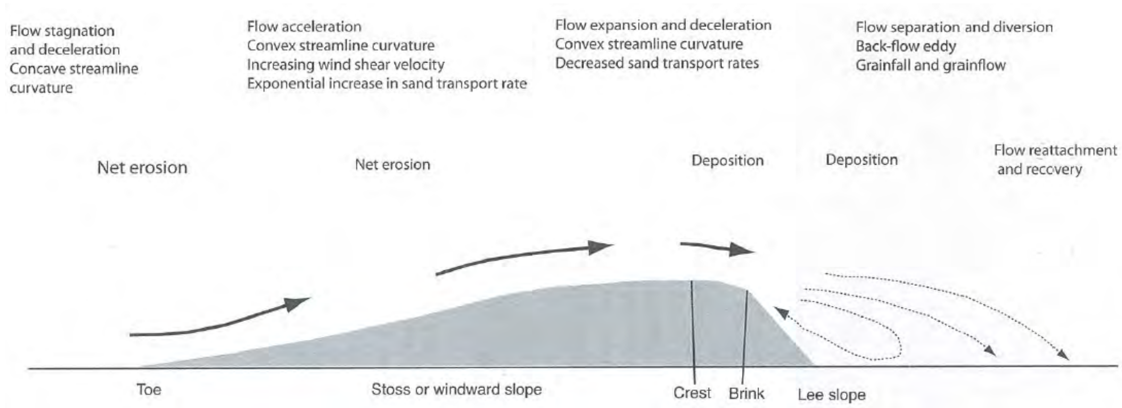


Figure 12. *Airflow of sand dunes (Lancaster 2011)*

There are two approaches to dune classifications. Morphological classifications are based on the external morphology of the dunes. Dynamic classifications consider the relationship between dune type and formative winds and sediment supply. Four common types of dunes are outlined below (Table 5).

Table 5. Summary of four common dune types

Crescentic dunes	These form in areas with unidirectional wind regime with crests aligned normal to the direction of the wind and sand transport. In plan view, the crescents are orientated such that they are concave on the lee side with their points extending downwind.
Linear dunes	These can occur as sinuous, relatively short dunes (also known as seif dunes) or longer, straight, vegetated dunes. They may also exist as simple, compound or complex formations.

Star dunes	Star dunes are large and complex dunes with pyramidal form and radiating arms. They occur in areas with strong seasonal changes in wind direction with winds from at least two opposing directions.
Parabolic dunes	Parabolic dunes form in partially vegetated areas with unidirectional winds. In plan view, they have a U shape with an active dune front and partly or fully vegetated arms trailing upwind (opposite orientation to crescentic dunes).

The dunes in the Atacama study area are predominantly vegetated linear dunes (see examples below Figure 13). They typically consist of straight subparallel ridges of up to 20 m high, spacing of 250-500 m apart and hundreds of metres long. In the study area, these ridges can often meet in Y-junctions. Linear dunes generally extend downwind and may migrate laterally, depending on dune stability.

Figure 13. *Vegetated linear sand dunes in the Atacama study area*

The Atacama dunes have well vegetated troughs and slopes with sparsely vegetated crests. The vegetation on the slopes provides some stability, however there is likely to be sand erosion and deposition occurring on the dune crests. This is likely to occur as sand transfers from one dune crest to another adjacent crest.

While the Atacama sand dunes are predominantly aeolian forms, they do contain fluvial features. The troughs between the Atacama dunes act as undefined watercourses following rainfall events. When runoff is generated following a significant rainfall event, the dune troughs drain to a depression or pan. Pans are one of the key features of the Atacama landscape (as well as the Jacinth, Ambrosia, Sonoran and Typhoon landscapes). They are located in topographic lows and often have little or no surface outflow. Pans may form in lineaments acting as conduits for groundwater movement, in linear depressions between sand dunes or where there is an obstruction to an ephemeral channel, for example, through dune extension (Shaw and Bryant 2011). Erosional processes, such as deflation (aeolian) and removal of material by sheetflow, can influence pan morphology. Pans are also aggradational features, receiving fine sediment during episodic inflows or aeolian deposits.

The dunes disappear towards the southwest corner of the Atacama study area, which is part of the J-A catchment. The landscape along southern access corridor is influenced much more by fluvial processes associated with ephemeral watercourses than by aeolian processes. These processes are discussed in the following section.

Ephemeral watercourses

The watercourses in the southern corridor are ephemeral streams, meaning they lack permanent flow. Instead overland flow only occurs in response to heavy rainfall events. Ephemeral stream channel form is generally controlled by high magnitude, low frequency floods and is modified at a slow rate by smaller flow events. Sediment movement through the watercourses typically occurs episodically in response to runoff generated by intense rainfall of short duration. These rainfall events can have a rapidly rising hydrograph and produce flash flooding, pushing sediment through the system. The classic ephemeral watercourse form, displaying a defined channel, is found predominantly in the J-A catchment.

The highly localised nature of rainfall in the region means that only a section of watercourse may experience flow following rainfall, with runoff being absorbed in the system before travelling to downstream reaches. Losses and decreasing flow in the downstream direction encourages deposition and storage of sediment within the system. Transmission losses, in conjunction with few or no significant tributaries, can also cause reduced channel capacity in the downstream direction, resulting in a narrowing of the channel or forming unchannelised alluvial surfaces or floodouts.

Arid ephemeral watercourse morphology is often a product of ongoing cycles of erosion and sedimentation. Levick et al (2008) suggest that it is the significant transmission losses and associated downstream reduction in stream power in ephemeral streams that result in the ongoing cycles of incision that are unrelated to catchment or channel disturbance. The more common smaller flows create conditions where sediment aggradation prevails. This aggraded sediment is then highly susceptible to incision during higher, less frequent flows. An example of this is shown below (Figure 14). Furthermore, sparse stabilising vegetation in semi-arid catchments leaves the hill slopes and channel bed and banks exposed and more vulnerable to erosion, particularly in the upper reaches where valley and slope gradients are steeper. The small watercourses in the upper reaches of the catchment are important in determining the amount of sediment available for transport and deposition in the system.

Figure 14. *Headward incision in the channel of an existing watercourse in the southern corridor*

River Styles®

The River Styles® framework has been developed by Gary Brierley and Kirstie Fryirs (2000) for the geomorphic classification of watercourses. It provides tools for interpreting watercourse character, behaviour, trajectory, condition and recovery potential. The River Styles® framework has previously been applied in the Jacinth and Ambrosia catchments (Alluvium 2013) and Sonoran Typhoon study areas (Alluvium 2014). These assessments will be referred to in this section to provide regional context.

This section outlines the approach to the River Styles® assessment, presents the findings of the assessment, including descriptions and spatial distribution of the River Styles® identified in the region, and discusses the implications of the findings for mining operations and the rehabilitation design.

River Styles® are identified at the reach scale and framed in the context of the valley setting. The valley setting is distinguished by the nature of the floodplain: a confined valley setting has no floodplain, a partly-confined valley setting has a discontinuous floodplain and a laterally unconfined valley setting has a continuous floodplain. Once the valley setting has been established, each River Style® is identified based on the stream's planform, assemblage of geomorphic units and bed material texture. The procedure used for River Style® assessments across Atacama region is based on the River Styles® procedural tree method (Figure 15), according to the dichotomous key.

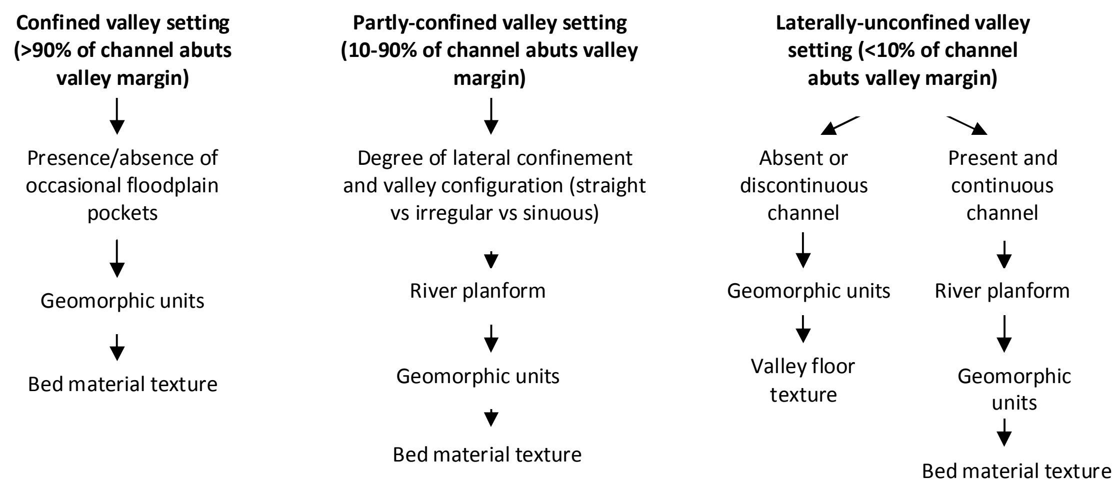


Figure 15. *River Styles® procedural tree (Brierley and Fryirs 2005, p. 264)*

Controls on River Style®

Assessment of a range of geomorphic controls on channel form and processes are incorporated into the assessment of River Style® for any given reach. The control factors that are relevant to the Atacama study area include:

- Aeolian movement of sediment
- Flow/discharge, including major floods, timing of most recent flood and duration of flooding events
- Valley / dune slope and vegetation characteristics
- Sediment sources, particle size and shape, sediment concentration of flow, lithology/density and soil erodability
- Soil characteristics, presence of calcrete or iron stone and groundwater seepage
- Human factors, such as mining and vehicle tracks

Method

A desktop assessment of River Styles® was undertaken in September 2014. This was based on available high resolution aerial imagery from 2013 and available GIS spatial data (2 m DEM). A field inspection was undertaken over 5 days in September 2014 using helicopter and four wheel drive vehicle.

The helicopter allowed us to complete inspections over a large area of difficult terrain, allowing us to see more of the study area than we could have managed otherwise. Importantly, the helicopter allowed us to complete aerial inspections of areas of particular interest and provided us with a different perspective to ground-based inspections. We used these aerial inspections to confirm catchment boundaries, look for defined water courses and classify pans. Scale and uniformity of the landscape features meant that a lot of the assessment could be undertaken from the air in a relatively short period of time. We then completed ground assessments of features that were difficult to view from the helicopter and at example sites of each feature we viewed from the air. We spent several hours in the helicopter on each day of inspections and spent the remainder of the time validating the assessments by undertaking ground truthing. The aerial and ground assessment sites are shown in Figure 16.

On the ground, we documented evidence of flow, drainage direction and pans using georeferenced photographs and ArcGIS. Information collected from the site inspection was then used to revise the desktop assessments and finalise the catchments, pan types and River Styles® for the study area.

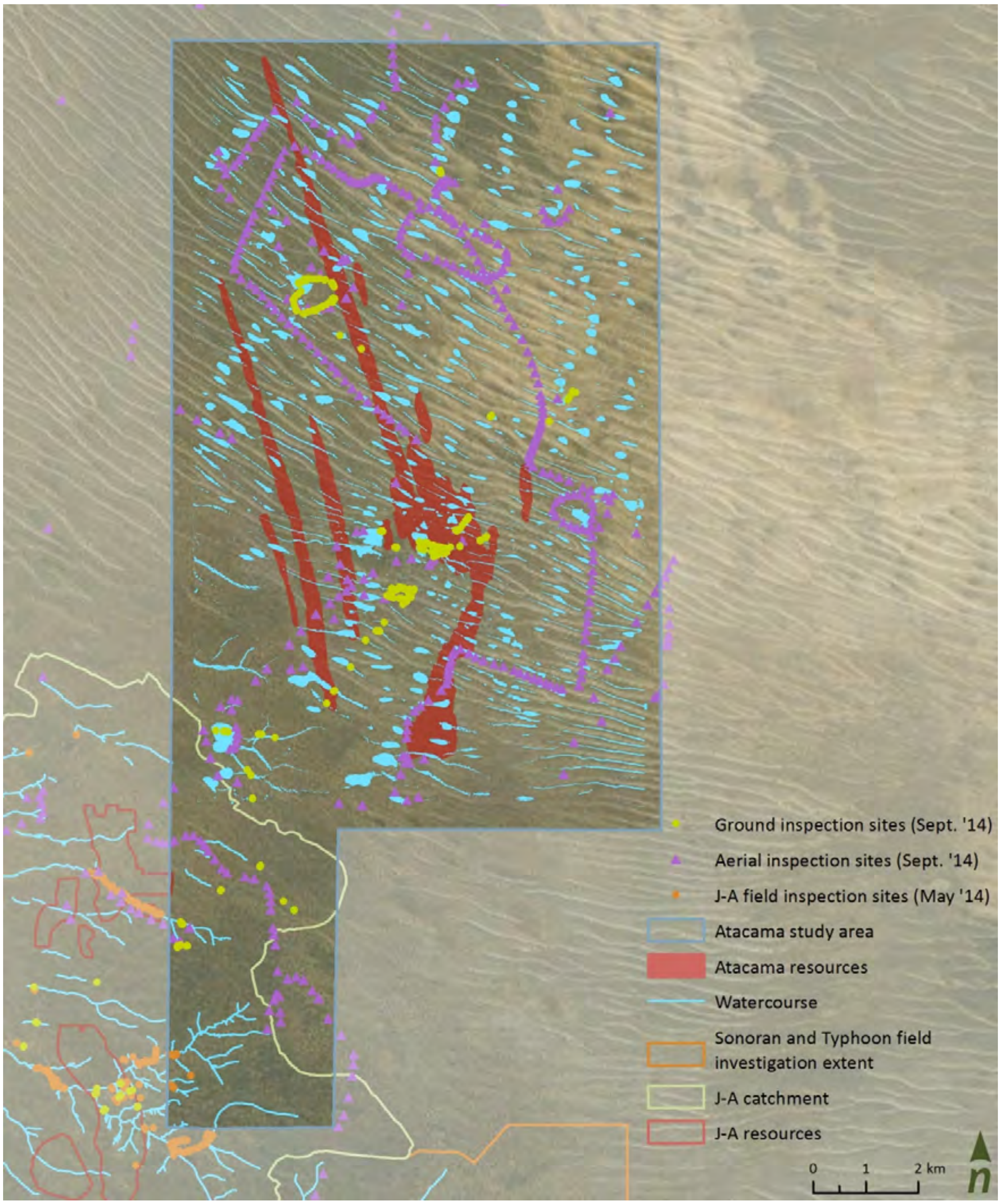


Figure 16. *Location of field inspection sites*

River Style® categories

A River Style® classification was completed over an area of 158 km^2, including the Atacama study area and southern access corridor. The assessment built upon and confirmed the River Style® assessment completed for the Jacinth-Ambrosia catchments in 2012. We identified a total of six different River Styles® and three pan styles across the area. The pan River Styles® do not represent a watercourse per se, however they are an important hydrologic and geomorphic feature and, thus, have been included in this classification. All six River Styles® were found in the southern access corridor, while only two were found in the main Atacama study area. All three pan styles were found in the Atacama study area. No new River Styles® were identified in this assessment, although one new pan style was. The River Styles® found in each region are listed below (Table 6 and Table 7).

Table 6. River Styles® within the Atacama study area

Valley setting	River Style®
Laterally Unconfined Valley Setting - Continuous	Interdunal bank confined gully
Laterally Unconfined Valley Setting - Discontinuous	Dune swale Terminal pan Upland pan Perched pan

Table 7. River Styles® within the southern access corridor

Valley setting	River Style®
Laterally Unconfined Valley Setting - Continuous	Interdunal bank confined gully Interdunal bank confined channel Interdunal wandering
Laterally Unconfined Valley Setting - Discontinuous	Arid valley fill Dune swale Chain of pans

The planform and potential adjustment of River Styles® in the laterally unconfined valley setting is not considered to be controlled by the valley margin. Watercourses in the southern corridor have developed within extensive interdunal floodplains where bed and bank materials are susceptible to erosion during flows while significant channel change typically occurs in response to large, infrequent flow events. Minor modifications can occur during smaller flow events. In the Atacama region, watercourses typically have no defined channel and thus cannot be laterally confined.

Laterally unconfined continuous channel (LUV CC) watercourses include interdunal bank confined channel, interdunal bank confined gully and interdunal wandering River Styles®. These typically lie in the mid and upper catchments of the study area. Watercourses in each of these River Styles® have incised or are experiencing ongoing incision.

Laterally unconfined discontinuous channel (LUV DC) watercourses in the study area include arid valley fill, dune swale, terminal pan, upland pan and perched pan River Styles®. Arid valley fill and perched pan River Styles® are generally found in the upper catchment, upland pan and dune swales are found in all catchment settings and terminal pans are found only in the lower catchment.

The arid zone River Style® tree (shown in Figure 17) illustrates the geomorphic classification of watercourse identified in the Atacama and Jacinth, Ambrosia, Sonoran and Typhoon study areas. It has been reviewed and further developed as part of this study. The distribution of each River Style® identified in the Atacama and southern corridor study area is shown below (Figure 18), with descriptions of each style provided in Table 8 . Greater detail of each style can be found in the River Style® proformas in Attachment B.

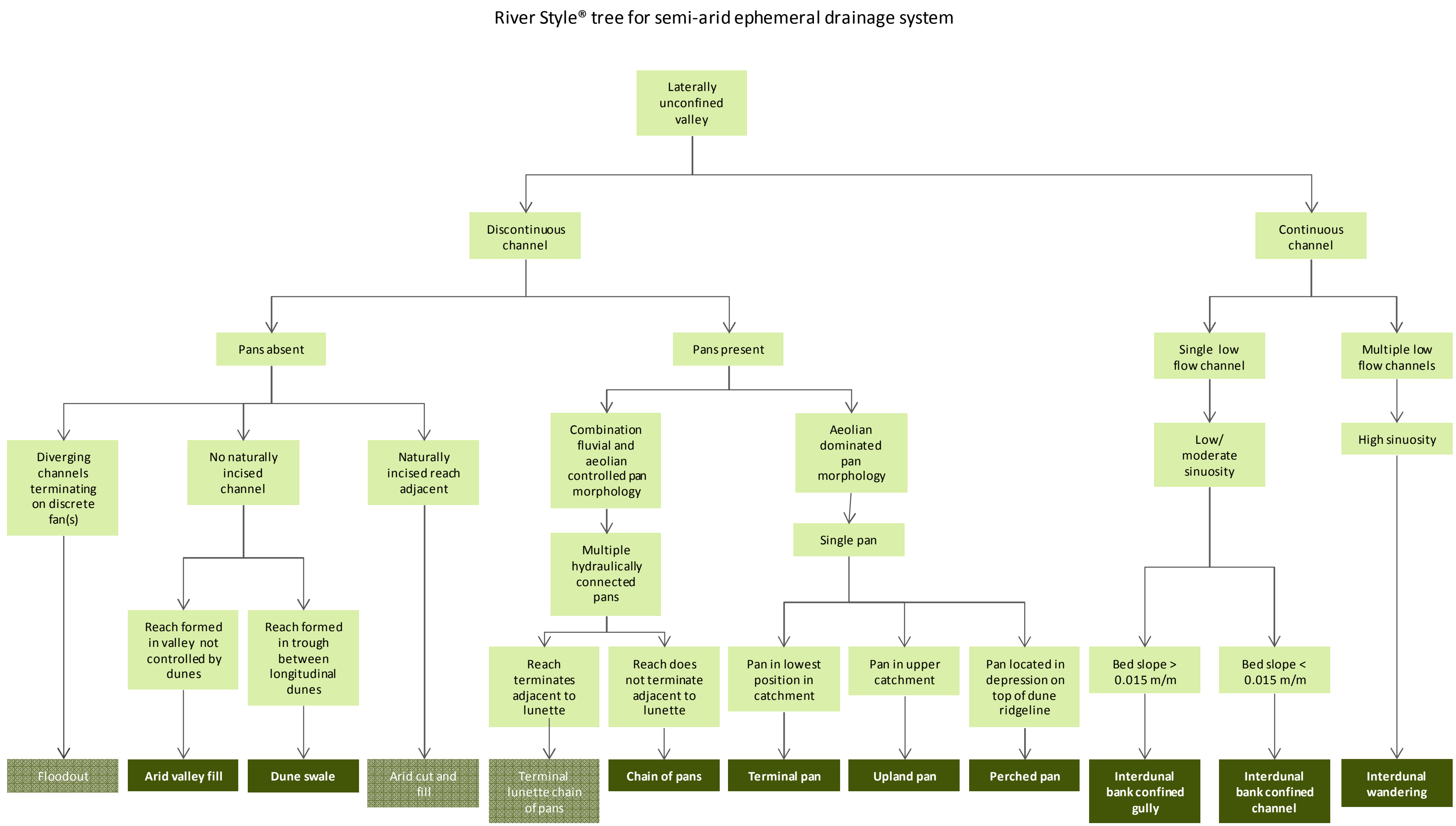


Figure 17. *River Style® tree for watercourses in the Iluka study areas. River Styles® observed in the Atacama study area are highlighted in dark green.*

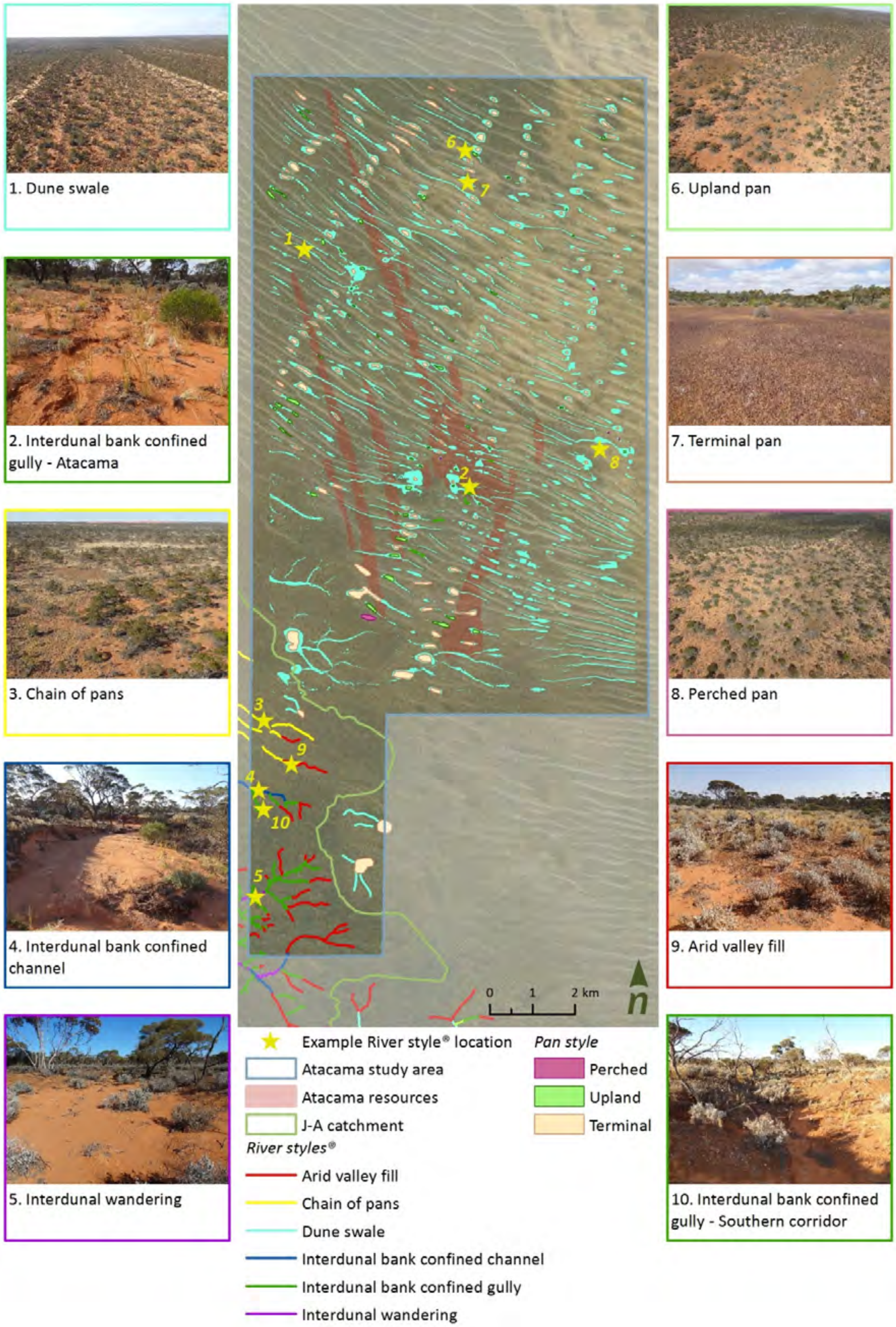


Figure 18. *Distribution and examples of each River Style® identified in the study area*

Table 8. Description of each River Style found in the Atacama study area

LUV DC – Dune swale

The dune swale River Style® forms in the depression between two linear dunes and has no defined channel. It has a broad u-shaped valley with a relatively flat gradient. Dune swales often drain to a pan but may occasionally form a confluence with another dune swale or feed into a defined channel. Vegetation is characterised by low shrubland with a biological soil crust ground cover.

The dune swale is the overwhelmingly dominant River Style® found in the Atacama region and has only a small presence in the southern corridor.

LUV CC – Interdunal bank confined gully

The interdunal bank confined gully River Style® falls within the unconfined, continuous channel group. It has a single, narrow main channel with low sinuosity that is relatively symmetrical in straighter sections and develops localised asymmetry at bends. The bed and banks consist of very fine sand and are not typically vegetated. An incision head is usually found at the upstream reach extent but can also be found mid reach.

Interdunal bank confined gullies are found predominantly in the mid-catchment areas in the southern corridor (photo example top). There were some instances of this River Style® identified in Atacama (photo example bottom). These watercourses appear to be in the early stages of their evolution and were only found adjacent to the Spine Track. It is likely that these watercourses formed in response to disturbance caused by construction and maintenance of the track and are indicative of the landscape's sensitivity to disturbance.

LUV DC – Chain of pans

The chain of pans River Style® is within the unconfined, discontinuous channel group. It generally presents as a depression along a broad valley floor with occasional pans present. A defined, incised channel may exist between pans. Pans vary in size and shape. Pans tend to be elongated in the direction of flow higher up in the interdunal corridor and can become wider, larger and may be fed by multiple drainage lines in the lower reaches. Vegetation is characterised by low shrubland with a biological soil crust ground cover. Trees are sparse in pans but are present along incised channels.

Chain of pans River Style® is found only in the southern corridor of the Atacama study area.

LUV CC – Interdunal bank confined channel

The interdunal bank confined channel River Style® falls within the unconfined, continuous channel group. Like the gully River Style®, it has a single main channel although it tends to be a wider channel with low to moderate sinuosity. Bed and bank material is predominantly fine sand, with calcrete outcropping occasionally present. The bed material tends to be present as a sand sheet, in which a low flow channel sometimes develops. Gullying or rilling can occur on the banks where overland flow enters the channel. Vegetation is generally absent from the bed while the banks are often vegetated with biological soil crust, scattered myalls and low shrubs.

The interdunal bank confined channel River Style® is found only in the southern corridor of the Atacama study area.

LUV CC – Interdunal wandering

The interdunal wandering River Style® is within the unconfined, continuous channel group. It contains a sinuous main channel in which multiple low flow channels have formed. Calcrete may also be present in the bed and in the banks. Occasional forced mid-channel bars may form where there is a flow obstruction, such as woody debris or vegetation. Low shrubs, grasses and biological soil crust may colonise the bed between flow events thereby further defining the multiple channels.

The interdunal wandering River Style® is found only in the southern corridor of the Atacama study area.

LUV DC – Upland pan

Upland pans have no defined channel, however sheet flow may occur during large flow events. In smaller events they will have similar hydrologic behaviour to a terminal pan, however during larger events they are likely to be hydrologically connected to downstream watercourses or a terminal pan. They develop through a combination of aeolian processes (namely deflation) and hydrologic processes, such as evaporation and groundwater – surface water interaction. Pans may aggrade through dissolution of sediment from ponded surface water, resulting in a pan surface that is typically flat and featureless. Upland pans vary in size and shape, reflecting the characteristics of the upstream drainage area. Pan vegetation is characterised by low shrubland with a biological soil crust cover.

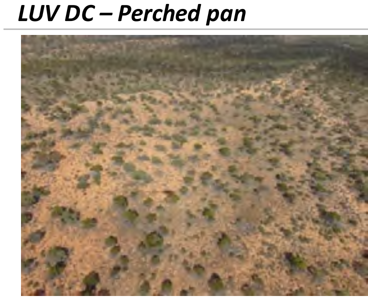
Upland pans are scattered throughout the Atacama region.

LUV DC – Terminal pan

Terminal pans have no defined channel. They develop through a combination of aeolian processes (namely deflation) and hydrologic processes, such as evaporation and groundwater – surface water interaction. Pans may aggrade through dissolution of sediment from ponded surface water, resulting in a pan surface that is typically flat and featureless. Terminal pans are located at the lowest point in the catchment and have no surface outflow. Terminal pans are typically elongated and vary in size, reflecting the characteristics of its catchment. Pan vegetation is characterised by low shrubland with a biological soil crust cover.

Terminal pans are found throughout the Atacama region with only a few examples found on the eastern fringe of the southern corridor.

LUV DC – Perched pan



Perched pans have no defined channel. They develop on top of the dune ridgeline, often at a Y-junction, through predominantly aeolian processes (namely deflation). Perched pans have a relatively tiny catchment and hydrologic processes, such as evaporation and aggradation through dissolution of sediment from ponded surface water, have only minor influence on pan development and morphology. Perched pans may be terminal or hydrologically connected to an adjacent dune swale or other pan. Perched pans may enable parallel dunes to connect over time. Pan vegetation is characterised by low shrubland with a biological soil crust cover.

Perched pans are few in number and found only in the Atacama region.

LUV DC – Arid valley fill

The arid valley fill River Style® is within the unconfined, discontinuous channel group. It has no defined channel and instead exists as a depression on the valley floor. It is typically located in the upper catchment. Arid valley fill is laterally stable although it is prone to incision resulting from headcut migration from a downstream incised reach (typically of an interdunal bank confined gully River Style®). Vegetation is characterised by low shrubland with a biological soil crust ground cover.

The arid valley fill River Style® is found only in the southern corridor of the Atacama study area.

River Styles® in the regional context

It is useful to compare River Styles® identified in the Atacama study area with those identified in the Jacinth Ambrosia catchment and Sonoran and Typhoon study area to provide a regional context for understanding the geomorphology of the area. The distribution and types of River Styles® in the three study areas are shown in Figure 19.

The dune swale is overwhelmingly the most common River Style® in the Atacama region. It is also common in the Sonoran and Typhoon study area, but is not found at all in the Jacinth and Ambrosia catchments. This is a reflection of proximity to the Yellabinna Dunefield and dominance of aeolian processes as a landscape control. The Atacama region is almost entirely within the dunefield, the eastern side of the Sonoran region lies on the fringe of the dunefield and the Typhoon region lies in a transitional zone between the dune field to the east and the flatter topography draining west towards Lake Ifould and south to Lake Tallacootra. Through this transitional region, the dune swales are often connected (via inflows or outflows) to other River Styles®, while in the Atacama region dune swales only drain to pans or other dune swale reaches.

The interdunal bank confined gully is the only River Style® to be found across all three study areas. In the Jacinth-Ambrosia and Sonoran-Typhoon study areas it typically occurs in the mid-catchments of the classical dendritic stream networks and watercourses in the transitional networks. The Atacama region is "dunal", not "interdunal" and it is to be expected that no "interdunal" River Styles® should be present there. We did, however, identify several interdunal bank confined gullies along the Spine Track. These appear to be relatively young watercourses and were found only in association with the track. It is likely that these formed in response to the construction and ongoing use of the Spine Track and are indicative of how sensitive the landscape is to disturbance.

Pans are an important feature in all three study areas, however they perform different functions across the landscape. In the Jacinth Ambrosia catchment the pans are generally hydraulically connected by watercourses (forming the chain of pans River Style®), whereas in Atacama, Sonoran and Typhoon the pans also act as water collection zones. The difference in how water leaves the pans, whether through surface flow or through groundwater seepage and/or evaporation, results in different geomorphic and ecological forms, as well as how the pan interacts with its catchment and, potentially, underlying groundwater. As such, the pans themselves are represented by their own River Style® in the Atacama, Sonoran and Typhoon study areas.

Terminal pans are found throughout Atacama and the Sonoran and Typhoon study areas (excluding the Lake Tallacootra catchment). The Atacama terminal pans are generally smaller and more elongated than those found to the south. This reflects the smaller and elongated catchments created by the linear dunes in the dunefield compared with the larger, irregular shaped catchments shaped by the complex dune network around Sonoran and Typhoon. There are a number of sites throughout the Atacama study area where the dune ridge has lowered sufficiently to hydraulically connect adjacent catchments, with up to ten adjacent catchments connecting in some places. This results in a concentration of surface flow towards the lowest point in the catchment. Following a significant rainfall event, water ponds over a large area at this location, with a terminal pan formed at the deepest point.

The Jacinth-Ambrosia study area has terminal lunette pans, which differ from terminal pans in the other study areas in that their form and processes are so heavily dependent on a specific feature, the lunette that fringes Lake Ifould. The lunette prevents surface water from discharging into the lake and instead accumulates in pans at the toe of the lunette.

Perched pans have only been identified in the Atacama region. They form at the top of the linear dune ridges, which are characteristic of Atacama and are not present in the other study areas.

Interdunal bank confined gullies were common in both study areas, reflecting the diversity of catchment positions in which this actively deepening style can occur. The other two continuous channel River Styles® (interdunal bank confined channel and interdunal wandering) occur only within the dendritic drainage networks of the Lake Tallacootra catchment and mid and upper Jacinth and Ambrosia catchment (including the southern corridor). Arid valley fill (referred to as "valley fill, sand" in the original Jacinth Ambrosia assessment) was found in all study areas except the Atacama region. It is almost always found in the upper catchment.

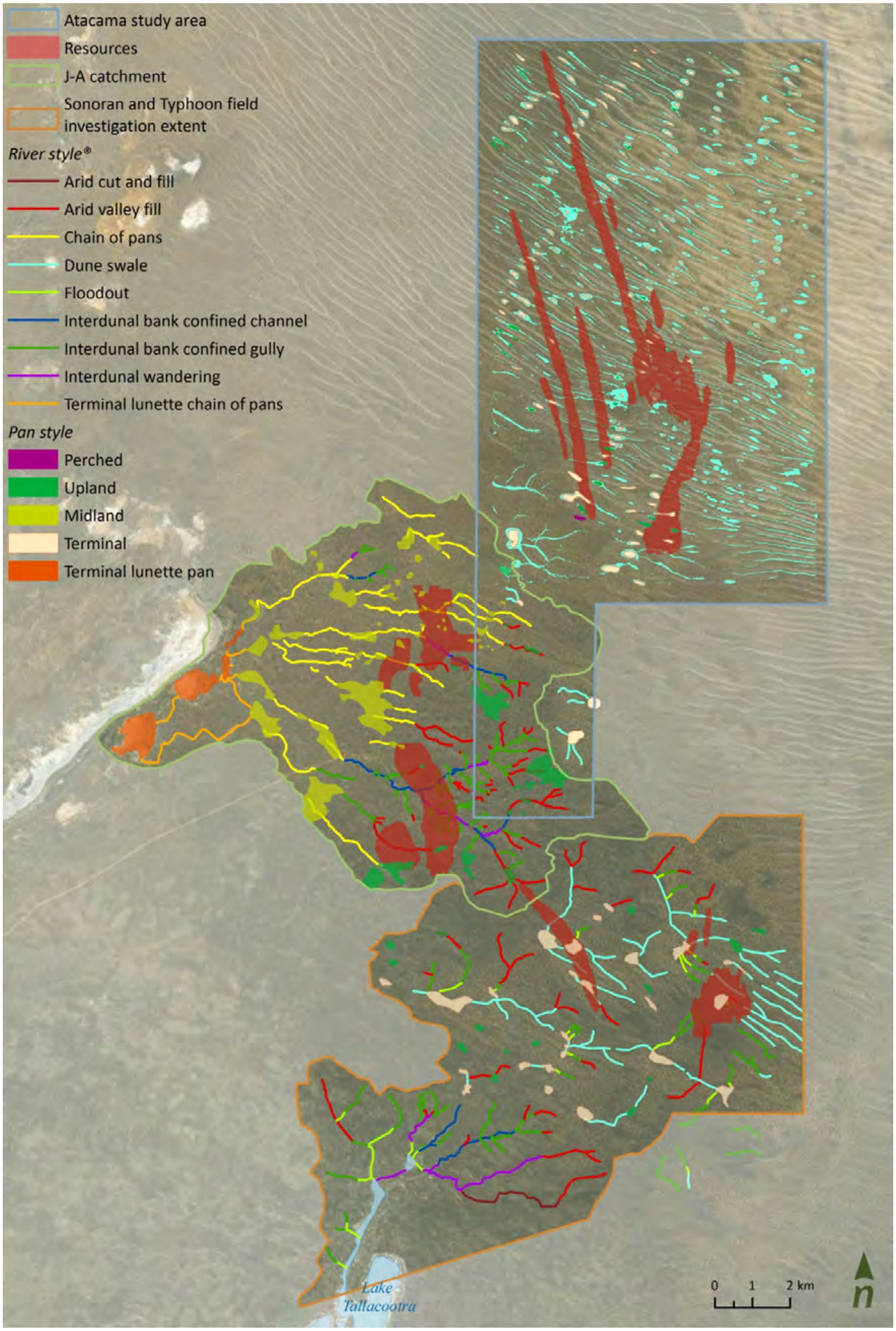


Figure 19. *Distribution of River Styles® across the Jacinth Ambrosia and Sonoran and Typhoon study areas*

Implications for mine planning

The Atacama landscape is characterised by multiple discrete catchments that intersect the mineral deposit. This means that following large rainfall events, surface water will flow towards the mine pits and infrastructure along multiple flow paths. Each flow path will need to be managed to protect the mine from flooding. It is important that this is done in such a way that adjacent catchments do not become hydraulically connected. Connecting previously discrete catchments is likely to result in concentrated volumes of surface water on the new low point in the combined catchment (potentially behind levees constructed to protect the mine), resulting in locally higher rates of subsurface infiltration.

There are several large catchments, where previously parallel, smaller catchments have naturally connected, that cross the mineral deposit (see Figure 20 for examples). These need to be considered during mine planning to ensure that critical mine infrastructure is not placed at the lowest points in these catchments as this is where surface water will be concentrated.

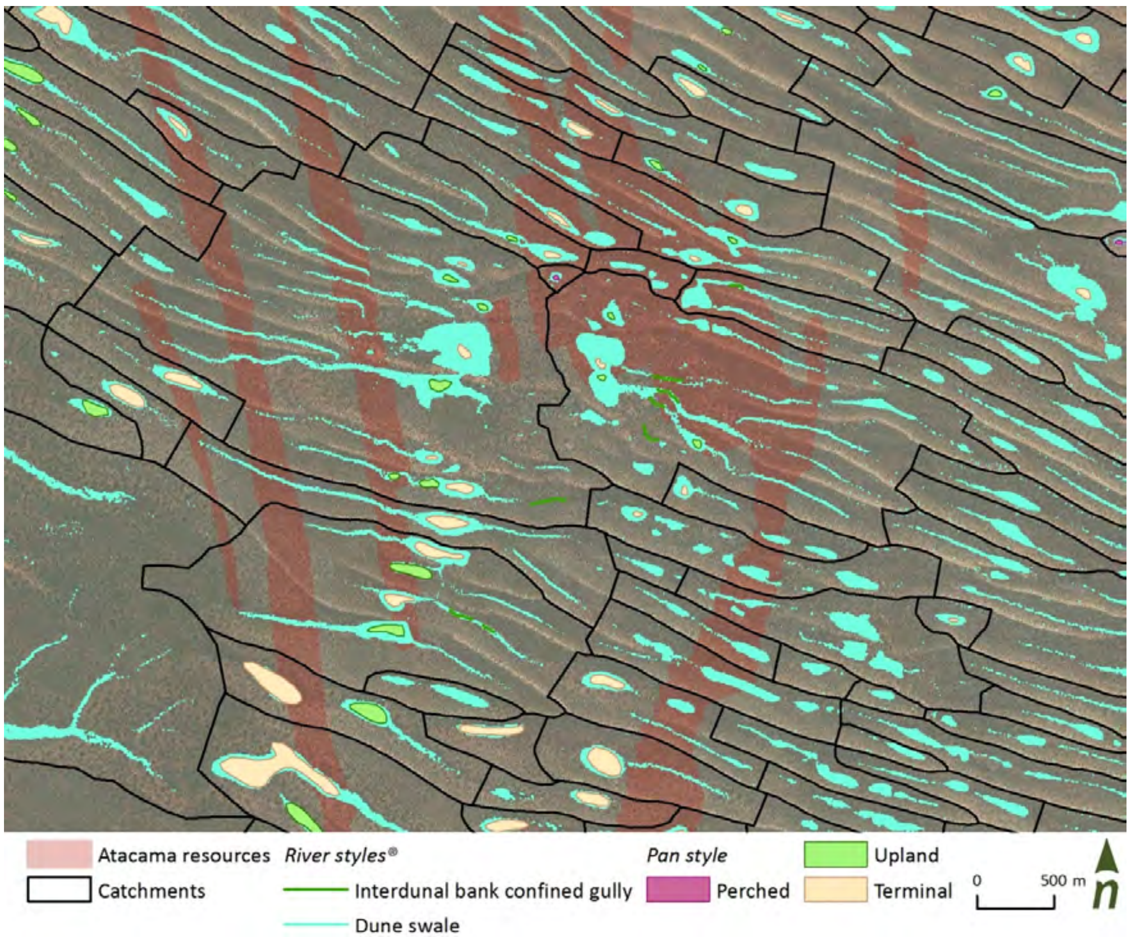


Figure 20. *Examples of variable catchment sizes at the Atacama mineral deposit*

During rehabilitation, Iluka will need to ensure that previously discrete catchments remain disconnected. If a sufficient rainfall event occurs while vegetation is still becoming established over the rehabilitated surface, rilling and gullying can be expected to occur, initiating channel development. Larger catchments will likely have greater surface flow, resulting in more extensive surface erosion. Larger catchments will also direct larger volumes of surface flow to the terminal pan, potentially increasing infiltration to groundwater or through mine tailings.

3.5 Surface water dependent ecosystems

A flora and fauna survey of the study area was conducted by EBS Ecology in September 2014. The survey added to flora and fauna data obtained for the nearby Jacinth Ambrosia mine site by EBS Ecology (2007 to 2012), SKM (2006), and the Department of Environment, Water and Natural Resources (DEWNR). A copy of the flora and fauna report (EBS, 2014) is provided in Attachment C and the following text summarises the main findings.

Flora

The study site is defined by the presence of a series of dune ridges overlying a calcrete bed layer which is irregularly expressed as outcrops and small rises throughout the study site. The dunes, while largely linear in dimension, fuse at various points entrapping linear water flow directionally. This has created sections whereby episodic rain events cause water to pond until emptying naturally through soil infiltration, evaporation or as transpiration through vegetation. Subsequently, vegetation community patterns within the Atacama study site is dictated by slow drivers such as soil type and substrate material, while dynamic drivers such as rainfall, run-off, fire and other disturbance factors such as camels determine shorter term changes. Primarily, this leads to distinct vegetation types limited by their ability to survive under these drivers which determine what can grow and where at any given point in time (McIlwee et al. 2013).

It is assumed that several of the ecosystems present within the Atacama site are dependent on the historical dynamic driver events and have seen changes or transitions from one state to the next. Westoby et al. (1989), proposed the state and transition model whereby ecosystems are undergoing a constant transition from one state to another and at some point a threshold is crossed that does not allow the ecosystem to return to the previous state. Observations would suggest that within the study area, the interdune swales are consistently comprised of Myall woodlands. What is not consistent however is the level or period of time in which this ecosystem is transitioning from one state to the next. This could be based on a range of elements such as evenness of rainfall across the study area, catchment size of pans or ability to shed water through infiltration. Theoretically, in the absence of water ponding it would be expected that a far more consistent swale community structure would be present across the study area.

The Atacama baseline survey identified a number of vegetation structures of which two are considered to have undergone changes in states due to dynamic changes from rainfall coupled with substrate type which itself is commonly associated with topography. The assumptions made are largely due to consistent changes in vegetation structure in keeping with flood modelling maps. The examples in Table 9 provide broad descriptions of the primary vegetation structures found within the Atacama study area and vegetation association mapping is presented in Figure 21.

It is considered that changes in hydrology within the Atacama study area will have limited impacts to the vegetation stratums in the short term (i.e.<10 years). Vegetation communities present within flood zones are not reliant on flows or flooding because these events occur at such infrequent intervals, they would not sustain ephemeral communities. All vegetation communities within the study area appear to be driven by soil depth primarily, with transitional communities present as responses to the last flood event. The period in which these areas stay inundated may also drive communities as a response to tolerance of extended wetting rather than reliance. All vegetation communities in proximity to the proposed development are well represented and this should ensure the ongoing viability of diverse ecosystems.

Regular monitoring and maintenance may be required to ensure design capacity and integrity is maintained. Inspections of surface water flows and possible impacts during large rain events may be required to confirm engineering assumptions.

Table 9. Description of vegetation associations and requirements for surface water

Vegetation group	Association	Description and requirements for surface water
Eucalyptus spp. Mixed Mallee over *Triodia* and *Eucalyptus yumbarrana* Mixed Mallee		Moderate depth loams in swales and flanks of dunes were dominated by a mix of species, primarily *Eucalyptus yumbarrana / E. pimpiniana* over *Triodia*. These are neither reliant nor tolerant of excessive moisture and require excellent drainage to persist in these areas.
Eucalyptus spp. / *Hakea francisiana / Grevillea stenobotrya* Tall Open Shrubland,		Dune crests are dominated by *Eucalyptus* spp. and *Callitris verrucosa* (Native Pine) over low shrubs and small trees such as *Grevillea stenobotrya* and *Hakea francisiana*. These species are very tolerant of the harsh conditions present in these landforms and are reliant on rainfall events only.
Acacia papyrocarpa (Western Myall) Woodlands and Senna spp. shrublands		Areas of low to mid elevation and clay loams over fragmented calcrete are typified by stands of *Acacia papyrocarpa* (Western Myall). The understorey is commonly dominated by *Maireana sedifolia* (Bluebush), *Cratystylis conocephala* (Daisy Bluebush), *Senna* spp. *Santalum acuminatum* (Quandong) and various other shrub and herbaceous species. The lowest elevation sites are typified by extensive areas of dead Myall with an often dense stand of Senna spp. It is assumed that these sites have historically supported open woodland structures until periods of extensive wetting or large single episodic rain events have occurred. Over an extended period, it might be assumed that transition states may tend towards a return of Western Myall woodlands. This is dependent on the availability of episodic germination events from specific rainfall events coupled with scarification and burying of seed (Ireland and Andrew 1996) or levels of post germination herbivory from species such as rabbits (Lange and Graham 1983) which were absent in other pre-European mass germination events . Slightly deeper soil profiles are dominated by Myall woodlands over bluebush often in association with Eucalyptus oleosa ssp. as the soil profile changes. This can often be a stark contrast where Eucalyptus spp. becomes obvious as

Vegetation group	Association	Description and requirements for surface water
		soon as the soil profile changes to sand in comparison to the Myall communities in the background. These transitional zones often feature inordinate levels of flora species richness due to the wide range of habitat niches available in a geographically small area.
Casuarina pauper (Black Oak) Woodlands		Calcareous outcrops with red sandy loams are dominated by *Casuarina pauper* (Black Oak) woodlands. These are commonly associated with other high alkaline soil tolerant species such as *Maireana sedifolia*, *M. trichoptera* and *M. pentatropis* as an understorey. These communities are reliant on rainfall only. Shallow soils and relatively steep topography of outcrops mean that runoff from these areas may contribute significantly to surrounding low elevation catchment areas. There was often ephemeral drainage lines emanating from these communities with the photo to the left below showing a typical gutter with calcrete scree scattered nearby. This contrasts significantly from the sand dune areas, where no sign of runoff was observed. Specific flora species were not associated with these drainage lines which are most likely due to the sporadic nature of run-off events.
Atriplex vesicaria Open Shrubland and *Alectryon oleifolius* (Bullock Bush) Shrubland		Examples of this community are present as small isolated pockets across the study area. It is assumed that these sites have a solid calcrete base that excludes the long term viability of *Acacia papyrocarpa* (Western Myall) emergents as seen on the nearby plain to the west. This has likely resulted in heavier clay alluvial silts building up collected as part of the catchment overlaying the calcrete. These sites are dominated by *Atriplex vesicaria* (Bladder Saltbush) shrubs and *Alectryon oleifolius* (Bullock Bush) along the fringes. Bullock Bush indicates longer term wetting patterns as this species is most commonly encountered on floodplains and fringes of dam banks and overflows in rangeland areas. The photo to the left shows Senna growing sparsely on a chenopod shrubland flat which may indicate an ongoing shift in transition to another state. Barely visible in the background is the grey coloured foliage of *Alectryon oleifolius* (Bullock Bush) on the fringe of the flat.

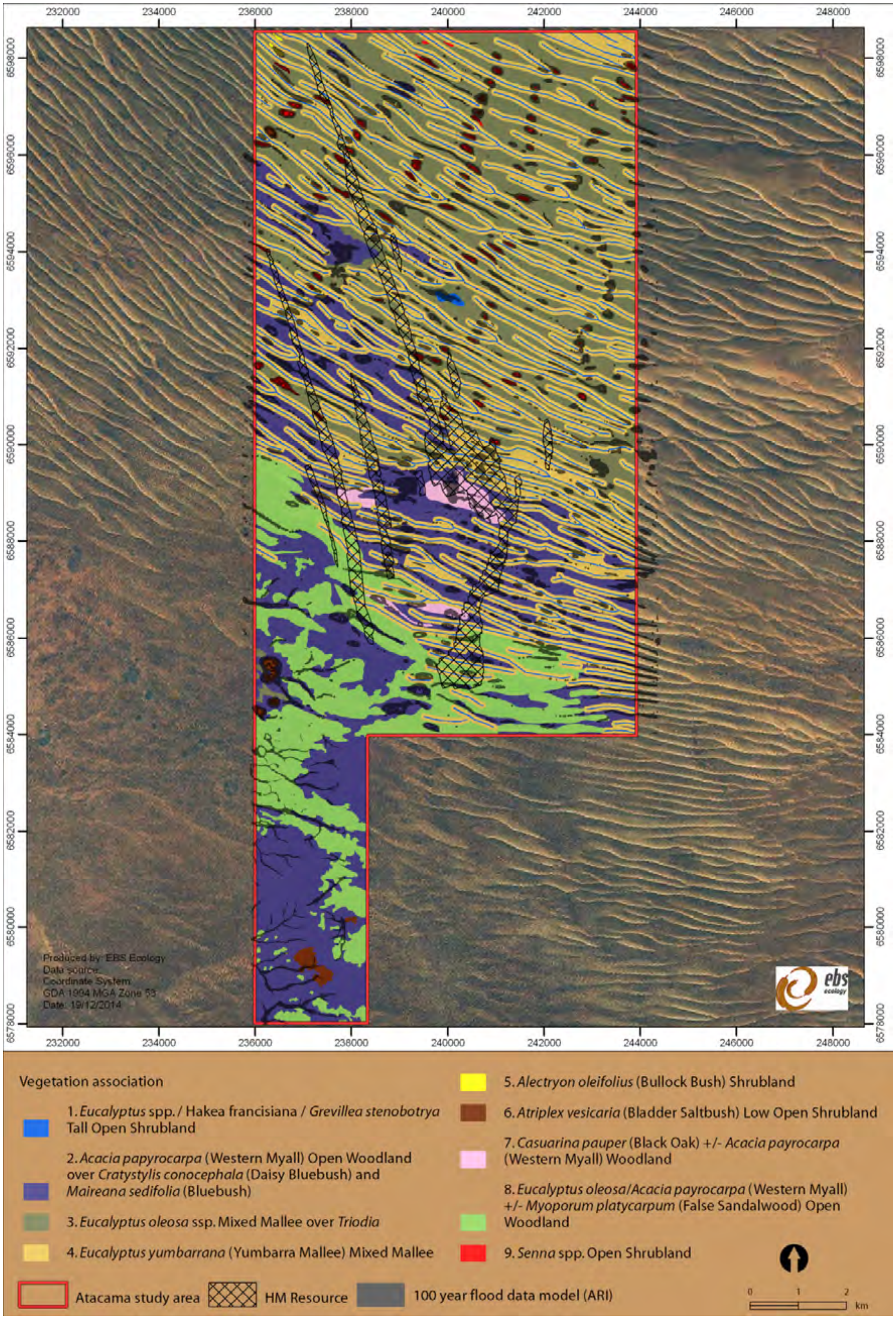


Figure 21. *Vegetation association mapping with watercourses*

Fauna

The following information is derived from a baseline fauna survey conducted within the Atacama study area in September 2014 by EBS Ecology (EBS 2014). Surveys for the nationally conservation rated Southern Marsupial Mole (Itjaritjara) (*Notoryctes typhlops*) are programmed for November 2014. The presence of the species is currently considered to be likely given the large area of preferred habitat available within the study area.

A summary of the fauna survey findings is presented in Table 10 and the complete fauna species lists from the study area are provided in Attachment C.

The occurrence of migratory bird species within the study area would generally be as an opportunistic visitor (e.g. to utilise seasonal resources and surface water when present) or as a fly-over species. It is considered unlikely that the identified migratory bird species would be reliant on surface water habitat within the Atacama study area.

Table 10. Summary of fauna expected and/or surveyed in the study area (adapted from EBS, 2014)

Fauna	Descriptions
Mammals	The total mammal species known to occur within the study area is 16, this includes 11 native and five introduced species (EBS, 2014). Common small ground dwelling mammals within the study area include the Little Long-tailed Dunnart (*Sminthopsis dolichura*), Mitchell's Hopping-mouse (*Notomys mitchellii*) and Sandy Inland Mouse (*Pseudomys hermannsburgensis*). The nationally conservation rated Sandhill Dunnart (*Sminthopsis psammophila*) was also detected during the EBS September 2014 survey. Large macropod species, Western Grey Kangaroo (*Macropus fuliginosus*) and Red Kangaroo (*Macropus rufus*) were detected in relatively low numbers during the EBS September 2014 survey. One species of microbat, the Lesser Long-eared Bat (*Nyctophilus geoffroyi*) was captured during the 2014 survey. It is likely that an additional four common microbat species would have been detected within the study area. Anabat calls recorded from the EBS September 2014 survey are currently being analysed by a sub-consultant. Surveys for the nationally conservation rated Southern Marsupial Mole (Itjaritjara) (*Notoryctes typhlops*) are programmed for November 2014. The presence of the species is currently considered to be likely given the large area of preferred habitat available within the study area. The five introduced species include One-humped Camel (*Camelus dromedarius*), Feral Cat (*Felis catus*), Red Fox (*Vulpes vulpes*), Rabbit (*Oryctolagus cuniculus*) and House Mouse (*Mus musculus*). None of the mammal species detected within the study area are totally reliant on habitat provided by ephemeral drainage lines and clay pans as highlighted in Figure 21
Reptiles	Thirty-six reptile species were detected within the study area during the EBS September 2014 survey (EBS, 2014). No reptiles with a conservation rating were detected, however the Black-naped Snake (*Neelaps bimaculatus*), which has a conservation rating of rare under the NPW Act is known to exist within the southern section of the study area (BDBSA 2014). Common diurnal species within the study area include Southern Spinifex Ctenotus (*Ctenotus atlas*), Dwarf Bearded Dragon (*Pogona minor*), Sandplain Ctenotus (*Ctenotus schomburgkii*), Crested Dragon (*Ctenophorus cristatus*) and Linga Dragon (*Diporiphora linga*). Common nocturnal species include the Starred Knob-tailed Gecko (*Nephrurus stellatus*), Beaded Gecko (*Lucasium damaeum*) and Desert Wood Gecko (*Diplodactylus wiru*). None of the reptile species detected within the study area are totally reliant on habitat provided by ephemeral drainage lines and clay pans as highlighted in Figure 21
Birds	A total of 51 bird species were recorded during the EBS September 2014 survey. Two old Malleefowl (*Leipoa ocellata*) mounds were located within the study area. The Malleefowl has a national conservation rating of vulnerable. Both mounds contained fragments of egg shell. It appears that the mounds have not been active for up to ten years. The state conservation rated Peregrine Falcon (*Falco peregrinus*), Restless Flycatcher (*Myiagra inquieta*) and Australian Bustard (*Ardeotis australis*) were recorded. One migratory species listed under the EPBC Act, the Rainbow Bee-eater (*Merops ornatus*) was also recorded during the September 2014 survey. Common birds within the study area include Masked Woodswallow (*Artamus personatus*), Weebill (*Smicrornis brevirostris*), White-fronted Honeyeater (*Purnella albifrons*), Yellow-plumed Honeyeater (*Ptilotula ornata*) and Yellow-throated Miner (*Manorina flavigula*). None of the bird species detected within the study area are totally reliant on habitat provided by ephemeral drainage lines and clay pans as

highlighted in Figure 21

4 Conclusions

Findings from the baseline assessment are summarised below:

1. There are two distinct landscape forms that influence surface water in the study area: the parallel, vegetated linear dunes surrounding the Atacama deposit and the gentle slopes dissected by the dendritic watercourse network of the J-A catchments along the southern corridor.

2. The Atacama deposit area is characterised by a multitude of discrete, terminal catchments. A XPSWMM 2D hydrodynamic model of the region demonstrated that many of these catchments remain separated in the 1000 ARI storm event. This indicates that potential impacts from the proposed mine development in the area will be contained within those individual catchments that cross the mineral deposit boundary.

3. Watercourses at the Atacama deposit are almost exclusively dune swales. These are likely to be easier to reinstate than River Styles® in the southern corridor due to their physical form.

4. Natural erosion processes in the region are controlled by vegetation, soil crusts and the landscape form (e.g. discrete, small catchments). Eroded material is transported during flood events into local pans within the terminal catchments.

5. The small interdunal bank confined gullies that have formed along the Spine Track are indicative of the landscape's sensitivity to disturbance. A single-lane sand vehicle track is only a minor disturbance to the landscape and may indicate that major infrastructure can have more significant impacts.

6. Vegetation species within the Atacama study area are not reliant on collection of surface water or periods of inundation to survive.

7. Potential surface water issues will depend on the placement of infrastructure in terminal pans. Results from flood modelling indicate that flood depths of up to 3 m are likely during the 1 in 100 yr ARI event (i.e. 82 mm of rain over 6 hours produces a flood depth of up to 3 m) in the pans in the vicinity of the Atacama deposits.

Based on the findings of the baseline study, we have compiled the following recommendations:

1. Mine planning should consider how to manage many flow paths within a small area discharging into the pit during mining operations. Multiple levees may be required to manage these discharge points. This issue will need further investigation when assessing potential impacts of the proposed mine plan.
2. Mine planning needs to consider potential issues of connecting previously discrete catchments during rehabilitation. This will not only change the physical and ecological form of the landscape, there will also be the potential for defined watercourses to form (due to an enlarged catchment area) and erode the rehabilitated surface.
3. The findings and flood modelling results this assessment should be used as a basis for assessing potential impacts to surface water and infrastructure once a proposed mine plan is finalised.
4. The physical form and processes identified during the baseline assessment should be incorporated into the design of reconstructed watercourses as part of the PEPR.
5. The gullies that have formed along the Spine Track demonstrate the sensitivity of the landscape to erosion, which should be investigated further in the impact assessment. This may have implications for placement of mining-related infrastructure, including number and location of access roads

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Attachment A
Hydrology method and assumptions

Modelling assumptions

Extreme to rare flows

To estimate flows, catchment boundaries need to be clearly defined. The challenge for the Atacama study area is that catchments are defined by sand dune ridges and there is a possibility that these catchments may merge during rare, extreme flow events. The merging of catchments under these circumstances would indicate whether the watercourses that dissect the Atacama resource deposit are supposed to be part of the bigger catchment or they are independent catchments.

For this purpose, the method described in AR&R (Reference?)was adopted to determine the 1000 year ARI event. The 1 in 1000 year event was determined based on an interpolation from the estimation of Probable Maximum Precipitation (PMP) and credible limit of extrapolation which is defined as the 100 year ARI storm event.

Probable Maximum Precipitation (PMP)

The Generalised Short Duration Method (GSDM) was used to estimate PMP for Atacama study area. The PMP rainfall depth were calculated and summarised in Table 11 for totally 6 flows including 15, 30 and 45 minutes and 1, 2, 3 and 6 hours rainfall events.

Table 11. Rainfall depth for PMP with different duration

	15 min	30 min	45 min	1 hour	2 hour	3 hour	6 hour
Rainfall depth (mm)	160	235	295	345	440	490	615

To interpolate the 1000 year event, an Annual Exceedance Probability (AEP) is assigned to the PMP. Based on the recommendations in GSDM and AR&R methods for catchments with less than 1,000 km^2, 1 in 1,000,000 has been selected for the PMP event. The estimated 1000 year ARI rainfall depth are summarised in Table 12. The initial and continuous losses for 1000 year ARI event were interpolated between PMP and 100 year ARI (IL=5.5 mm and CL=3.77).

Table 12. Estimated 1000 year ARI rainfall depth with different durations

	15 min	30 min	45 min	1 hour	2 hour	3 hour	6 hour
Rainfall depth (mm)	53.4	74.2	88.5	99.6	120.6	133	159

To simulate rainfall-runoff in Atacama study area, a two-dimensional hydraulic model was developed using XPSWMM software. XPSWMM is an advanced software package for dynamic modelling of one and two dimensional river systems and is used to simulate rainfall storm events in a catchment. The hydrodynamic model was run for the 1000 storm event to define catchment boundaries and the results indicated that catchments remain separated with surface water terminating in pans.

Land surface

Geometry for the subject reach is derived from aerial photogammetry captured in 2013. Since an infrastructure corridor connecting J-A mine to the Atacama deposits is a point of interest for Iluka, the flood condition of a narrow strip of land adjacent to the Ambrosia deposit (referred to as the southern access corridor in the report) was investigated. The only available topographic data in this region were one metre contour lines that cover three quarters of the corridor and two-meter contour lines that cover the whole area. Combing these two sources of data produced a vertical wall where the data intersected (Figure 22). A surface created using 2 m contour lines solely was tested in XPSWMM model and produced low quality results. Therefore, the surface was created using 1 m contour lines for 90% of the southern access corridor and the catchment extent for the remaining 10% was determined by manually analysing the 2 m contours.

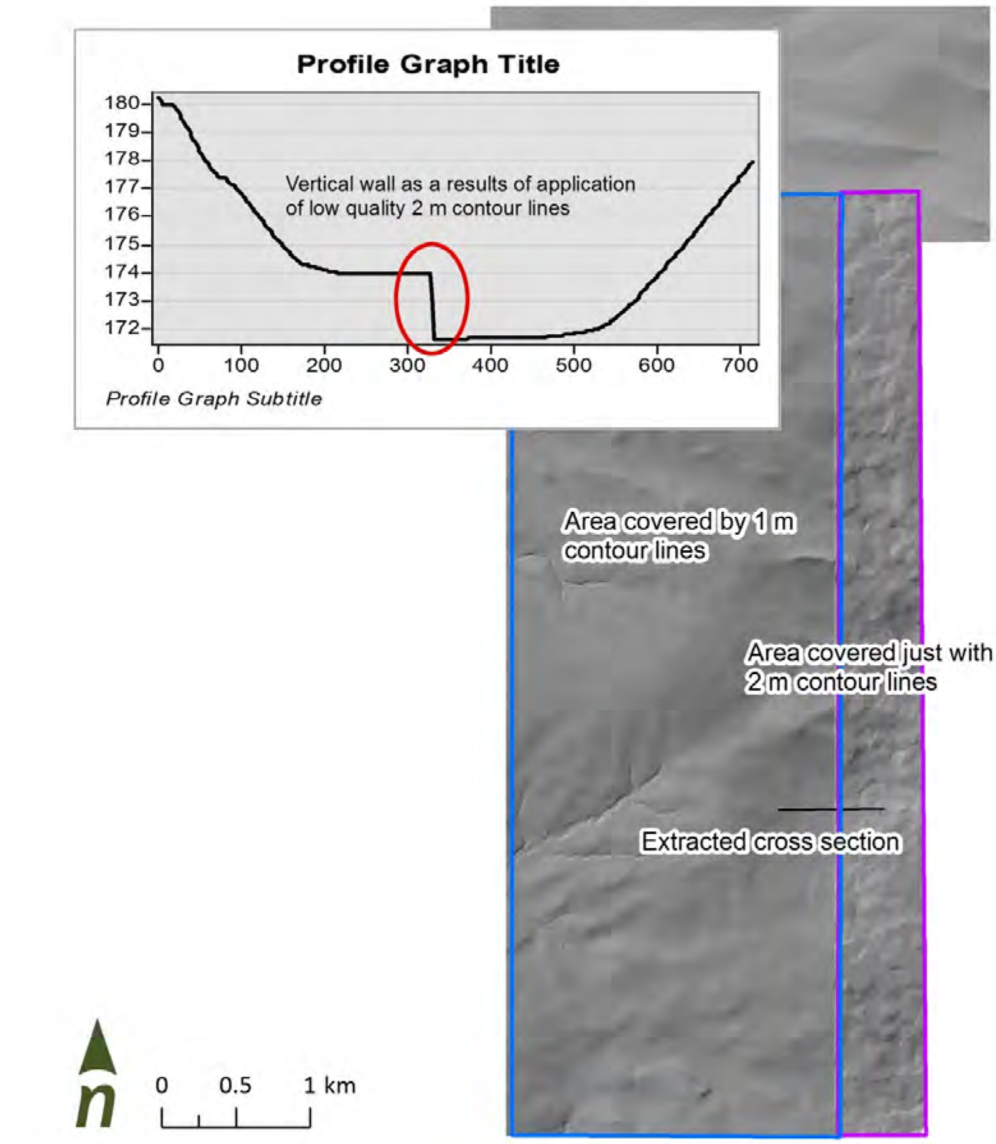

Figure 22 *Surface created using combination of 1 and 2 m contour lines and elevation in the boundary of layers*

Boundary conditions

The normal hydraulic depth was adopted as the downstream boundary condition in the XPSWMM model to ensure the water freely exits the downstream boundary of the model. The upstream boundary condition set to critical rainfall characteristics.

Roughness coefficient

Manning's *n* value which represents the frictional resistance to flow was estimated based on photos and observations of vegetation coverage during field work. Based on these two references the vegetation coverage does not vary significantly across the study area therefore a Manning *n* value of 0.035 was adopted for modelling.

Calibration based on initial and continuous losses
The nearest rainfall station to the study area is Jacinth rainfall station with approximately 6 years of data. Although the catchment sizes in Atacama mine is different from Jacinth and Ambrosia, this station is the only available source of data in this region. Catchments with different sizes and shapes behave differently in similar storm events and application of this rainfall station provides a rough estimation for Atacama study area catchments.

Based on Australian Rainfall and Runoff guideline (AR&R) a minimum of three independent storm events and generated flows are required to extract the hydrological behaviour of a catchment. Although this level of data is not available for the region, we attempted to use one recent large storm event to demonstrate how this data could be calibrated in the future. For this purpose RORB Win version 6.15, was used. The kc value for the RORB model was derived based on that recommended within RORB for South Australia, equal to 5.06. The value of m set to 0.8 (kc=0.89A^0.55).

One of the most significant observed rainfall events during mine operation period occurred on 15 February 2014 and produced significant runoff and flooding issues at the J-A mine site. The magnitude and distribution of this storm event has been recorded by Jacinth rain gauge station and Figure 23 represents temporal distribution pattern of this event. Captured photos and measured watermarks by Alluvium team during their field survey in March 2014 provided sufficient data to estimate relevant flows and calibrate a hydrology model for this flood event (Figure 24). The HEC-RAS model developed for J-A mine site was used to estimate the required flow to produce similar watermarks and corresponding flood depths. Table 13 shows measured watermarks during field visit and estimated flow for observed watermarks using HEC-RAS.

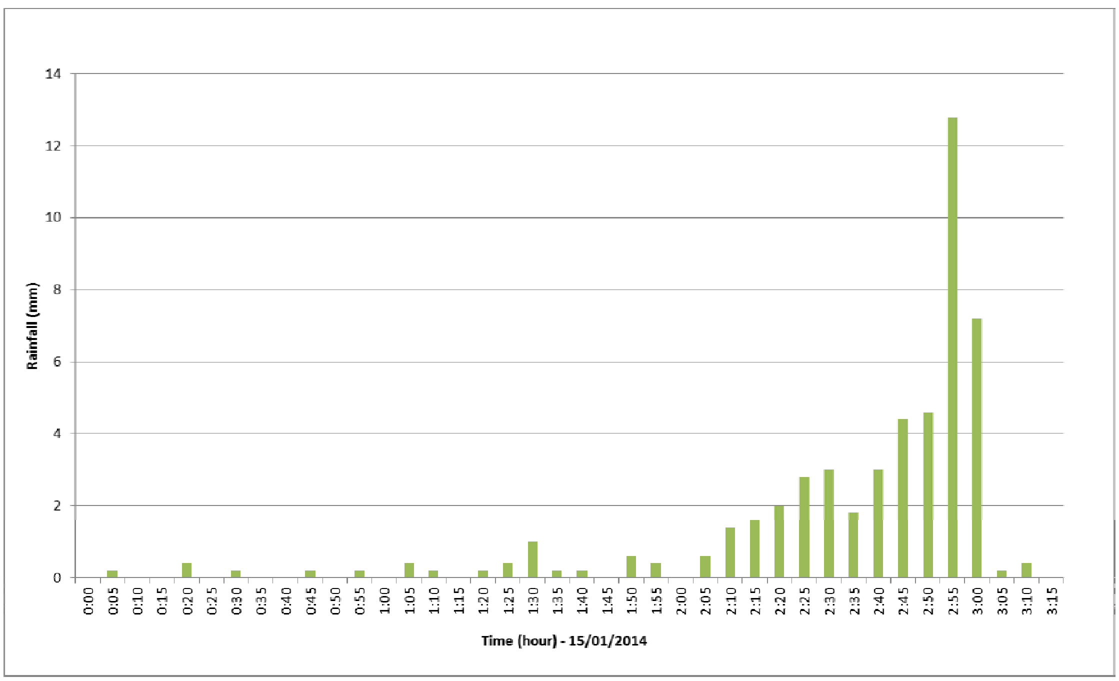

Figure 23. *Hyetograph of 15 February 2014*

Calibration revealed a high potential soil absorbance for the catchment (initial loss = 46.5 mm and continuous loss=4 mm/h) which is compatible with anecdotal evidence. This is in contrast to the initial loss recommended by AR&R (15 mm).

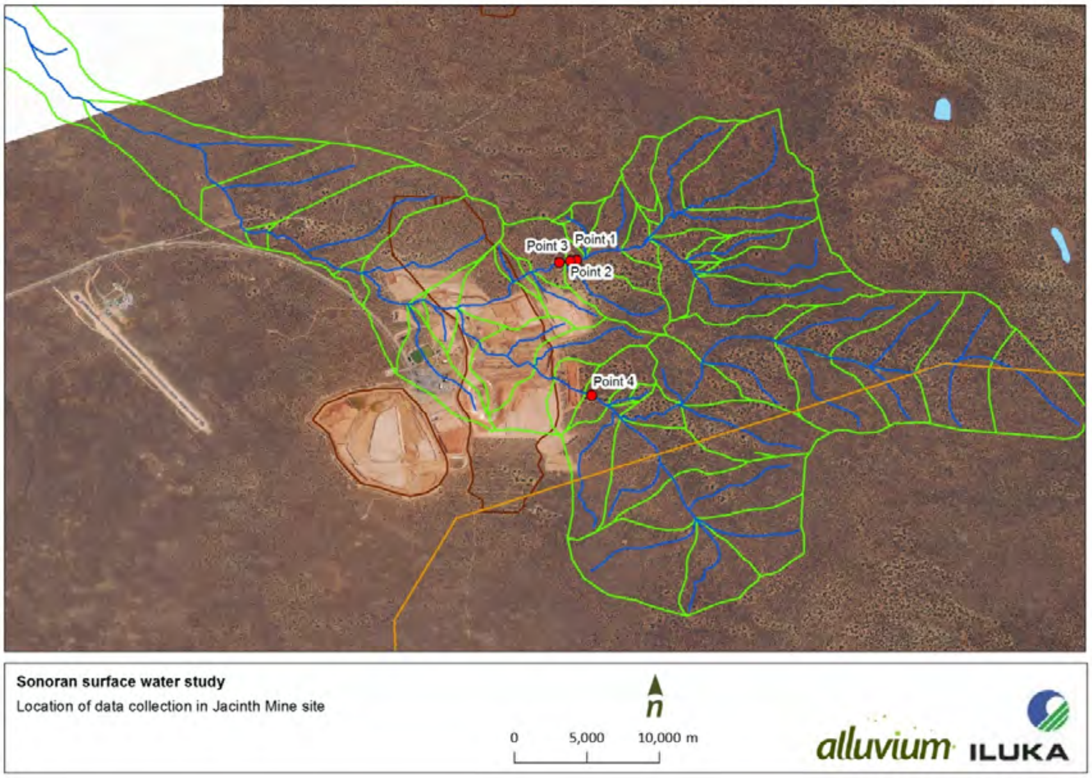

Figure 24. *Location of data collection in Jacinth catchment*

Table 13. Measured watermarks and calculated flow using HEC-RAS

Location of measurement	Observed flow depth (m)	Observed flow width (m)	required flow to produce observed watermarks (m^3/s)	Simulated flow depth (m)	Simulated top flow width (m)
Jacinth North – point 1	0.38	5.7	3	0.37	8
Jacinth North – point 2	0.42	7.7	3	0.63	7.5
Jacinth North – point 3	0.42	6.5	2.45	0.4	5
Jacinth South – point 4	0.6	-	10.96	0.6	-

A single significant rainfall event is not representative of region storm events and therefore the initial and continuous losses for storm events need to be set to recommended values for arid zones in South Australia (IL = 15 mm and CL= 4 mm/h), as outlined in AR&R. The collection of data as outlined in Table 13 for two additional rainfall events of similar magnitude or larger would enable site specific values for initial loss and continual loss to be derived and applied. To represent the potential changes in using calibrated parameters, a flood modelling test was undertaken for both calibrated and recommended losses by AR&R across the Atacama study area. The flood return period chosen for flood modelling was 50 year ARI which is the first return period with rainfall depth more than calibrated initial loss and closest to the observed rainfall depth in early 2014. Figure 25 denotes the potential differences between application of calibrated and recommended rainfall losses by AR&R.

It is not recommended that the partially calibrated results are used for the purposes of designing mine infrastructure until data from two other rainfall events can be applied.

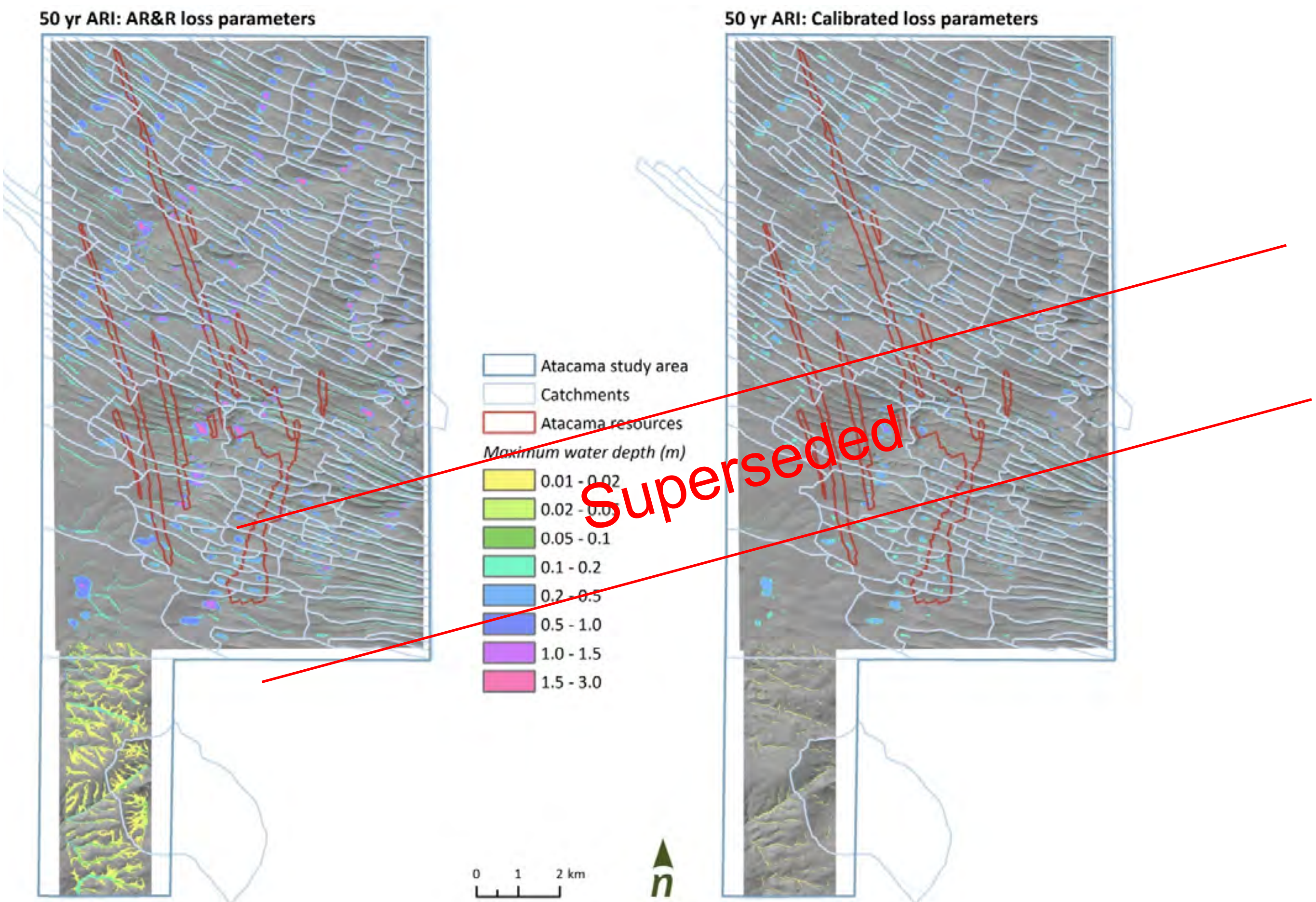

Figure 25. *Difference in application of partially calibrated and recommended rainfall losses by AR&R*

Attachment B
River Style proformas

Interdunal bank confined gully

Defining attributes of River Style®

- Laterally unconfined valley setting (<10% of channel abuts valley margin)
- Present and continuous channel
- Single channel
- Low/moderate sinuosity
- Bed slope > 0.015 m/m
- Sand bed
- **Interdunal bank confined gully River Style®**

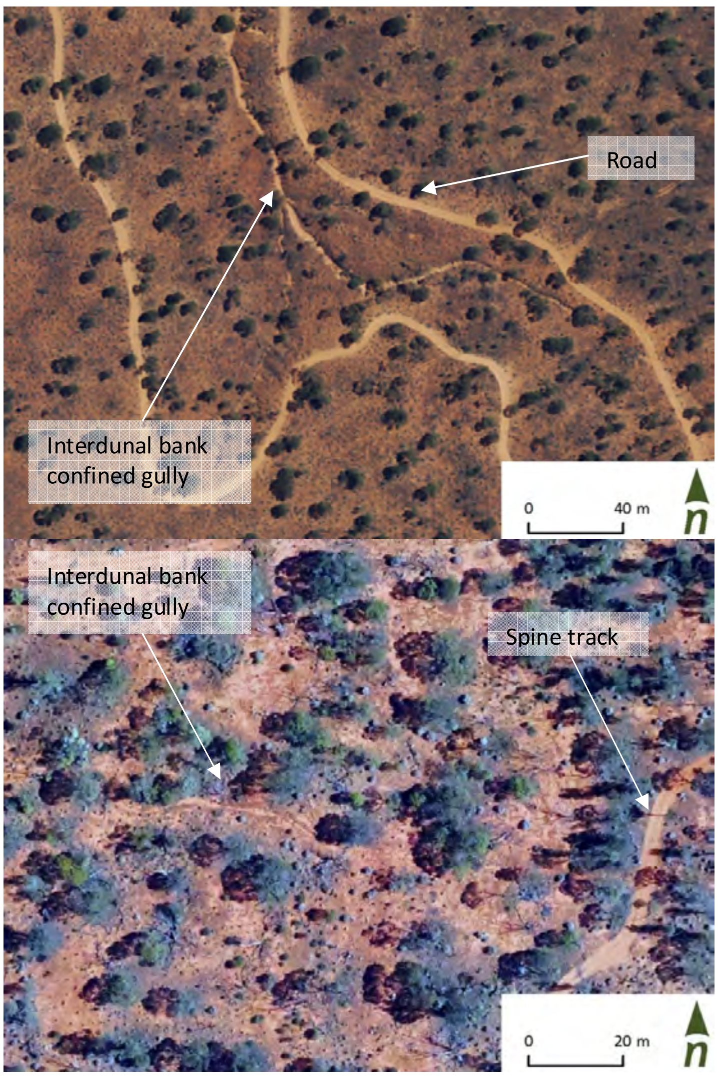

Figure 26. *Example aerial view of Interdunal bank confined gully River Style® in the southern corridor (top) and adjacent to the Spine Track in the Atacama region (bottom)*

Figure 27. *Example photos of interdunal bank confined gully River Style® in the southern corridor (left) and the Atacama region (right)*

Proforma: Interdunal bank confined gully

DETAILS OF ANALYSIS	
Air photographs:	*Atacama 10cm RGB*
Analysts:	*Clare Ferguson, Karen White*
Date:	*September 2014*
RIVER CHARACTER	
Valley-setting	Laterally unconfined
Channel planform (sinuosity # of channels channel stability)	Single main channel with generally low sinuosity Predominantly sand bed with possible calcrete present Typically tributary channels (1st or 2nd order streams) that are undergoing active incision
Sediment	Very fine sand (0.06 – 2 mm)
Channel geometry (size and shape)	Channel geometry is relatively symmetrical along straighter sections. Localised asymmetry occurs at bends, where the outside bank tends to steeper (at times near vertical) while the inside bank is more gradual.
Geomorphic units (geometry, sedimentology)	***Instream*** **Incision head** – incision heads are typically located at the upstream reach extent and may also be found within the reach **Sand splay** – sand splay may be located immediately upstream of a confluence ***Floodplain*** **Incised overland flow paths** - gullying can occur along steeper sections of bank where overland flow enters the main channel and where biological soil crust is absent. These can vary in width and length and have the potential to develop into new interdunal bank confined gully, sand River Style® reaches.
Vegetation associations	***Instream geomorphic units*** Instream vegetation is largely absent. ***Floodplain geomorphic units*** Vegetation is characterised by low shrubland, grasses and a scattered myall overstorey, with extensive biological soil crust ground cover in the interspaces.
RIVER BEHAVIOUR	
Cease to flow	Cease to flow is the predominant flow state.
Intermittent flow	Flow is infrequent, can be quite localised and is generally short-lived. Intermittent flow is often in response to localised and low rainfall. Intermittent flow may result in localised scour of bed sediment, sediment deposition and development of low flow channel
Continuous flow	Fine sediment is transported as a suspended load within the channel. Localised scour and flushing of bed sediments will occur in areas with increased depth (forced pools, deepening on concave (outer) bends) and along concave banks. Incision head migration within the channel and rill development on the banks are likely. Deposition on the falling limb of continuous flow events can produce accretion of finer sediment (sand/silt) across the bed, resulting in a uniform bed.
Overbank stage	At overbank stage the floodplain is engaged. For these entrenched systems, this occurs rarely and only in extreme flood events. When it does occur, flows dissipate and coarse and fine sediment deposition occurs across the floodplain extent.
CONTROLS	
Typical landscape	Mid catchment in the southern corridor, adjacent to the Spine Track in the Atacama region
Process zone	Sediment transport and deposition zone
Typical valley morphology	Laterally unconfined – broad, undulating floodplain across the valley floor.

Interdunal bank confined channel

Defining attributes of River Style®

- Laterally unconfined valley setting (<10% of channel abuts valley margin)
- Present and continuous channel
- Single channel
- Low/moderate sinuosity
- Bed slope < 0.015 m/m
- Sand bed
- **Interdunal bank confined channel River Style®**

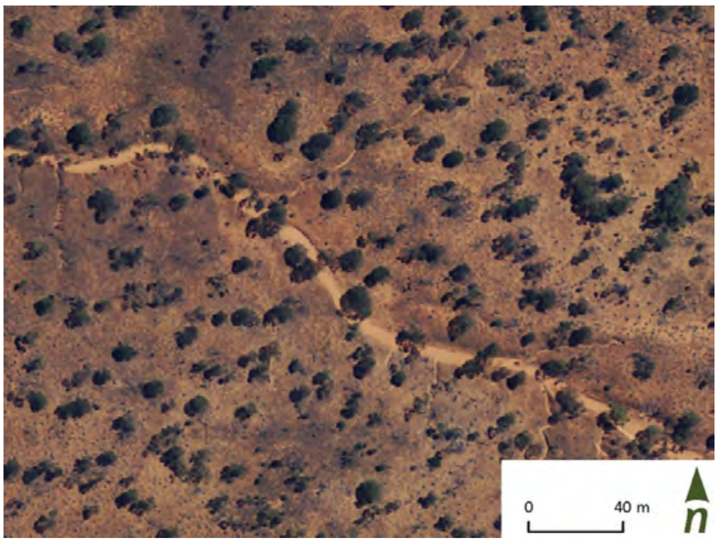

Figure 28. *Example aerial view of Interdunal bank confined channel River Style®*

Figure 29. *Example photo of interdunal bank confined channel River Style®*

Proforma: Interdunal bank confined channel

DETAILS OF ANALYSIS	
Air photographs:	*Atacama 10cm RGB*
Analysts:	*Clare Ferguson, Karen White*
Date:	*September 2014*
RIVER CHARACTER	
Valley-setting	Laterally unconfined
Channel planform (sinuosity # of channels channel stability)	Single main channel with generally low to morderate sinuosity Predominantly sand bed with possible calcrete present Typically channels of main streams (3rd order streams and above) that are generally stable
Sediment	Very fine sand (0.06 – 2 mm)
Channel geometry (size and shape)	Channel geometry is relatively symmetrical along straighter sections. Localised asymmetry occurs at bends, where the outside bank tends to be steeper (at times near vertical) while the inside bank is more gradual.
Geomorphic units (geometry, sedimentology)	***Instream*** **Sand sheet** – relatively homogenous, flat sand deposits covering the entire bed **Inset low flow channel** – a low flow channel may develop in sand sheet **Forced mid-channel bars** – Occasional forced mid-channel bars are likely to occur where a bar form has been induced by a flow obstruction, such as large woody debris or vegetation. ***Floodplain*** **Incised overland flow paths** - gullying can occur along steeper sections of bank where overland enters the main channel and where biological soil crust is absent. These can vary in width and length and have the potential to develop into interdunal bank confined gully River Style® reaches.
Vegetation associations	***Instream geomorphic units*** Vegetation is generally absent from the bed, while scattered myalls and low shrubs with abundant biological soil crust may be present on the banks. ***Floodplain geomorphic units*** Vegetation is characterised by low shrubland, grasses and a scattered myall overstorey, with extensive biological soil crust ground cover in the interspaces.
RIVER BEHAVIOUR	
Cease to flow	Cease to flow is the predominant flow state.
Intermittent flow	Flow is infrequent, can be quite localised, is generally short-lived and is likely to have significant transmission losses. Intermittent flow is often in response to localised and low rainfall. Intermittent flow may result in localised scour of bed sediment, sediment deposition and development of low flow channel
Continuous flow	Fine sediment is transported as a suspended load within the channel. Localised scour and flushing of bed sediments will occur in areas with increased depth (forced pools, deepening on concave (outer) bends) and along concave banks. Deposition on the falling limb of continuous flow events can produce accretion of finer sediment (sand/silt) across the bed, resulting in a uniform bed.
Overbank stage	At overbank stage the floodplain is engaged. For these entrenched systems, this occurs rarely and only in extreme flood events. When it does occur, flows dissipate and coarse and fine sediment deposition occurs across the floodplain extent.
CONTROLS	
Typical landscape	Mid and lower catchment, southern corridor. Not found in the Atacama region
Process zone	Sediment transport and deposition zone
Typical valley morphology	Laterally unconfined – broad, undulating floodplain across the valley floor.

Interdunal wandering

Defining attributes of River Style®

- Laterally unconfined valley setting (<10% of channel abuts valley margin)
- Present and continuous channel
- Multiple low flow channels
- High sinuosity
- Sand bed
- **Interdunal wandering River Style®**

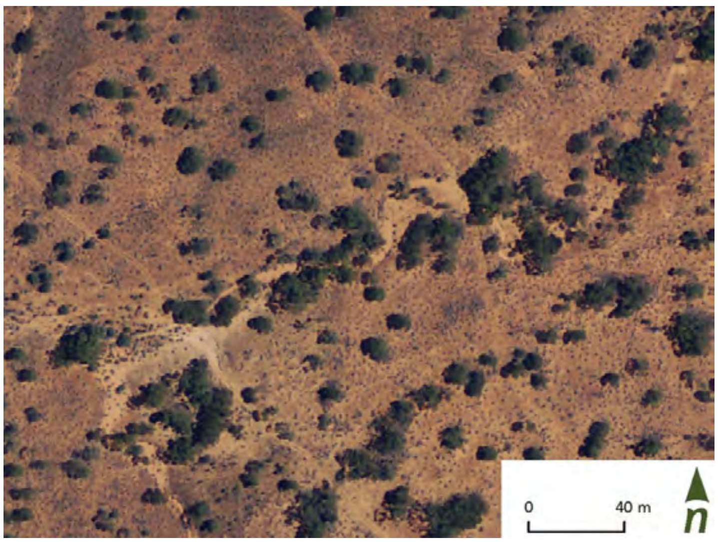

Figure 30. Example aerial view of Interdunal wandering River Style®

Figure 31. *Example photo of interdunal wandering River Style®*

Proforma: Interdunal wandering

DETAILS OF ANALYSIS	
Air photographs:	*Atacama 10cm RGB*
Analysts:	*Clare Ferguson, Karen White*
Date:	*September 2014*
RIVER CHARACTER	
Valley-setting	Laterally unconfined
Channel planform (sinuosity # of channels channel stability)	Single main channel with generally high sinuosity and multiple low flow channels Predominantly sand bed with possible calcrete present
Sediment	Very fine sand (0.06 – 2 mm)
Channel geometry (size and shape)	Channel geometry is relatively symmetrical along straighter sections. Localised asymmetry occurs at bends, where the outside bank tends to be steeper (at times near vertical) while the inside bank is more gradual.
Geomorphic units (geometry, sedimentology)	***Instream*** **Sand sheet** – relatively homogenous, flat sand deposits covering the entire bed **Multiple low flow channel** – multiple, braided low flow channels may develop in sand sheet **Forced mid-channel bars** – Occasional forced mid-channel bars are likely to occur where a bar form has been induced by a flow obstruction, such as large woody debris or vegetation. ***Floodplain*** **Incised overland flow paths** - gullying can occur along steeper sections of bank where overland enters the main channel and where biological soil crust is absent. These can vary from centimetres to over a metre in width and can be tens of metres in length. Gullies can have the potential to form new tributary channels.
Vegetation associations	***Instream geomorphic units*** Instream vegetation is minimal. Low shrubland, grasses and biological soil crust may colonise the bed in between low flow channels ***Floodplain geomorphic units*** Vegetation is characterised by low shrubland, grasses and a scattered myall overstorey, with extensive biological soil crust ground cover in the interspaces.
RIVER BEHAVIOUR	
Cease to flow	Cease to flow is the predominant flow state.
Intermittent flow	Flow is infrequent, can be quite localised and is generally short-lived. Intermittent flow is often in response to localised and low rainfall. Intermittent flow may result in localised scour of bed sediment, sediment deposition and development of low flow channel
Continuous flow	Fine sediment is transported as a suspended load within the channel. Localized scour and flushing of bed sediments will occur in areas with increased depth (forced pools, deepening on concave (outer) bends) and along concave banks. Deposition on the falling limb of continuous flow events can produce accretion of finer sediment (sand/silt) across the bed, resulting in a uniform bed in which low flow channels may subsequently form
Overbank stage	At overbank stage the floodplain is engaged. For these entrenched systems, this occurs rarely and only in extreme flood events. When it does occur, flows dissipate and coarse and fine sediment deposition occurs across the floodplain extent.
CONTROLS	
Typical landscape	Mid and lower catchment, southern corridor. Not found in the Atacama region
Process zone	Sediment transport and deposition zone
Typical valley morphology	Laterally unconfined – broad, undulating floodplain across the valley floor.

Dune swale

Defining attributes of River Style®

- Unconfined valley setting
- Discontinuous channel
- No discrete fans/splay, pans absent
- Reach formed in trough between linear dunes
- **Dune swale River Style®**

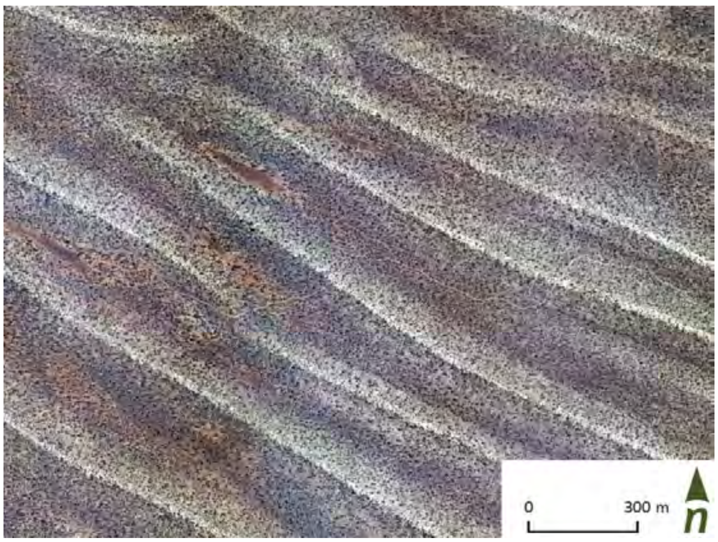

Figure 32. *Example aerial view of dune swale River Style®*

Figure 33. *Example of dune swale River Style®*

Proforma: Dune swale

DETAILS OF ANALYSIS	
Air photographs:	*Atacama 10cm RGB*
Analysts:	*Clare Ferguson, Karen White*
Date:	*September 2014*
RIVER CHARACTER	
Valley-setting	Laterally unconfined
Channel planform (sinuosity # of channels lateral stability)	No continuous channel, generally presents as depression along dune trough Laterally stable May be prone to incision resulting from headcut migration from downstream interdunal bank confined River Style® reaches, if dune swale does not terminate in pan.
Sediment (bed and banks)	Very fine sand (0.06 – 2 mm), biological soil crust likely to be present along flow path.
Channel geometry (size and shape)	N/A (no defined bed or banks)
Geomorphic units (geometry, sedimentology)	***Floodplain*** Dune swale typically consists of vertically accreted sands.
Vegetation associations	***Floodplain geomorphic units*** Areas of low to mid elevation and clay loams over fragmented calcrete are typified by stands of *Acacia papyrocarpa* (Western Myall). The understorey is commonly dominated by *Maireana sedifolia* (Bluebush), *Cratystylis conocephala* (Daisy Bluebush), *Senna* spp. *Santalum acuminatum* (Quandong) and various other shrub and herbaceous species. The lowest elevation sites are typified by extensive areas of dead Myall with an often dense stand of Senna spp.
RIVER BEHAVIOUR	
Cease to flow	Cease to flow is the predominant flow state. During cease to flow, dune swale presents as a broad, u-shaped depression.
Intermittent flow	Flow is infrequent, can be quite localised and is generally short-lived. Intermittent flow is often in response to localised and low rainfall. Flow is unlikely to connect all reaches
Continuous	At higher flows, surface flow will likely be visible along the swale floor as sheet flow over the depression. Fine suspended sediments may be mobilised and re-deposited along the swale floor.
Overbank stage	Under large flood events, the extent of surface flow will dissipate more broadly across the swale, maintaining relatively low stream powers. Some sediment may be locally scoured and re-disbursed, however whole-scale scour of the drainage line will not occur unless an incision process is initiated or migrates from an incised reach downstream.

CONTROLS	
Typical landscape	Upper and mid catchment in the southern corridor, all catchment settings in the Atacama region
Process zone	Source and transport
Typical valley morphology	Laterally unconfined fill, broad u-shaped valley bounded by sand dunes

Terminal pan

Defining attributes of River Style®

- Unconfined valley setting
- Discontinuous channel
- Pans present
- Aeolian dominated pan morphology
- Single pan
- Pan located at lowest point in catchment
- **Terminal pan River Style®**
- Pan may be hydraulically connected to adjacent terminal pan(s) during/following high rainfall runoff events (ie, merging of adjacent terminal pans). There is otherwise no surface outflow.
- Pans form through combination of aeolian processes (namely deflation) and hydrologic process, such as evaporation and groundwater – surface water interaction.
- Pans vary in size and shape.
- Pans may aggrade through dissolution of sediment from ponded surface water, resulting in a pan surface that is typically flat and featureless. Sediment deposition can also occur at the margin, typically in association with floodouts
- Pan vegetation is characterised by *Atriplex vesicaria* (Bladder Saltbush) shrubs and *Alectryon oleifolius* (Bullock Bush) along the fringes. Bullock Bush indicates longer term wetting patterns as this species is most commonly encountered on floodplains in rangeland areas

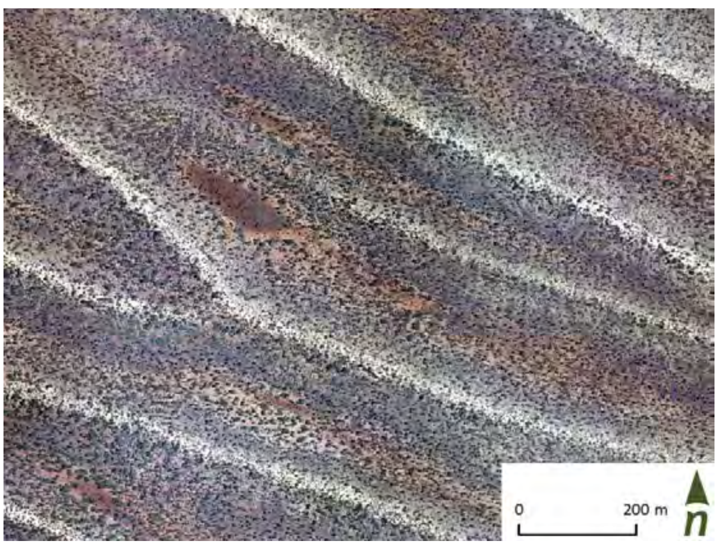

Figure 34. *Example aerial view of terminal pan River Style®*

Figure 35. *Example photo of a terminal pan*

Upland pan

Defining attributes of River Style®

- Unconfined valley setting
- Discontinuous channel
- Pans present
- Aeolian dominated pan morphology
- Single pan
- Pan located not at lowest point in catchment
- **Upland pan River Style®**
- Pans are likely to hydraulically connected to watercourses and/or pans downstream during/following high rainfall events but otherwise remain disconnected
- Pans form through combination of aeolian processes (namely deflation) and hydrologic process, such as evaporation and groundwater – surface water interaction.
- Pans vary in size and shape but are typically elongated in the direction of flow and smaller than terminal pans.
- Pans may aggrade through dissolution of sediment from ponded surface water, resulting in a pan surface that is typically flat and featureless.
- Pan vegetation is characterised by low shrubland with a biological soil crust ground cover.
- Pans may receive inflow from a defined water course or overland sheet flow

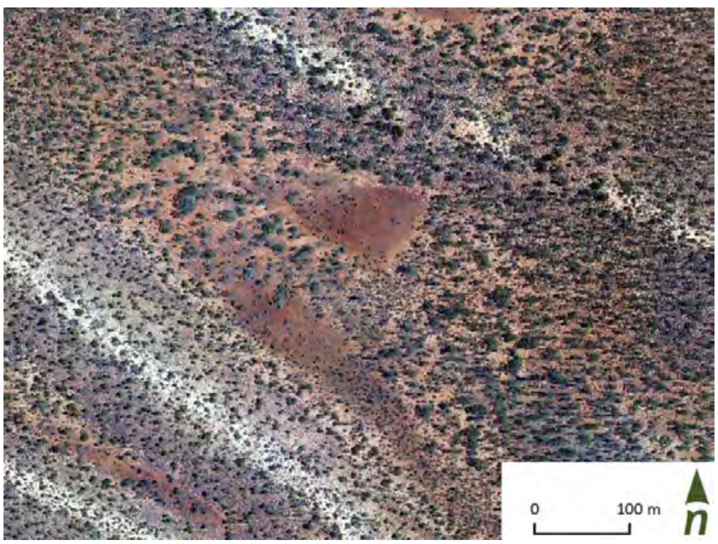

Figure 36. *Example aerial view of upland pan River Style® with a terminal pan to its north*

Perched pan

Defining attributes of River Style®

- Unconfined valley setting
- Discontinuous channel
- Pans present
- Aeolian dominated pan morphology
- Single pan
- Pan located in depression on top of dune ridge
- **Perched pan River Style®**
- Pans may be hydraulically connected to watercourses and/or pans downstream during/following high rainfall events but otherwise remain disconnected
- Pans form primarily through aeolian processes (namely deflation).
- Pans vary in shape but are typically relatively small.
- Pans receive only small inflows and aggradation through dissolution of sediment from ponded water is minor
- Pan vegetation is characterised by low shrubland.

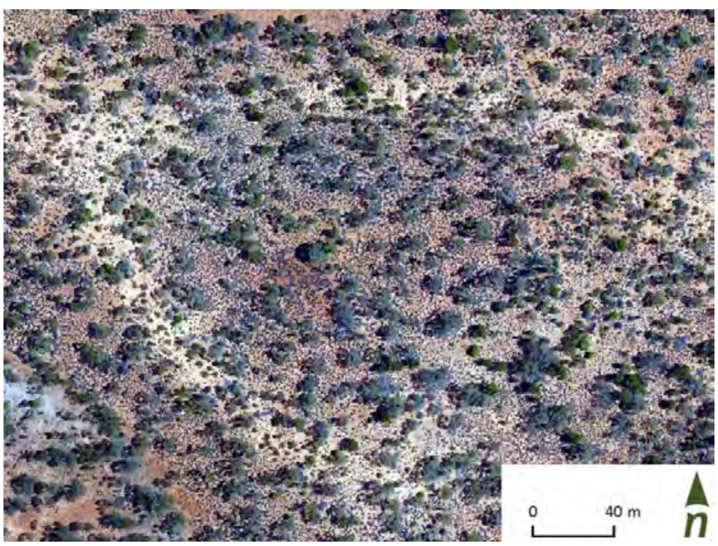

Figure 37. *Aerial view of a perched pan River Style®*

Attachment C
Flora and fauna survey

Atacama Development Project – Assessment of Flora and Fauna for Surface Water Dependent

Atacama Development Project – Assessment of Flora and Fauna for Surface Water Dependent Ecosystems

13 November 2014

Version 2

Prepared by EBS Ecology for Alluvium Consulting

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Front cover photo: Flood pan in northern section of Atacama study site.

GLOSSARY AND ABBREVIATION OF TERMS

BDBSA	Biological Database of South Australia
DEWNR	Department of Environment, Water and Natural Resources
DoE	Department of the Environment
EBS	EBS Ecology
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IBRA	Interim Biogeographically Regionalisation of Australia
J-A	Jacinth Ambrosia mine site
NPW Act	*National Parks and Wildlife Act 1972*
NRM	Natural Resources Management
NRM Act	*Natural Resources Management Act 2004*
NVC	Native Vegetation Council
RR	Regional Reserve
spp.	species (plural)
ssp.	subspecies

Table of Contents

1 INTRODUCTION

EBS Ecology (EBS) was contracted by Alluvium Consulting to provide baseline data on the flora and fauna species present within the Atacama study area as a component of a broader hydrology and geomorphology study for the proposed Atacama mineral sands project, in the far west of South Australia. A baseline flora and fauna assessment was conducted by EBS on behalf of Iluka Resources at the proposed Atacama mineral sands project during September 2014.

The objectives of this study were to:

- Describe the existing flora, fauna and migratory avifauna species including bats found within the study area.
- Describe the biological communities including those of state and national significance that were observed within the study area.
- Map vegetation associations and describe the vegetation stratums within the study area.
- Provide information on any significant surface water dependent ecological systems which may be impacted by changes to existing surface water regimes.

1.1 Study area and administrative boundaries

The study area is located in the eastern Eucla Basin, South Australia, approximately 200 km north-west of Ceduna. The Atacama deposit is located to the north east of Iluka's Jacinth Ambrosia Operation (J-A) as shown in Figure 38. The Atacama study area is within Iluka's Exploration Licence 5198.

The study area is located within the Yellabinna Regional Reserve (RR), owned by the Crown (South Australian Minister for Environment) and managed through the South Australian Department of Environment, Water and Natural Resources (DEWNR). Regional reserves are multiple-use reserves with a conservation function. Any wildlife or the natural or historic features of the land can be conserved and at the same time, the natural resources of the land can be utilised. Yellabinna RR is a large reserve which conserves a contiguous area of mostly mallee vegetation with high wilderness values. The dominant land uses of the reserve are conservation of wildlife, landscape and historic features, mineral exploration and tourism (DEWNR 2012).

The area is not serviced by a local council; rather the management and governance authority for the area falls to the Outback Communities Authority, under The *Outback Communities (Administration and Management) Act 2009*. The study area falls within the Alinytjara Wilurara Natural Resources Management Board region.

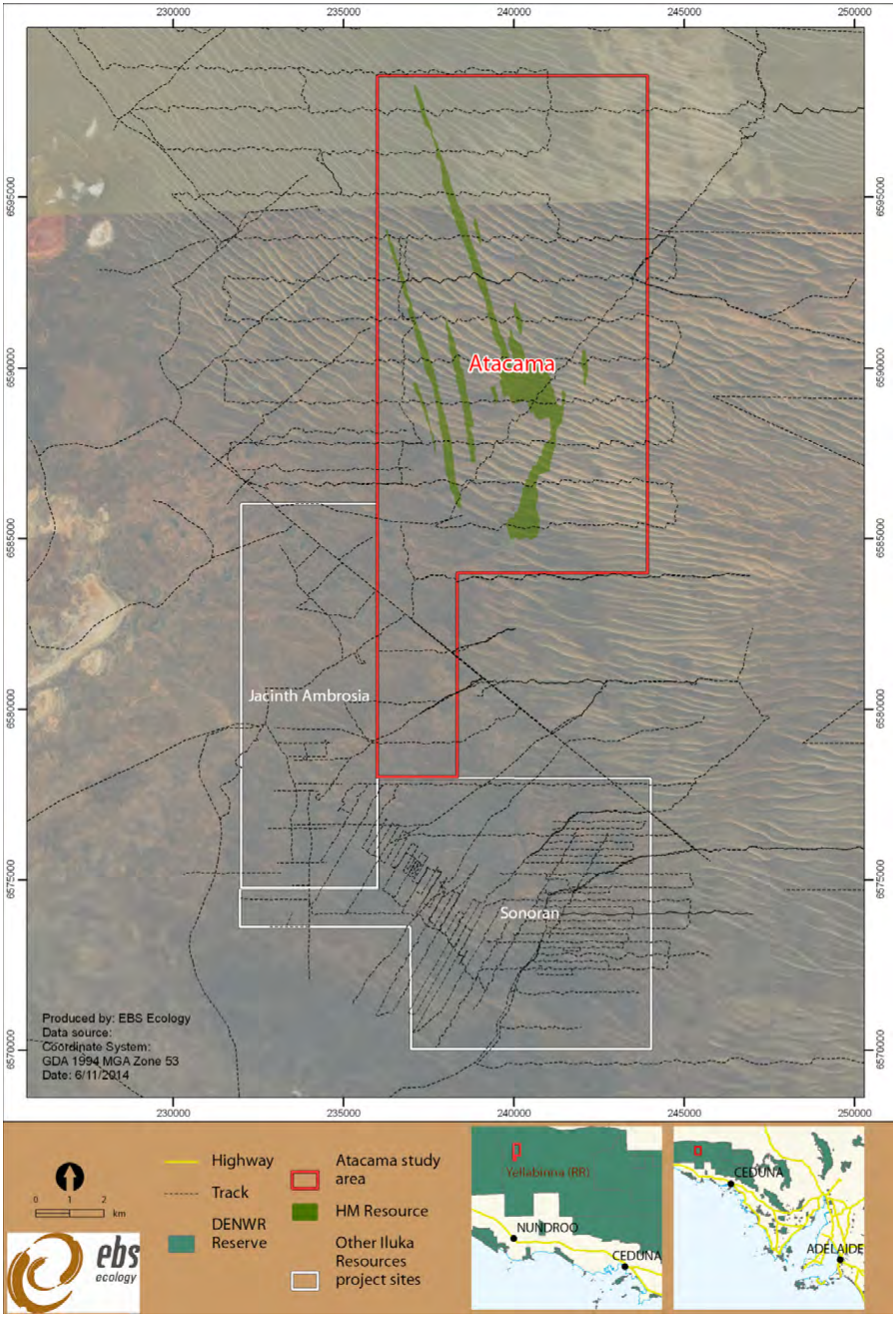


Figure 38. Atacama location and study area.

1.2 Environmental setting

1.2.1 Landscape position

Interim Biogeographical Regionalisation of Australia (IBRA) is a landscape based approach to classify the land surface across a range of environmental attributes, which is used to assess and plan for the protection of biodiversity (DoE 2013a). IBRA establishes a hierarchy of ecosystem classification for which the physical, climatic and biological characteristics are described. Bioregions are continental scale ecosystems distinguished from adjacent regions by their broad physical and biological characteristics. They may include more than 30 landforms and 50 vegetation associations. Sub-regions are sub-continental scale ecosystems occurring within bioregions and may include up to 15 landforms and 30 vegetation associations. Environmental associations are local scale ecosystems occurring within subregions.

The study area falls within the Yellabinna IBRA environmental association, within the Yellabinna IBRA sub-region and Great Victoria Desert IBRA bioregion. A summary description of the bioregions, subregions and associations is provided in Table 14 and a map of the IBRA boundaries is provided in Figure 39.

Table 14. IBRA Region, sub-region, and environmental association environmental landscape summary.

Great Victoria Desert IBRA bioregion	
Arid active sand-ridge desert of deep Quaternary aeolian sands overlying Permian and Mesozoic strata of the Officer Basin. Tree steppe of *Eucalyptus gongylocarpa*, Mulga and *E. youngiana* over hummock grassland dominated by *Triodia basedowii*. Arid, with summer and winter rain.	
Yellabinna IBRA sub-region	
This subregion comprises essentially the field of regular parallel dunes of the Great Victoria Desert and tracts of salt lakes. The dune field mantles erosional plain and low outcrops of granite or volcanic form inselbergs or tors within the dune field. The dunes consist mainly of sand derived from the Western Australian Shield, with a gradual colour change southward to where white sands derived from the coast predominate. Interdunal areas support *Eucalyptus socialis/E. gracilis* open scrub on red calcareous earths, while dunes support E. *socialis/Triodia irritans* open scrub on reddish siliceous sands. A chenopod shrubland of *Halosarcia* spp. and *Sclerostegia tenuis* occurs on the black calcareous loams of the depressions.	
Remnant vegetation	Approximately 99 % (4,457,950 ha) of the subregion is mapped as remnant native vegetation, of which 56 % (2,511,703 ha) is formally conserved.
Landform	Stable NW-SE longitudinal dunes, locally broken by granite hills and ridges of metamorphic rocks. Dunes closely spaced.
Geology	Vast dune sand and inter-dune corridors of clay, silt and very fine sand; evaporite deposits in numerous salt lakes (gypsum, halite); kopi ridges and dunes; some silcrete and calcrete (rare).
Soil	Sand soils with weak pedologic development, red calcareous earths, and red siliceous sands.
Vegetation	Mallee heath and shrublands.
Yellabinna IBRA association	
Remnant vegetation	Approximately 99 % (4,416,228 ha) of the association is mapped as remnant native vegetation, of which 57 % (2,503,966 ha) is formally conserved.
Landform	Plains with closely spaced easterly trending dunes and occasional rock outcrops.
Geology	Sand, alluvium, granite and silcrete.
Soil	Red calcareous earths, reddish siliceous sands and crusty red duplex soils.
Vegetation	Open scrub of beaked red mallee and yorrell and open scrub of beaked red mallee and spinifex.

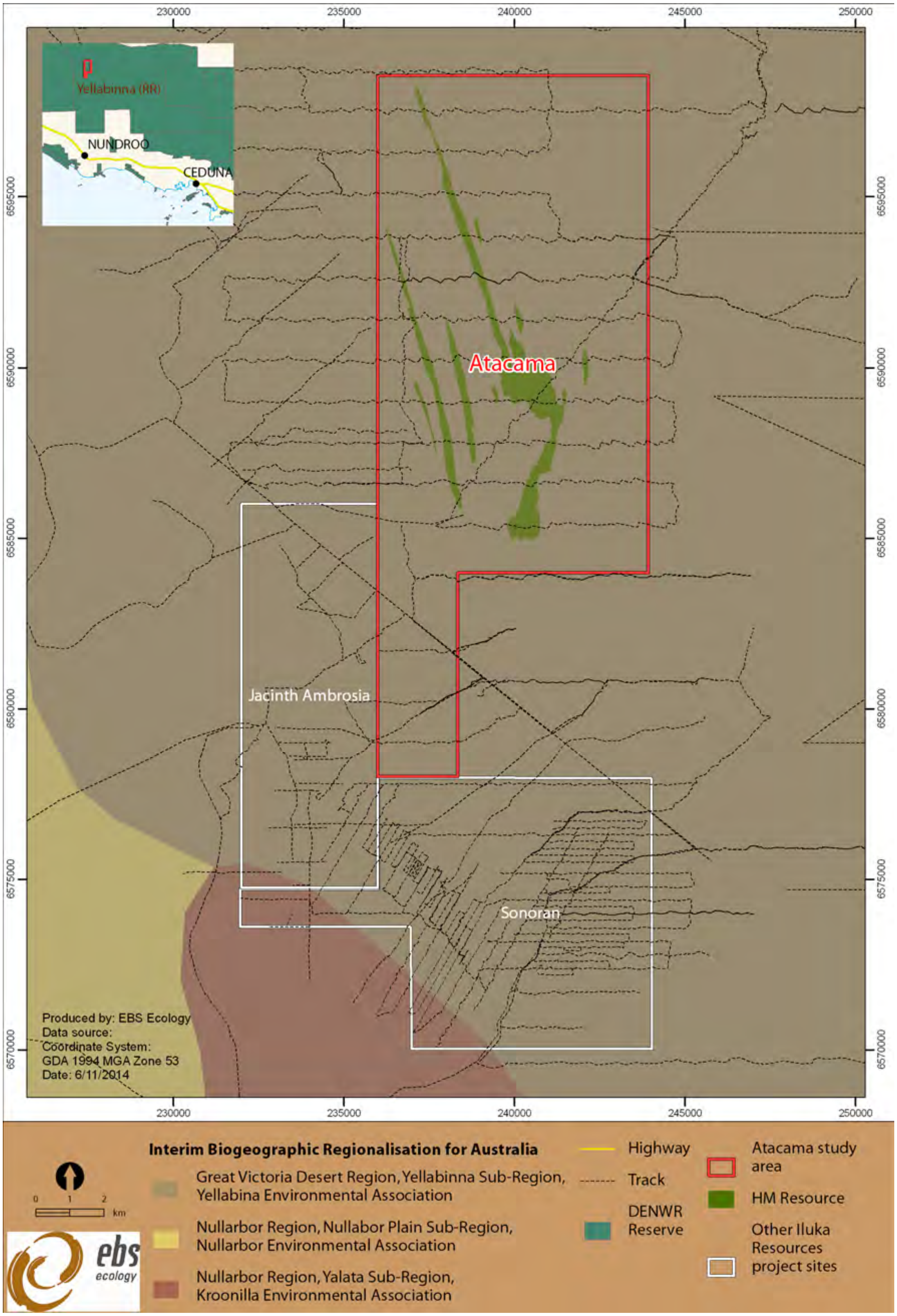


Figure 39. IBRA regions and environmental associations.

2 METHODS

2.1 Database searches

The online Protected Matters Search Tool was used to determine matters of national environmental significance under the Commonwealth EPBC Act that may occur or may have suitable habitat occurring within the study area (DoE 2013b). A search was completed based on the centre point of the study area with a 10 km buffer applied.

A search of the Biological Database of South Australia (BDBSA) was obtained from the Department of Environment, Water and Natural Resources (DEWNR) in October 2014, to identify flora and fauna species previously recorded within a 50 km buffer around the study area (DEWNR 2014). The BDBSA is comprised of an integrated collection of corporate databases which meet DEWNR standards for data quality, integrity and maintenance. In addition to DEWNR biological data the BDBSA also includes data from partner organisations (Birds Australia, Birds SA, Australasian Wader Study Group, SA Museum, and other State Government Agencies). This data is included under agreement with the partner organisation for ease of distribution but they remain owners of the data and should be contacted directly for further information.

2.2 Field survey

The following methods were implemented during a baseline flora and fauna assessment conducted by EBS on behalf of Iluka Resources at the proposed Atacama mineral sands project during September 2014.

2.2.1 Flora survey

Vegetation data was collected as per the requirements under the *Native Vegetation Act 1991*. The following methods were used during the survey:

- Ramble survey - This is a rapid survey approach whereby all vegetation types were visited, paying attention to visit areas of distinct local variation in moisture, slope, aspect or substrate. The survey focused on trying to maximise coverage of the area in the available time, ensuring the maximum number of flora species are recorded for each area / vegetation community. Survey time varied primarily according to vegetation type, topography, diversity and access.
- Targeted searches - Searches for threatened flora species (with a particular focus on Ooldea Guinea Flower) were undertaken as part of the general ramble surveys.

2.2.2 Fauna survey

The fauna trapping methodology was based on the method approved by DEWNR with modifications in design to suit the site particulars and recommendations by EPBC mammal survey guidelines. The following methods were used during the survey:

- Trapping sites - included the use of pitfall traps, funnel traps, Elliot traps and Cage traps.
- Bird surveys - Point-count bird survey.
- Targeted Malleefowl survey -_The survey involved aerial transects at 100 m intervals in a north/south direction one day and east/west another day.
- Bat surveys -Bat surveys were undertaken at each fauna site utilising AnaBat detectors (recording device which records bat ultrasonic echolocation calls).

3 RESULTS

3.1 Database search results

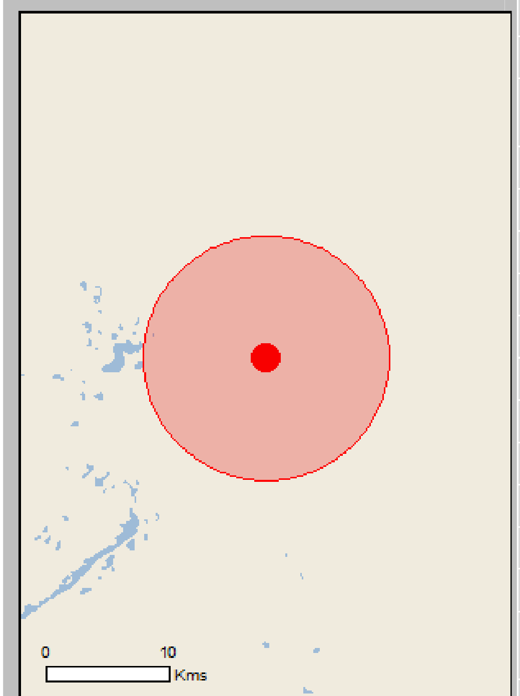
3.1.1 Matters of national environmental significance

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search highlighted the following matters of national environmental significance protected under the EPBC Act that may be relevant for the study area.

Four threatened species and four migratory species were highlighted in the Protected Matters Search as potentially occurring or having suitable habitat potentially occurring within proximity to the study area.

Table 15. Summary of the results of the EPBC Act Protected Matters Search (10 km buffer).

Search area (10 km buffer)



Matters of National significance under the EPBC Act 1999	Identified within the search area
World Heritage Properties	None
National Heritage Properties	None
Wetlands of International Significance	None
Great Barrier Reef Marine Park	None
Commonwealth Marine Areas	None
Threatened Ecological Communities	None
Threatened Species	4
Migratory Species	4
Commonwealth Lands	None
Commonwealth Heritage Places	None
Listed Marine Species	5
Whales and other Cetaceans	None
Critical Habitats	None
Commonwealth Reserves	None
Places on the Register of the National Estate	2 (Yellabinna area and Yellabinna region)
State and Territory Reserves	1 (Yellabinna, South Australia)
Regional Forest Agreements	None
Invasive Species	6
Nationally Important Wetlands	None
Key Ecological Features (Marine)	None

3.1.2 Threatened and migratory species

The conservation status of flora and fauna species is specified under legislation at the national (EPBC Act) and State (NPW Act) level. Migratory and marine listed species are not necessarily considered threatened, but benefit from a nationally coordinated approach to conservation. Their occurrence within the study area would generally be as an opportunistic visitor (e.g. to utilise seasonal resources and surface water) or as a fly-over species.

The EPBC Protected Matters Search and the BDBSA search identified the following threatened species as potentially occurring or having suitable habitat potentially occurring within the study area (Table 16):

- One nationally threatened plant species
- One nationally threatened bird species
- Two nationally threatened mammal species
- Five migratory and/or marine bird species listed under the EPBC Act
- 11 state threatened plants species
- 11 state threatened bird species
- Two state threatened bird sub-species (note: it is uncertain whether the records are of the threatened or non-threatened sub-species due to range overlaps between sub-species)
- Two state threatened mammal species
- One state threatened reptile species

A likelihood of occurrence rating of 'Highly Likely', 'Likely', 'Possible' or 'Unlikely' has been assigned to each threatened species highlighted from these searches using the following criteria:

- date of the most recent record (taking into consideration the date of the last surveys conducted in the area)
- proximity of the records (distance to the study area)
- landscape location of the records, vegetation remnancy and vegetation type of the record location (taking into consideration the landscape, remnancy and vegetation type of the study area, with higher likelihood assigned to species that were found in similar locations/condition/vegetation associations)
- knowledge of the species habitat preferences, causes of its decline, and local population trends.

3.1.3 Threatened ecological communities

Threatened ecological communities are recognised under the EPBC Act. Based on the EPBC Protected Matters Search results (DoE 2013b) no nationally threatened ecological communities are known to occur within the study area.

Table 16. Threatened and migratory species identified as potentially occurring within the study area based on database searches.

Scientific name	Common name	Conservation status		Last BDBSA sighting	BDBSA (50 km buffer)	EPBC Protected Matters Search	Location/habitat preference	Likelihood of occurrence within study area
		Aus	SA					
Plants								
Alyogyne pinoniana var. microandra			V	09/10/1987	✓		Red Brown dunes with limestone underbase, slopes of dunes and upper swales.	Unlikely
Austrostipa nullanulla	Club Spear-grass		V	08/08/2006	✓		Across the north of SA it is restricted to gypsum soils surrounding saline lakes. The habitat varies from chenopod shrubland, and mixed-species grassland, through to grassland dominated by *Austrostipa nullanulla*. On the Eyre Peninsula, it has been recorded growing in association with *Acacia rigens* (Nealie), *Allocasuarina helmsii* (Helm's Oak-bush) and an understorey of *Zygophyllum aurantiacum* (Shrubby Twinleaf), E*nneapogon* sp. (Bottle-washers) and small Compositae sp. It has been recorded by Badman (2006) in the J-A area.	Unlikely
Austrostipa vickeryana	Vickery's Spear-grass		R	10/10/1998	✓		Occurs within the Nullarbor and Gairdner-Torrens Basin regions, within inland saline areas.	Unlikely
Corynotheca licrota	Sand Lily		R	9/10/1987	✓		Grows on sand ridges in association with Triodia and mallee communities. Stems emerge annually from tuberous rootstock	Possible
Daviesia benthamii ssp. humilis	Mallee Bitter-pea		R	05/10/1987	✓		Dune swales, associated with mallee habitats	Unlikely
Frankenia cinerea			R	23/08/2005	✓		Saltpans and adjacent areas Recorded by Badman (2006) in J-A	Unlikely

Scientific name	Common name	Conservation status		Last BDBSA sighting	BDBSA (50 km buffer)	EPBC Protected Matters Search	Location/habitat preference	Likelihood of occurrence within study area
		Aus	SA					
							area	
Gratwickia monochaeta			R	08/08/2006	✓		Found on various sites but usually in sand; apparently uncommon. Recorded by Badman (2006) in J-A area.	Present
Hibbertia crispula	Ooldea Guinea-flower	VU	V	09/10/1987	✓	✓	Known from only two disjunct locations, the Lake Everard region and the Ooldea region of South Australia. EBS has previously recorded this species south of Ooldea on the top of large dune crests amongst Acacia shrubs and Spinifex, with Mallee and Spinifex in the surrounding swales.	Possible
Maireana suaedifolia	Lax Bluebush		R	28/05/2010	✓		Sand dunes and swales adjacent to saltpans	Possible
Melaleuca leiocarpa	Pungent Honey-myrtle		R	09/09/2005	✓		Sand dunes in association with *Eucalyptus yumbarrana*, Spinifex and Dodonaea.	Present
Santalum spicatum	Sandalwood		V	11/04/2012	✓		A root parasite on many species, commonly *Acacia* species such as *A. acuminata* (Jam) and *A. aneura* (Mulga). It grows on a wide range of soils including calcareous and solonised types in drier parts of its range. Scattered around the study area. Recorded by Badman (2006) in the JA area.	Present
Birds								
Acanthiza iredalei ssp. *iredalei*	Slender-billed Thornbill (western ssp)		^R	24/09/1984	✓	✓	Prefers chenopod shrublands dominated by Samphire or *Maireana* spp. (Bluebush) and *Atriplex* spp. (Saltbush).	Possible

Scientific name	Common name	Conservation status		Last BDBSA sighting	BDBSA (50 km buffer)	EPBC Protected Matters Search	Location/habitat preference	Likelihood of occurrence within study area
		Aus	SA					
Amytornis striatus	Striated Grasswren		R	26/03/1909	✓		Confined to areas with mature spinifex (*Triodia sp.*), usually in association with mallee eucalypts and sandy soils. Usually occupies vegetation with a post fire age of 6 to 30 years	Possible
Apus pacificus	Fork-tailed Swift	Mi, Ma				✓	Mostly occurring over inland plains but sometimes above foothills or in coastal areas. These tend to be being dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh treeless grassland and sand plains covered with Spinifex, open farmland and inland and coastal sand-dunes	Possible – fly over
Ardea alba	Cattle Egret	Mi, Ma	R			✓	Grasslands, woodlands and wetlands with a preference for moist areas with tall grass, or shallow open wetlands, and wetland margins.	Possible – irregular visitor if surface water is present
Ardeotis australis	Australian Bustard		V	10/04/2012	✓		Found on dry plains, grasslands and in open woodland The species is highly nomadic and apparently moves in response to rainfall.	Present
Cacatua leadbeateri	Major Mitchell's Cockatoo		R	16/04/2009	✓		Sporadically distributed across the arid and semi-arid interior of Australia, in a wide range of habitats including grassland, gibber, saltbush, mulga, casuarinas, and mallee woodlands, as well as tree-lined watercourses. Will use artificial water sources.	Highly likely
Charadrius veredus	Oriental Plover, Oriental Dotterel	Mi, Ma				✓	In non-breeding grounds, they prefer coastal habitats such as	Unlikely

Scientific name	Common name	Conservation status		Last BDBSA sighting	BDBSA (50 km buffer)	EPBC Protected Matters Search	Location/habitat preference	Likelihood of occurrence within study area
		Aus	SA					
							estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands.	
Cinclosoma castanotus ssp. *castanotus*	Chestnut Quail-thrush (eastern ssp)		^R	24/09/2009	✓		Suitable Chenopod\habitats available in survey area; confirmed previous observations at Ooldea (SKM 2006).	Unlikely
Climacteris affinis	White-browed Treecreeper		R	10/03/2005	✓		Occurring mostly in tall shrubland and low woodland dominated by acacias, such as Mulga, Western Myall and Gidgee, or Casuarinas, and Callitris.	Highly likely
Leipoa ocellata	Malleefowl	VU	V	27/09/2009	✓	✓	Occupies shrublands and low woodlands dominated by mallee vegetation. Habitat type includes Eucalypt or native pine Callitris woodlands, Acacia shrublands, Melaleuca uncinata vegetation or coastal heathlands. Active Malleefowl nests known from east of the study area (Moseby 2012).	Possible
Merops ornatus	Rainbow Bee-eater	Mi, Ma				✓	Open woodlands and shrublands, including mallee, and in open forests that are usually dominated by eucalypts. It also occurs in grasslands, especially in arid or semi-arid areas, in riparian, floodplain or wetland vegetation assemblages. Widespread, transient and highly mobile.	Present
Myiagra inquieta	Restless Flycatcher		R	01/06/1999	✓		Open forests, woodlands, farmland and inland scrub. They can inhabit *Eucalyptus camaldulensis*, *E.*	Present

Scientific name	Common name	Conservation status		Last BDBSA sighting	BDBSA (50 km buffer)	EPBC Protected Matters Search	Location/habitat preference	Likelihood of occurrence within study area
		Aus	SA					
							leucoxylon and box woodlands, and in open mallee (*E. oleosa*, *E. gracilis*) low woodland-low open forests. Recorded by SKM (2006) in open mallee.	
Neophema splendida	Scarlet-chested Parrot		R	1/08/2007	✓		Inhabits semi-arid areas with mallee and mulga scrublands/open woodlands with spinifex and saltbush ground covers. Occurs in both recently burnt and older growth mallee. Forages on or near the ground for seeds of grasses, including spinifex, herbs and acacias	Present
Northiella haematogaster ssp. *narethae*	Naretha Bluebonnet		^R	06/04/2006	✓		Usually found in or within sight of Casuarina and Acacia woodland, and usually near Chenopod shrubland. They are often far from water. They nest in tree hollows, and eat the seeds of both native and exotic plants	Unlikely
Pachycephala inornata	Gilbert's Whistler		R	15/04/2009	✓		Occurs in ranges, plains and foothills in arid and semi-arid timbered habitats. Generally found in Mallee shrublands, often in association with an understorey of spinifex and low shrubs including acacias, hakeas and Senna. Forages on or near the ground.	Likely
Pandion haliaetus	Osprey	Ma	E			✓		Unlikely
Mammals								
Notoryctes typhlops	Southern Marsupial Mole (Itjaritjara)	EN	V	03/04/2001	✓	✓	Often recorded in sandy dunes, mulga, saltbush and spinifex on sand ridge desert and with various	Present

Scientific name	Common name	Conservation status		Last BDBSA sighting	BDBSA (50 km buffer)	EPBC Protected Matters Search	Location/habitat preference	Likelihood of occurrence within study area
		Aus	SA					
							Acacias and other shrubs (EBS 2009d).	
Sminthopsis psammophila	Sandhill Dunnart	EN	E	27/05/2012	✓	✓	Prefers semi-arid habitats characterised by parallel sand dunes with associations of open mallee with a diverse shrub layer and Spinifex (*Triodia* spp.).	Present
Reptiles								
Neelaps bimaculatus	Western Black-naped Snake		R	08/11/2005	✓		Prefers leaf litter within Mallee and Mallee/Myall sand dune associations. Two *N. bimaculatus* were recorded at a fauna site in 2005. The fauna trapping site was located within the southern section of the study area in 2005 (SKM 2005).	Present
Varanus brevicauda	Short-tailed Pygmy Goanna		R	02/06/2010	✓		Desert sand plains and dunes with spinifex. Shelters in burrows at the base of Spinifex hummocks. Restricted to the northern section of the Great Victorian Desert towards the WA border. *Note: The 2010 record from near Ooldea is highly likely to have been an incorrect identification (Matt Launer confirmed the incorrect BDBSA record with the SA Museum).*	Not likely

Aus: Australia (*Environment Protection and Biodiversity Conservation Act 1999*). **SA:** South Australia (*National Parks and Wildlife Act 1972*). **Conservation Codes: CE:** Critically Endangered. **EN/E:** Endangered. **VU/V:** Vulnerable. **R:** Rare. **Mi:** Migratory. **Ma:** Marine.

^ It is uncertain whether these records are of the threatened sub-species due to range overlaps.

3.2 Flora

The following observations were made from a baseline flora and fauna assessment conducted by EBS on behalf of Iluka Resources at the proposed Atacama mineral sands project during September 2014. The study site is defined by the presence of a series of dune ridges overlying a calcrete bed layer which is irregularly expressed as outcrops and small rises throughout the study site. The dunes, while largely linear in dimension, fuse at various points entrapping linear water flow directionally. This has created sections whereby episodic rain events cause water to pond until emptying naturally through soil infiltration, evaporation or as transpiration through vegetation. Subsequently, vegetation community patterns within the Atacama study site are dictated by slow drivers such as soil type and substrate material, while dynamic drivers such as rainfall, run-off and other disturbance factors, such as camels, determine shorter term changes. Primarily, this leads to distinct vegetation types limited by their ability to survive under these drivers and determines what can grow and where it grows at any given point in time (*McIlwee et al.* 2013).

It is assumed that several of the ecosystems present within the Atacama site are dependent on historical dynamic driver events and have seen changes or transitions from one state to the next. *Westoby et al*. (1989), proposed the state and transition model whereby ecosystems are undergoing a constant transition from one state to another and at some point a threshold is crossed that does not allow the ecosystem to return to the previous state. Observations of the study area suggest that the interdune swales are consistently comprised of Myall woodlands. What is not consistent however is the level or period of time in which this ecosystem is transitioning from one state to the next. This could be based on a range of elements such as evenness of rainfall across the study area, catchment size of pans or ability to shed water through infiltration. Theoretically, in the absence of water ponding it would be expected that a far more consistent swale community structure would be present across the study area.

3.2.1 Vegetation structures

The Atacama baseline survey identified a number of vegetation structures of which two are considered to have undergone changes in states due to dynamic changes from rainfall coupled with substrate type which itself is commonly associated with topography. The assumptions made are largely due to consistent changes in vegetation structure in keeping with flood modelling maps conducted by Alluvium. The examples below are broad descriptions of the primary vegetation structures found within the Atacama study area.

***Atriplex vesicaria* Open Shrubland and *Alectryon oleifolius* (Bullock Bush) Shrubland**

Examples of this community are present as small isolated pockets across the study area. It is assumed that these sites have a solid calcrete base that excludes the long term viability of *Acacia papyrocarpa* (Western Myall) emergent's as seen on the nearby plain to the west. This has likely resulted in heavier clay alluvial silts building up collected as part of the catchment overlaying the calcrete. These sites are dominated by *Atriplex vesicaria* (Bladder Saltbush) shrubs and *Alectryon oleifolius* (Bullock Bush) along the fringes. Bullock Bush indicates longer term wetting patterns as this species is most commonly encountered on floodplains and fringes of dam banks and overflows in rangeland areas. Figure 40 below shows Senna growing sparsely on a chenopod shrubland flat which may indicate an ongoing shift in transition to another state. Barely visible in the background is the grey coloured foliage of *Alectryon oleifolius* (Bullock Bush) on the fringe of the flat.

Figure 40. Chenopod shrubland.

Acacia papyrocarpa (Western Myall) Woodlands and Senna spp. shrublands

Areas of low to mid elevation and clay loams over fragmented calcrete are typified by stands of *Acacia papyrocarpa* (Western Myall). The understorey is commonly dominated by *Maireana sedifolia* (Bluebush), *Cratystylis conocephala* (Daisy Bluebush), *Senna* spp. *Santalum acuminatum* (Quandong) and various other shrub and herbaceous species. The lowest elevation sites are typified by extensive areas of dead Myall with an often dense stand of *Senna* spp.

Over an extended period, it might be assumed that transition states may tend towards a return of Western Myall woodlands. This is dependent on the availability of episodic germination events from specific rainfall events coupled with scarification and burying of seed (Ireland and Andrew 1996) or levels of post germination herbivory from species such as rabbits (Lange and Graham 1983) which were absent in other pre-European mass germination events .

Figure 41. Low Myall Woodlands.

Figure 42. Transition zone from dune (light colour) to clay loam (Orange colour).

Slightly deeper soil profiles are dominated by Myall woodlands over bluebush often in association with *Eucalyptus oleosa* ssp. as the soil profile changes. This can often be a stark contrast as shown above in Figure 42 where *Eucalyptus* spp. (foreground) becomes obvious as soon as the soil profile changes to sand in comparison to the Myall communities in the background. These transitional zones often feature inordinate levels of flora species richness due to the wide range of habitat niches available in a geographically small area.

Casuarina pauper (Black Oak) Woodlands

Calcareous outcrops with red sandy loams are dominated by *Casuarina pauper* (Black Oak) woodlands. These are commonly associated with other high alkaline soil tolerant species such as *Maireana sedifolia*, *M. trichoptera* and *M. pentatropis* as an understorey. These communities are reliant on rainfall only.

Shallow soils and relatively steep topography of outcrops mean that runoff from these areas may contribute significantly to surrounding low elevation catchment areas. There was often ephemeral drainage lines emanating from these communities with Figure 43 below showing a typical gutter with calcrete scree scattered nearby. This contrasts significantly from the sand dune areas, where no sign of runoff was observed. Specific flora species were not associated with these drainage lines which are most likely due to the sporadic nature of run-off events.

Figure 43. Ephemeral creek emanating from calcareous outcrop.

Eucalyptus spp. Mixed Mallee over Triodia and Eucalyptus yumbarrana Mixed Mallee

Moderate depth loams in swales and flanks of dunes were dominated by a mix of species, primarily *Eucalyptus yumbarrana / E. pimpiniana* over *Triodia*. These are neither reliant nor tolerant of excessive moisture and require excellent drainage to persist in these areas.

Eucalyptus spp. / Hakea francisiana / Grevillea stenobotrya Tall Open Shrubland,

Dune crests are dominated by *Eucalyptus* spp. and *Callitris verrucosa* (Native Pine) over low shrubs and small trees such as *Grevillea stenobotrya* and *Hakea francisiana*. These species are very tolerant of the harsh conditions present in these landforms and are reliant on rainfall events only.

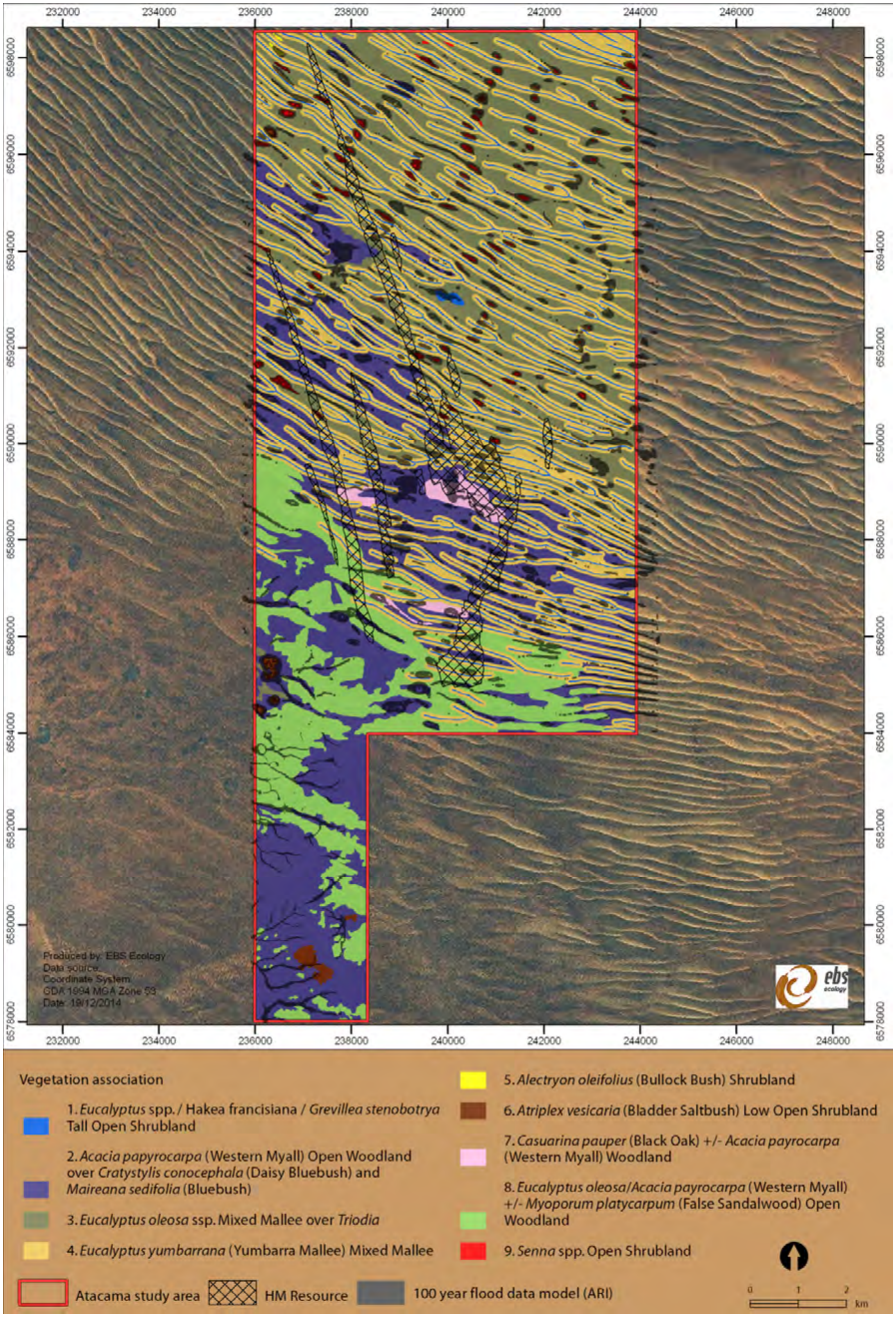


Figure 44. Vegetation associations within the Atacama study area.

3.3 Fauna

Active searching and bird surveys were conducted within the ephemeral drainage line and flood pan areas, however no trapping methods were utilised during the 2104 flora and fauna survey. None of the fauna species recorded within these areas during the active searches and bird surveys were reliant on habitat provided by the drainage line and flood pan areas.

In comparison to the dune landscape, flood pan areas lack extensive habitat resources such as hollow bearing trees and accumulation of dense leaf litter. Hard pan soils limit the availability of suitable burrowing sites for small reptile and mammal species.

A high number of the fauna species present within the study area are likely to only periodically forage within the ephemeral habitat zones. The ephemeral zones do not offer any specialized fauna habitat which is not found elsewhere within the study area. The Australian Bustard (*Ardeotis australis*) was recorded at a large flood pan area in the southern section of the study area during the 2014 survey. The bird was foraging within the Bladder Salt-Bush and Spear-grass (*Austrostipa* sp.) vegetation.

The following results are from a baseline flora and fauna assessment conducted by EBS on behalf of Iluka Resources at the proposed Atacama mineral sands project during September 2014. These results are provided to highlight the species which may be periodically residing or foraging within the drainage line and flood pan areas.

3.3.1 Mammals

The total mammal species known to occur within the study area is 16, this includes 11 native and five introduced species (Table 17). Common small ground dwelling mammals within the study area include the Little Long-tailed Dunnart (*Sminthopsis dolichura*), Mitchell's Hopping-mouse (*Notomys mitchellii*) and Sandy Inland Mouse (*Pseudomys hermannsburgensis*). The nationally conservation rated Sandhill Dunnart (*Sminthopsis psammophila*) was also detected during the EBS September 2014 survey.

Large macropod species, Western Grey Kangaroo (*Macropus fuliginosus*) and Red Kangaroo (*Macropus rufus*) were detected in relatively low numbers during the EBS September 2014 survey. One species of microbat, the Lesser Long-eared Bat (*Nyctophilus geoffroyi*) was captured during the 2014 survey. It is likely that an additional four common microbat species would have been detected within the study area. Anabat calls recorded from the EBS September 2014 survey are currently being analysed by a sub-consultant.

Surveys for the nationally conservation rated Southern Marsupial Mole (Itjaritjara) (*Notoryctes typhlops*) are programmed for November 2014. The presence of the species is currently considered to be likely given the large area of preferred habitat available within the study area.

The five introduced species include One-humped Camel (*Camelus dromedarius*), Feral Cat (*Felis catus*), Red Fox (*Vulpes vulpes*), Rabbit (*Oryctolagus cuniculus*) and House Mouse (*Mus musculus*).

Table 17. Mammal species detected during the September 2014 Atacama survey.

Family	Species name	Common name	Conservation status	
			Aus	SA
BURRAMYIDAE	*Cercartetus concinnus*	Western Pygmy-possum		
CAMELIDAE	**Camelus dromedarius*	One-humped Camel		
CANIDAE	*Canis lupus*	Feral Dog, Dingo		
CANIDAE	**Vulpes vulpes*	Fox (Red Fox)		
DASYURIDAE	*Ningaui yvonneae*	Southern Ningaui		
DASYURIDAE	*Sminthopsis dolichura*	Little Long-tailed Dunnart		
DASYURIDAE	*Sminthopsis psammophila*	Sandhill Dunnart	EN	V
FELIDAE	**Felis catus*	Domestic Cat (Feral Cat)		
LEPORIDAE	**Oryctolagus cuniculus*	Rabbit (European Rabbit)		
MACROPODIDAE	*Macropus fuliginosus*	Western Grey Kangaroo		
MACROPODIDAE	*Macropus rufus*	Red Kangaroo		
MURIDAE	**Mus musculus*	House Mouse		
MURIDAE	*Notomys mitchellii*	Mitchell's Hopping-mouse		
MURIDAE	*Pseudomys hermannsburgensis*	Sandy Inland Mouse		
VESPERTILIONIDAE	*Nyctophilus geoffroyi*	Lesser Long-eared Bat		
VOMBATIDAE	*Lasiorhinus latifrons*	Southern Hairy-nosed Wombat		

Aus: Australia (*Environment Protection and Biodiversity Conservation Act 1999*). **SA:** South Australia (*National Parks and Wildlife Act 1972*). **Conservation Codes: CE:** Critically Endangered. **EN/E:** Endangered. **VU/V:** Vulnerable. **R:** Rare.

***** Denotes introduced species.

3.3.2 Reptiles

Thirty-six reptile species were detected within the study area during the EBS September 2014 survey (Table 18). No reptiles with a conservation were detected, however the Black-naped Snake (*Neelaps bimaculatus*), which has a conservation rating of rare under the NPW Act is known to exist within the southern section of the study area (BDBSA 2014 and SKM 2005).

Common diurnal species within the study area include Southern Spinifex Ctenotus (*Ctenotus atlas*), Dwarf Bearded Dragon (*Pogona minor*), Sandplain Ctenotus (*Ctenotus schomburgkii*), Crested Dragon (*Ctenophorus cristatus*) and Linga Dragon (*Diporiphora linga*). Common nocturnal species include the Starred Knob-tailed Gecko (*Nephrurus stellatus*), Beaded Gecko (*Lucasium damaeum*) and Desert Wood Gecko (*Diplodactylus wiru*).

Table 18. Reptile species detected during the September 2014 Atacama survey.

Family	Species name	Common name	Conservation status	
			Aus	SA
AGAMIDAE	*Ctenophorus cristatus*	Crested Dragon		
AGAMIDAE	*Ctenophorus fordi*	Mallee Dragon		
AGAMIDAE	*Ctenophorus isolepis*	Military Dragon		

Family	Species name	Common name	Conservation status	
			Aus	SA
AGAMIDAE	*Diporiphora linga*	Linga Dragon		
AGAMIDAE	*Moloch horridus*	Thorny Devil		
AGAMIDAE	*Pogona minor*	Dwarf Bearded Dragon		
CARPHODACTYLIDAE	*Nephrurus laevissimus*	Pale Knob-tailed Gecko		
CARPHODACTYLIDAE	*Nephrurus stellatus*	Starred Knob-tailed Gecko		
DIPLODACTYLIDAE	*Diplodactylus wiru*	Desert Wood Gecko		
DIPLODACTYLIDAE	*Lucasium bungabinna*	Southern Sandplain Gecko		
DIPLODACTYLIDAE	*Lucasium damaeum*	Beaded Gecko		
DIPLODACTYLIDAE	*Strophurus assimilis*	Thorn-tailed Gecko		
DIPLODACTYLIDAE	*Strophurus elderi*	Jewelled Gecko		
ELAPIDAE	*Brachyurophis fasciolatus*	Narrow-banded Snake		
ELAPIDAE	*Brachyurophis semifasciatus*	Half-girdled Snake		
ELAPIDAE	*Demansia reticulata*	Desert Whipsnake		
ELAPIDAE	*Pseudonaja modesta*	Five-ringed Snake		
GEKKONIDAE	*Gehyra purpurascens*	Purple Dtella		
GEKKONIDAE	*Gehyra variegata*	Tree Dtella		
PYGOPODIDAE	*Delma butleri*	Spinifex Snake-lizard		
PYGOPODIDAE	*Delma petersoni*	Painted Snake-lizard		
PYGOPODIDAE	*Lialis burtonis*	Burton's Legless Lizard		
SCINCIDAE	*Ctenotus atlas*	Southern Spinifex Ctenotus		
SCINCIDAE	*Ctenotus schomburgkii*	Sandplain Ctenotus		
SCINCIDAE	*Ctenotus taeniatus*	Eyrean Ctenotus		
SCINCIDAE	*Cyclodomorphus melanops*	Spinifex Slender Bluetongue		
SCINCIDAE	*Lerista desertorum*	Great Desert Slider		
SCINCIDAE	*Lerista labialis*	Eastern Two-toed Slider		
SCINCIDAE	*Lerista taeniata*	Ribbon Slider		
SCINCIDAE	*Lerista terdigitata*	Southern Three-toed Slider		
SCINCIDAE	*Lerista timida*	Dwarf Three-toed Slider		
SCINCIDAE	*Liopholis inornata*	Desert Skink		
SCINCIDAE	*Morethia butleri*	Butler's Snake-eye		
TYPHLOPIDAE	*Ramphotyphlops bicolor*	Southern Blind Snake		
VARANIDAE	*Varanus eremius*	Desert Pygmy Goanna		
VARANIDAE	*Varanus gilleni*	Pygmy Mulga Goanna		

Aus: Australia (*Environment Protection and Biodiversity Conservation Act 1999*). **SA:** South Australia (*National Parks and Wildlife Act 1972*). **Conservation Codes:** **CE:** Critically Endangered. **EN/E:** Endangered. **VU/V:** Vulnerable. **R:** Rare.

3.3.3 Birds

A total of 51 bird species were recorded during the EBS September 2014 survey. Two old Malleefowl (*Leipoa ocellata*) mounds were located within the study area. The Malleefowl has a national conservation rating of vulnerable. Both mounds contained fragments of egg shell. It appears that the mounds have not been active for up to ten years. The state conservation rated Peregrine Falcon (*Falco peregrinus*), Restless Flycatcher (*Myiagra inquieta*) and Australian Bustard (*Ardeotis australis*) were recorded. One migratory species listed under the EPBC Act, the Rainbow Bee-eater (*Merops ornatus*) was also recorded during the September 2014 survey.

Common birds within the study area include Masked Woodswallow (*Artamus personatus*), Weebill (*Smicrornis brevirostris*), White-fronted Honeyeater (*Purnella albifrons*), Yellow-plumed Honeyeater (*Ptilotula ornata*) and Yellow-throated Miner (*Manorina flavigula*).

Table 19. Bird species detected during the September 2014 Atacama survey.

Family	Species name	Common name	Conservation status	
			Aus	SA
ACANTHIZIDAE	*Acanthiza apicalis*	Inland Thornbill		
ACANTHIZIDAE	*Acanthiza uropygialis*	Chestnut-rumped Thornbill		
ACANTHIZIDAE	*Smicrornis brevirostris*	Weebill		
ACCIPITRIDAE	*Accipiter cirrhocephalus*	Collared Sparrowhawk		
ACCIPITRIDAE	*Circus assimilis*	Spotted Harrier		
ACCIPITRIDAE	*Hieraaetus morphnoides*	Little Eagle		
AEGOTHELIDAE	*Aegotheles cristatus*	Australian Owlet-nightjar		
ALCEDINIDAE	*Todiramphus pyrrhopygius*	Red-backed Kingfisher		
ARTAMIDAE	*Artamus cinereus*	Black-faced Woodswallow		
ARTAMIDAE	*Artamus leucorhynchus*	White-breasted Woodswallow		
ARTAMIDAE	*Artamus personatus*	Masked Woodswallow		
ARTAMIDAE	*Cracticus torquatus*	Grey Butcherbird		
ARTAMIDAE	*Gymnorhina tibicen*	Australian Magpie		
CACATUIDAE	*Nymphicus hollandicus*	Cockatiel		
CAMPEPHAGIDAE	*Coracina maxima*	Ground Cuckooshrike		
CAMPEPHAGIDAE	*Coracina novaehollandiae*	Black-faced Cuckooshrike		
CAMPEPHAGIDAE	*Lalage tricolor*	White-winged Triller		
COLUMBIDAE	*Phaps chalcoptera*	Common Bronzewing		
CUCULIDAE	*Cacomantis pallidus*	Pallid Cuckoo		
CUCULIDAE	*Chalcites basalis*	Horsfield's Bronze Cuckoo		
CUCULIDAE	*Chalcites osculans*	Black-eared Cuckoo		
DICAEIDAE	*Dicaeum hirundinaceum*	Mistletoebird		
FALCONIDAE	*Falco berigora*	Brown Falcon		
FALCONIDAE	*Falco peregrinus*	Peregrine Falcon		R
HIRUNDINIDAE	*Petrochelidon nigricans*	Tree Martin		

Family	Species name	Common name	Conservation status	
			Aus	SA
MALURIDAE	*Malurus splendens*	Splendid Fairywren		
MEGAPODIIDAE	*Leipoa ocellata*	Malleefowl	VU	V
MELIPHAGIDAE	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater		
MELIPHAGIDAE	*Certhionyx variegatus*	Pied Honeyeater		
MELIPHAGIDAE	*Epthianura tricolor*	Crimson Chat		
MELIPHAGIDAE	*Manorina flavigula*	Yellow-throated Miner		
MELIPHAGIDAE	*Ptilotula ornata*	Yellow-plumed Honeyeater		
MELIPHAGIDAE	*Purnella albifrons*	White-fronted Honeyeater		
MEROPIDAE	*Merops ornatus*	Rainbow Bee-eater		
MONARCHIDAE	*Myiagra inquieta*	Restless Flycatcher		R
NEOSITTIDAE	*Daphoenositta chrysoptera*	Varied Sittella		
OREOICIDAE	*Oreoica gutturalis*	Crested Bellbird		
OTIDIDAE	*Ardeotis australis*	Australian Bustard		V
PACHYCEPHALIDAE	*Colluricincla harmonica*	Grey Shrikethrush		
PACHYCEPHALIDAE	*Pachycephala rufiventris*	Rufous Whistler		
PARDALOTIDAE	*Pardalotus striatus*	Striated Pardalote		
PETROICIDAE	*Melanodryas cucullata*	Hooded Robin		
PETROICIDAE	*Microeca fascinans*	Jacky Winter		
PETROICIDAE	*Petroica goodenovii*	Red-capped Robin		
PODARGIDAE	*Podargus strigoides*	Tawny Frogmouth		
POMATOSTOMIDAE	*Pomatostomus superciliosus*	White-browed Babbler		
PSITTACIDAE	*Barnardius zonarius*	Australian Ringneck		
PSITTACIDAE	*Melopsittacus undulatus*	Budgerigar		
PSITTACIDAE	*Psephotus varius*	Mulga Parrot		
RHIPIDURIDAE	*Rhipidura leucophrys*	Willie Wagtail		
TURNICIDAE	*Turnix velox*	Little Buttonquail		

Aus: Australia (*Environment Protection and Biodiversity Conservation Act 1999*). **SA:** South Australia (*National Parks and Wildlife Act 1972*). **Conservation Codes: CE:** Critically Endangered. **EN/E:** Endangered. **VU/V:** Vulnerable. **R:** Rare.

4 DISCUSSION

It is considered that changes in hydrology within the Atacama study area will have limited impacts to the vegetation stratums in the short term (i.e.<10 years). Vegetation communities present within flood zones are not reliant on flows or flooding because these events occur at such infrequent intervals, they would not sustain ephemeral communities. All vegetation communities within the study area appear to be driven by soil depth primarily, with transitional communities present as responses to the last flood event. The period in which these areas stay inundated may also drive communities as a response to tolerance of extended wetting rather than reliance. All vegetation communities in proximity to the proposed development are well represented and this should ensure the ongoing viability of diverse ecosystems.

The occurrence of migratory bird species within the study area would generally be as an opportunistic visitor (e.g. to utilise seasonal resources and surface water when present) or as a fly-over species. It is considered unlikely that the identified migratory bird species would be reliant on habitat within the Atacama study area.

There will be some localised impacts to mammals (including bats), reptiles and birds foraging and/or residing in and adjacent to selected ephemeral watercourses due to hydrology and geomorphology changes associated with mining operations. Impacts may include loss of habitat due to silt deposits and decreased insect activity due to potential impacts on vegetation. The potential impact on vegetation may then influence insect behaviour and impact on the foraging patterns of fauna species. The likely result would be that these fauna move away from the disturbance area, however this is not considered likely to pose significant population impacts.

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Appendix B
Flood modelling report

EMM
creating opportunities

B.1 Introduction

B.1.1 Overview

In 2009, Iluka Resources Limited (Iluka) commenced mining operations of the Jacinth-Ambrosia (J-A) mineral sand deposit in the Eucla Basin, approximately 200 km north-west of Ceduna in South Australia. The Atacama satellite mineral deposit is located approximately 5 km northeast of the existing J-A site (Figure B.1).

This technical appendix describes the potential flooding effects associated with development of the Atacama deposit.

B.1.2 Modelling approach

This study was carried out in accordance with guidance in the current edition of Australian Rainfall and Runoff (ARR 2019) (Ball, et al., 2019), using associated datasets where available, and industry standard software packages.

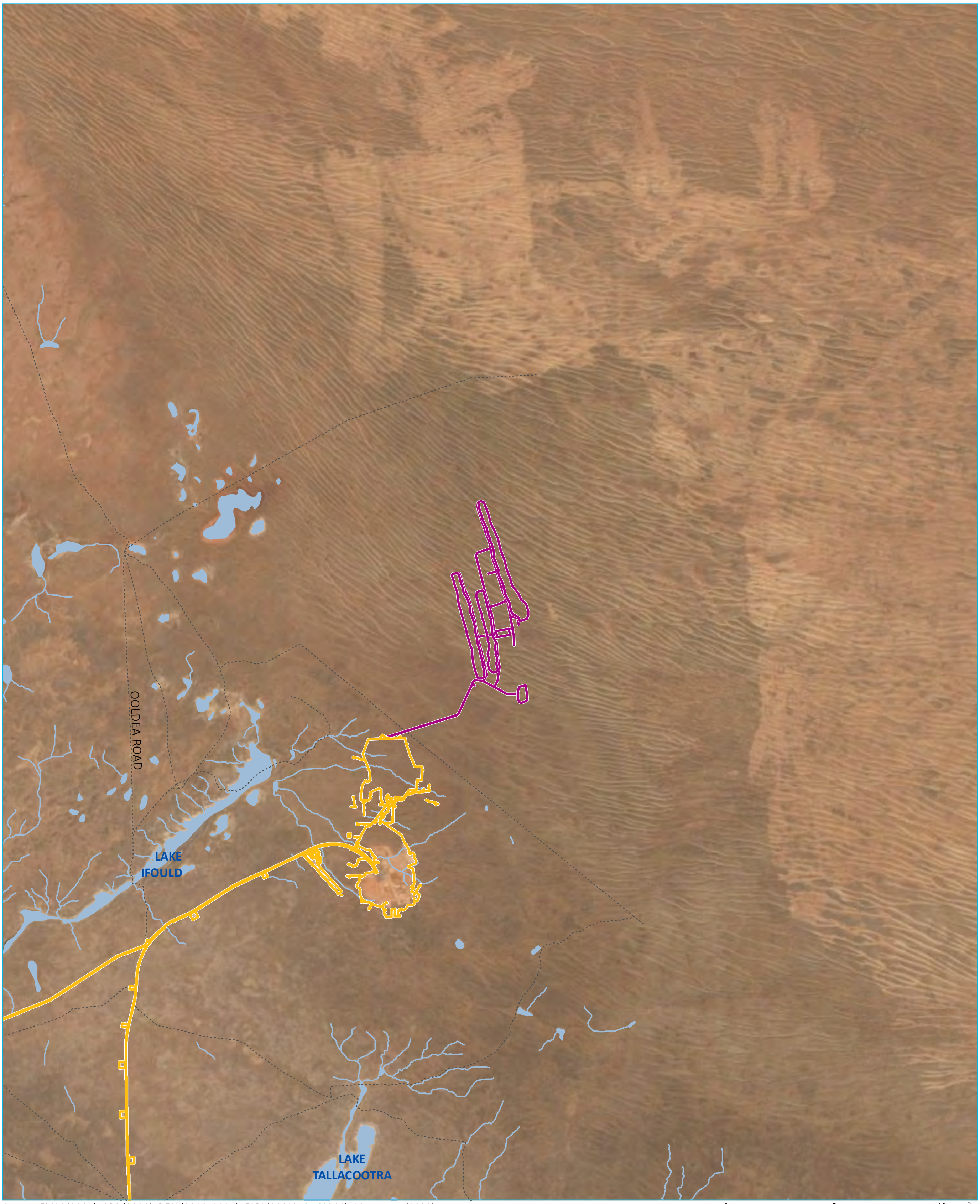
EMM developed direct rainfall (rain-on-grid) hydraulic models using the TUFLOW 2D software (BMT, 2018), release 2020-10-AA, which was the latest major TUFLOW release at the time of modelling. The 2D heavily parallelised compute (HPC) solver was used with sub-grid sampling (SGS). TUFLOW is a 2D numerical simulation free-surface water flow modelling tool for rivers, floodplains, estuaries, coastlines, and urban environments commonly used within Australia for assessing drainage and flooding. Roads, channels, culverts, and embankments can be included in TUFLOW models, and comparisons made between pre- and post-development flood behaviour.

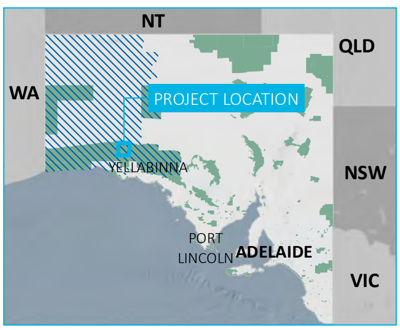
Model calibration was not possible as there are no gauged creeks within the model domain to use as calibration targets. Validation against the ARR (2016) Regional Flood Frequency Estimation (RFFE) model was also not possible as the RFFE model does not produce results in arid regions.

B.1.3 Data

The following datasets were used in the development of the TUFLOW model:

- client supplied LiDAR derived digital elevation model (DEM):
  - Extent: the proposed mine site location and surrounding area (approximately 215 km^2);
  - Resolution: 2 m;
- design storm Intensity Frequency Duration (IFD) data, downloaded via the Design Rainfall Data System (Bureau of Meteorology, 2016);
- design storm data for the modelled catchment area, downloaded from the ARR Data Hub (http://data.arr-software.org/); and
- details of mine site infrastructure as provided by Iluka.





Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

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KEY

- Project layout
- J-A mine disturbance footprint

Existing environment

- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody

INSET KEY

- Public protected area
- Alinytjara Wilurara NRM Zone

Project layout and regional location

Atacama surface water assessment

Figure B.1

EMM creating opportunities

B.2 Design storm data

Australian Rainfall and Runoff (ARR 2019) is a national guideline document, data source and software suite that can be used for the estimation of design flood characteristics in Australia. In 2016, a major revision to ARR was released, followed by a major update in 2019 (Ball, et al., 2019). ARR 2019 is the 4th edition of ARR and represents industry best practice. It is published and supported by the Commonwealth of Australia and is publically available online and free of charge via the ARR Data Hub (http://data.arr-software.org/).

Design storms modelled in TUFLOW were developed following ARR 2019 methodology, using the following data:

- design storm Intensity Frequency Duration (IFD) data, downloaded via the Design Rainfall Data System (2016) (Bureau of Meteorology, 2016); and
- design storm data for the modelled catchment areas, downloaded from the ARR Data Hub, including:
  - Areal Reduction Factors (ARFs);
  - temporal patterns;
  - initial loss and continuing loss (ILCL) values (Note that ILCL values are not available at the project location. Modelled ILCL values were chosen based on the best available information); and
  - pre-burst rainfall depths.

B.2.1 Rainfall data (IFD)

IFD data describes the relationship between rainfall intensity, storm frequency and storm duration and forms the basis of design storms for hydrologic modelling. Figure B.2 shows IFD curves typical for the Project Area.

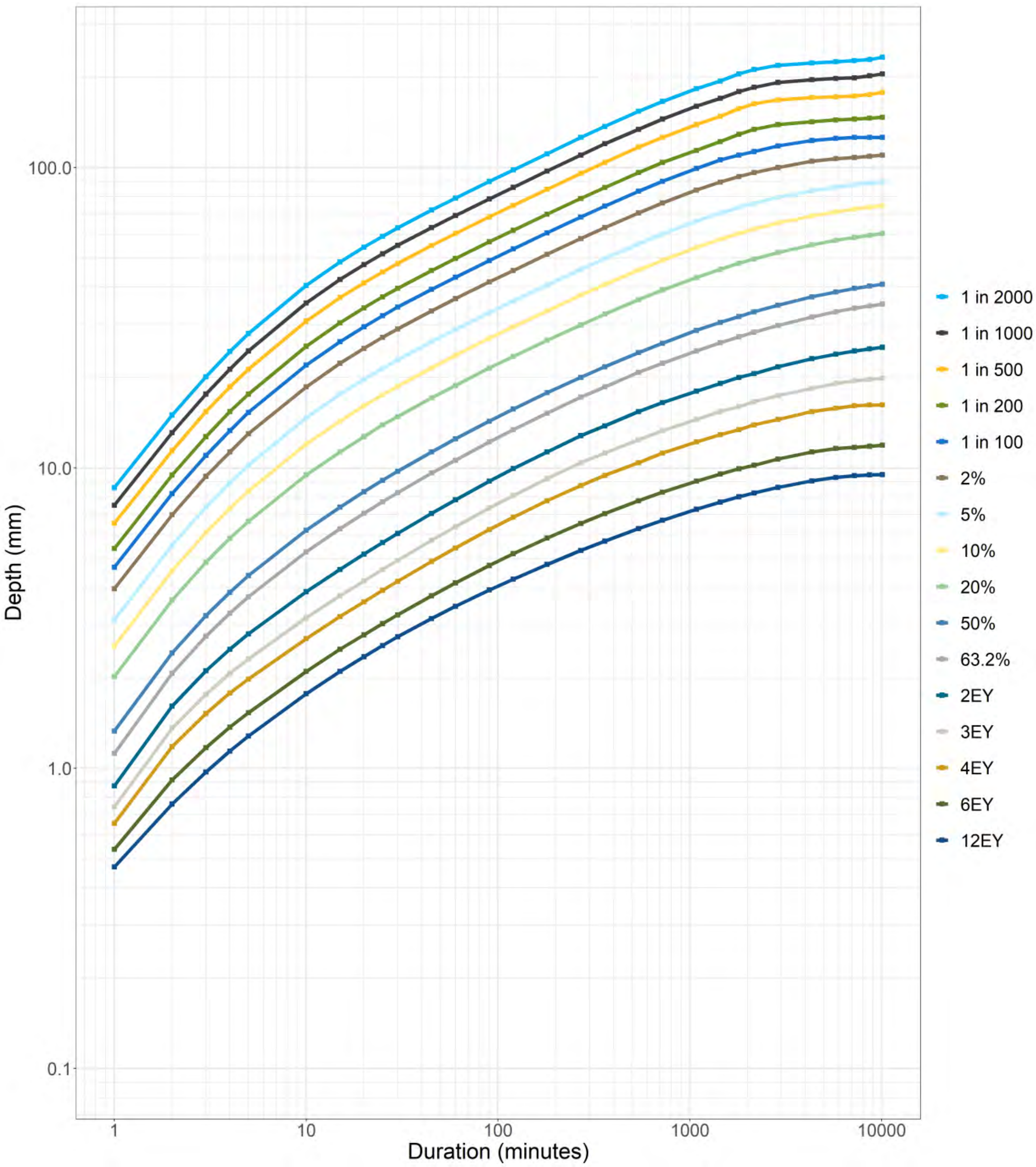


Figure B.2 IFD curves for the Project Area (Bureau of Meteorology, 2016)

B.2.2 Design storm data

Data from the ARR Data Hub was downloaded for the project at the following location: latitude = -30.853, longitude = 132.221.

i Areal reduction factors (ARFs)

When catchments are sufficiently large, design rainfall intensities at a given point are not representative of the areal average rainfall intensity across the catchment because larger catchments are less likely than smaller catchments to experience high intensity storms simultaneously over the whole of the catchment area (Ball, et al., 2019). ARFs are provided via the ARR Data Hub and represent the ratio between the design values of areal average rainfall and point rainfall, computed for the same duration and AEP.

For short duration storms, ARFs are calculated in the same way across Australia. However, for long duration storms, ARFs are calculated regionally. Figure B.3 shows the ARF regions across Australia. The project is on the boundary of the Southern Semi-arid ARF region and the Inland Arid region.

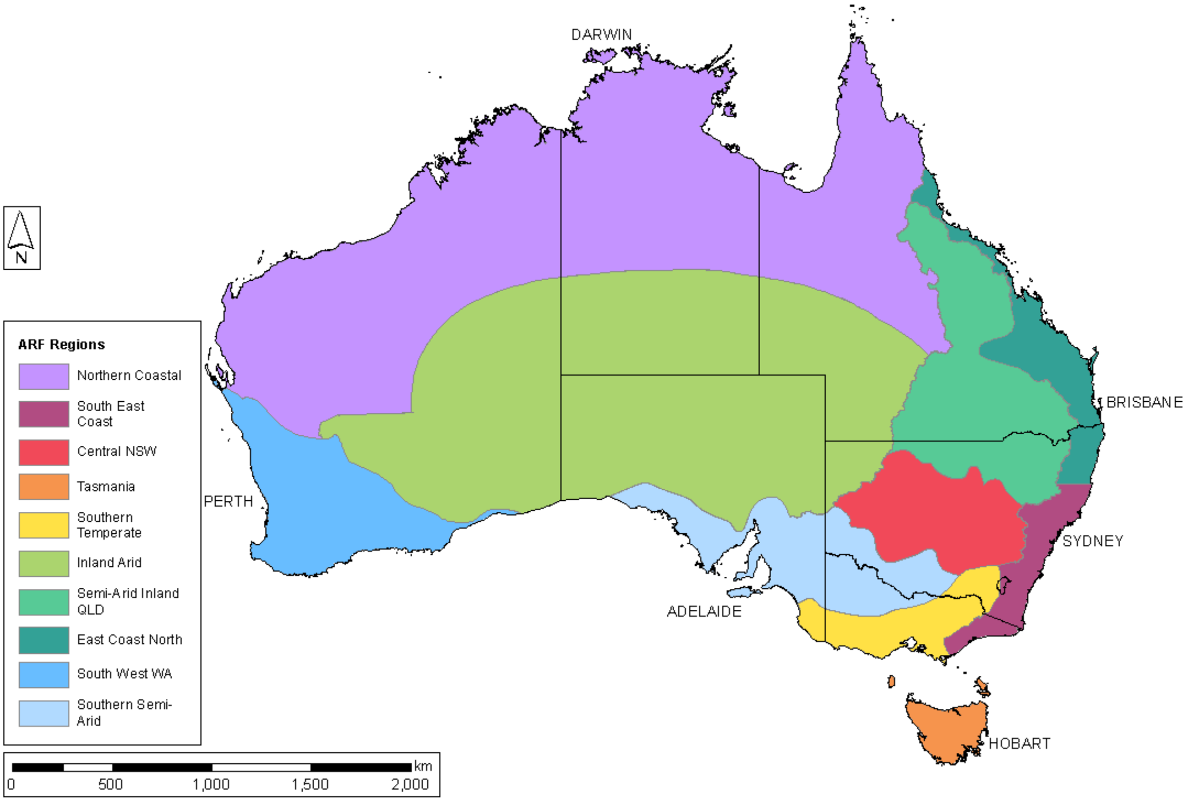


Figure B.3 ARF Regions for long duration storms (Ball, et al., 2019)

The concept of applying ARFs is based on the expectation that flood results are required at discrete points of interest. When flood modelling is undertaken to develop design flood results across a catchment area (eg depth), there is no single ARF that suits every location equally as each location has a differently sized upstream catchment. Therefore, ARF should be selected such that the results are applicable to the model purpose and using an ARF for the most downstream point of the model may not be the best choice if there are many points of interest in the middle of the model.

At the Atacama site, most swales have a relatively small contributing catchment area (ie less than 5 km^2). Using the example of a 1% AEP, 12 hour design flood event; Table B.1 shows how ARF varies with catchment size in the Project Area.

Table B.1 Varying ARF with catchment size in the Project Area

Catchment area (km²)	ARF (1% AEP 12 hour storm)
1	1.000
5	0.982
10	0.970
100	0.918

In summary, there is no perfect ARF to select when the end result of the model is to develop design flood results across, and at many locations within, a broad catchment area. An ARF of 1.0 was used in the model as an appropriate compromise for the multiple points of interest through the modelled catchment area. Additionally, using an ARF of 1.0 provides a conservative estimate of design flood results which is appropriate to inform the design of road infrastructure.

ii Temporal patterns

Temporal patterns describe how rainfall is distributed over the duration of a storm and can significantly affect estimated peak flow. Figure B.4 shows the temporal pattern regions across Australia. The project is in the Rangelands temporal pattern region.

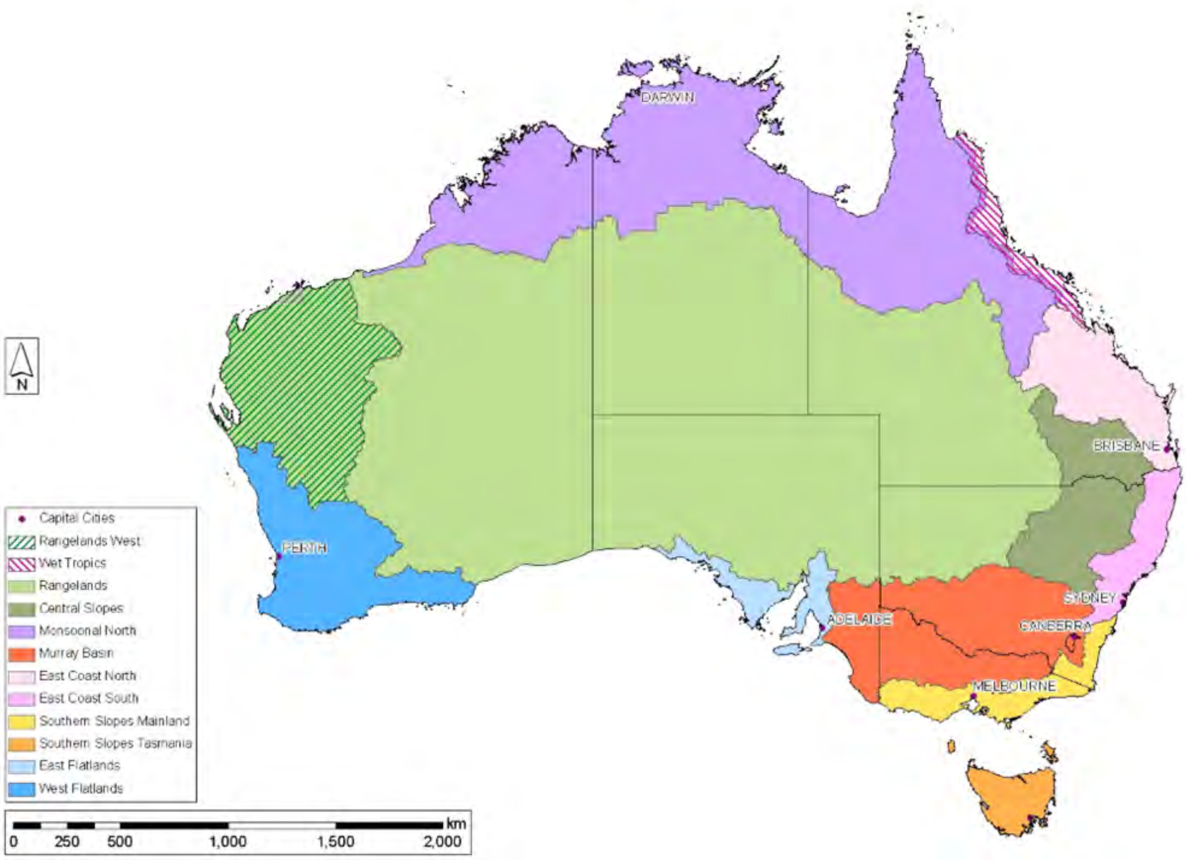


Figure B.4 Temporal pattern regions (Ball, et al., 2019)

For each storm duration, ten temporal patterns are published via the ARR Data Hub. The ten temporal patterns include some with a greater percentage of rain occurring near the start of the storm (front-loaded), some with a greater percentage towards the middle of the storm (middle-loaded) and some with a greater percentage near the end of the storm (back-loaded).

The recommended approach described in ARR 2019 for using the temporal patterns is to model them as an ensemble for each storm duration and AEP (ie all ten patterns are modelled for each duration and AEP). This approach is illustrated in Figure B.5.

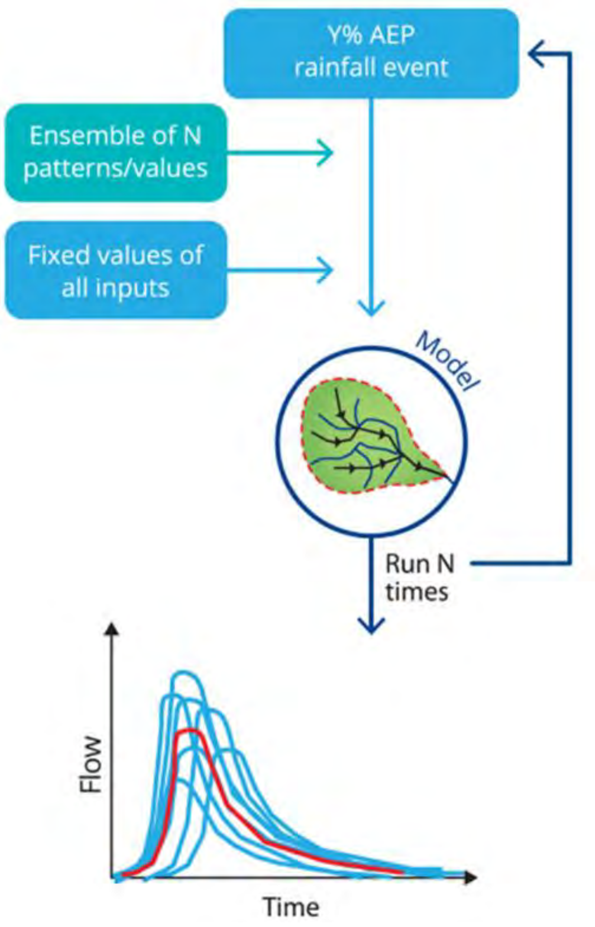


Figure B.5 Ensemble approach to flood modelling using the temporal patterns (Ball, et al., 2019)

Using temporal patterns and the ensemble approach significantly increases the number of model runs required to produce results for a catchment. Peak flows for each storm duration can be calculated by taking the mean peak flow result across all ten patterns. The critical duration storm is determined as the storm duration that resulted in the highest peak flow.

iii Rainfall losses

Not all rainfall is converted to runoff, with 'rainfall losses' attributed to the following key processes: interception by vegetation; infiltration into the soil; retention on the surface (depression storage); and transmission loss through the stream bed and banks. These key processes are illustrated in Figure B.6.

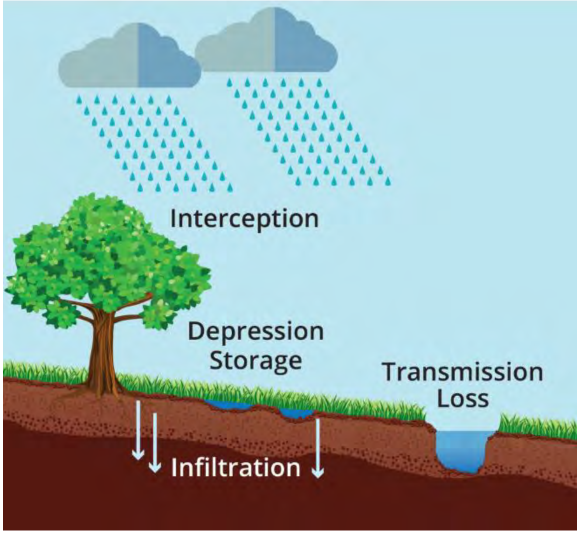


Figure B.6 Key processes contributing to rainfall loss (Ball, et al., 2019)

While there are several ways to model rainfall losses, ARR 2019 recommends the Initial Loss–Continuing Loss model (ILCL) whereby rainfall loss mechanisms are lumped together as:

- Initial loss – occurs in the beginning of a storm before any runoff is generated. The first rain falling on a catchment wets the vegetation, fills depressions and infiltrates into the soil (ie before the soil surface is saturated).
- Continuing loss – is applied for the remainder of the storm. Once parts of the catchment become saturated runoff begins, though some rain continues to be lost to infiltration and evaporation.

This is consistent with the concept of runoff produced by infiltration excess, ie that runoff occurs when rainfall intensity exceeds the infiltration capacity of the soil. Figure B.7 depicts the ILCL model.

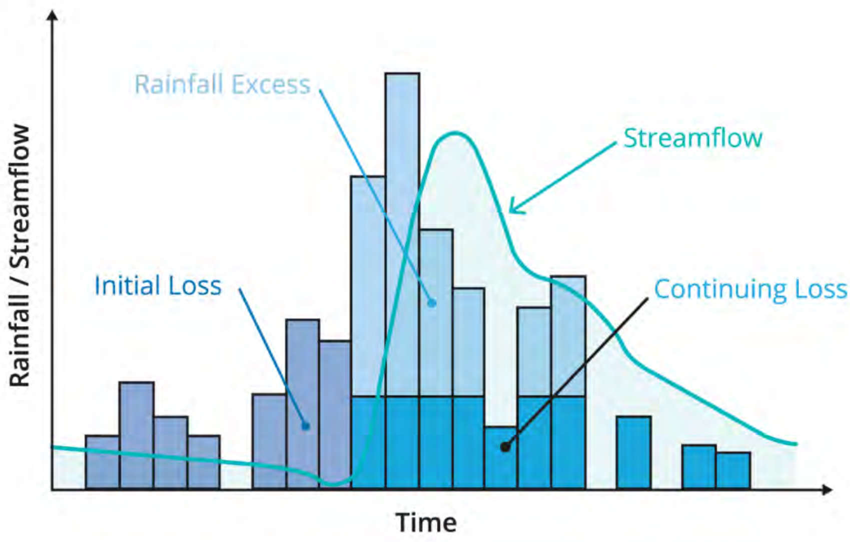


Figure B.7 Initial Loss–Continuing Loss (ILCL) model (Ball, et al., 2019)

ILCL data was revised in 2016 as part of the ARR revision process resulting in a spatial dataset of ILCL values across Australia (Figure B.8) which are available via the ARR Data Hub. The regional loss equations were considered unreliable for locations with less than 350 mm of rainfall, and so no data was presented for inland Australia, including at the project location.

In the absence of ILCL data from the ARR Data Hub for the project location, ILCL values for the Project Area were chosen based on:

- literature review of arid zone hydrology;
- consideration of runoff calibration work reported in the baseline surface water assessment conducted by Alluvium in 2014, included as Appendix A;
- visual inspection of aerial imagery, soils and landscape data; and
- EMM's experience across a range of arid hydrology flood modelling projects, including conducting on-site field infiltration testing at other arid South Australian sites.

While rainfall loss data for South Australia's arid zone is not available in the current version of ARR (2019), the previous version of ARR (1987) included design loss rates for South Australia, including the arid zone, and these are summarised in Table B.2.

Table B.2 Design loss rates for South Australia (Institution of Engineers, 1987)

Location	Season	Initial Loss (mm)	Continuing Loss (mm/hr)	References
Humid Zone	Winter	10	2.5	WBCM Pty Ltd Drainage Study, Brownhill Glen Osmond, Parklands & Keswick Creeks Vol2, (1984)
(Mediterranean)	Summer	25	4	
	All	30	1	B.C Tonkin & Associates (1985)
Arid Zone	All	15	4	Cordery, Pilgrim & Doran (1983)
	All	15-40	1-3	Lipp (1983)

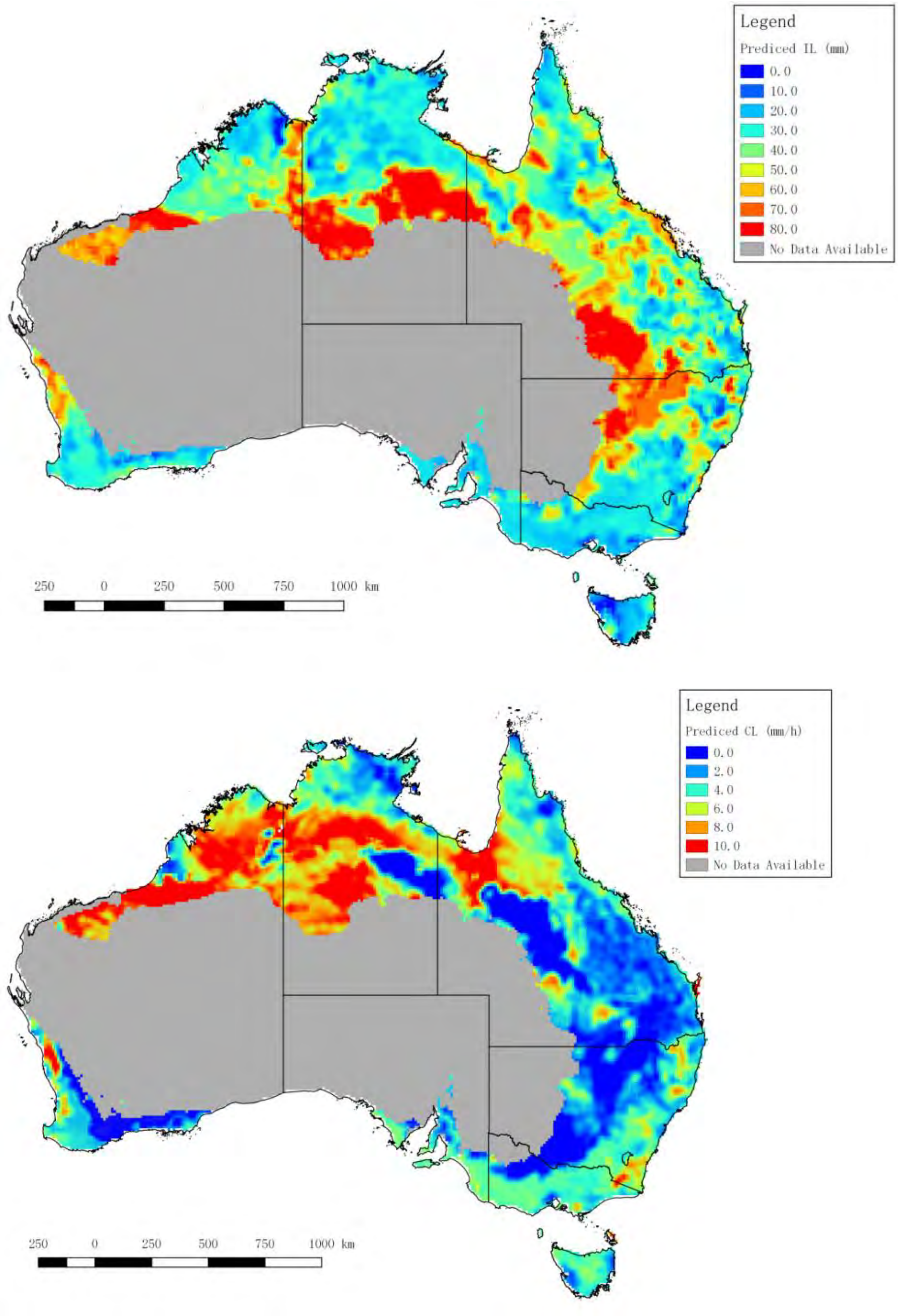


Figure B.8 Spatial distribution of IL and CL values (Hill, Zhang, & Nathan, 2016)

As part of the baseline surface water assessment conducted by Alluvium in 2014 (Appendix A), a hydrology model was calibrated to a single high rainfall event. Calibrated losses were: IL = 46.5 mm, CL = 4 mm/hr. However, as a single significant rainfall event is not representative of region storm events, the study recommended that these values should not be used.

For this study, in the absence of site-specific rainfall loss data from the ARR datahub or from on-site field soil infiltration testing, the ILCL values given in Table B.3 were applied within the flood model based on the information described above.

Table B.3 ILCL values used in this study

Land use category	Initial loss (IL) mm	Continuing loss (CL) mm/hr
Undeveloped dunes and open landscape	40	4
Impervious areas	1	0

Sensitivity testing of the ILCL values for the 'undeveloped dunes and open landscape' land use category was undertaken with IL of 0 mm, 15 mm, 30 mm, and CL of 1 mm/hr, 2 mm/hr and 3 mm/hr (see Chapter B.5).

iv Pre-burst rainfall

Pre-burst rainfall is storm rainfall that occurs before the main rainfall burst, and which may wet the soil and reduce the infiltration which then occurs during the main storm burst. The ARR Data Hub provides estimates of pre-burst rainfall depths to be applied to storms of varying duration and AEP (Figure B.9).

For each modelled storm duration and AEP, median pre-burst depths from the ARR Data Hub were applied in the TUFLOW model as a constant rate over 1 hour before the design storm burst.

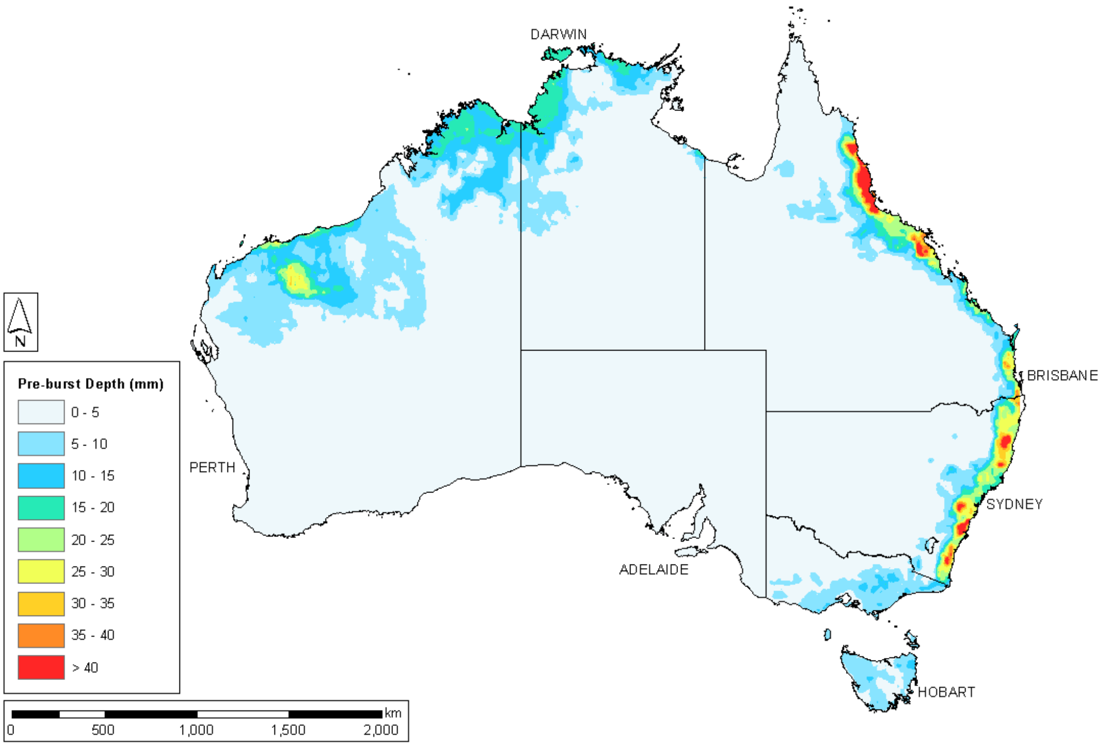


Figure B.9 Pre-burst depths (Ball, et al., 2019)

B.2.3 Climate change

i Climate trends

In 2015, the CSIRO and the BoM released the latest set of national climate projections for Australia. Results from this research are available on the Climate Change in Australia website (https://www.climatechangeinaustralia.gov.au/) (CSIRO and Bureau of Meteorology, 2015). This website summarises the likely impacts of climate change on South Australia during the 21st century, including:

- increased temperatures;
- reduced rainfall;
- increased rainfall variability;
- increased intensity of extreme rainfall events;
- increased evaporation; and
- changes in the frequency of extreme weather events, including flooding.

A report into the impacts of climate change on the Alinytjara Wilurara (AW) region indicates that for the south sub-region (where the Atacama site is located) (Wiseman & Bardsley, 2015):

- little change in rainfall (± 5%) is predicted by 2030;
- little change (± 5%) to much drier (< -15%) rainfall conditions are predicted by 2090, but with large uncertainty;
- winter and spring rainfall likely to decline more than other seasons;
- rainfall will become more variable, with more intense extreme events likely; and
- higher potential evapotranspiration (PET) rates are expected to reduce the permanence of open water sources.

Climate change will increase the likelihood of large floods, cause longer dry periods between rains, and increased demands on water resources by people and ecosystems in the region due to hotter temperatures. The magnitude of the changes cannot be confidently projected (CSIRO and Bureau of Meteorology, 2015).

In conclusion, future rainfall trends in the region are highly uncertain. As such, planning should proceed on the basis that the region will continue to experience high variability in the frequency and magnitude of large rainfall events (RDA Far North SA, 2016).

ii January 2022 rainfall event

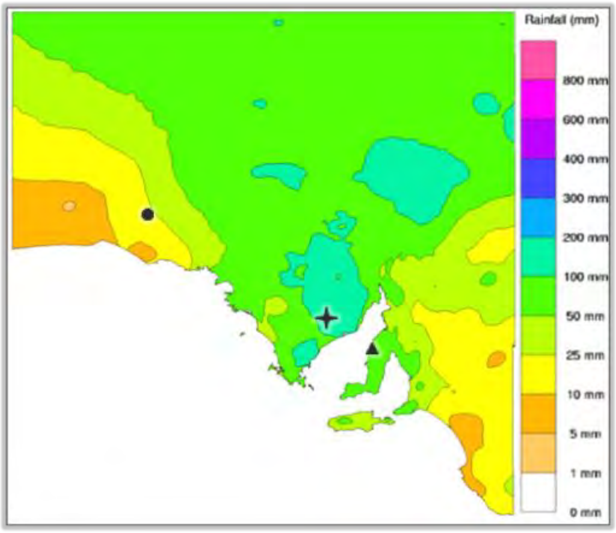
January 2022 was South Australia's fourth wettest January on record and the wettest since 1984, with rainfall 175% above average rainfall for the state as a whole (Bureau of Meteorology, 2022). Rainfall was particularly high over the Eyre Peninsula and northern parts of South Australia, with several sites experiencing their highest January daily rainfall on record (mostly falling between the 21st and 25th of January) and/or highest total January rainfall on record.

The extreme rainfall event resulted in widespread flooding which damaged large sections of the State's sealed and unsealed road network, destroyed houses, cut off major freight routes, and isolated remote communities. The event was declared a major emergency by the South Australian government (ABC news, 2022).

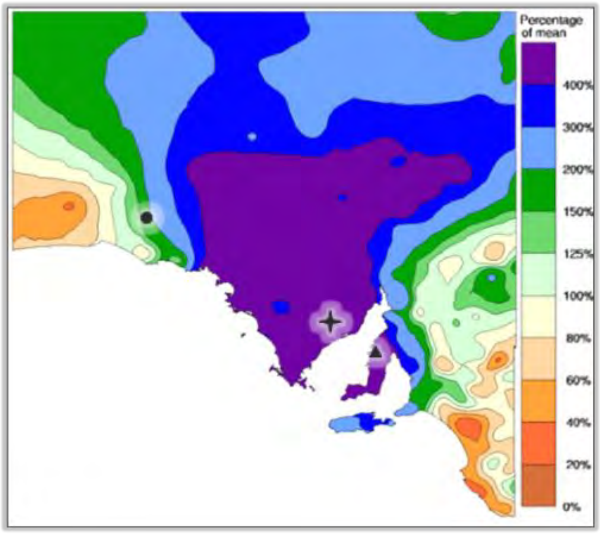
With sensationalist news reports using words such as ‘unprecedented’, questions have been asked in the public domain regarding whether the current tools for flood prediction are appropriate, or invalidated by climate uncertainty. The data presented below illustrates that the January 2022 South Australia rainfall was predictable and that the current tools remain appropriate.

Figure B.10 shows three rainfall maps for South Australia for January 2022 (Bureau of Meteorology, 2022):

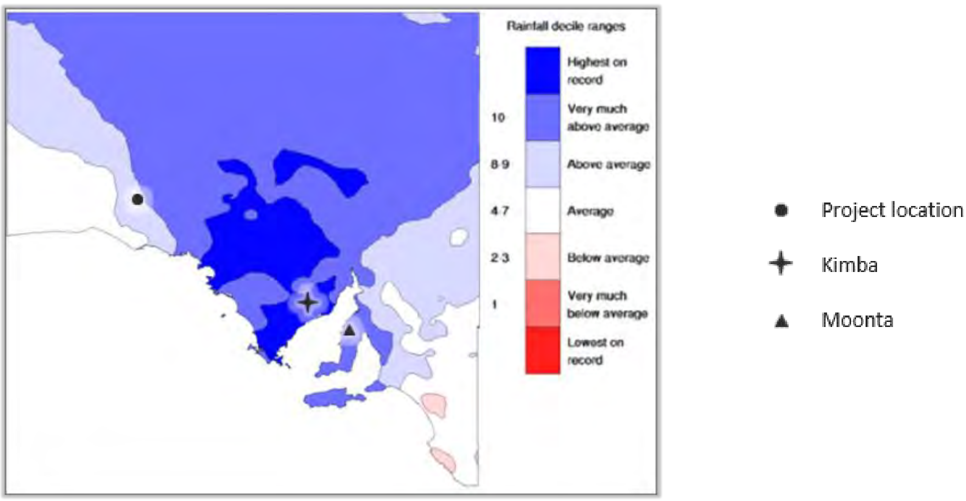
- total observed rainfall for the month of January 2022 (top, left);
- rainfall percentages for the month of January 2022 (expressed as a percentage of the mean, relative to the base period 1961–1990) (top, right); and
- rainfall decile ranges for the month of January (based on the period 1900–January 2022) (bottom).



South Australian total rainfall (mm)



South Australian rainfall percentages
Base period 1961–1990



South Australian rainfall deciles
Base period 1900–January 2022

Figure B.10 South Australian rainfall maps for January 2022 (Bureau of Meteorology, 2022)

These rainfall maps show that the highest rainfall was centred over the Eyre Peninsula, with a large area experiencing the highest rainfall on record at more than 400% of mean January rainfall.

To further explore the January 2022 event, particularly in terms of how it relates to flooding in arid South Australia, data was further analysed at two rainfall sites: Kimba on the Eyre Peninsula and Moonta at the top of the Yorke Peninsula. The location of these rainfall sites (as well as the project location) is indicated on the rainfall maps in Figure B.10.

Relevant data for these sites is summarised in Table B.4.

Table B.4 January 2022 rainfall data at two rainfall sites in South Australia

Rainfall site	BoM station number	Length of record	2022 highest January daily rainfall	Previous highest January daily rainfall	2022 January rainfall	Average January rainfall	Highest daily rainfall on record before January 2022
Kimba	18040	102	160 mm 22/01/2022	69.6 mm 30/01/1974	213 mm	19.3 mm	149.9 mm 18/02/1946
Moonta	22011	151	64 mm 25/01/2022	46.7 mm 25/01/1941	85 mm	14.6 mm	94.7 mm 18/02/1946

Figure B.11 shows the IFD curves for Kimba and Moonta with the 24 hour, 48 hour, 72 hour and 96 hour rainfall depths from the January 2022 event superimposed. As detailed in Table B.4, both sites experienced significant rainfall on the 18th February 1946, therefore the 24 hour rainfall depth from that day is also plotted.

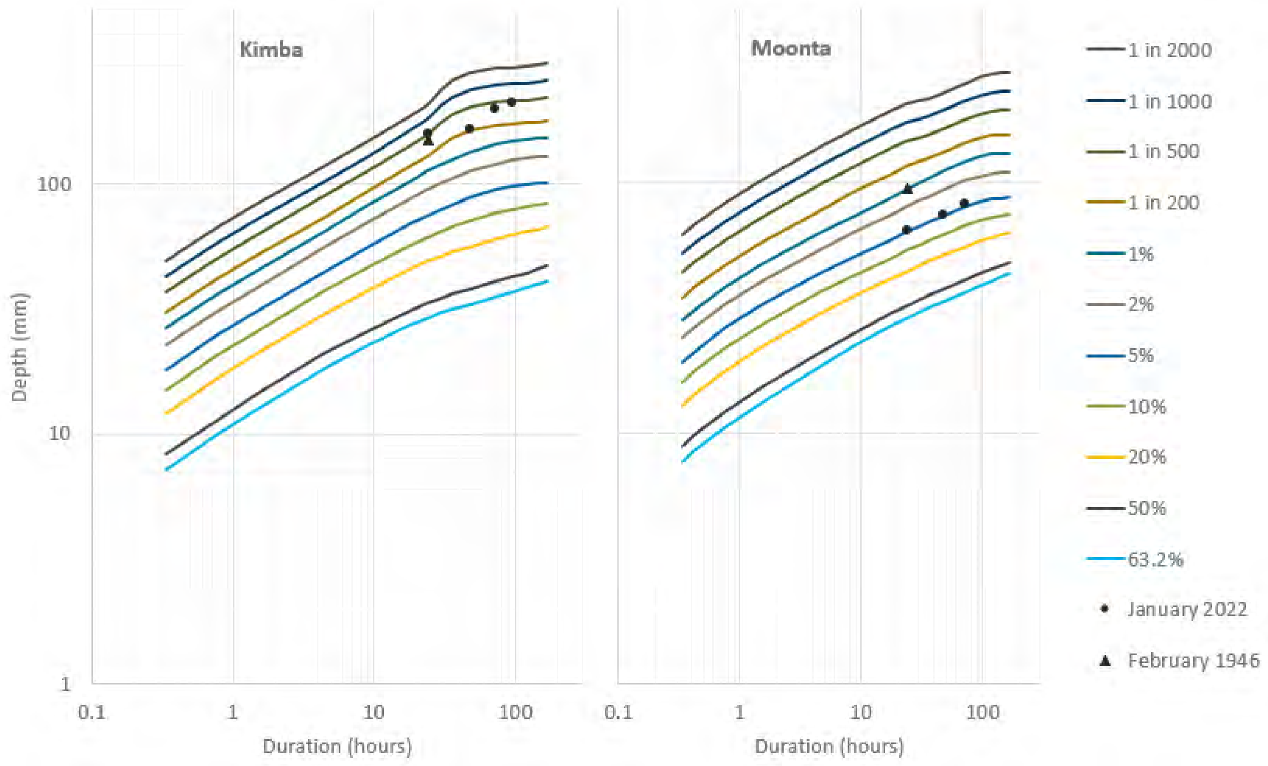


Figure B.11 IFD curves for two rainfall sites in South Australia, showing the January 2022 event

At Kimba, both the 1946 event and 2022 event lie between the '1 in 500' and '1 in 200' lines on the IFD curves. The likelihood of two 1 in 200 events occurring in 102 years of record is low but possible. Notwithstanding the nomenclature, events of this magnitude are not expected to occur once every 200 years, but rather with an 0.5% annual exceedance probability.

The probability of two 0.5% AEP events occurring in 102 years of record is approximately 9% (the probability of no 0.5% AEP events in that timeframe is approximately 60%, and the probability of one 0.5% AEP event is approximately 30%).

At Moonta, the January 2022 event generated approximately a 1 in 20 (5% AEP) rainfall, and similar rainfall would be expected to occur within the life of the project.

From Figure B.11, the IFD data indicate that the 1946 event was approximately a 1 in 100 (1% AEP) event, approximately aligning with the observed frequency that this rainfall has occurred once in 150 years.

Across all the weather stations in Australia, it is not unreasonable to expect that several of them would record high intensity storms at a higher than average rate, while others would record high intensity storms at a lower than average rate.

Overall, the January 2022 rainfall is consistent with current IFD data. Events of this magnitude and intensity are able to be predicted and modelled under the ARR 2019 framework and methodology which is described in this report and was applied in this study.

iii Climate change application to flood modelling

Australian Rainfall and Runoff: A Guide to Flood Estimation (Ball, et al., 2019) presents a decision tree for selecting an appropriate method for applying climate change effects to flood studies. The first step to this decision tree is to determine the planning horizon, with the recommendation that projects of around 20 years duration will likely experience similar climate to that on which the IFD data was based and that applying a simple factor to rainfall to assess climate change risk to flood effects is appropriate.

Flood design guidance is then provided which recommends that for each degree of local warming, design rainfall intensity should be increased by 5% (Ball, et al., 2019). With 2°C warming expected by 2050, this would result in an increased intensity of 10%.

At the site, the 1 in 100 (1% AEP) storm intensity is approximately 10% higher than the 1 in 50 (2% AEP) storm intensity. This means that the current climate 1 in 100 flood results can be taken as approximately equivalent to the future climate 1 in 50 flood results.

B.3 Flood model

A TUFLOW hydraulic model was developed for the area of the proposed Atacama mine site. The purpose of this model was:

- to characterise surface water drainage and flood behaviour in the vicinity of the proposed mine site;
- to determine peak design flow, velocity and depth at locations within the mine site and in the broader area surrounding the mine site; and
- to inform design of mine infrastructure, including the size and location of hydraulic structures (eg culverts), in the future.

Figure B.12 shows the layout of this model for the existing, pre-development landscape.

B.3.1 Grid size

The model was run with a calculation grid size of 10 m, with sub-grid sampling utilising the full 2 m grid resolution to develop hydraulic parameters for each model cell. This allowed fuller utilisation of the DEM dataset in the model without excessively high model run times.

B.3.2 Model timestep

TUFLOW HPC uses an adaptive timestep approach to maintain unconditional stability during simulations. Timesteps are automatically adjusted during the simulation to maintain stability, based a range of criterion (BMT, 2018).

Timesteps during model runs were typically in the order of 0.1–5 seconds, with an average of around 2 seconds.

B.3.3 Catchment roughness

For this study, Manning's n values were chosen based on field observations provided in Appendix A, summarised in Table B.5.

Table B.5 Manning's n values used in this study

Land use category	Manning's n value in the model
Undeveloped dunes and open landscape	0.035
Cleared	0.025

A manning's n value of 0.035 was used for major streamlines in the modelled catchment area. This roughness value is suitable for clean, winding natural stream channels with some pools, shoals, weeds and stones (Chow, 1959).

Calibration of catchment roughness values was not undertaken for this model, but could be undertaken in the future to provide higher confidence in modelled results.

Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

KEY

Model extent

Rainfall zone

Zone 1

Zone 2

Zone 3

Zone 4

Baseline (pre mining)

Atacama surface water assessment
Figure B.12

EMM creating opportunities

B.3.4 Structures

There are currently no hydraulic structures within the model domain.

When modelling the developed scenario, the haul road was included in the model at the design elevation, with breaks at nominated culvert locations to allow flow to pass across the road alignment. Culverts have not yet been designed, and this method of leaving openings across linear infrastructure at culvert locations is typical for comparative assessment of effects studies when exact details are unknown.

B.3.5 Boundary conditions

The model contains a distributed rainfall boundary which supplies water into the model.

Due to the large number of catchments included in the model, downstream flow boundaries were not added to the edges of the model computational grid. Runoff pooled at the edge of the grid, with these locations removed from the results prior to presentation.

B.3.6 Application of rainfall losses

Within the TUFLOW model, rainfall losses can be applied in one or both of the following ways (BMT, 2018):

1. water is removed from the rainfall data before it is added to the model; or
2. water is lost (infiltrated and evaporated) from wet model cells over time.

Option 2 is a closer match to the processes which occur in arid South Australia, as it allows runoff to soak into dry creek beds and disappear before reaching the coast. In contrast, when using option 1, once runoff begins no further water is removed from the model and creeks will continue to flow all the way to the downstream model boundary.

B.3.7 Calibration and validation

The TUFLOW model was not calibrated as there are no gauged creeks within the model domain to use as calibration targets.

Validation against the ARR (2016) Regional Flood Frequency Estimation (RFFE) model was not possible as the RFFE model does not produce results in arid regions.

The installation of site based gauging stations could be used to update/calibrate this model in the future.

B.3.8 Scenarios and model runs

The model was run for three scenarios: baseline (pre-mining), during mining and post closure. Details of these scenarios, and how they were implemented in the flood model, are provided in Table B.6.

Table B.6 Flood model scenarios

Scenario name	Description	Model implementation	Figure number
Baseline (pre-mining)	The existing, pre-development landscape		Figure B.12
During mining	Maximum development[1], including all proposed mine site infrastructure:		Figure B.13
	• mine pits (bunded to their full extent) – NOTE: pit excavation will cross multiple dune swales, and bund walls would be required to exclude ponding flood waters from the pit	Excluded from model domain	
	• roads, pads	Terrain modified to design road elevations provided by Iluka ILCL and Manning's n values changed (see Table B.3 and Table B.5)	
	• topsoil, ponds, stockpiles (bunded)	Excluded from model domain	
	• culverts	Terrain modified to allow flow at culvert locations provided by Iluka	
Post closure	Mine site rehabilitated:		Figure B.14
	• mine pits backfilled	Terrain modified to design backfill elevations provided by Iluka	
	• roads, pad and culverts remain	as for 'During mining' scenario	
	• topsoil, ponds, stockpiles removed	Terrain as for 'Baseline (pre-mining)' scenario	

1. NOTE: the mine plan describes progressive rehabilitation, and so the entire footprint of each pit will not be open at any one time. However, to model multiple mine plan stages would have required many more model simulations and maps for little additional clarity regarding impacts, as the pits cross many individual swale catchments which are discretely impacted. The presented results for this scenario may thus be viewed as a composite effects map illustrating how each swale catchment will be affected when mining occurs in that area.

For each of the scenarios described in Table B.6, the following AEPs were modelled:

- 1% AEP (1 in 100 AEP);
- 2% AEP (1 in 50 AEP); and
- 0.5% AEP (1 in 200 AEP).

Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

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KEY

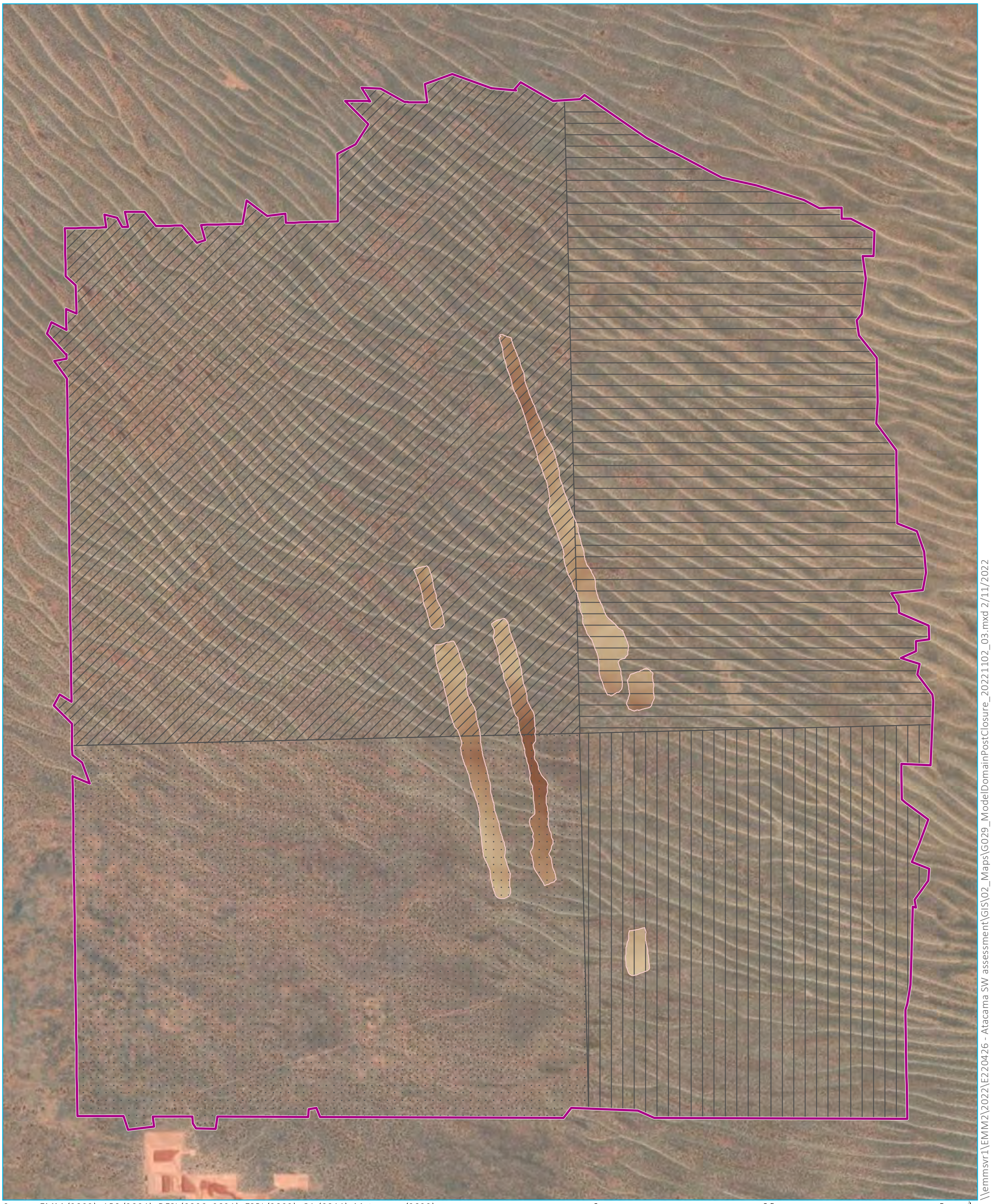
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Culvert location
- Model extent

Rainfall zone

- Zone 1
- Zone 2
- Zone 3
- Zone 4

Model domain - during mining

Atacama surface water assessment
Figure B.13



Model domain - post closure

Atacama surface water assessment
Figure B.14

EMM creating opportunities

B.4 Modelled results

For each modelled scenario and AEP, the TUFLOW model produced gridded results across the mine site model domain for water surface, depth, velocity, and hazard. Results were trimmed using a cut off depth of 0.1 m (water depths shallower than 0.1 m are not shown on any result maps).

Figure B.15 shows the general flood hazard vulnerability curves from the Australian Disaster Resilience Handbook (AIDR, 2017) and describes the hazard categories which are produced as results from the model.

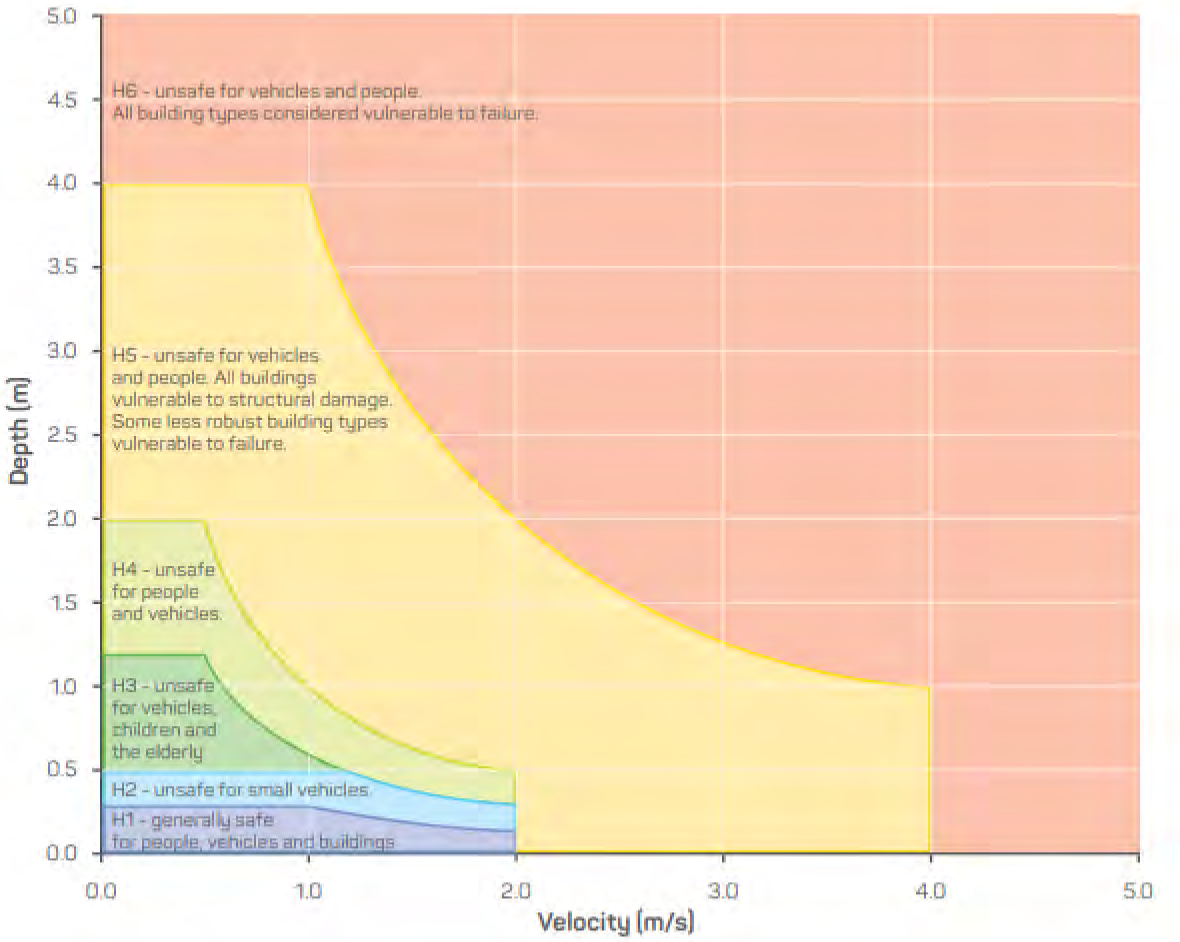


Figure B.15 General flood hazard vulnerability curves (AIDR, 2017)

In this section, for each modelled scenario, the following results are presented:

- peak design flows and depths at key locations throughout the model domain (for the 1% AEP design event); and
- mapped results (for the 1% AEP, 2% AEP and 0.5% AEP design events):
  - peak design depth (and peak flood inundation extent);
  - peak design velocity; and
  - peak design hazard.

NOTE: the mine plan describes progressive rehabilitation, and so the entire footprint of each pit will not be open at any one time.

However, to model multiple mine plan stages would have required many more model simulations and maps for little additional clarity regarding impacts, as the pits cross many individual swale catchments which are discretely impacted. The presented results for the 'During mining' scenario may thus be viewed as a composite effects map illustrating how each swale catchment will be affected when mining occurs in that area.

B.4.1 Peak design flows and depths

Table B.7 gives peak 1% AEP peak design flows at several reporting locations across the model domain for each scenario. Reporting points are shown in Figure B.18.

Table B.7 Peak design flows at key locations within the model domain

Reporting point	Description	Peak flow, 1% AEP (1 in 100)		
		Baseline (pre-mining) (m^3/s)	During mining (m^3/s)	Post closure (m^3/s)
RP_Flow_1	• ~1-2 km away from the mine site • upstream of RP_Depth_4	3.7	3.5 (-5%)	3.7 -
RP_Flow_2	• ~3-4 km away from the mine site	7.4	7.4 -	7.4 -
RP_Flow_3	• unnamed creek line to Lake Ifould, 3 km away from the mine site • downstream of the road from the mine site to the J-A mine site	19.4	19.3 (-1%)	19.4 -
RP_Flow_4	• ~600 m upstream of the road from the mine site to the J-A mine site	5.9	5.9 -	5.9 -
RP_Flow_5	• ~700 m upstream of the road from the mine site to the J-A mine site • downstream of bunded mine infrastructure • upstream of RP_Depth_5	3.1	1.2 (-61%)	3.1 -
RP_Flow_6	• culvert location along the road from the mine site to the J-A mine site • upstream of RP_Depth_6	3.2	2.8 (-13%)	3.2 -

For most locations in the model domain, the critical duration storm for flow was generally between 2 hours and 4.5 hours. Figure B.16 shows the range of peak design flows at the reporting location RP_Flow_1 for the 1% AEP storms with durations of 1 to 24 hours; the 4.5 hour storm yielded the highest mean peak design flow. Across the 10 temporal patterns modelled for the 4.5 hour storm, flows varied by approximately ± 60%.

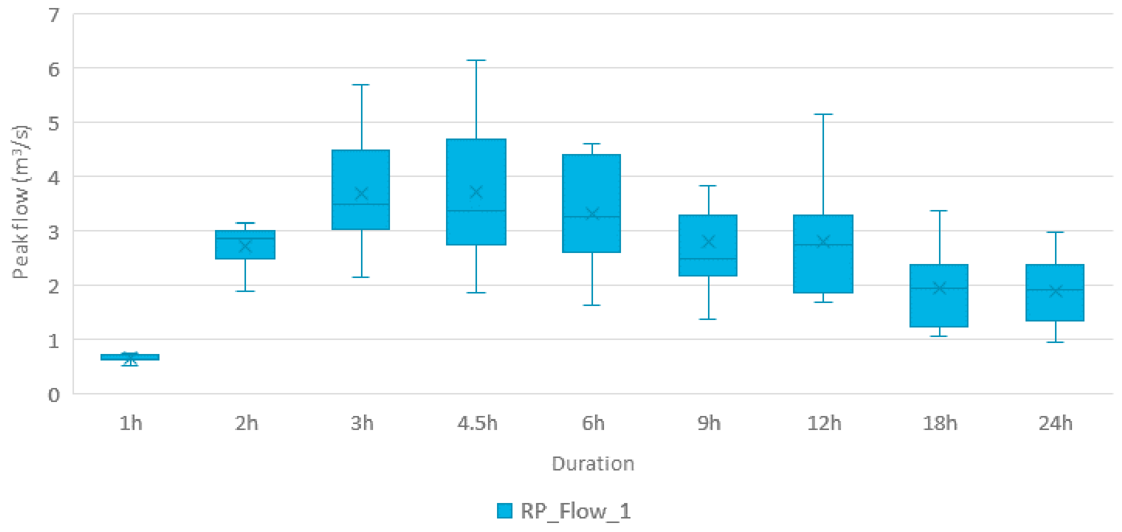


Figure B.16 Peak design flow results at RP_Flow_1 (1% AEP)

Table B.8 gives peak 1% AEP peak design depths at several reporting locations across the model domain for each scenario. Reporting points are shown in Figure B.18.

Table B.8 Peak design depths at key locations within the model domain

Reporting point	Description	Peak depth, 1% AEP (1 in 100)		
		Baseline (pre-mining) (m)	During mining (m)	Post closure (m)
RP_Depth_1	• ~350 m downstream of mine pit	1.2	0.8 (-33%)	0.9 (-25%)
RP_Depth_2	• ~500 m away from the mine site	1.5	1.3 (-13%)	1.6 (+7%)
RP_Depth_3	• ~400 m downstream of mine pit	1.4	0.9 (-36%)	1.3 (-7%)
RP_Depth_4	• ~ 3 km downstream of mine pit/away from the mine site • Downstream of RP_Flow_1	0.6	0.6 -	0.6 -
RP_Depth_5	• Immediately upstream of the road from the mine site to the J-A mine site (culvert) • Downstream of RP_Flow_5	0.9	0.7 (-22%)	0.9 -
RP_Depth_6	• Immediately downstream of the road from the mine site to the J-A mine site (culvert) • Downstream of RP_Flow_6	0.6	0.6 -	0.6 -

For most locations in the model domain, the critical duration storm for depth was 12 hours. Figure B.16 shows the range of peak design depths at the reporting location RP_Depth_4 for the 1% AEP storms with durations of 1 to 24 hours; the 12 hour storm yielded the highest mean peak design depth. Across the 10 temporal patterns modelled for the 12 hour storm, depths varied by approximately ± 25%.

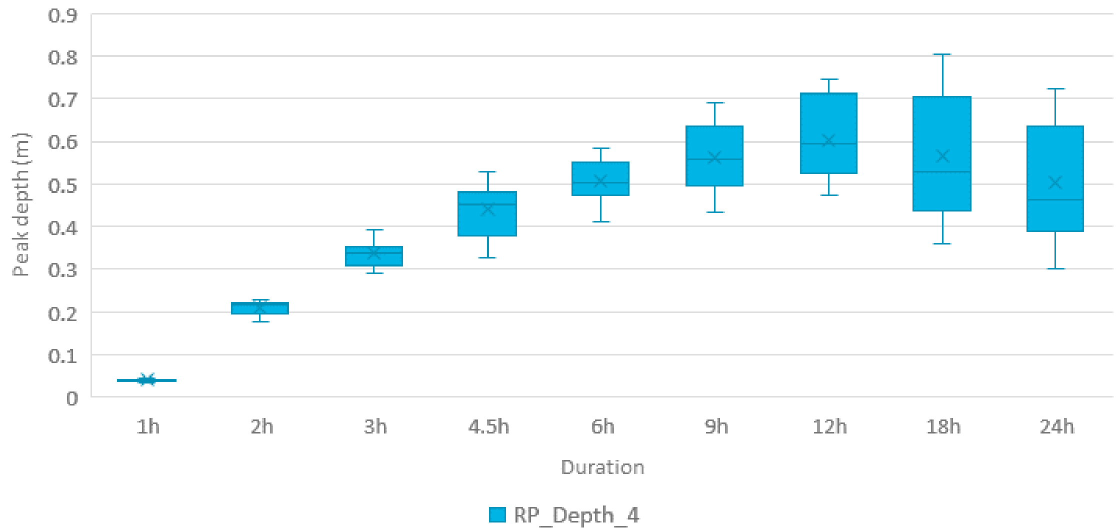
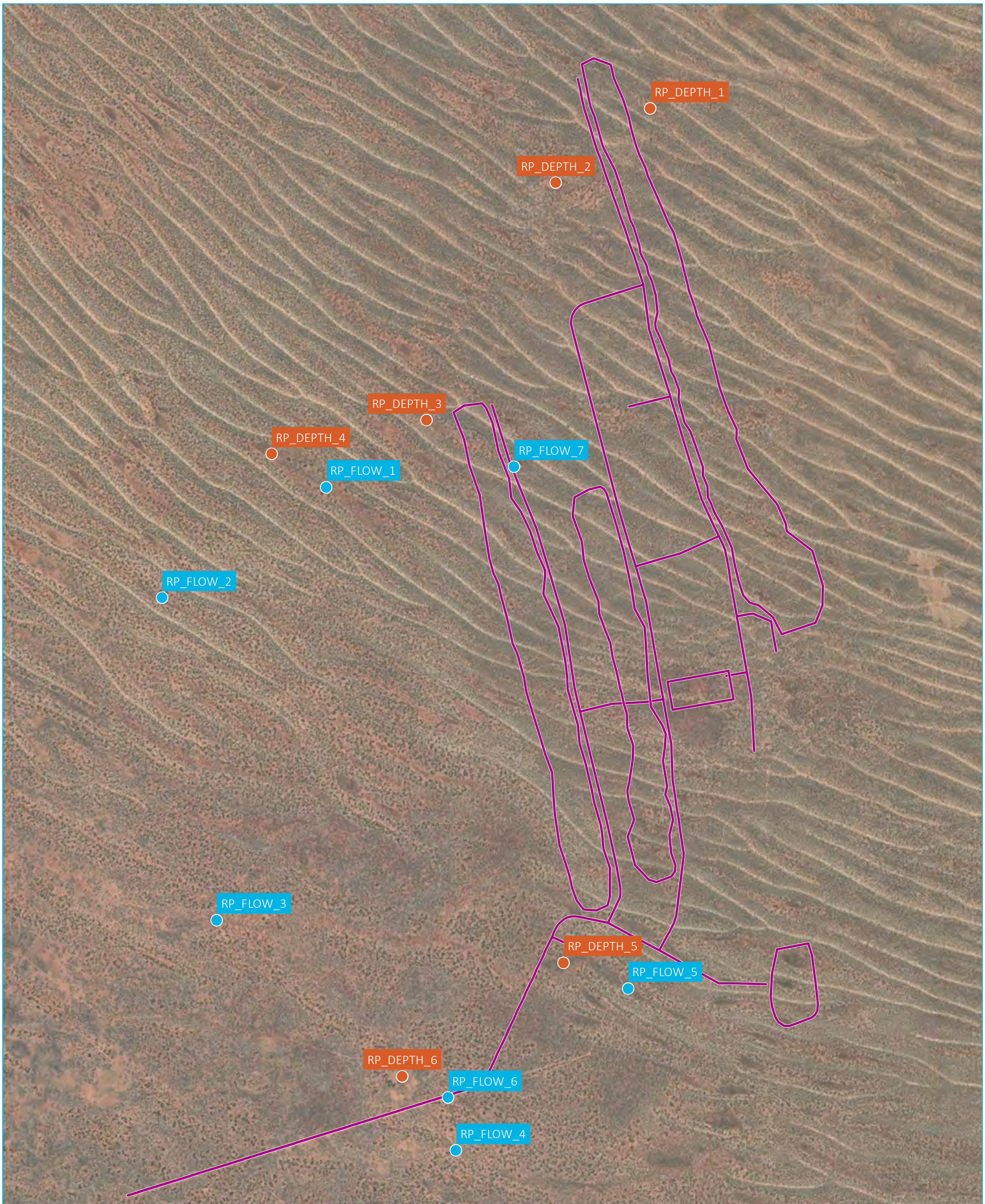


Figure B.17 Peak design depth results at RP_Depth_4 (1% AEP)

These results show that:

- during mining and post closure, changes to the flood regime are restricted to the dune swales in which excavation or construction occurs and there is no change to the flood regime 3-4 km away from the mine site;
- during mining, the biggest changes to the flood regime are due to loss of catchment area due to bunded areas; and
- changes to the flood regime during mining generally return to baseline conditions under the post closure scenario.



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Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 0.5 1 km
GDA 1994 MGA Zone 53
N

KEY

Project layout (pits, roads)

Reporting location - depth

Reporting location - flow

Model reporting locations

Atacama surface water assessment

Figure B.18

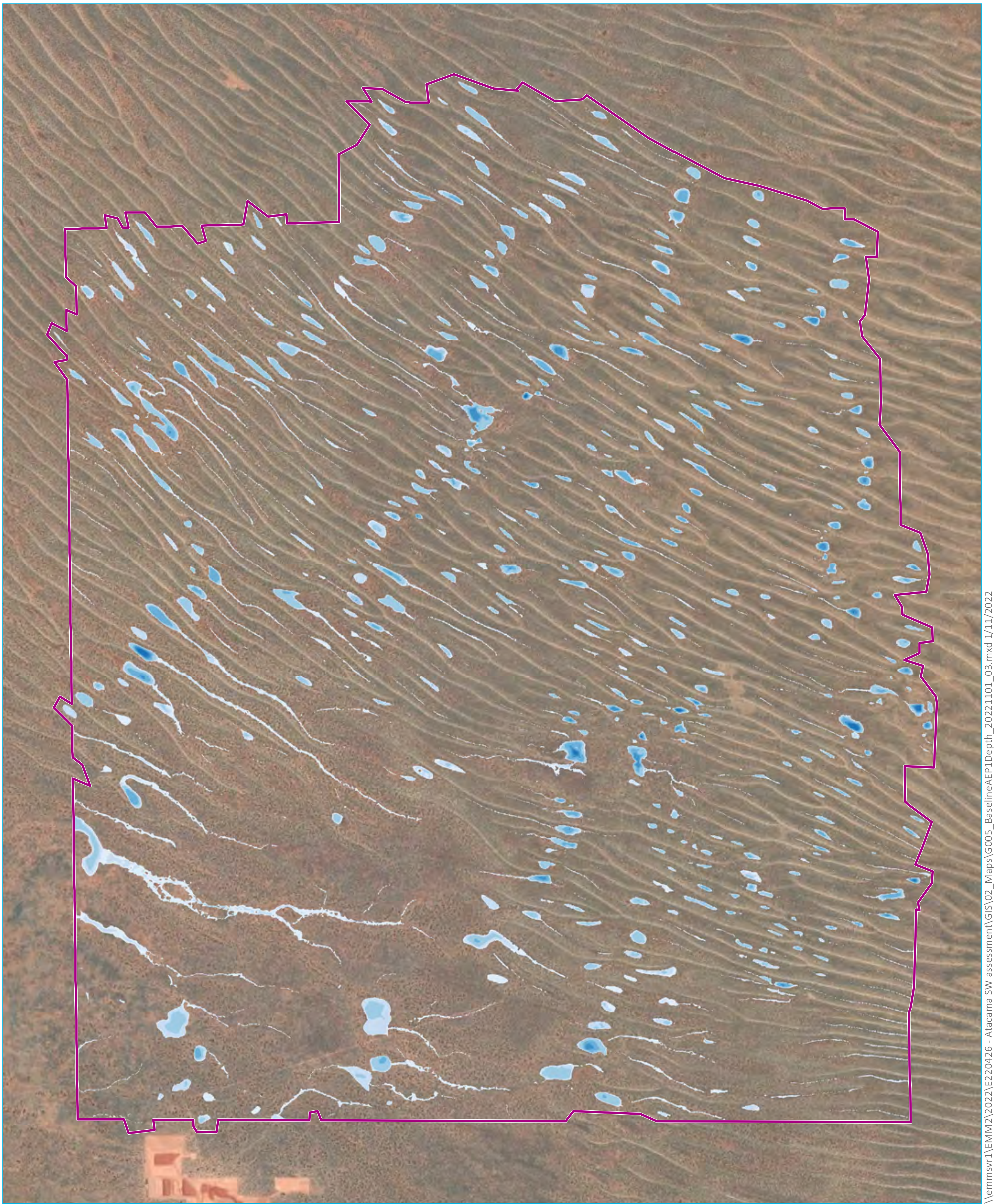
EMM creating opportunities

B.4.2 Mapped peak flood results

Results are presented in this section as per Table B.9.

Table B.9 Figure numbers for mapped results

AEP	Mapped result type	Baseline (pre-mining)	During mining	Post closure
1% (1 in 100)	Peak design depth (and peak flood inundation extent)	Figure B.19	Figure B.20	Figure B.21
	Change in peak design depth (Afflux)		Figure B.22	Figure B.23
	Peak design velocity	Figure B.24	Figure B.25	Figure B.26
	Change in peak design velocity		Figure B.27	Figure B.28
	Peak design hazard		Figure B.29	
2% (1 in 50)	Peak design depth (and peak flood inundation extent)	Figure B.30	Figure B.31	Figure B.32
	Change in peak design depth (Afflux)		Figure B.33	Figure B.34
	Peak design velocity	Figure B.35	Figure B.36	Figure B.37
	Change in peak design velocity		Figure B.38	Figure B.39
	Peak design hazard		Figure B.40	
0.5% (1 in 200)	Peak design depth (and peak flood inundation extent)	Figure B.41	Figure B.42	Figure B.43
	Change in peak design depth (Afflux)		Figure B.44	Figure B.45
	Peak design velocity	Figure B.46	Figure B.47	Figure B.48
	Change in peak design velocity		Figure B.49	Figure B.50
	Peak design hazard		Figure B.51	



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

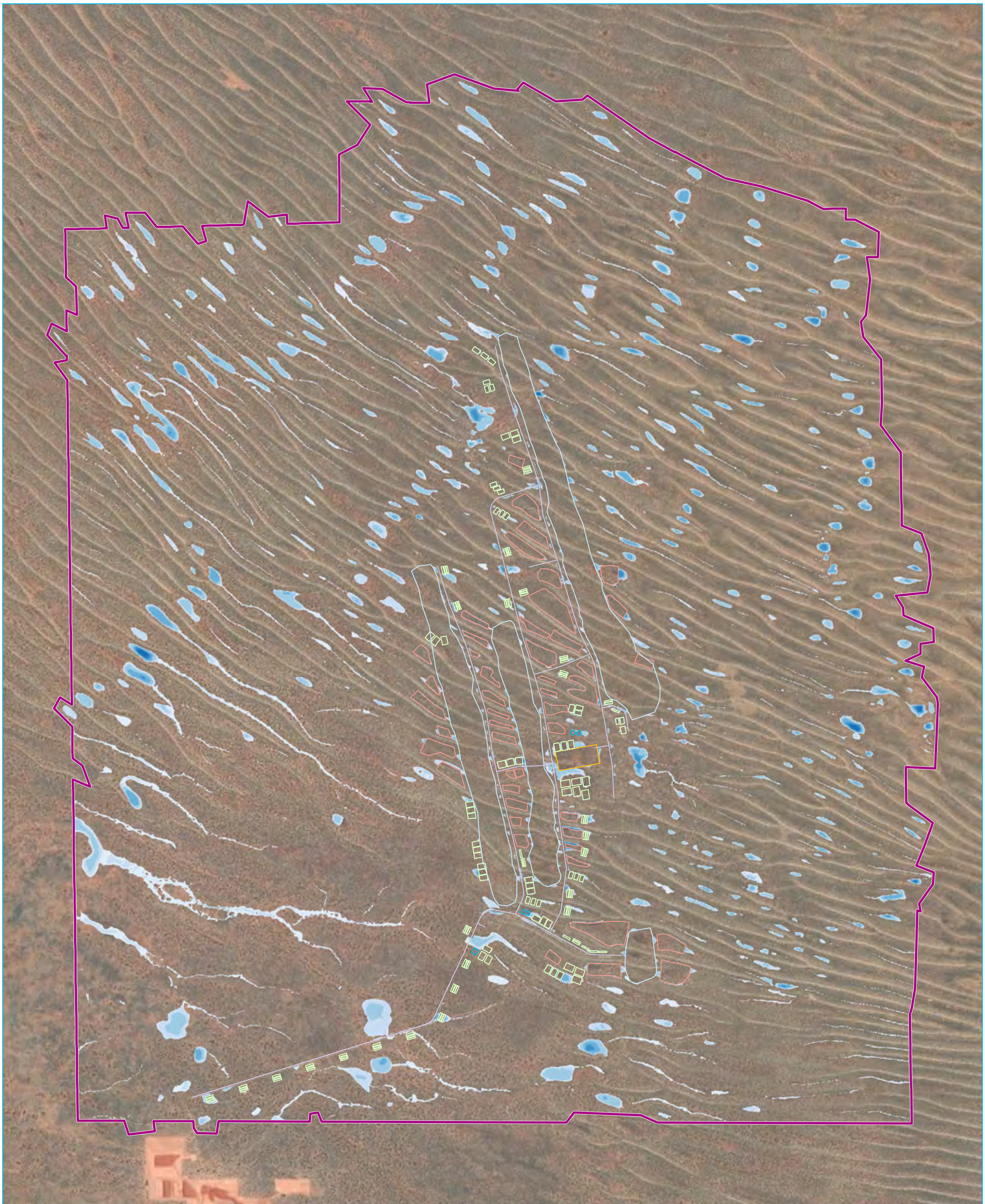
Maximum water depth (m)

- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 1% AEP - baseline (pre mining)

Atacama surface water assessment
Figure B.19

creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km
GDA 1994 MGA Zone 53
N

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KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

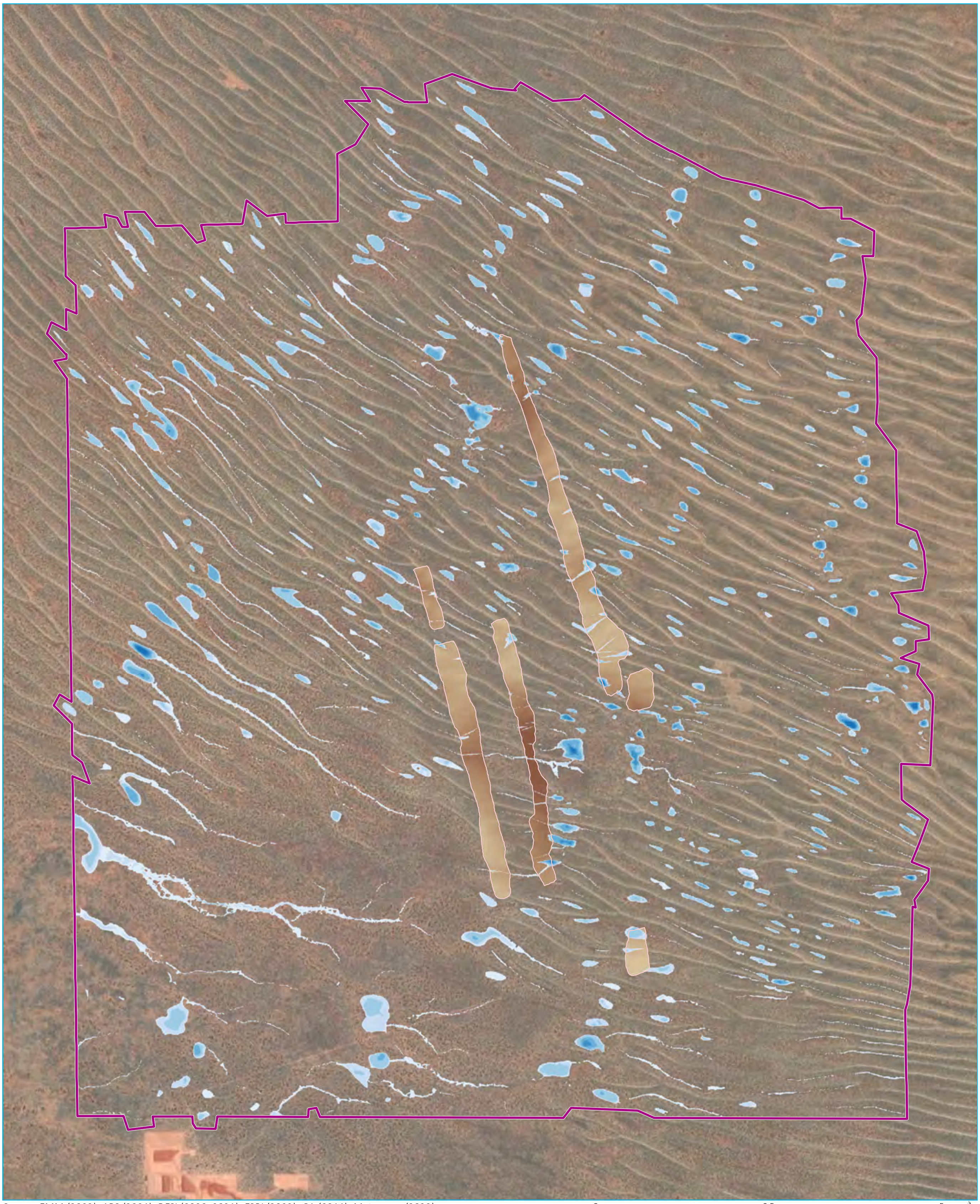
Maximum water depth (m)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 1% AEP - during mining

Atacama surface water assessment
Figure B.20

EMM
creating opportunities



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Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Backfilled pit changed elevation

Maximum water depth (m)

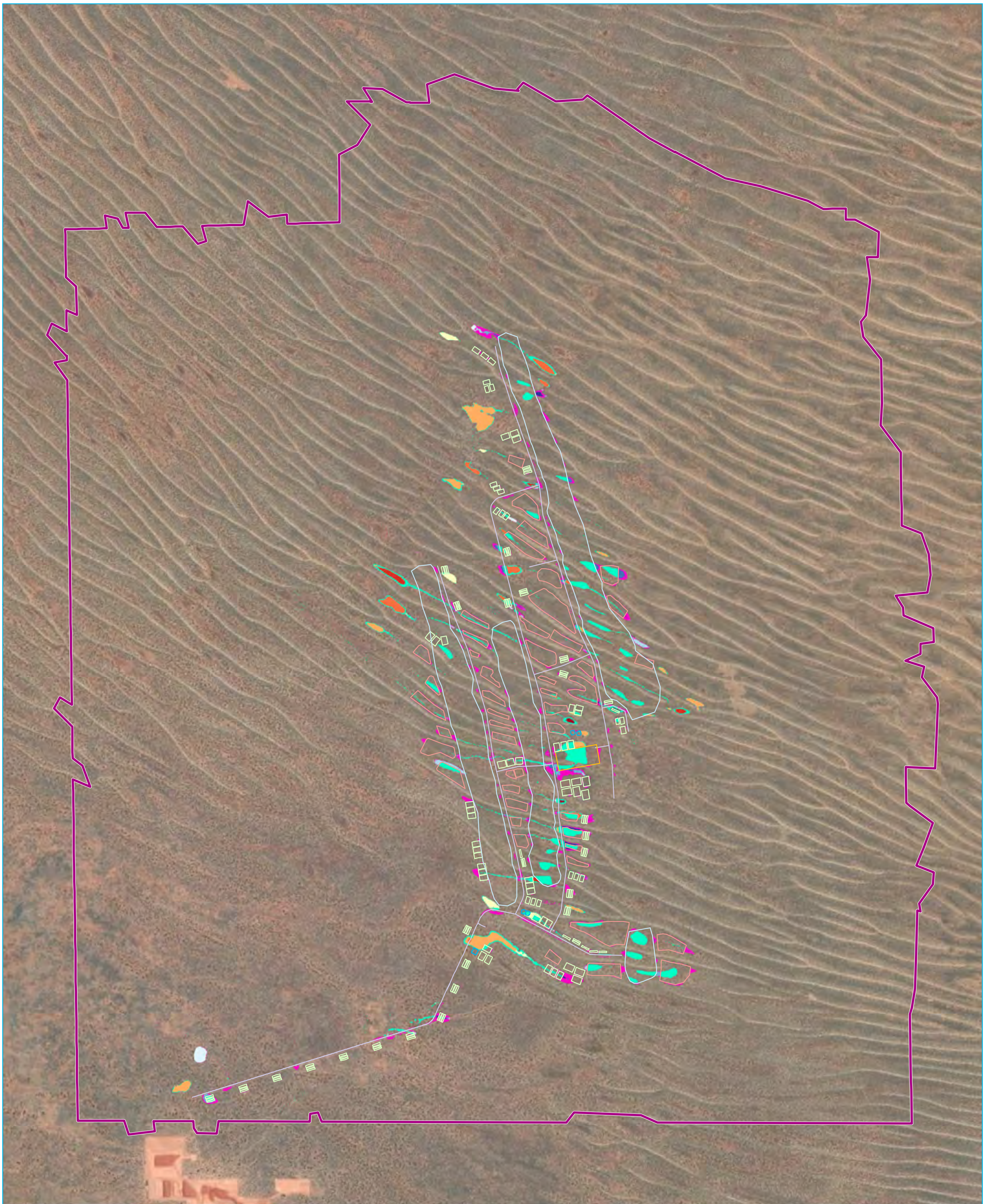
- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 1% AEP - post closure

Atacama surface water assessment

Figure B.21

EMM creating opportunities



\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G011_ChangeAEP1Depth_20221101_03.mxd 1/11/2022

Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

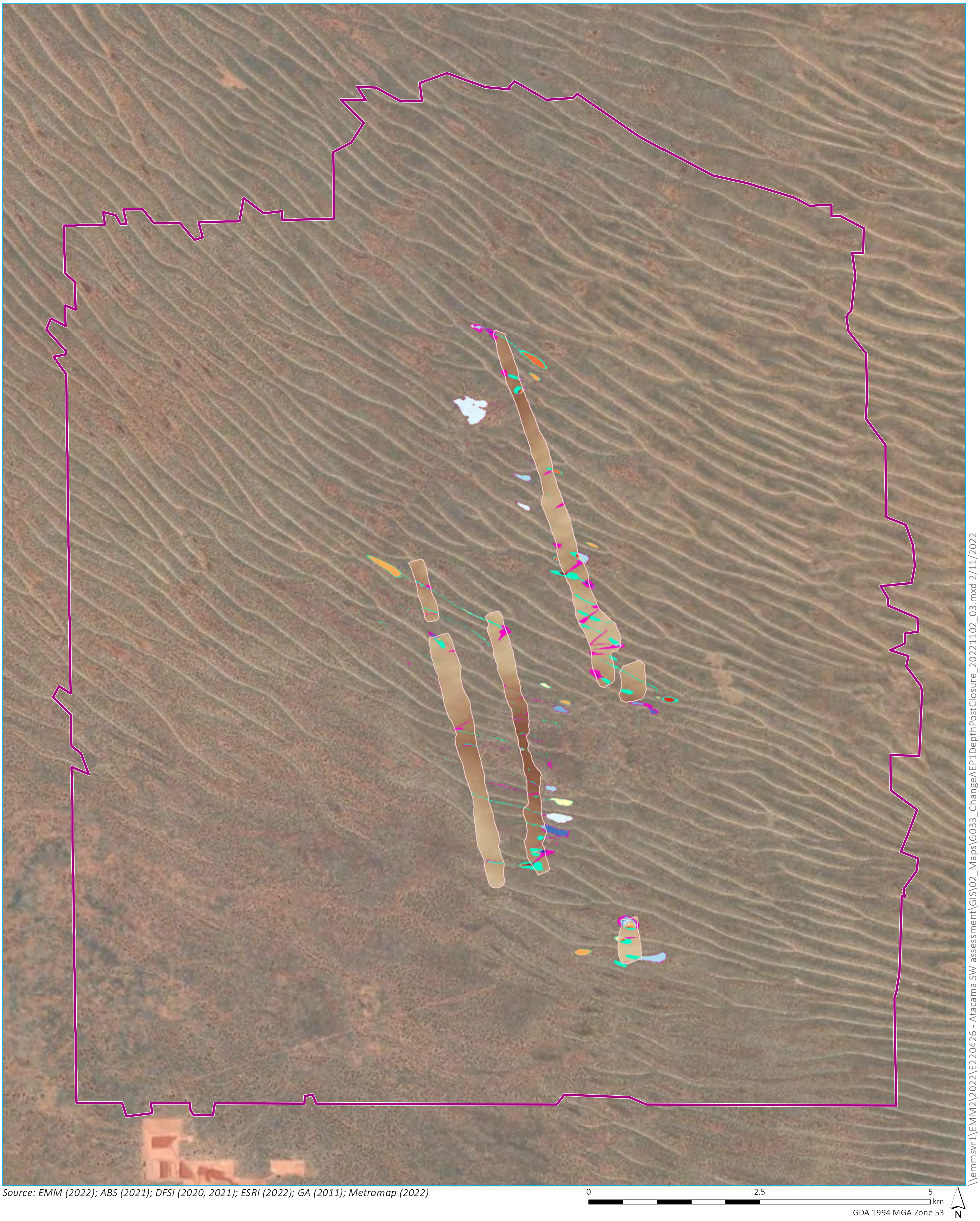
KEY

Model extent	Was wet now dry	-0.1 - -0.05
Proposed pit	Was dry now wet	-0.05 - 0.05
Proposed pads	Change in peak flood depth (m)	0.05 - 0.1
Proposed ponds	< -1	0.1 - 0.25
Proposed stockpiles	-1 - -0.5	0.25 - 0.5
Proposed topsoil placement	-0.5 - -0.25	0.5 - 1
Proposed road alignment	-0.25 - -0.1	> 1

Afflux - change in peak design depth 1% AEP - during mining

Atacama surface water assessment
Figure B.22

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent
Backfilled pit changed elevation
Was wet now dry
Was dry now wet

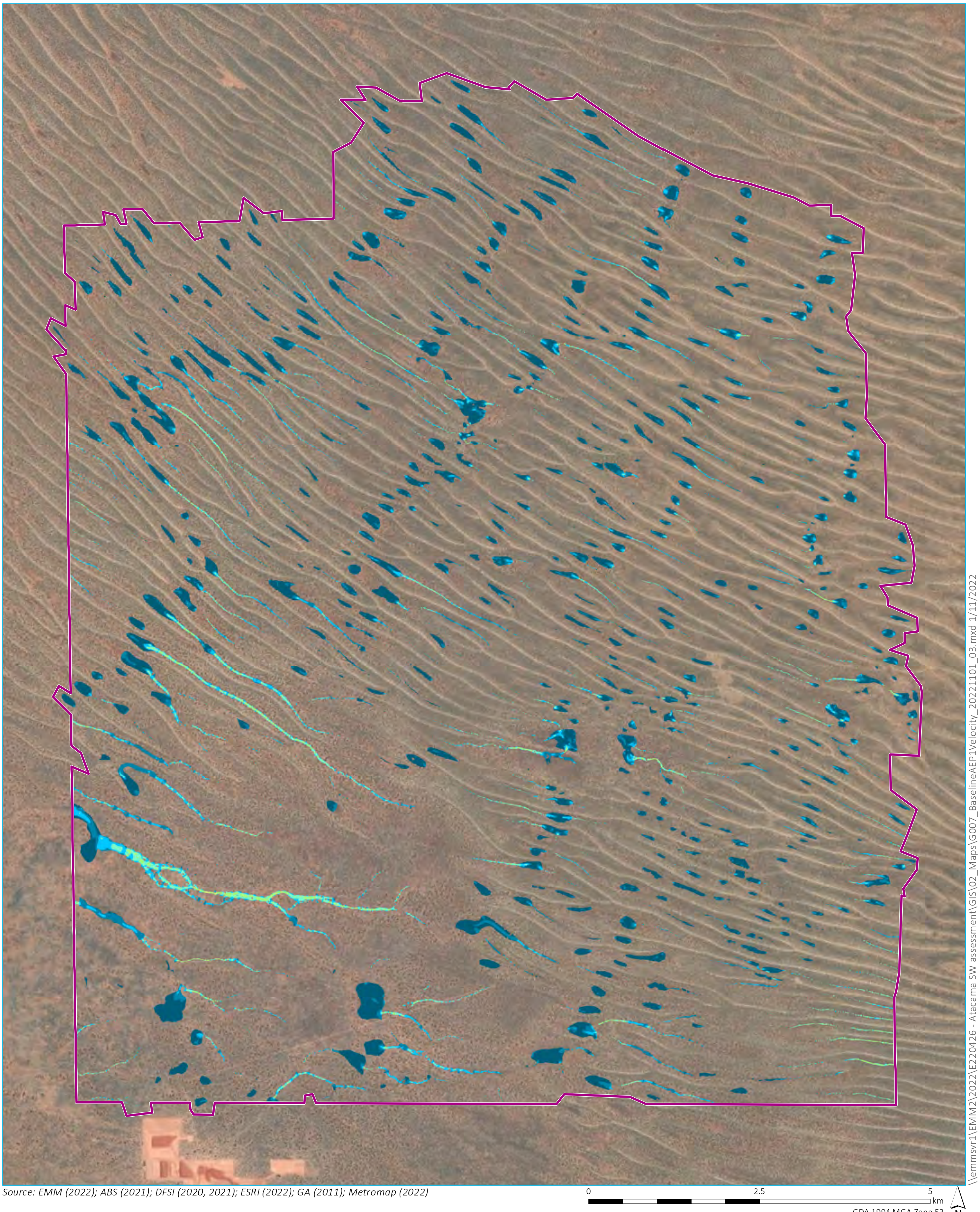
Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 1% AEP - post closure

Atacama surface water assessment
Figure B.23

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Maximum water velocity (m/s)

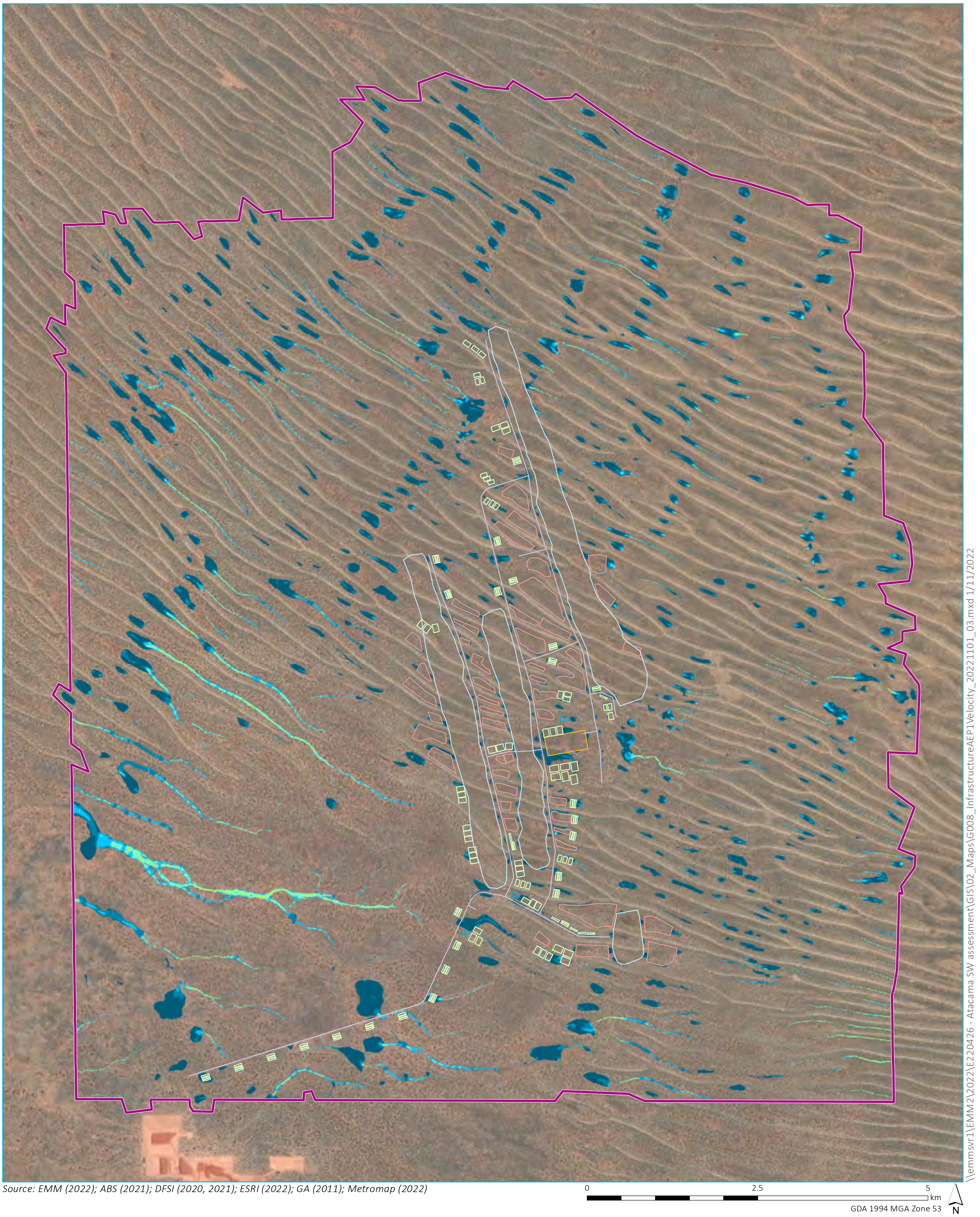
- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5

Peak design velocity 1% AEP - baseline (pre mining)

Atacama surface water assessment

Figure B.24

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

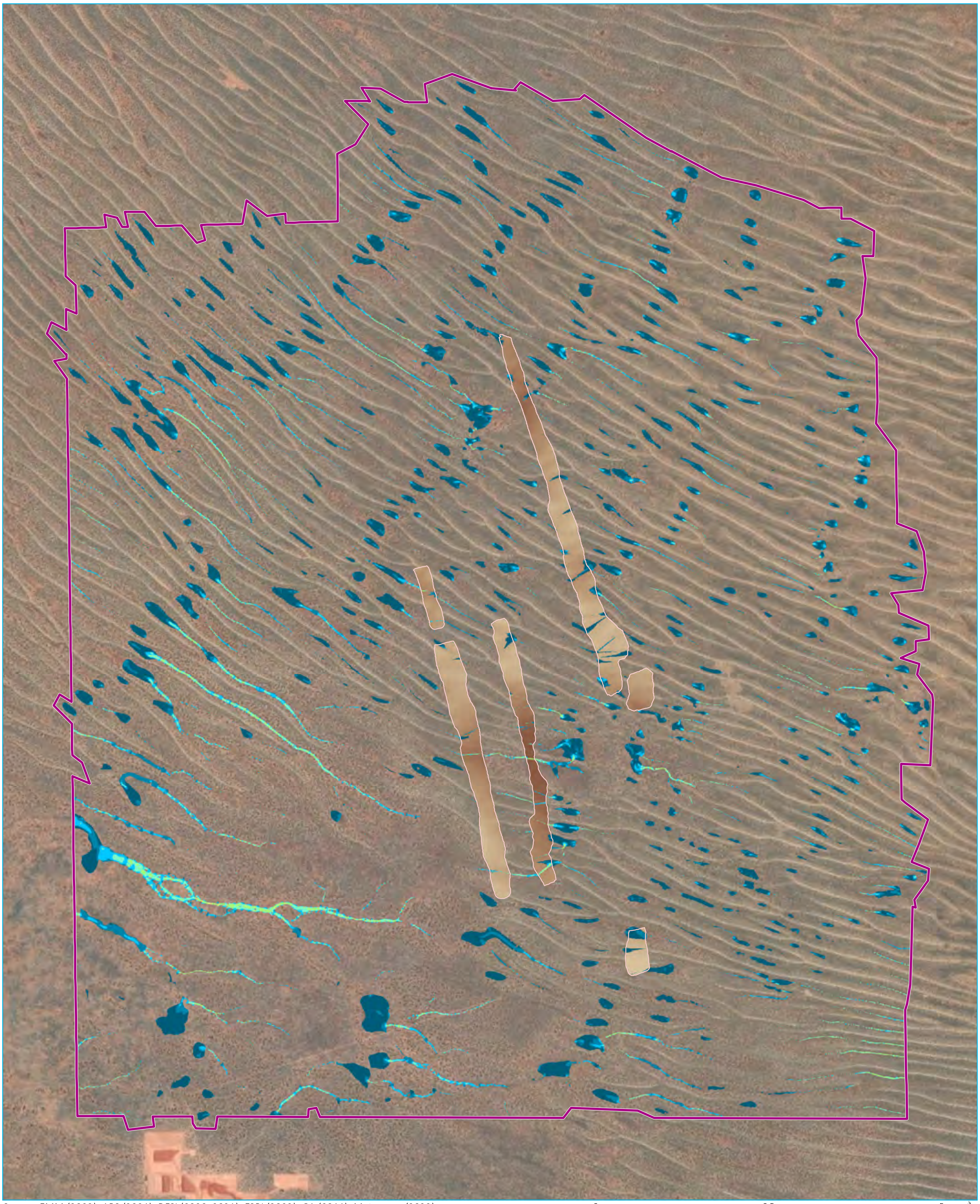
Maximum water velocity (m/s)

- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5

Peak design velocity 1% AEP - during mining

Atacama surface water assessment
Figure B.25

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

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KEY

Model extent

Backfilled pit changed elevation

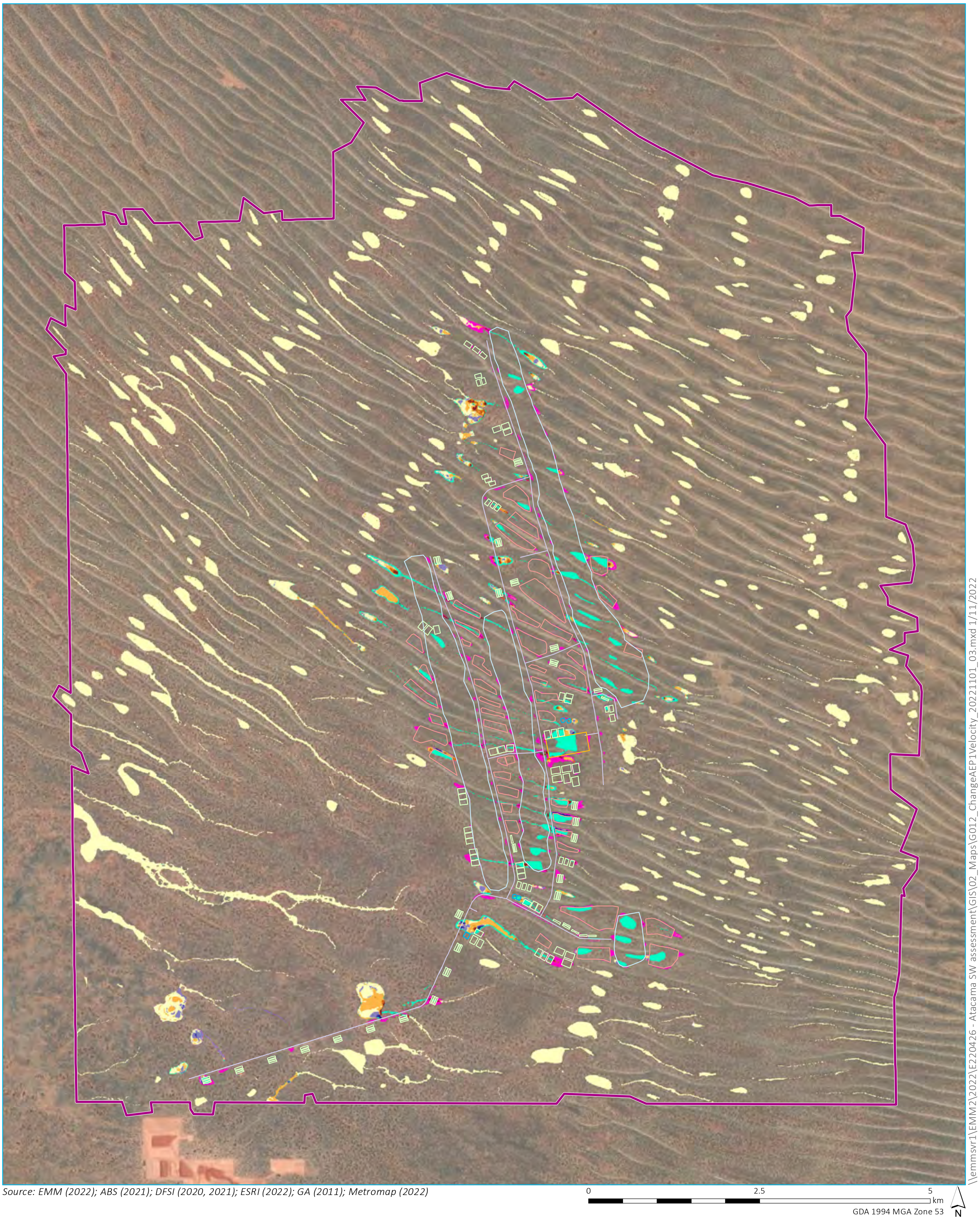
Maximum water velocity (m/s)

- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5

Peak design velocity 1% AEP - post closure

Atacama surface water assessment
Figure B.26

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Was wet now dry
- Was dry now wet

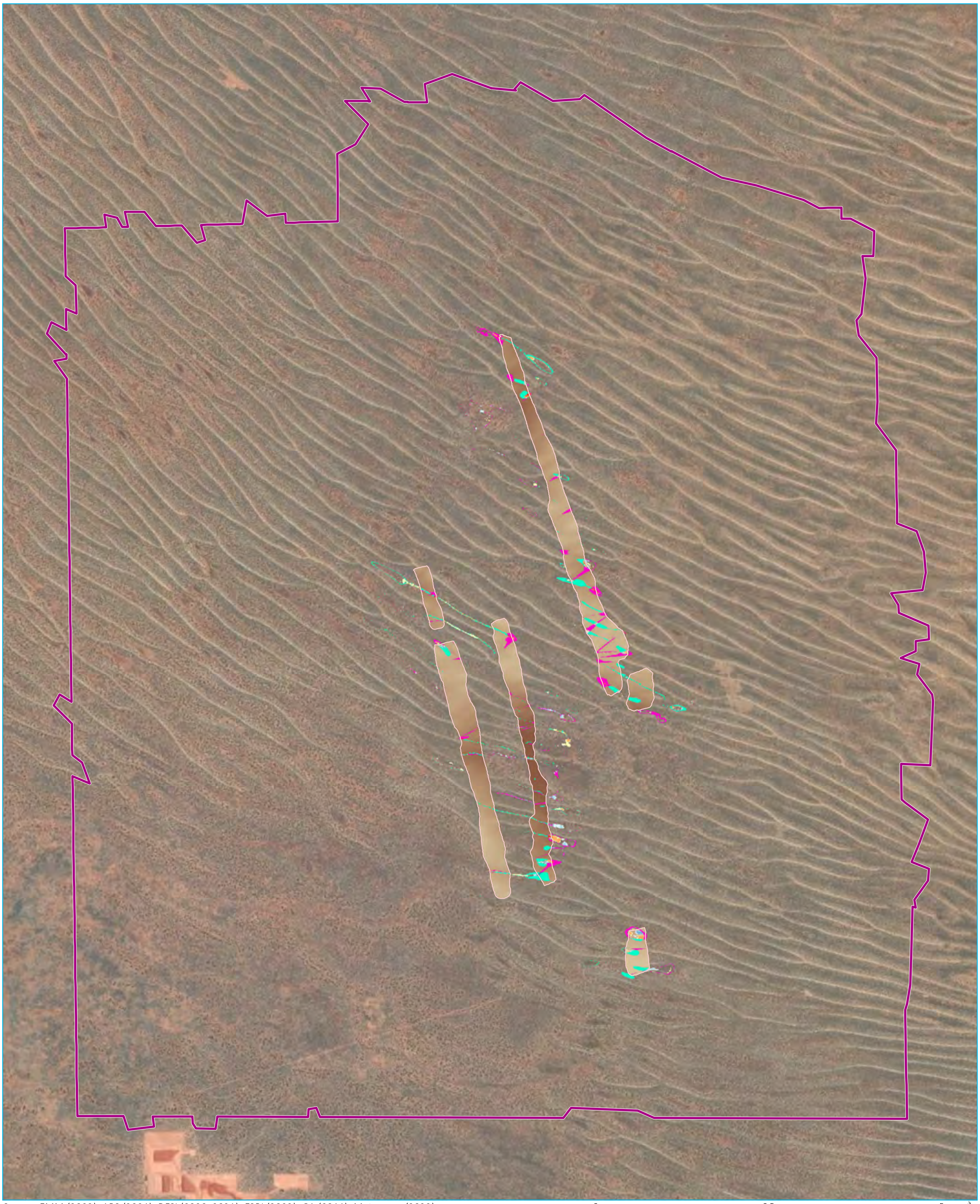
Change in flood velocity (m/s)

- < -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- -0.01 to +0.01
- +.01 to +0.1
- +0.1 to +0.2
- > +0.2

Change in peak design velocity 1% AEP - during mining

Atacama surface water assessment
Figure B.27

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

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KEY

- Model extent
- Backfilled pit changed elevation
- Was wet now dry
- Was dry now wet

Change in peak water velocity (m/s)

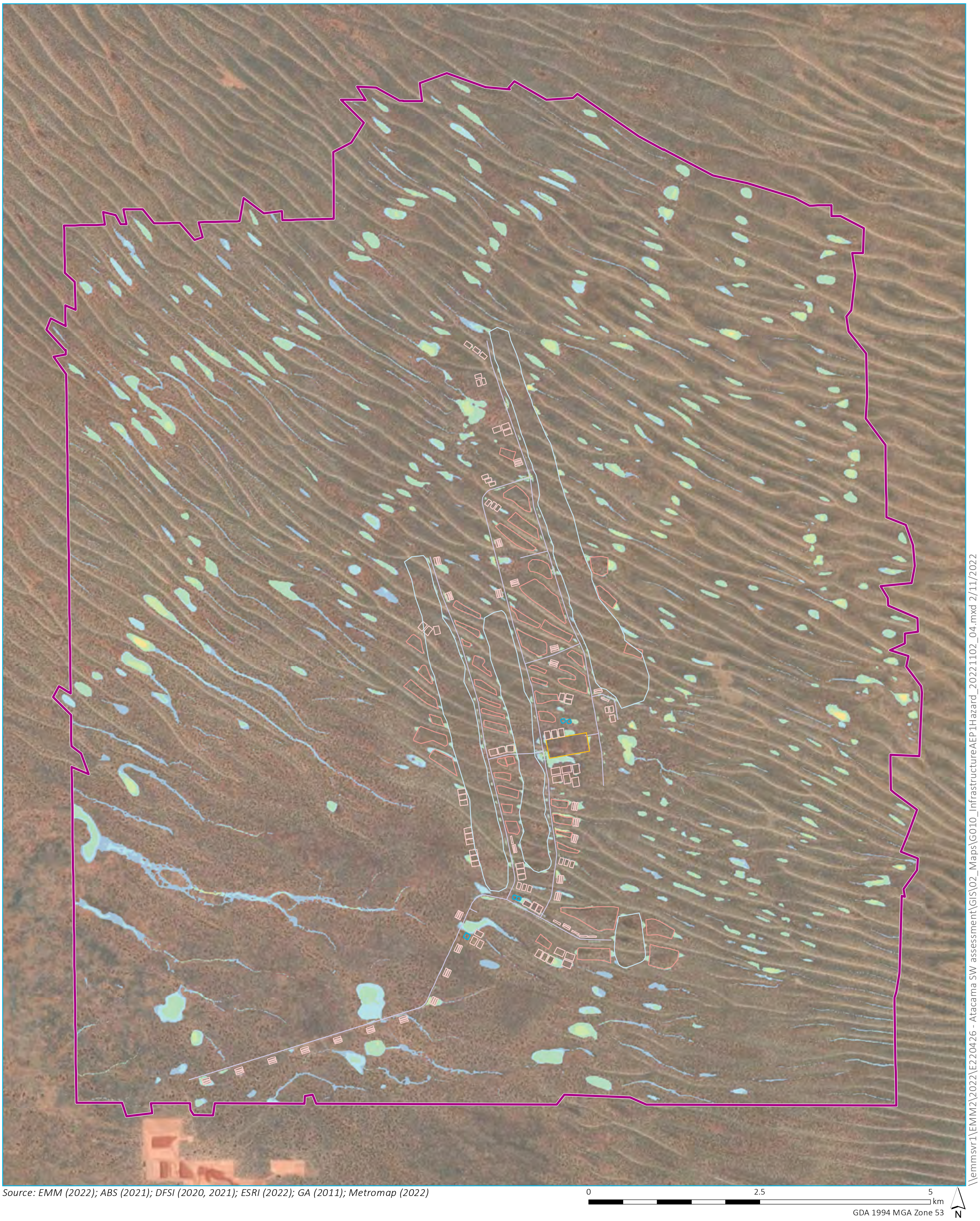
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design velocity 1% AEP - post closure

Atacama surface water assessment

Figure B.28

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

Maximum flood hazard (H1-H6)

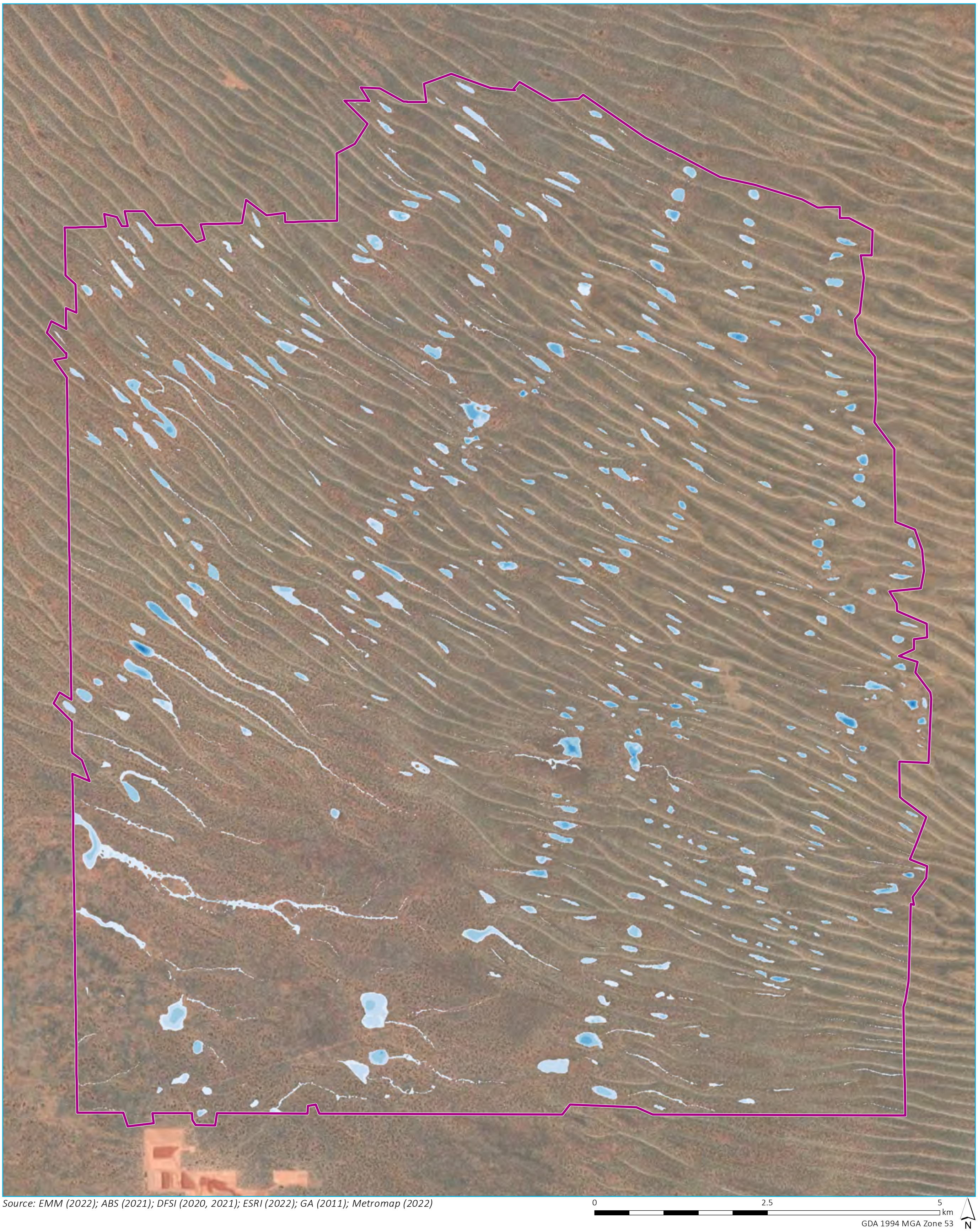
- H5
- H4
- H3
- H2
- H1

Peak design hazard 1% AEP - during mining

Atacama surface water assessment

Figure B.29

EMM creating opportunities



\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G013_BaselineAEP2Depth_20221101_03.mxd 1/11/2022

Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

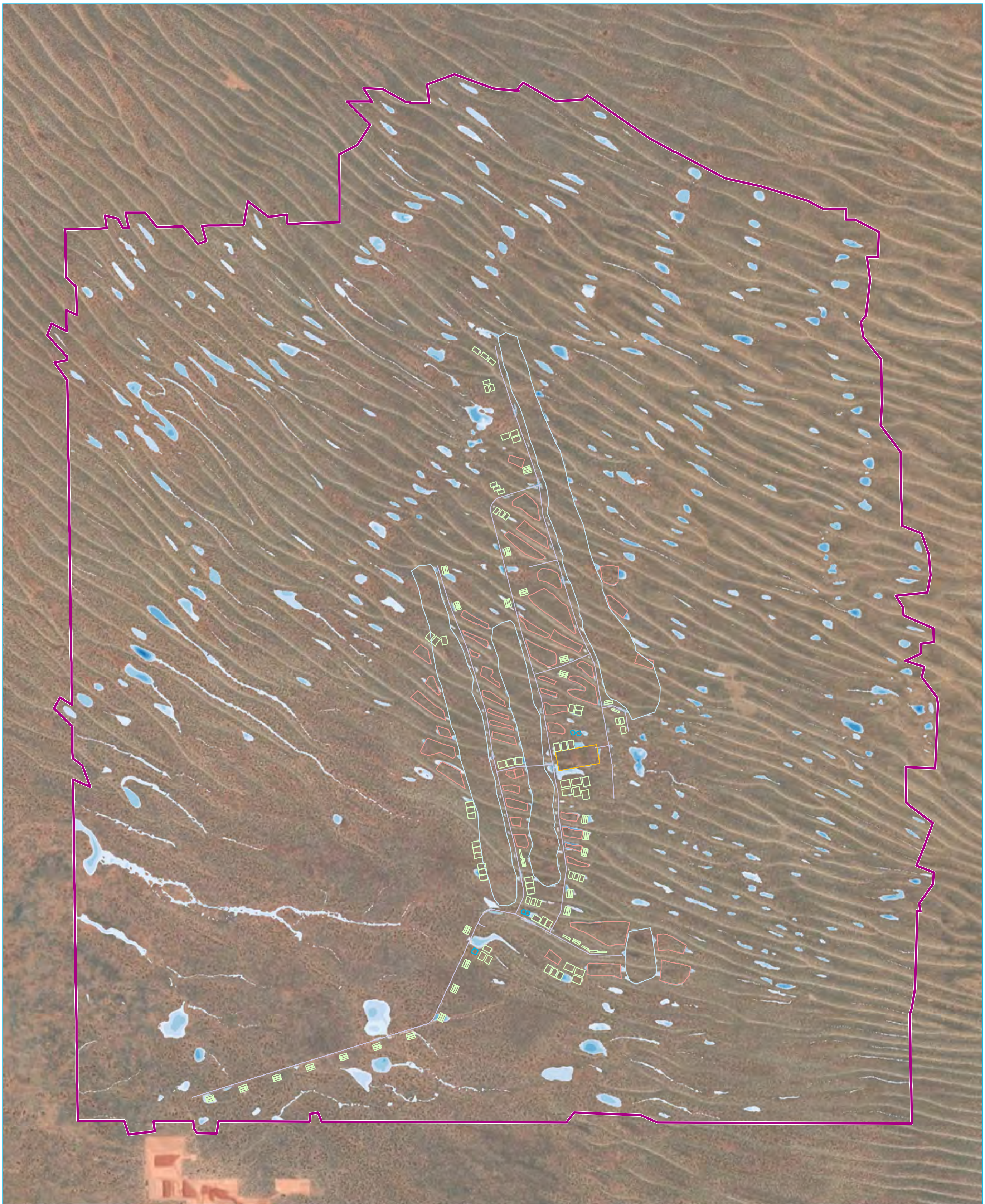
Maximum water depth (m)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 2% AEP - baseline (pre mining)

Atacama surface water assessment
Figure B.30

EMM
creating opportunities



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Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

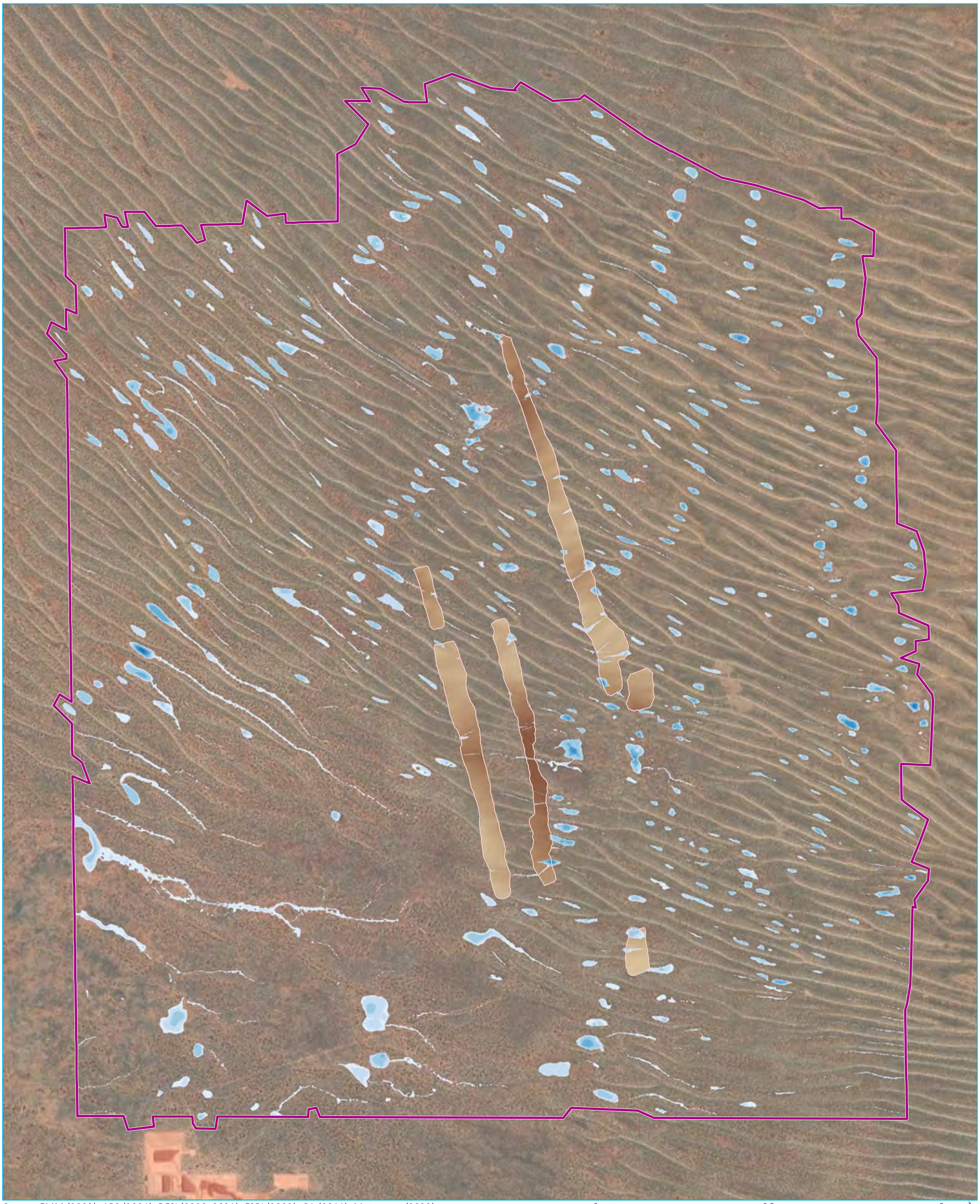
Maximum water depth (m)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

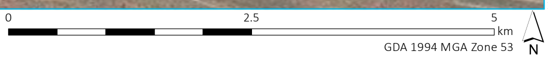
Peak design depth 2% AEP - during mining

Atacama surface water assessment
Figure B.31

EMM
creating opportunities



Source: *EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)*



\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G035_PostClosureAEP2Depth_20221102_03.mxd 2/11/2022

KEY

Model extent

Backfilled pit changed elevation

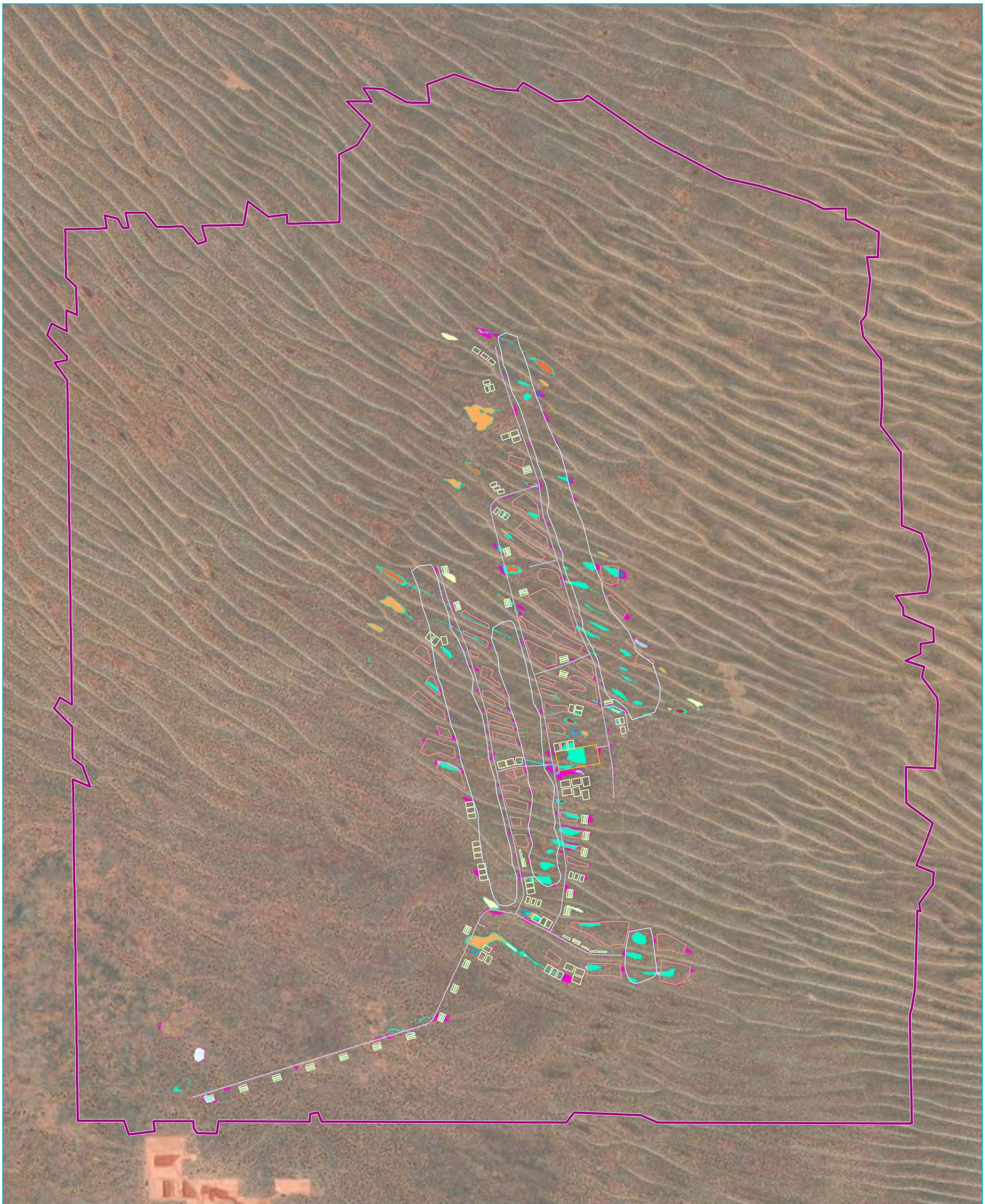
Maximum water depth (m)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3

Peak design depth 2% AEP - post closure

Atacama surface water assessment
Figure B.32

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Was wet now dry
- Was dry now wet

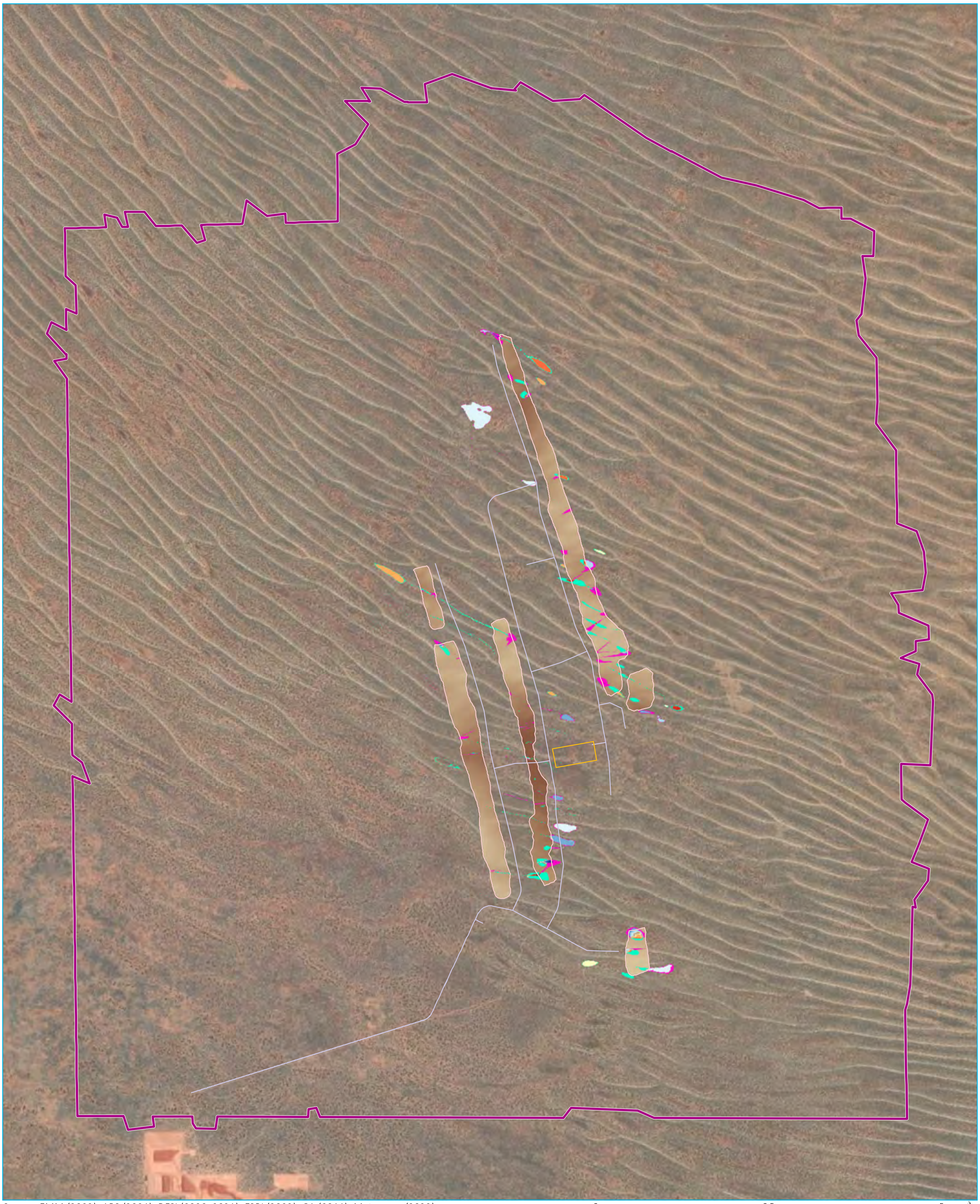
Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 2% AEP - during mining

Atacama surface water assessment
Figure B.33

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G038_ChangeAEP2DepthPostClosure_20221102_03.mxd 2/11/2022

KEY

- Model extent
- Proposed pads
- Backfilled pit changed elevation
- Proposed road alignment
- Was wet now dry
- Was dry now wet

Change in peak flood depth (m)

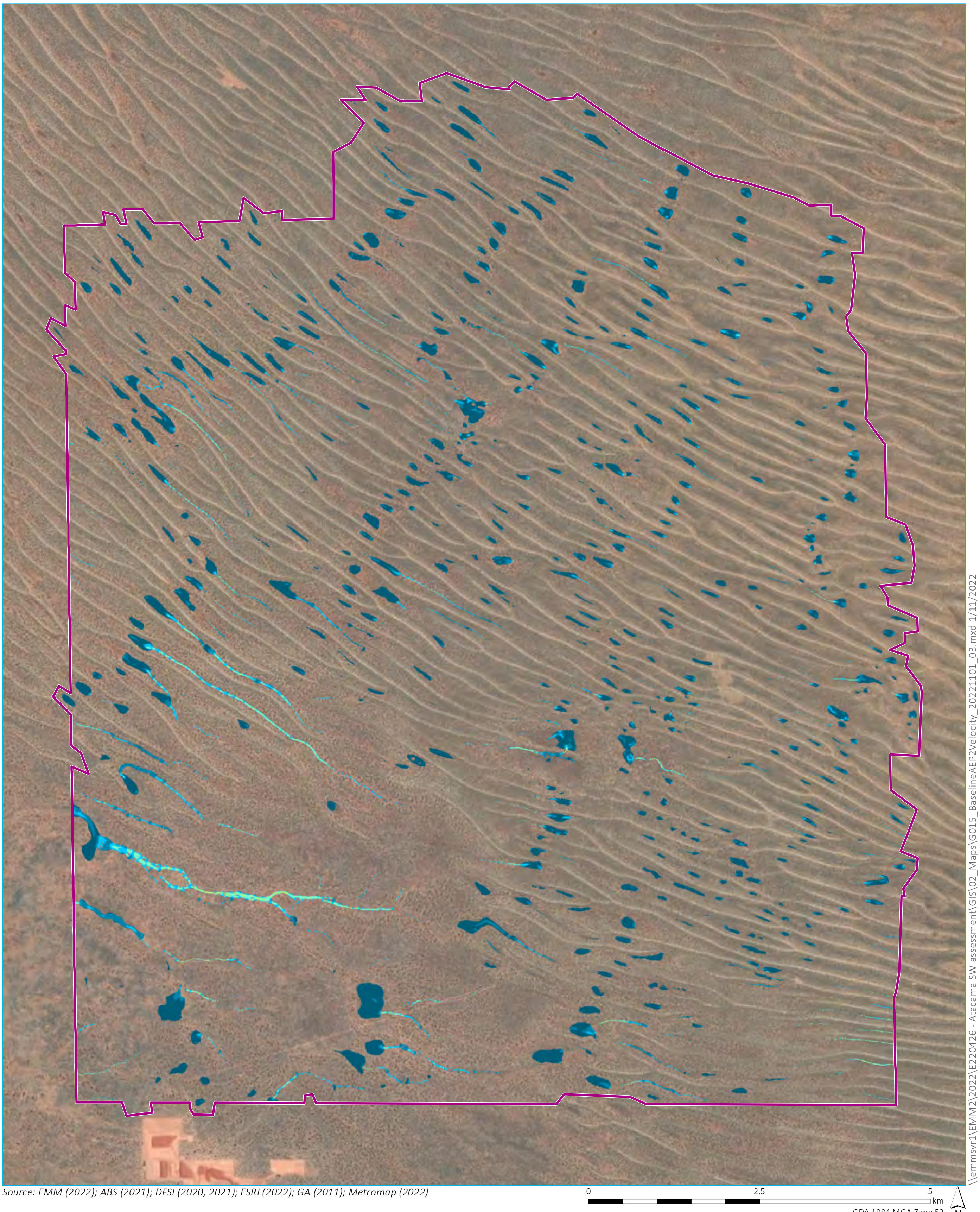
- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 2% AEP - post closure

Atacama surface water assessment

Figure B.34

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

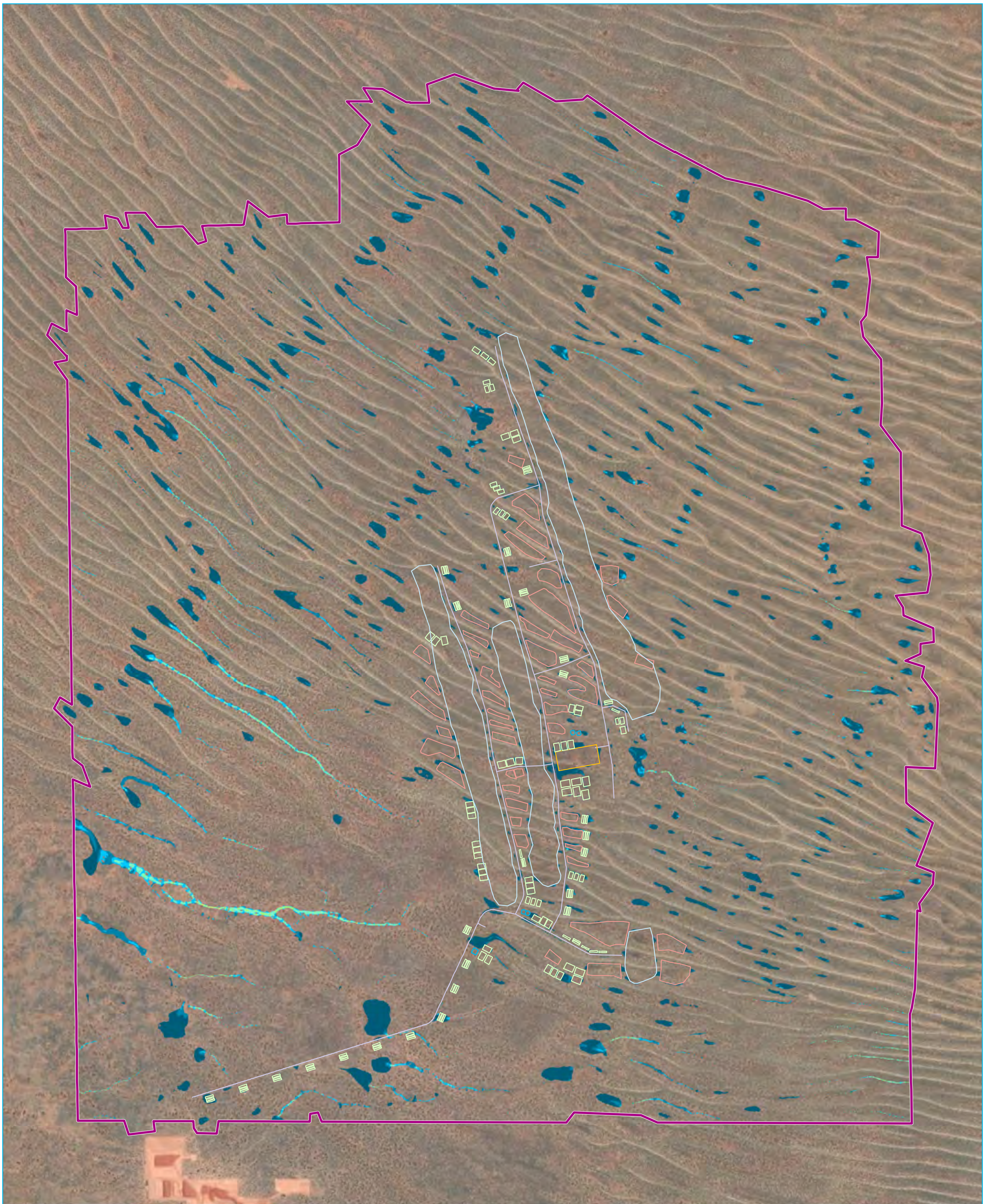
Maximum water velocity (m/s)

- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2

Peak design velocity 2% AEP - baseline (pre mining)

Atacama surface water assessment

Figure B.35



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G016_InfrastructureAEP2Velocity_20221101_03.mxd 1/11/2022

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

Maximum water velocity (m/s)

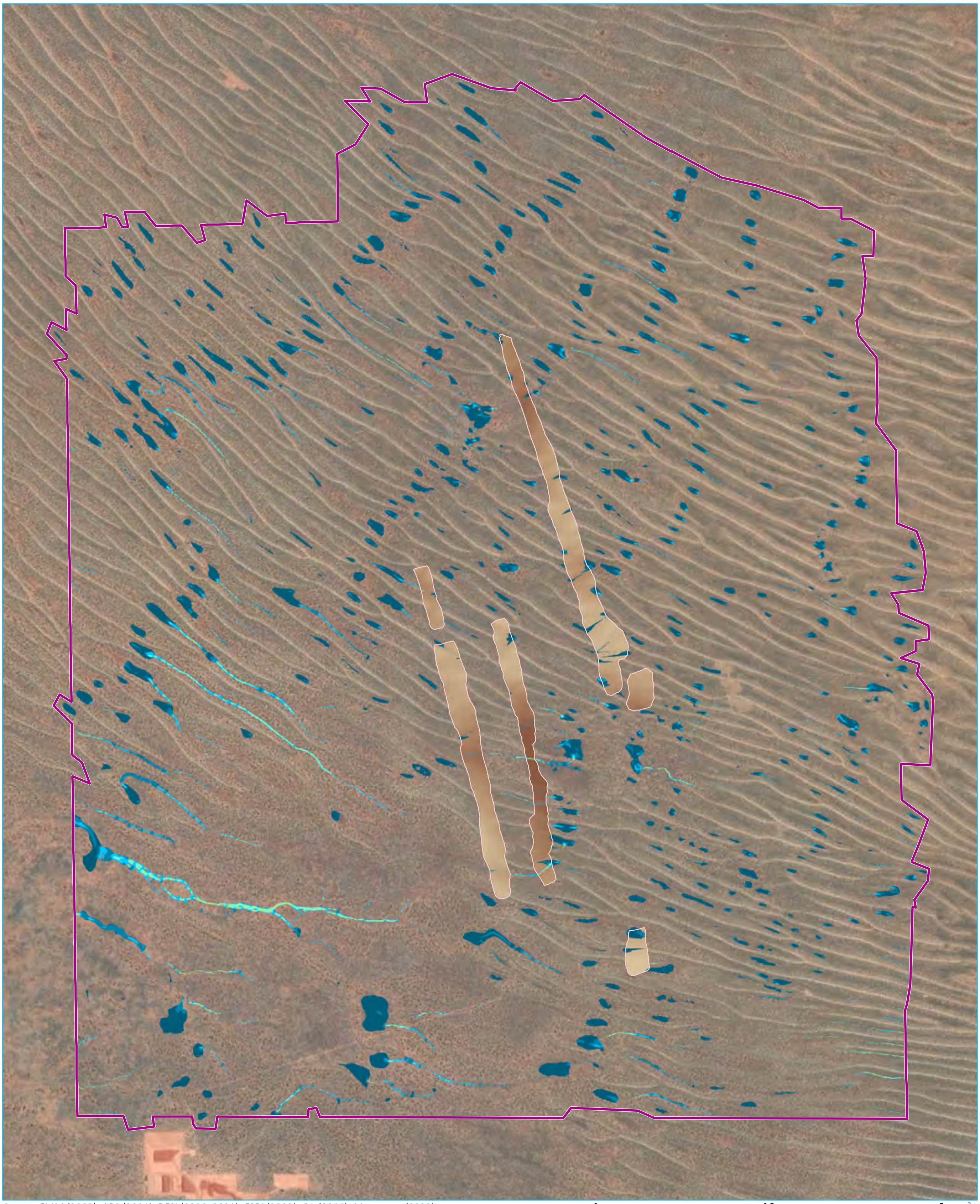
- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2

Peak design velocity 2% AEP - during mining

Atacama surface water assessment

Figure B.36

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Backfilled pit changed elevation

Maximum water velocity (m/s)

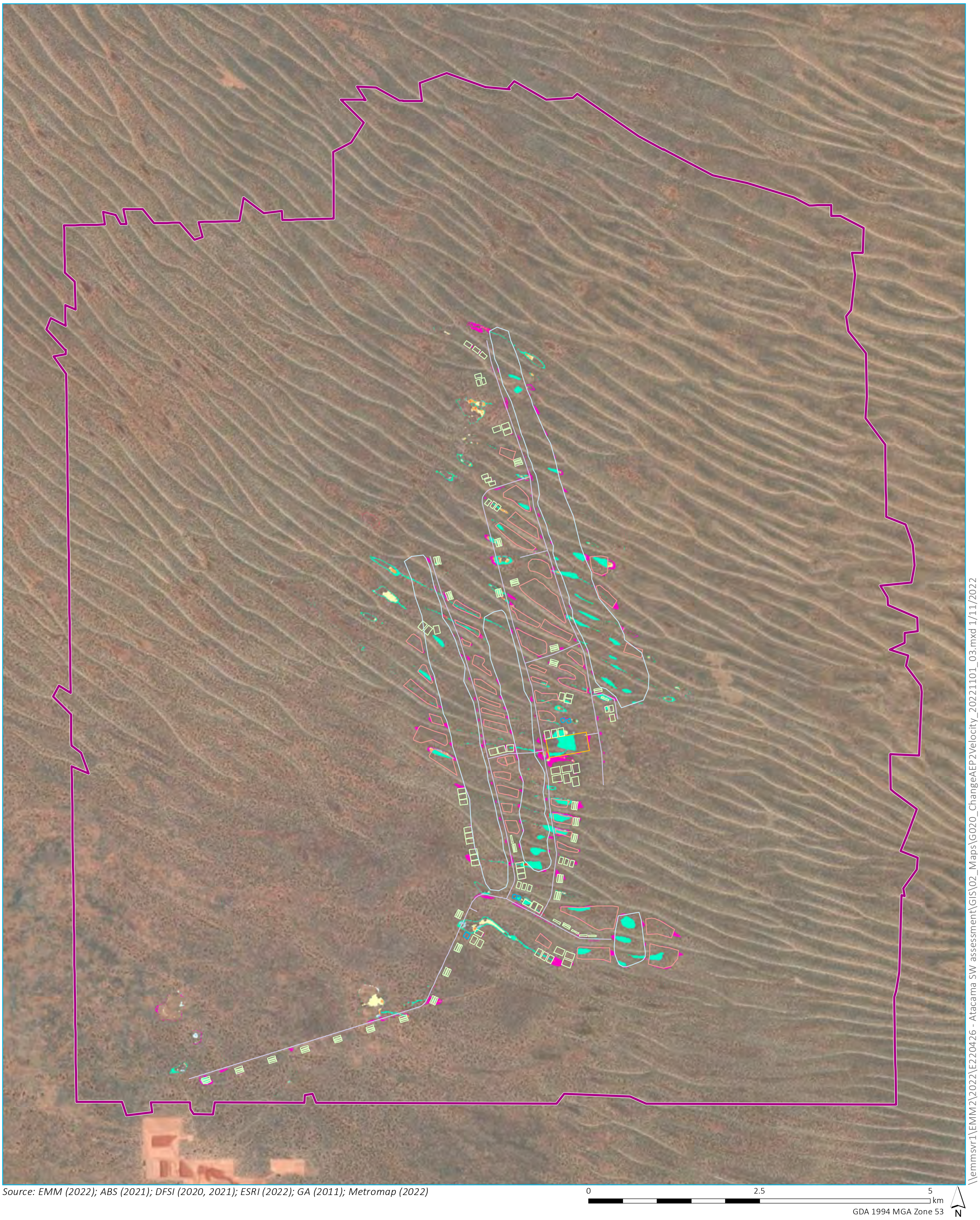
- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2

Peak design velocity 2% AEP - post closure

Atacama surface water assessment

Figure B.37

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Model extent
- Was wet now dry
- Was dry now wet

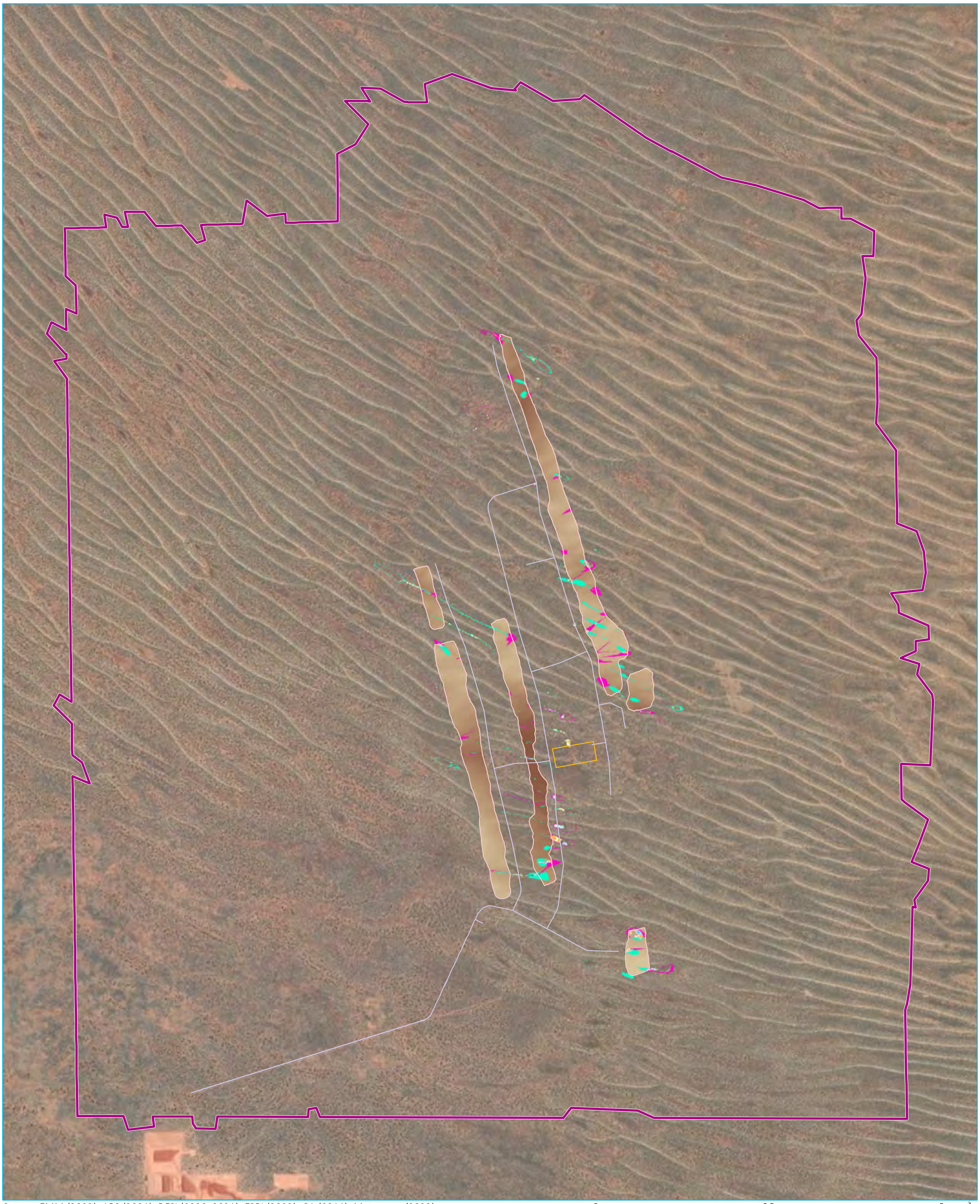
Change in peak water velocity (m/s)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1

Change in peak design velocity 2% AEP - during mining

Atacama surface water assessment
Figure B.38

EMM creating opportunities



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Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

KEY

- Model extent
- Proposed pads
- Backfilled pit changed elevation
- Proposed road alignment
- Was wet now dry
- Was dry now wet

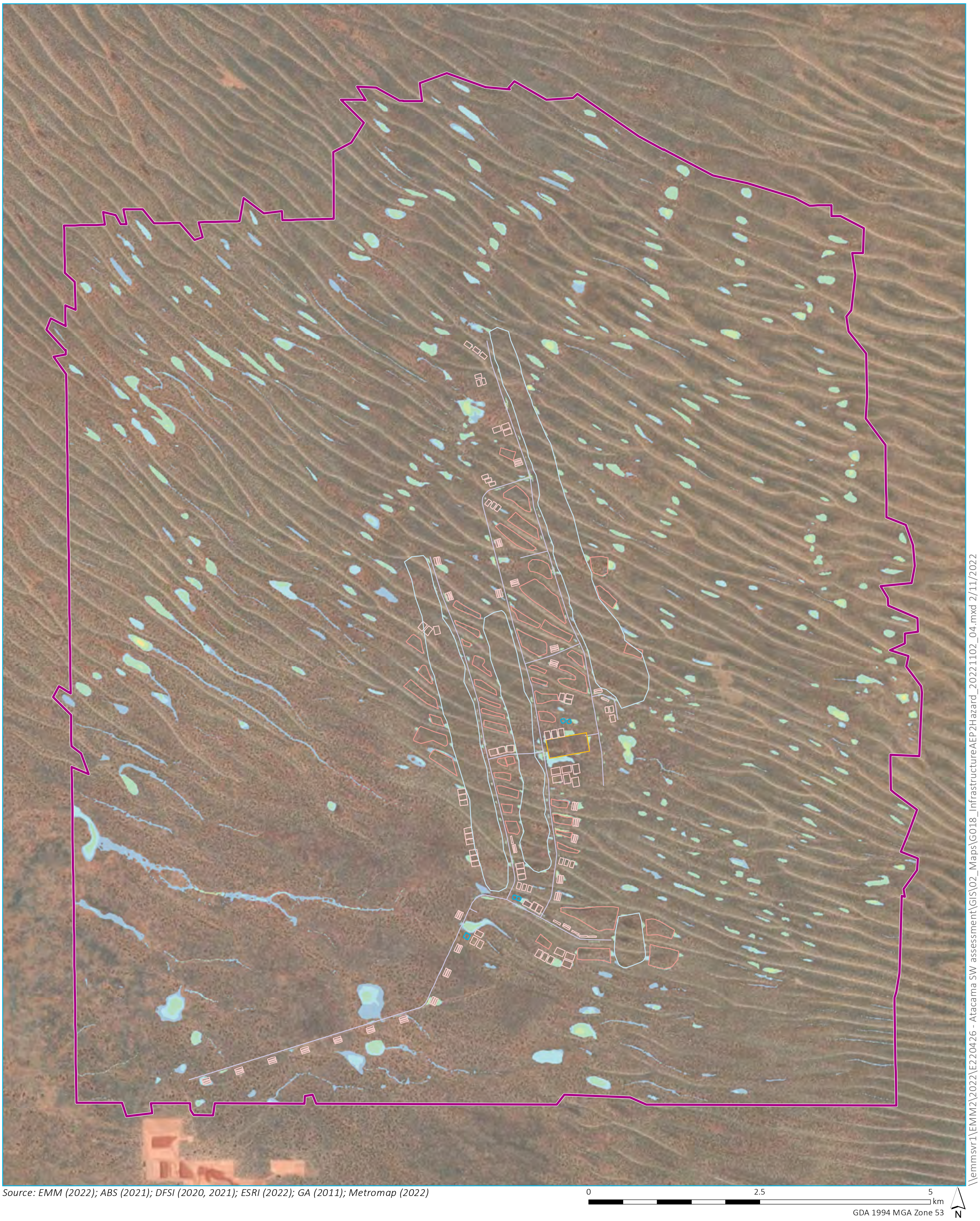
Change in peak water velocity (m/s)

- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1

Afflux - change in peak design velocity 2% AEP - post closure

Atacama surface water assessment
Figure B.39

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

Maximum flood hazard (H1-H6)

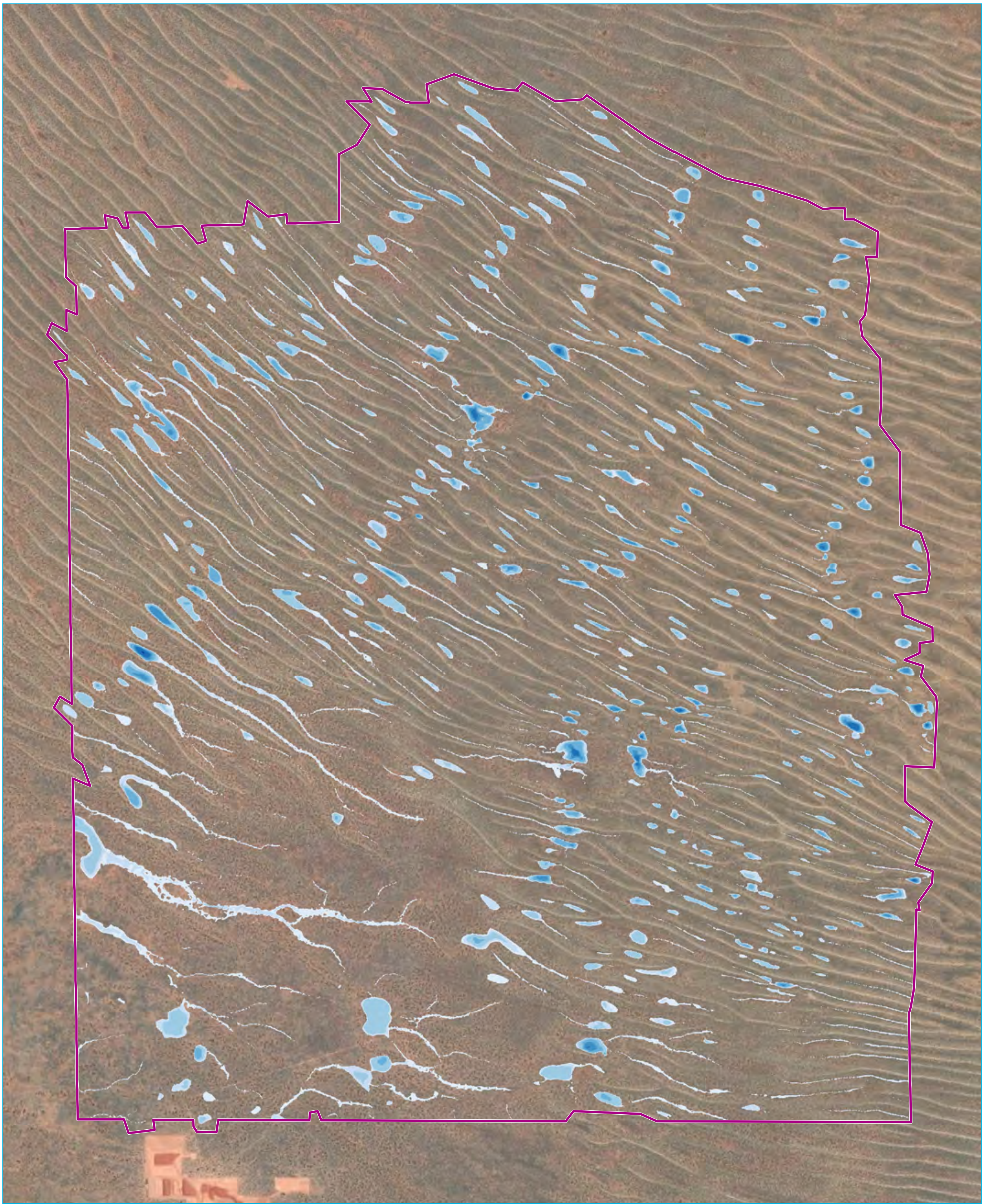
- H5
- H4
- H3
- H2
- H1

Peak design hazard 2% AEP - during mining

Atacama surface water assessment

Figure B.40

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Maximum water depth (m)

0.1 - 0.25

0.25 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

2 - 3

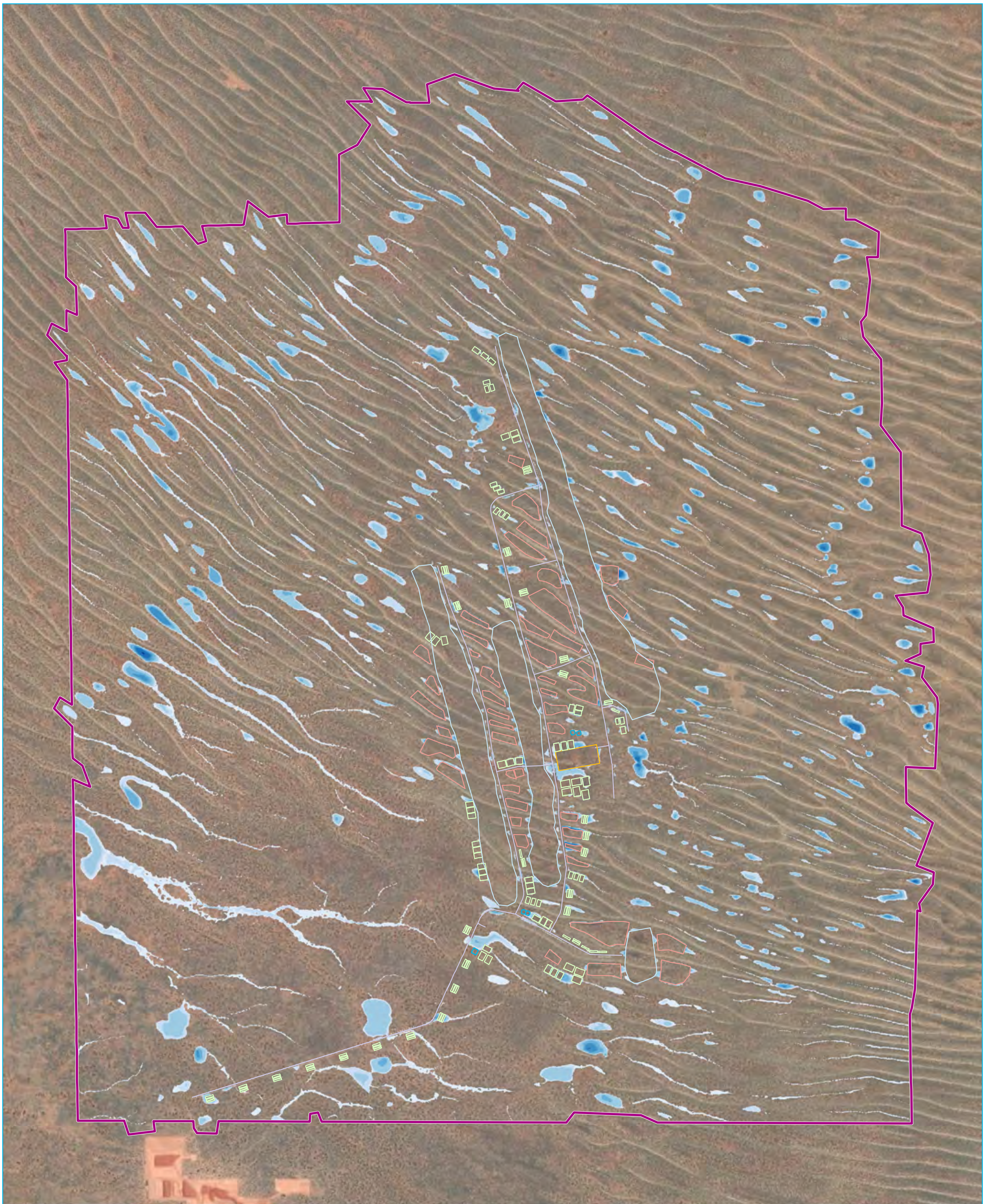
> 3

Peak design depth 0.5% AEP - baseline (pre mining)

Atacama surface water assessment

Figure B.41

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km
GDA 1994 MGA Zone 53
N

\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G022_InfrastructureAEP05Depth_20221101_03.mxd 1/11/2022

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment

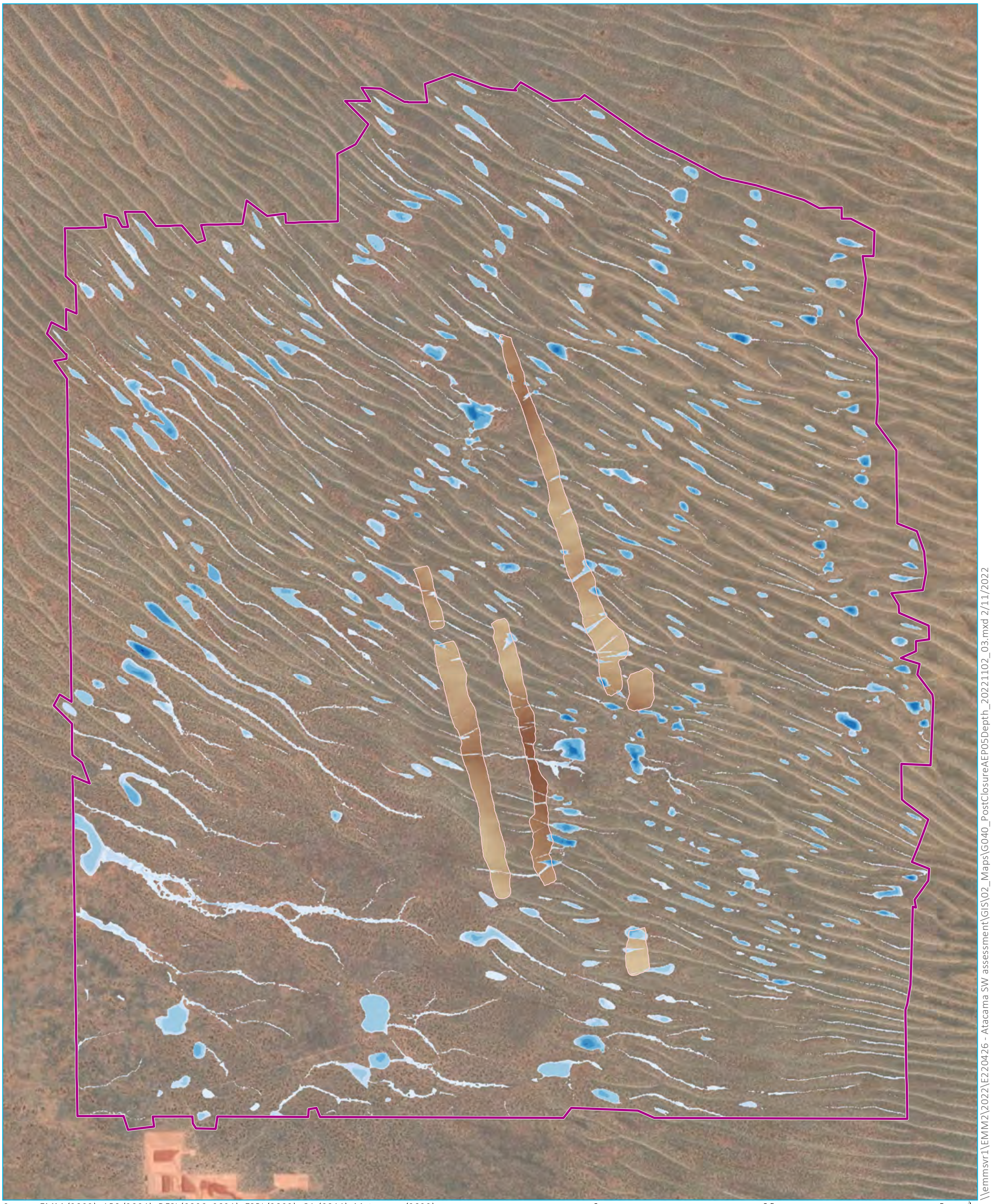
Maximum water depth (m)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

Peak design depth 0.5% AEP - during mining

Atacama surface water assessment
Figure B.42

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

KEY

Model extent

Backfilled pit changed elevation

Maximum water depth (m)

0.1 - 0.25

0.25 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

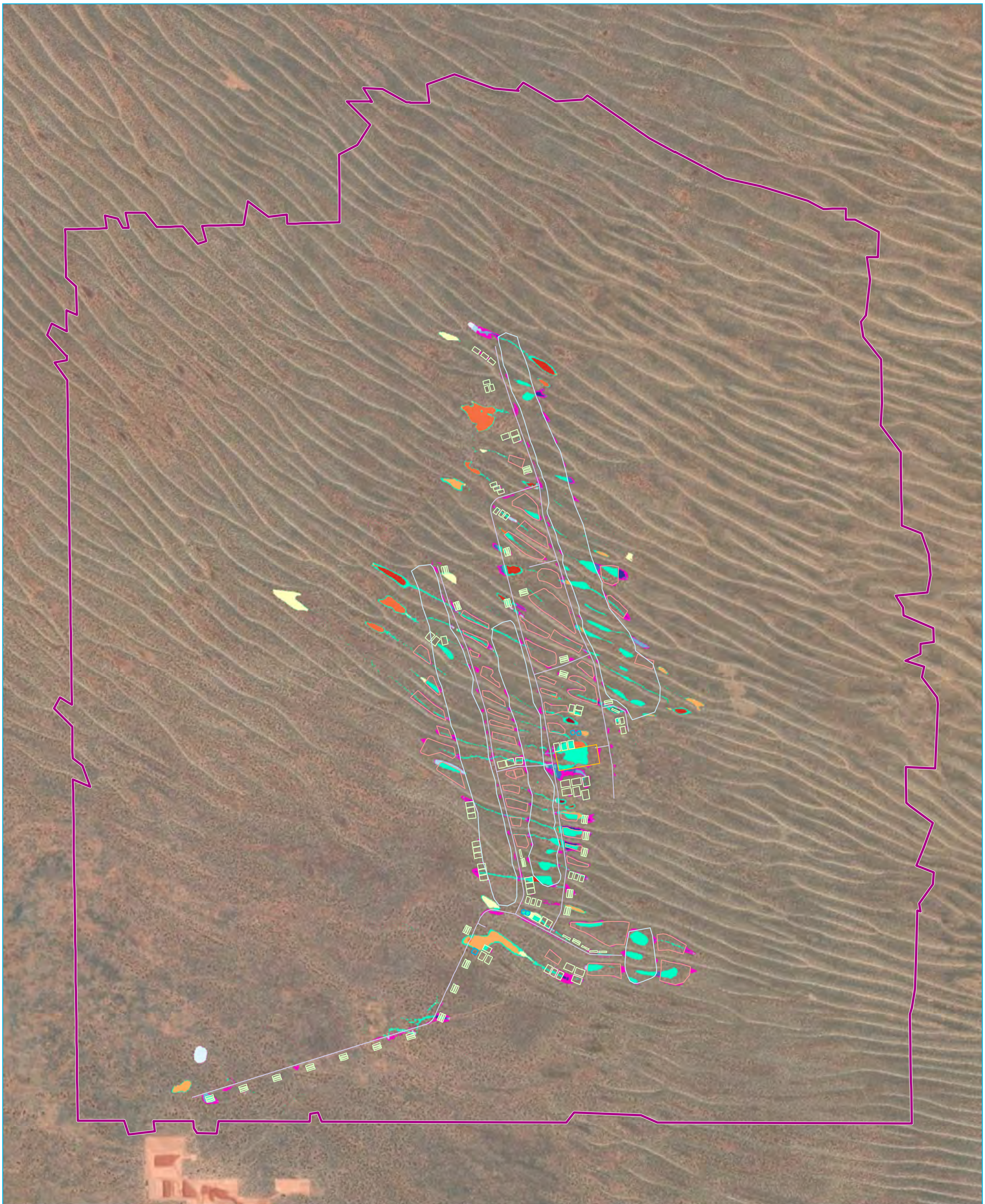
2 - 3

> 3

Afflux - change in peak design velocity 2% AEP - post closure

Atacama surface water assessment

Figure B.43



Source: *EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)*

0 2.5 5 km

GDA 1994 MGA Zone 53

N

\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G027_ChangeAEP05Depth_20221101_03.mxd 1/11/2022

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Was wet now dry
- Was dry now wet

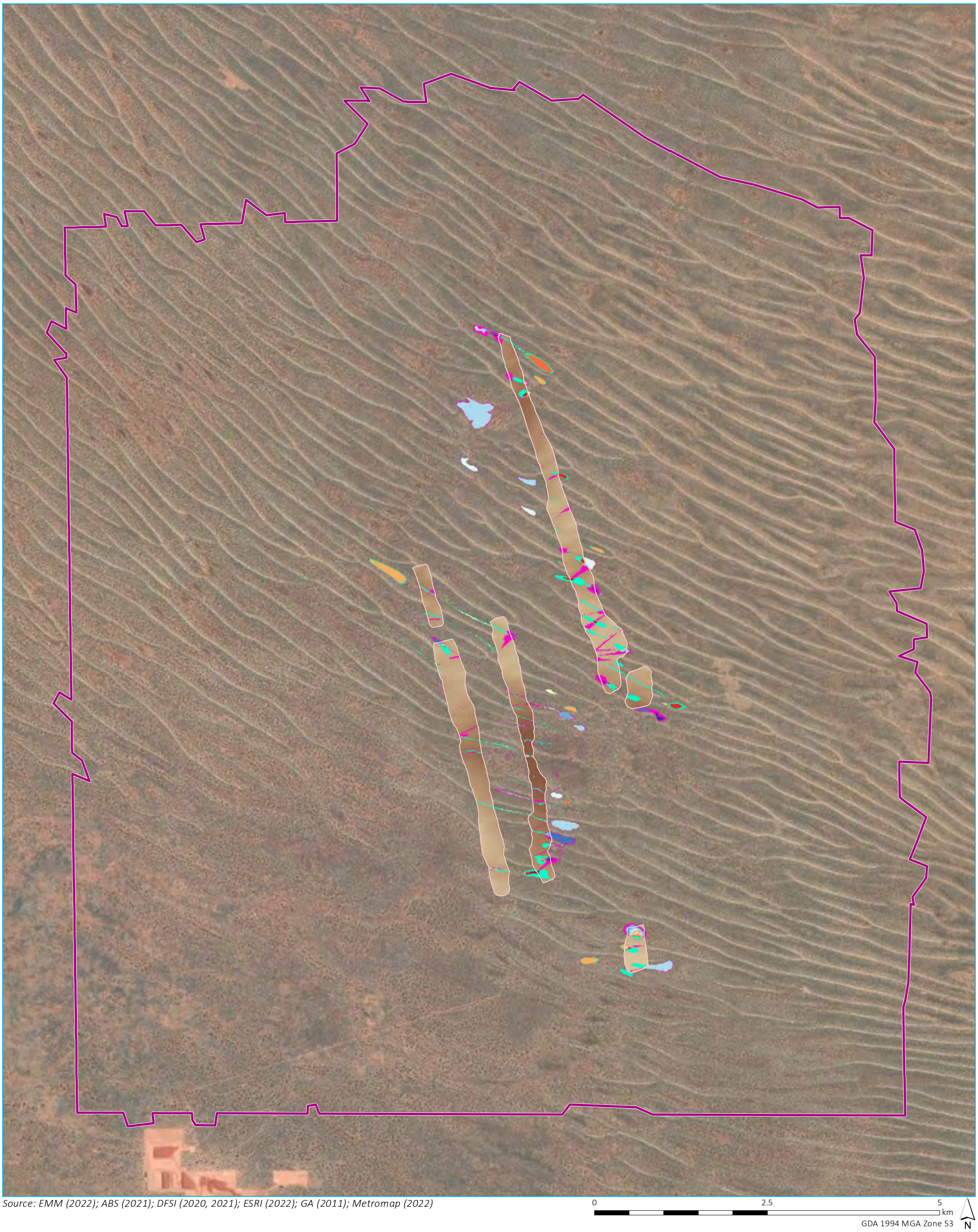
Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 0.5% AEP - during mining

Atacama surface water assessment
Figure B.44

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

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KEY

- Model extent
- Backfilled pit changed elevation
- Was wet now dry
- Was dry now wet

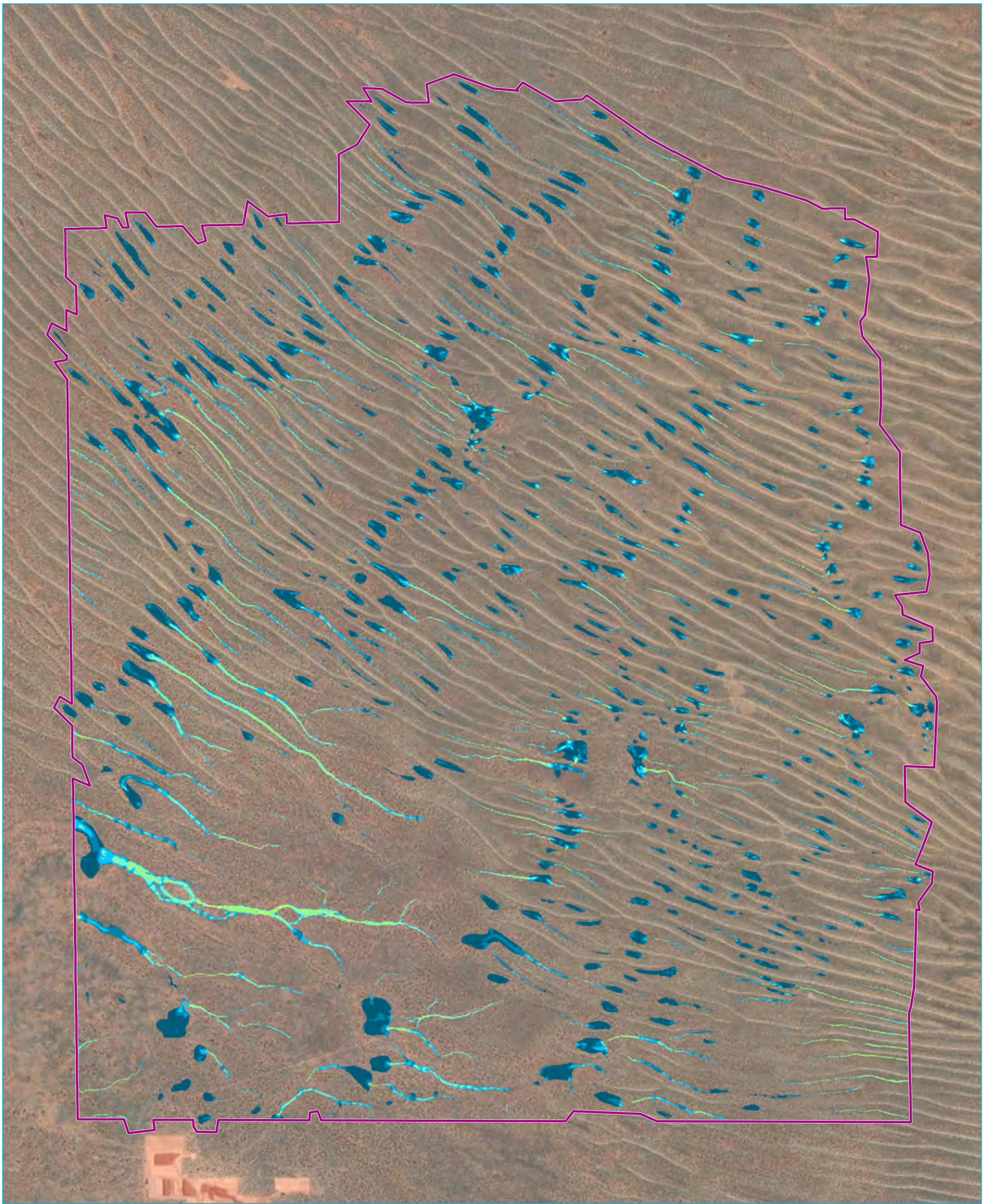
Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design depth 0.5% AEP - post closure

Atacama surface water assessment
Figure B.45

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G023_BaselineAEP05Velocity_20221101_03.mxd 1/11/2022

KEY

Model extent

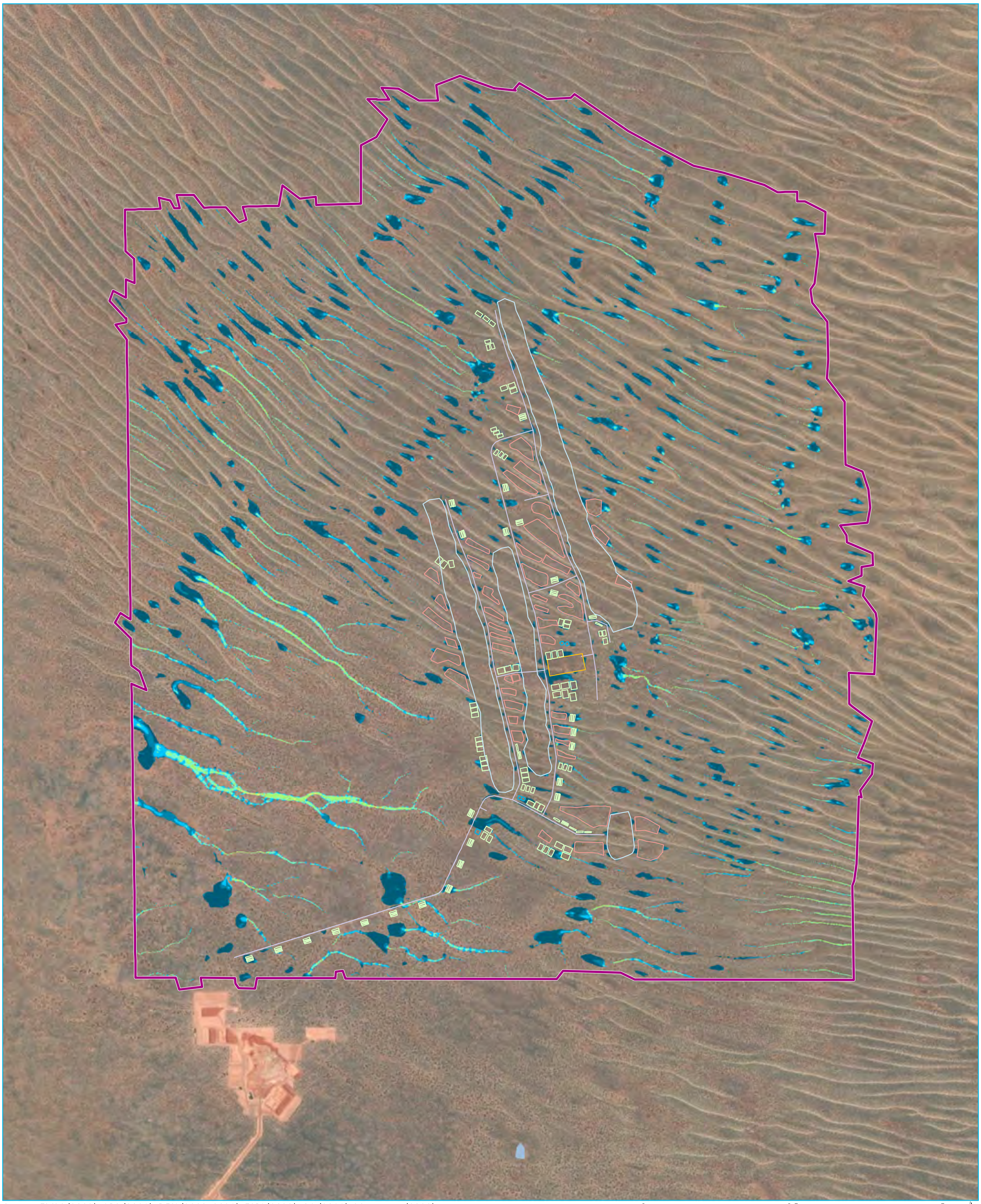
Maximum water velocity (m/s)

- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5

Peak design velocity 0.5% AEP - baseline (pre mining)

Atacama surface water assessment
Figure B.46

EMM
creating opportunities



\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G024_InfrastructureAEP05Velocity_20221101_03.mxd 1/11/2022

Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

0 2.5 5 km

GDA 1994 MGA Zone 53

N

KEY

- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Model extent
- Waterbody

Maximum water velocity (m/s)

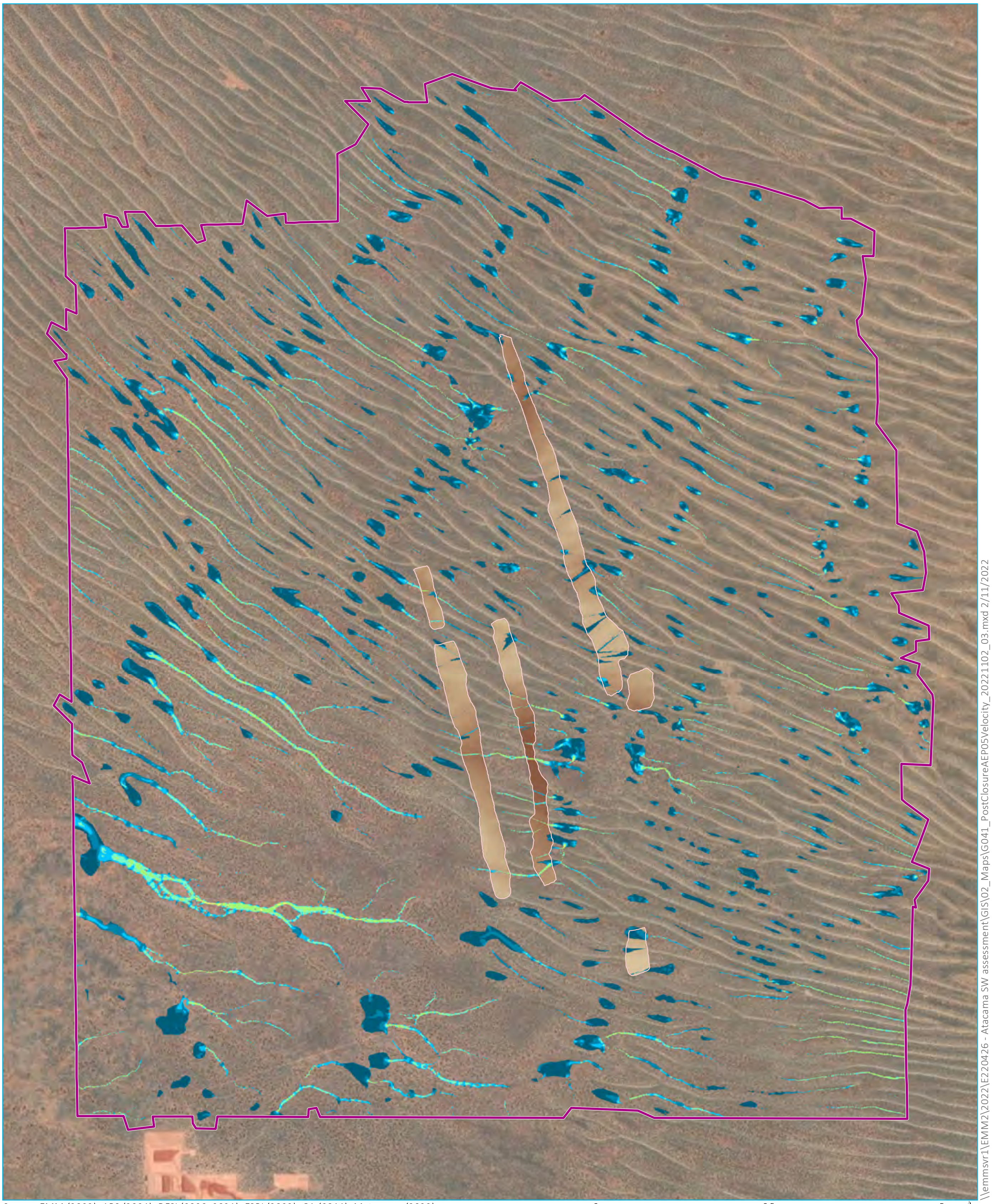
- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5

Peak design velocity 0.5% AEP - during mining

Atacama surface water assessment

Figure B.47

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

Model extent

Backfilled pit changed elevation

Maximum water velocity (m/s)

< 0.25

0.25 - 0.5

0.5 - 0.75

0.75 - 1

1 - 1.5

1.5 - 2

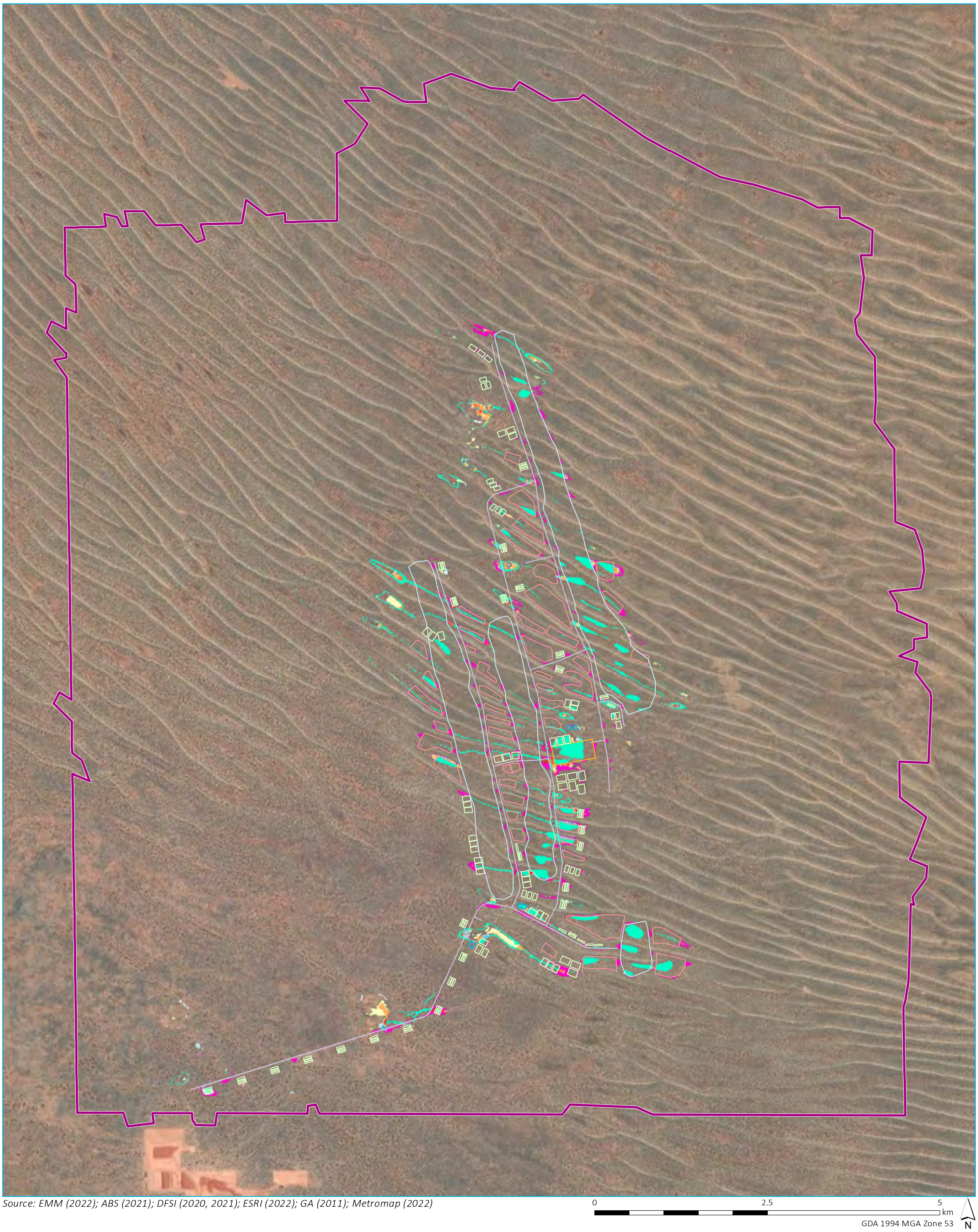
2 - 2.5

Peak design velocity 0.5% AEP - post closure

Atacama surface water assessment

Figure B.48

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

\\emmsvr1\EMM2\2022\E220426 - Atacama SW assessment\GIS\02_Maps\G028_ChangeAEP05Velocity_20221101_03.mxd 1/11/2022

KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement
- Proposed road alignment
- Was wet now dry
- Was dry now wet

Change in peak water velocity (m/s)

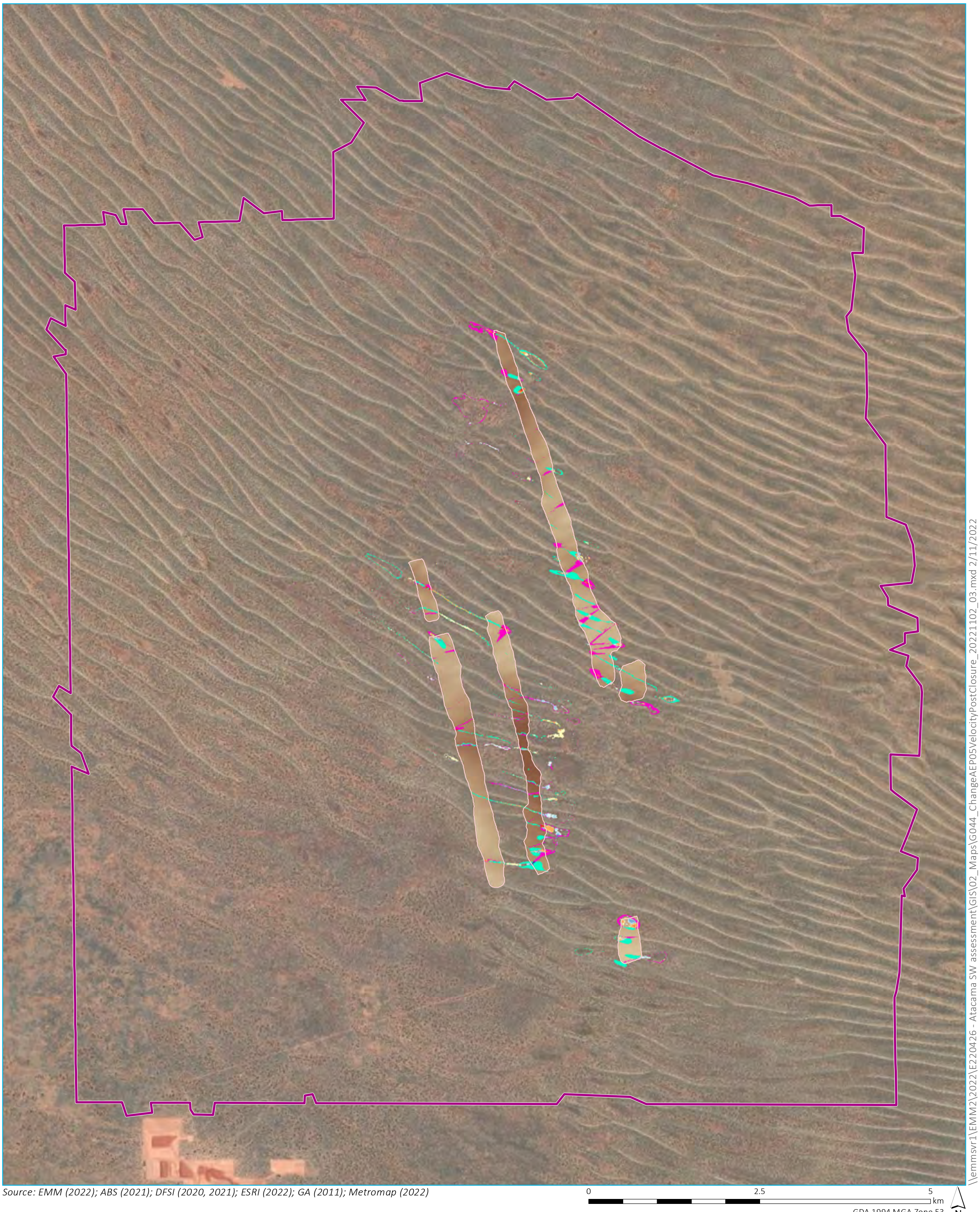
- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Change in peak design velocity 0.5% AEP - during mining

Atacama surface water assessment

Figure B.49

EMM creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2020, 2021); ESRI (2022); GA (2011); Metromap (2022)

KEY

- Model extent
- Backfilled pit changed elevation
- Was wet now dry
- Was dry now wet

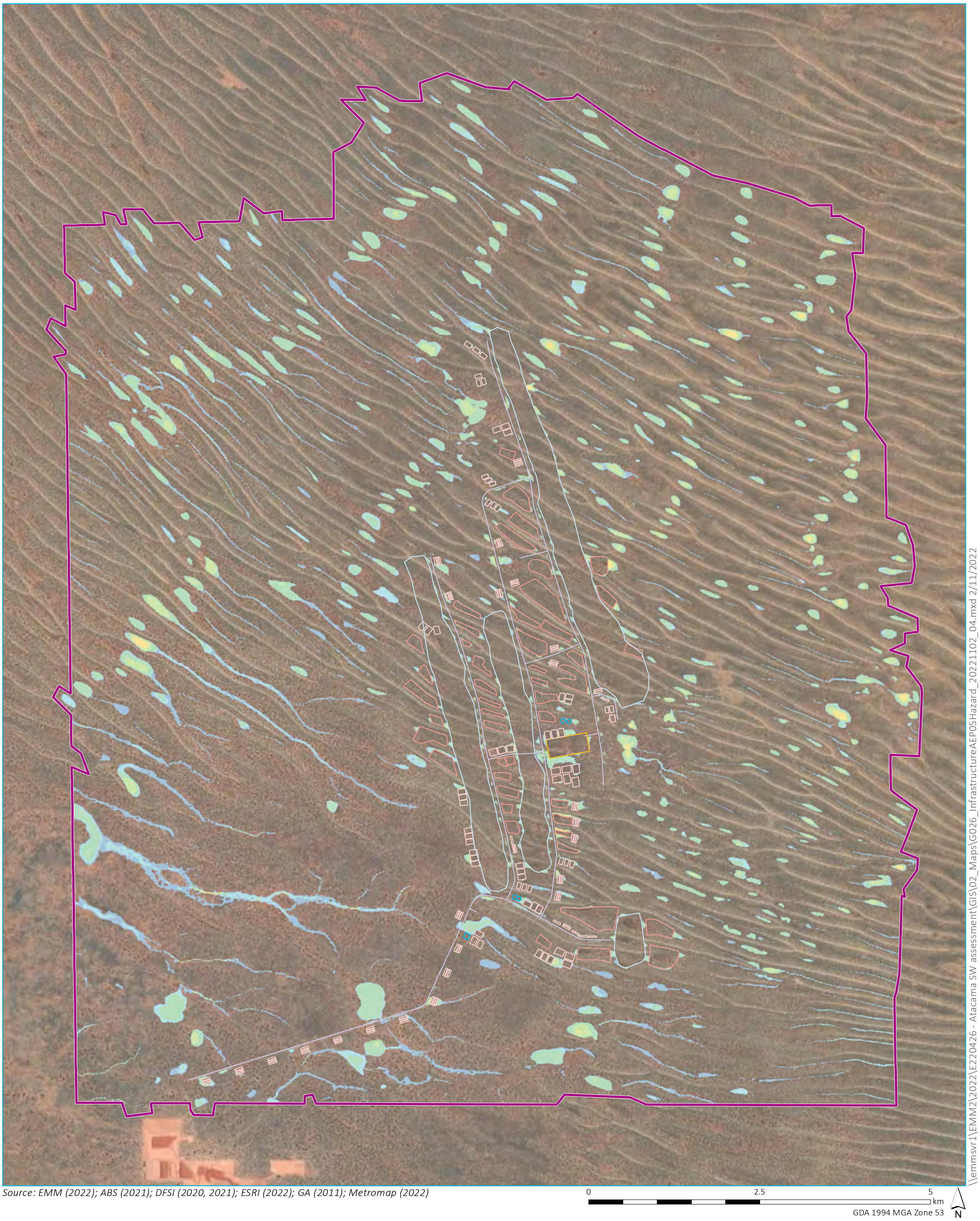
Change in peak water velocity (m/s)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Afflux - change in peak design velocity 0.5% AEP - post closure

Atacama surface water assessment
Figure B.50

EMM creating opportunities



KEY

- Model extent
- Proposed pit
- Proposed pads
- Proposed ponds
- Proposed stockpiles
- Proposed topsoil placement

Maximum flood hazard (H1-H6)

- H5
- H4
- H3
- H2
- H1

Peak design hazard 0.5% AEP - during mining

Atacama surface water assessment
Figure B.51

EMM creating opportunities

Modelling illustrated that at the proposed Atacama mine site, flooding is restricted to ponding in swales between dunes. There are no waterways in the vicinity of the pits, pads, or contractor facilities.

Pit excavation will cross a number of dune swales, and bund walls would be required to exclude ponding flood waters from the pit. The peak modelled depth adjacent to a pit bund was approximately 2.5 m for the 1% AEP (1 in 100) storm, increasing to approximately 2.8 m in the 0.5% AEP (1 in 200) storm. Following mine closure, bund walls would be removed, and the pits surfaces would be remediated to become low points within the dune system.

A number of unnamed ephemeral creeks lie between the proposed Atacama site and the existing J-A site, which flow from east to west after rain, terminating at Lake Ifould. These creeks would be crossed by the proposed haul road between Atacama and existing J-A. At crossing points, flows are expected to be relatively minor, with depths of less than 0.2 m and peak velocities of around 0.6 m/s (Figure 4.4) reported by the model. Design of culverts for these crossing locations would be undertaken according to published guidelines utilising the design flow results extracted from the flood model.

During mining and post closure, changes to the flood regime would be restricted to the dune swales in which excavation or construction occurs. Within approximately 2-3 km away from the mine site, the flood regime is not affected by the mine.

The landscape would remain wet for a period following a storm event, particularly in the terminal pans where water pools and slowly evaporates/infiltrates following storm events. If another storm event occurs while the landscape is wet, rainfall losses may be lowered (as the landscape has less capacity to store water) and increased peak flows and depths may be expected (section B.5 includes results of sensitivity runs testing the sensitivity of depth results to changed IL and CL values).

B.5 Sensitivity

B.5.1 Overall model uncertainty and sensitivity

A standardised qualitative set of descriptors of model uncertainty and sensitivity, as summarised in Table B.10, has been applied to the two TUFLOW models to allow readers unfamiliar with the modelling software and methods to contextualise the statements made regarding data sources, methods, and reliability of outputs.

Table B.10 Standardised model sensitivity descriptors

Ranking	Descriptor
Input uncertainty	
A	• Extensive data • Field verified • Limited use of assumptions
B	• Limited data • Use of industry recognised or benchmarked data • Some assumptions
C	• Numerous assumptions • Limited (if any) verification
Software/methodology uncertainty	
A	• Recognised method and application • Industry standard approach
B	• New method or new application of existing method • Not industry recognised
C	• *ad hoc* methodology • Informal approach
Results sensitivity	
A	• Predictions not sensitive to input variation
B	• Some sensitivity of input variations
C	• Predictions highly sensitive to input variations • Sensitivity not studied/unknown

The uncertainty and sensitivity of flood modelling inputs and results are described below and summarised in Table B.11.

- Topographic data was assigned a ranking of 'A' as this data was collected at a high resolution across the mine site.
- Rainfall IFD data was assigned 'B' as it is industry recognised, benchmarked data from the BoM.
- Although it is industry recognised, data from the ARR Data Hub was assigned a 'C' because it has a high level of inherent uncertainty and is based on numerous assumptions, with limited verification – especially in the arid zone of South Australia.

- Initial and continuing losses was assigned a 'C' as it is based on numerous assumptions and there is verification from only one runoff event, using photographical evidence and no measured water depth or velocity data.
- The material roughness was assigned 'C' as it is based on site photos and recognised industry data without gauged data for model calibration.
- The TUFLOW modelling and results processing followed and industry standard approach and is therefore rated 'A'.
- ARR design storm methodology was ranked 'A' because the methodology is accepted as industry standard.

For the intended purpose of describing flood characteristics across the mine site, the model is considered adequate, with a 'B' sensitivity rating. For the purpose of detailed infrastructure design, the results are less certain, with a 'C' sensitivity rating. However, these results will be adequate when combined with conservative design principals.

A higher degree of certainty in modelled results could be achieved in the future via:

- on-site field infiltration testing to improve confidence in the rainfall loss inputs; and
- the installation of site-based stream gauging stations to update/calibrate this model following future rainfall runoff events.

Table B.11 Hydraulic model (TUFLOW) uncertainty and sensitivity for this study

Item	Ranking
Inputs	
Topographic information	A
Rainfall IFD data	B
ARR Data Hub	C
Initial and continuing losses	C
Material roughness	C
Hydraulic structures	B
Method	
Model grid size and use of SGS	A
ARR design storm methodology	A
Results	
Flow rates	C
Mapped peak flood results	B

B.5.2 Sensitivity run results

A set of sensitivity runs was undertaken to test the sensitivity of peak design depth to changes in rainfall losses, using the 12 hour duration storm and temporal pattern TP05 (with a peak depth closest to the mean peak depth across the ensemble of storms). Sensitivity testing was undertaken for: IL of 0 mm, 15 mm, 30 mm; and CL of 1 mm/hr, 2 mm/hr and 3 mm/hr.

For reporting location RP_Depth_4, Figure B.52 shows the range of peak design depths for the 1% AEP storms with durations of 1 to 24 hours with the results of the sensitivity runs added.

These results show that:

- lower infiltration causes increased depths (up to approximately +200% at this location);
- below 12 hours, the depth result at this location was most sensitive to IL. Less rainfall lost at the start of the storm burst has a greater impact on the peak depth for shorter storm bursts; and
- above 12 hours, the depth result at this location was much less sensitive to IL and more sensitive to CL. More rainfall is converted to runoff over a longer period of time for longer storm bursts.

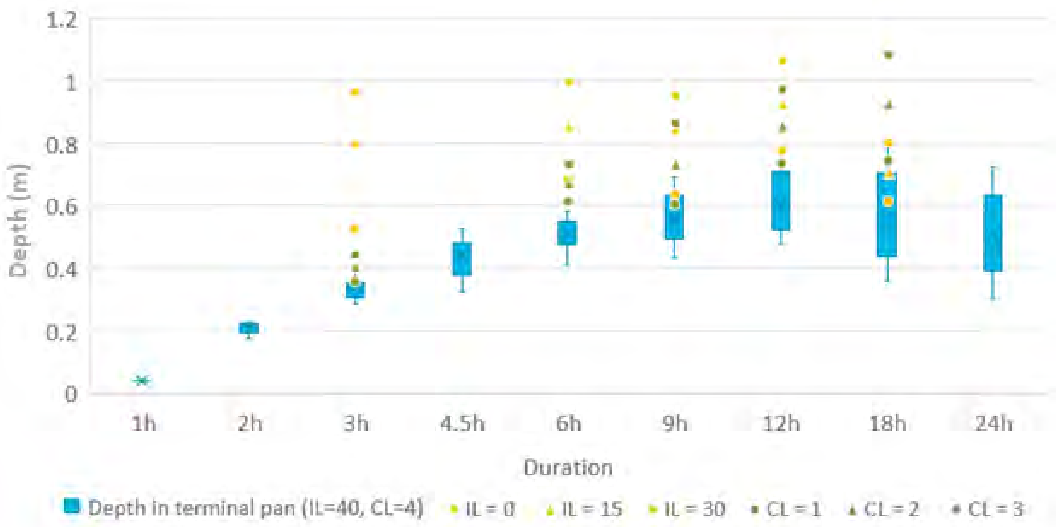


Figure B.52 Peak design depth results at RP_Depth_4 (1% AEP) with sensitivity results

In certain conditions (eg wet antecedent conditions which saturate the catchment) flooding could be greater than at other times. Engineering design should thus consider the effect that greater depths might have on the design, eg: would a depth of double the design depth cause the infrastructure to fail? If so, would the failure be simple to remedy or cause significant damage? Could the failure be averted by a minor change that increases flood immunity or robustness?

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Atacama Project

Social Impact Assessment

February 2023

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Atacama Project
Social Impact Assessment
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	Name	Date	Signature
Prepared by:	Carla Martinez; Caitlin Treacy	10/02/2023	
Reviewed by:	Stephanie Luyks; Danielle van Kampen	10/02/2023	
Approved by:	Stephanie Luyks	10/02/2023	

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Glossary

A1	Eyre Highway
ABS	Australian Bureau of Statistics
ANTS	Agreements, Treaties and Negotiated Settlements
AQIA	Air Quality Impact Assessment
CO	Carbon Monoxide
CHMP	Cultural Heritage Management Plan
Community	Anyone affected by or interested in the Project, including individuals, community groups, Aboriginal and Torres Strait Islander communities, culturally and linguistically diverse communities or, stakeholder groups.
Combined impacts	Social changes brought up due to extension of Jacinth Ambrosia life of mine and operation of Atacama Project.
Cumulative impacts	Incremental social changes that may result due to the interaction between the Project and other large-scale projects within the study area.
DAWE	Department of Agriculture, Water and the Environment
DEM	Department of Energy and Mining
DEW	Department of Environment and Water
Direct impacts	Social changes resulting from the construction of the Project.
EAP	Employee Assistance Program
EPA	Environment Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act 1999
EIA	Ecology Impact Assessment
ERIA	Environmental Radiation Impact Assessment
FIFO	Fly-in-Fly-Out
FTE	Full Time Equivalent
FWC	Far West Coast Aboriginal groups, including Mirning Peoples, Wirangu Peoples, Kokatha Peoples, The descendants of Edward Roberts, Yalata Peoples and Maralinga Tjaratja (Oak Valley) Peoples
FWCAC	Far West Coast Aboriginal Corporation
GP	General Practitioner
HMC	Heavy Mineral Concentrate
ICMM	International Council on Mining and Metals
ICSEA	Index of Community Socio-Educational Advantage

ILOC	Indigenous Locations
ILUA	Indigenous Land Use Agreement
Iluka	Iluka Resources Pty Ltd
IPA	Indigenous Protected Area
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
J-A	Jacinth-Ambrosia Mine
LGA	Local Government Area
Local area	The Ceduna Local Government Area (LGA), which encompasses the town of Ceduna and surrounding localities including Thevenard, Smoky Bay, Denial Bay, and Koonibba Key townships and communities outside the Ceduna LGA, including Yalata, Penong, Maralinga (Oak Valley), and Scotdesco
MLA	Mining Lease Application
MNES	Matters of National Environmental Significance
MLP	Mining Lease Proposal
MUP	Mining Unit Plant
NO_2	Nitrogen Dioxide
NPWS	National Parks and Wildlife Service
NSW DPE	New South Wales Department of Planning and Environment
NTMA	Native Title Mining Agreement
OCA	Outback Communities Authority
PEPR	Program for Environment Protection and Rehabilitation
Project	The Atacama Project
Project area	The Atacama Project disturbance footprint
Q1	Quarter 1
RDAEP	Regional Development Australia Eyre Peninsula
Regional area	Eyre Peninsula and South West Region SA3
RNTBC	Registered Native Title Body Corporate
SA	South Australia
SA3	ABS Statistical Area Level 3
SAL	Social Areas and Localities
SIA	Social Impact Assessment
SIA Guideline	NSW Department of Planning and Energy 2020 SIA Guideline

SMP	Social Management Plan
Stakeholder group	A group or organisation that represents several people with an interest in a project
TIA	Traffic Impact Assessment
Unincorporated area	An area that is not governed by a local municipal council or corporation.

Executive summary

Overview of proposal

About this report

Iluka Resources Limited (Iluka) are currently preparing a Mining Lease Application (MLA) for the development of the proposed Atacama Mining Lease (ML) into an operational high-grade mineral sands mine, in close proximity to the currently operational Jacinth-Ambrosia (J-A) mine. The proposed Atacama Project (the Project) is expected to encompass a 2,138-hectare footprint (including a 50 m buffer around the project limits) located in the Yellabinna Regional Reserve, approximately 800 km from Adelaide and 270 km from the Port of Thevenard, in South Australia (SA). This social impact assessment (SIA) is a technical report to support the Project's MLA.

This report provides a description of the existing social environment, to establish a baseline for identifying the type and level of change that could be experienced in the locality. This report also identifies the potential positive and negative impacts on local communities in the local and regional areas from the Project during construction, operation and closure, as well as cumulative impacts during construction and operations. The Project has been assessed as an extension of the existing J-A, and the combined effects of J-A operations have been considered throughout this report.

Finally, this report presents a plan for mitigation, management and monitoring of potential adverse social impacts and the enhancement of positive impacts.

The SIA was prepared in accordance with, and guidance from the South Australia Mining Regulations 2020 (Terms of Reference 006 (TOR006) – *Mineral mine lease/licence applications – Notice under Section 36 of the Mining Act*) and Minerals Regulatory Guidelines (MG2a) – *Preparation of a mining application for metallic and industrial minerals*) and, in absence of SIA guidelines in SA, the 2021 *Social Impact Assessment Guideline for State Significant Projects* of the New South Wales Department of Planning and Environment (NSW DPE).

Summary of existing environment

J-A is considered the world's largest zircon mine, and one of the major producers of Heavy Mineral Concentrate (HMC) in South Australia. Mining represents 6.2% of direct employment across the Eyre Peninsula and South West Region, and accounts for 3.2% of employment in Ceduna.

The Ceduna Local Government Area (LGA) encompasses the town of Ceduna and surrounding localities including Thevenard, Smoky Bay, Denial Bay, and Koonibba. The LGA covers a total area of 5,427 km^2 and has a total population of 3,505. Some of the key characteristics of Ceduna LGA are:

- the majority of residents (78%) are Australian born and approximately 25% of the LGA's residents identify as Aboriginal and/or Torres Strait Islander
- the most common language spoken at home (other than English) is Pitjantjatjara (2.1%)
- the Far West Coast (FWC) Aboriginal Group are acknowledged as the Traditional Owners of lands and waters in the Ceduna LGA and surrounds, and the Far West Coast Aboriginal Corporation (FWCAC) are the Registered Native Title Body Corporate (RNTBC) for the region
- between 2001 and 2016, the Ceduna LGA experienced a population decrease of 7.8%, however from 2016 to 2021 the population increased slightly by 3%
- more than half (59%) of residents in the Ceduna LGA work full-time and 29% work part-time
- Ceduna LGA has an Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) decile rating of 2, which indicates that the Ceduna LGA is one of the more disadvantaged LGAs in Australia.

Summary of social impacts

The continuity and enhancement of existing controls, in addition to the implementation of new measures, will bring the impacts identified as High and Very High to a Medium and Low level of significance, and in some cases, bring High benefits to a Very High level of significance. Mitigation measures suggested including a Social Management Plan in order to establish the ongoing monitoring and evaluation of social impacts with an adaptive management approach to identify any emerging impacts.

Construction and operations

The potential positive social impacts during construction and operation of the Project are as follows:

- increased employment opportunities for local residents
- increased local procurement and business opportunities
- enhanced community cohesion, wellbeing and active lifestyles as a result of the Iluka sponsorship program
- increased employment, education and business opportunities for FWC people
- increased organisational capacity of FWCAC and
- increased local infrastructure accessibility.

Four pre-mitigated High or Very High negative social impacts were identified to potentially occur during construction and operation of the Atacama Project, which would all be reduced to a medium level of significance given the continuation and implementation of suggested measures. The negative social impacts with a Medium residual significance are summarised below, with all other construction and operation impacts receiving a Low residual impact rating:

- diminished wellbeing amongst Indigenous employees
- disturbance or damage to Aboriginal material cultural heritage
- impacts to Aboriginal cultural landscapes and values
- impacts to the landscape and associated aesthetic values.

Closure

The potential social impacts with a Medium residual significance rating that may occur during closure of the Atacama Project are summarised below:

- detrimental effects on local livelihoods due to lower remuneration in alternative employment and drop-in economic activity in local townships
- changes to community wellbeing and cohesion due to a decline of active workforce and families, increased welfare dependency and loss of sponsorships
- deterioration of Aboriginal outcomes due to fewer employment and training opportunities, as well as reduced FWCAC revenue
- reduced accessibility to services, goods and infrastructure as a result of increased prices
- permanent changes to landscape affect aesthetic values of local communities, FWCAC and visitors to Yellabinna Parks.

Summary of impact management measures

Iluka would be responsible for continuing to implement existing J-A controls and develop new social impact mitigations and enhancement plans during pre-construction, construction, operation and closure of the proposal.

Iluka will continue and enhance where necessary the following existing J-A controls:

- local employment programs
- communication with key stakeholders
- social investment mechanisms
- Employee Assistance Program (EAP) and mental health awareness training
- volunteering program
- cultural awareness training
- Cultural Heritage Management Plan (CHMP) and Heritage Discover and Clearance Procedure.

In addition, Iluka will implement the following new controls:

- local procurement plan
- road safety campaign
- cultural provisions for all Indigenous employees
- enhance rehabilitation by actively involving and consulting with FWCAC members
- avoid use of private rental housing during construction
- monitor local health service capacity during construction
- site visits to rehabilitated land.

The following measures are proposed in anticipation of mine closure:

- dependency assessment
- pre-closure social investment strategy
- pre-closure and closure Community and Stakeholder Engagement Plan
- support FWC businesses in transition
- support financial planning of the FWCAC
- support FWCAC in adopting the management of Aboriginal cultural heritage at the Project site
- mine infrastructure audit and repurpose assessment
- site visits to rehabilitated land.

1 Introduction

Iluka Resources Limited (Iluka) has identified a new opportunity to develop a high-grade mineral sands deposit located within the Yellabinna Regional Reserve, approximately 800 km from Adelaide and 270 km from the Port of Thevenard, known as the Atacama Project (the Project). The Project is located approximately 5 km from the existing Jacinth-Ambrosia (J-A) mine owned and operated by Iluka.

The projected mine life of the Project is approximately seven years, including overburden stripping and backfilling of voids. It is anticipated that the J-A mine life would be extended by approximately four years because of the Project.

On 9 November 2022 the Project was determined to be a controlled action (Environment Protection and Biodiversity Conservation Act 1999 [EPBC] Reference Number 2022/09289) for threatened species. It has been confirmed that the Project will be assessed by both the Commonwealth and State of South Australia via a Mining Lease Application (MLA) and Mining Lease Proposal (MLP).

This Social Impact Assessment (SIA) report has been prepared by WSP Australia to support the MLA, MLP and Program for Environment Protection and Rehabilitation (PEPR) for the Project.

This report documents the process and outcomes of the assessment of potential social impacts associated with the Project, both positive and negative, that may occur during the pre-construction, construction, operation and closure phases of the Project.

1.1 About this document

The purpose of this SIA is to better understand how the Project will be experienced by people in the local and regional area, or the geographical area in which the majority of social impacts are likely to materialise. The SIA also considers the potential combined impacts of the four year operational extension of the J-A operations on key communities and stakeholders.

The SIA study area includes the Ceduna Local Government Area (LGA), the townships of Yalata, Penong, Maralinga (Oak Valley), and Scotdesco, and the Eyre Peninsula and Southwest Region (see Section 4.1). This analysis is achieved through existing social environment data based on Australian Bureau of Statistics (ABS) indicators and supplemented by community and stakeholder consultation. After consultation, and potential impacts have been identified and assessed, a preliminary framework for managing impacts is presented in the Social Management Plan (SMP).

Through a range of management measures implemented by Iluka, negative impacts will be mitigated, monitored and adaptively managed, and positive impacts will be enhanced.

Further detail on SIA methodology can be found in Chapter 3 of this report.

Social impacts are often associated with other environmental or economic impacts. Technical papers completed for the MLP that present environmental and economic impacts referenced in this SIA include:

- Matters of National Environmental Significance (MNES) Assessment for the Atacama Project (Ecological, 2022)
- Atacama Traffic Impacts Study (HATCH, 2022)
- Air Quality Impact Assessment (Jacobs, 2022)
- Atacama Ecological Impact Assessment (Eco Logical, 2022)
- Environmental Radiation Impact Assessment (Radiation Consulting Australia, 2022).

1.2 Project description

The Project is a newly identified opportunity to develop a high-grade mineral sands deposit located approximately 5 km from the existing J-A mine, within the Yellabinna Regional Reserve, approximately 800 km from Adelaide and 270 km from the Port of Thevenard.

The Project falls within Exploration Licence (EL) 5947 which is owned by Iluka, an Australian listed ASX 100 company.

The projected mine life of the Project is approximately seven years, including overburden stripping and backfilling of voids. It is anticipated that the J-A mine life would be extended by approximately four years by inclusion of the Project.

The mining method of the Project would include four open pits, with the following characteristics:

- Western Pit: approximately 5,000 m long, 350 m wide and 60 m deep
- Central Pit: approximately 3,900 m long, 290 m wide and 45 m deep
- Eastern Pit: approximately 5,800 m long, 470 m wide and 75 m deep
- Southern Pit: approximately 675 m long, 345 m wide and 60 m deep.

The Project footprint would require clearing approximately 2,138 ha of native vegetation.

The Project would result in approximately 4.1 Mt of Heavy Mineral Concentrate (HMC) produced for transport by ship to Iluka's Western Australia (WA) processing facilities. At its peak it is expected that up to 1 Mt of HMC will be stockpiled on site at any given time. Processing of the HMC produces the final products of zircon, rutile and ilmenite. The main product, zircon, is used in the manufacture of ceramics, including floor and wall tiles and sanitary ware, as well as in casting and foundry applications. Zircon is also used for the manufacture of zirconium chemicals that have a range of derivative applications, including zirconium metal.

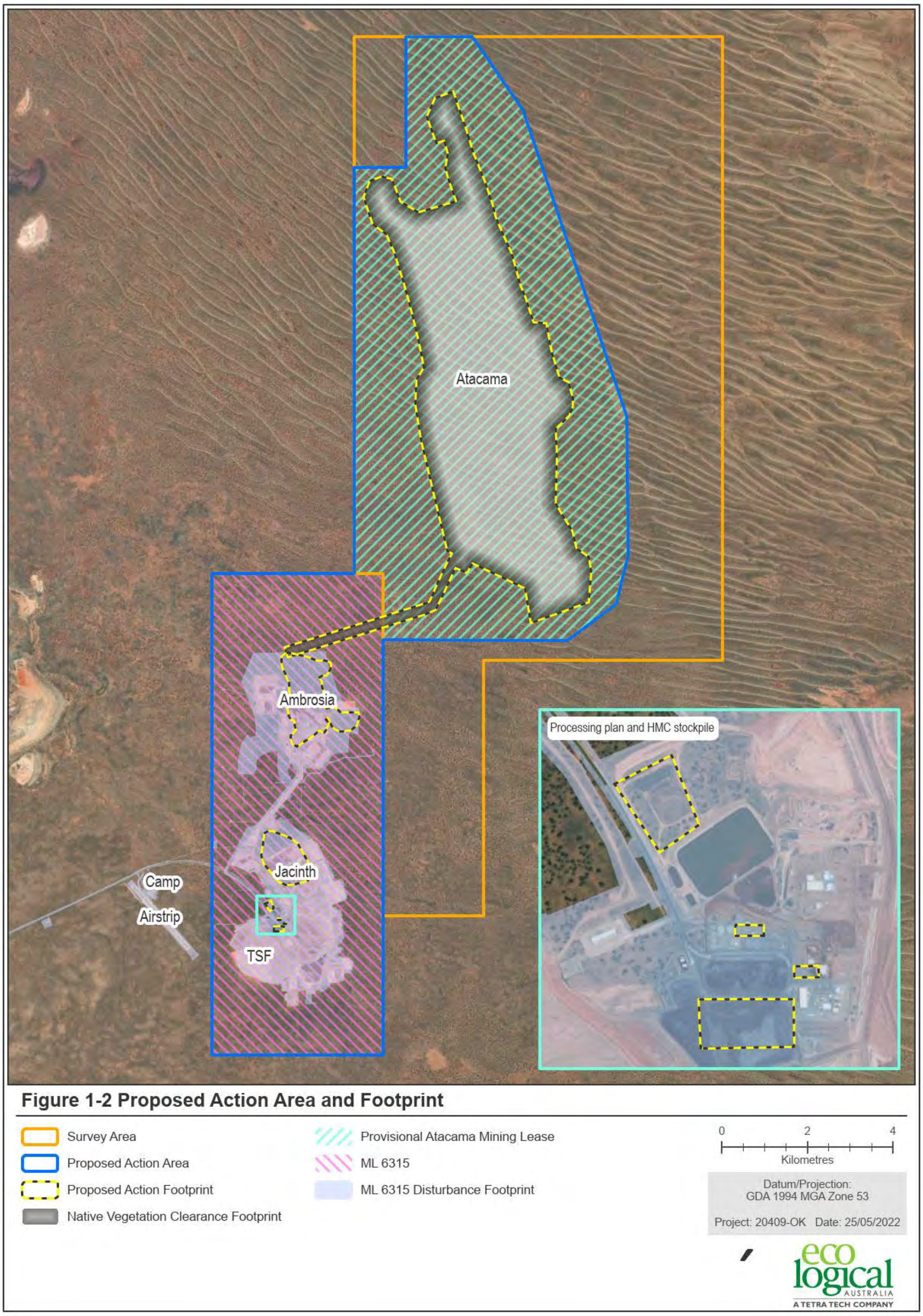
A self-supported Sand Tailings stockpile will be constructed at J-A for the storage of tailings material from Atacama to enable its processing through the J-A concentrator. The Sand Tailings stockpile will be constructed on the existing disturbance footprint at Jacinth. As a result of process material from Atacama being disposed of at Jacinth, there will be a landform change at Atacama post closure which has been agreed to in principle by key external stakeholders and traditional owner groups.

The total Project workforce on site during mining operations is expected to be approximately 300–350 full time equivalent (FTE) workers including contractors. During the 12 month construction period, average workforce numbers will be approximately 50, with a peak construction workforce of 90. Accommodation for the workforce, construction and operational, will be at the existing J-A camp, which will require approximately 197 additional beds to accommodate the increased workforce. There will be an on-site medic available to treat the Project workforce.

Utilities for the Project will be sourced from the J-A site and upgraded. Power will be sourced from the onsite (diesel/ solar) power station at J-A. Additional solar capacity is being investigated. The instantaneous power demand at Atacama will be approximately 4 MW greater than the J-A peak demand.

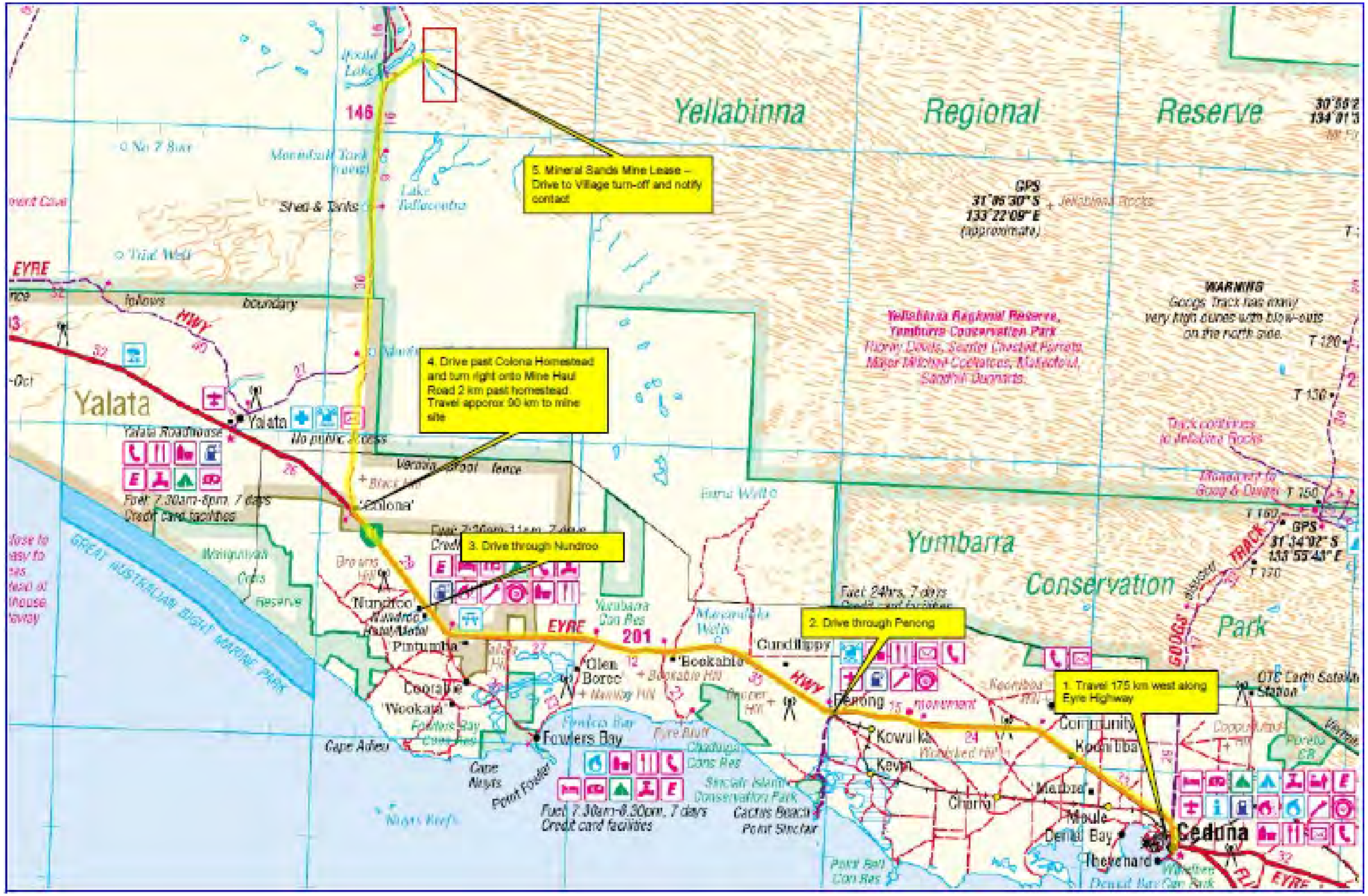
Water will be sourced from the existing wellfield used for the J-A mine site, located approximately 40 km from the J-A mine site and screened within the paleochannel aquifer. The wellfield has a design capacity of approximately 360 L/s or 1,200 m^3/h. Current (2022) water use for J-A is approximately 360 m^3/h (or 100 L/s). The additional capacity required for the Atacama Project is incremental for processing purposes. For dust suppression purposes, an additional 0.8 ML/d (or 34 m^3/h) of potable water is expected to be required for the Project. With the efficiency of a new RO plant at J-A, this would amount to approximately 175 m^3/h of saline consumption, resulting in a total water requirement across both projects of approximately 550 m^3/h. There will be a significant requirement for additional dust-suppression and seeding water when mining and rehabilitating the Atacama Project disturbance footprint requiring an approximate additional 50 m^3/h of water to be converted to RO water.

Mining will occur 24/7, 7 days a week, with progressive rehabilitation, and processing through the J-A Concentrator. Production life at J-A will be extended by 6 years but there will be no annual increase in truck movements via the existing route from J-A to Port Thevenard. The same trucking route will be used. The construction phase will require the transportation of materials to site, which is anticipated to result in approximately 400–450 total deliveries to site during the construction phase. The construction phase of the project are also anticipated to result in an additional total 20–40 vehicle movements, and the operational phase will result in 20-40 additional movements per day along the Eyre Highway and Ooldea Road due to the anticipated increase in workforce.



Source: Iluka Resources Ltd, 2022

Figure 1.1 Project location



Source: *Iluka Resources Ltd, 2014*

Figure 1.2 Existing J-A designated truck route alignment

2 Legislation and policy context

The strategic context of the Project is influenced by the outcomes of strategic plans prepared at the local and regional government levels, in addition to state and national legislation and policies. The following sections provide an overview of legislative, policy and strategic documents that are relevant to the SIA as well as guidance for regional economic and community development, and vision for the social locality and region.

2.1 Legislation

2.1.1 Commonwealth Legislation

2.1.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

Under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), proposed 'actions' that have the potential to significantly impact on Matters of National Environmental Significance (MNES), the environment of Commonwealth land, or that are being carried out by an Australian Government agency, must be referred to the Commonwealth Minister for the Environment for assessment.

On 9 November 2022 the Project was determined to be a controlled action (Environment Protection and Biodiversity Conservation Act 1999 [EPBC] Reference Number 2022/09289) for threatened species. It has been confirmed that the Project will be assessed by both the Commonwealth and State of South Australia via a Mining Lease Application (MLA) and Mining Lease Proposal (MLP).

This SIA report has been prepared by WSP Australia to support the MLA, MLP and Program for Environment Protection and Rehabilitation (PEPR) for the Project.

2.1.2 South Australia Legislation

2.1.2.1 South Australia Mining Act 1971 (Version 2021)

Part 6 sets out the requirement for the application of Mining Leases (ML), which includes the assessment of the environmental impacts of the proposed operations. The applicant must provide the results of the consultation undertaken in connection with the proposed operations and an assessment how the proposal may impact on the local community and outline management measures if required.

Part 9B provides guidance for the mineral sector on Native Title holders. It establishes that a production tenement may not be granted or registered over Native Title land unless the mining operations to be carried out under the tenement are authorised by a pre-existing agreement (such as an NTMA), registered determination, or Indigenous Land Use Agreement (ILUA) registered under the *Native Title Act 1993*.

As such, a Native Title Agreement must be made with the Traditional Owners, through the Registered Native Title Body Corporate (RNTBC) who is the Far West Coast Aboriginal Corporation (FWCAC) and registered with the SA Government for a ML to be issued. Following productive negotiations, a term sheet has been agreed in principle between Iluka and the FWCAC and drafting of a detailed agreement has commenced. The matter is planned to go to a community vote in Q1 2023 with agreement execution targeted by end Q2.

Part 10A establishes the requirements for PEPR to ensure that authorised operations that have (or potentially have) adverse environmental and social impacts are properly managed to reduce those impacts as far as reasonably practicable and eliminate, as far as reasonably practicable, risk of significant long term environmental harm; and ensure that land adversely affected by authorised operations is properly rehabilitated.

2.1.2.2 South Australia Mining Regulations 2020

SIA requirements for Mining Leases in SA are outlined in the 2020 South Australian Mining Regulations under Section 48 of Part 11 – Common provisions. The regulations state that a SIA should comply with the following requirements:

- provide a description of the impacts on people and communities that are reasonably expected to occur as a result of authorised operations that are proposed to be carried out under the tenement or the proposed change in operations (as the case may be)
- provide an outline of the measures that are to be used to manage, limit or remedy those impacts (in the case of negative impacts), or to facilitate or ensure those impacts (in the case of positive impacts)
- be balanced, objective and concise
- state any limitations that apply, or should apply, to the use of information
- identify any matter in relation to which there is a significant lack of information or a significant degree of uncertainty
- so far as is relevant, identify the sensitivity to change of any assumption that has been made and any significant risks that may arise if an assumption is later found to be incorrect
- be in a form determined by the Minister, be supported by such evidence as the Minister may determine and comply with any requirement of the Minister relating to the amount or detail of information that must be provided.

2.2 Relevant guidelines

2.2.1 2021 Social Impact Assessment Guideline, NSW DPE

In the absence of direct guidance on SIA within the SA jurisdiction the 2021 *Social Impact Assessment Guideline for State Significant Projects* of the New South Wales Department of Planning and Environment (NSW DPE) (SIA guideline) is partially adopted for this social impact assessment, in relation to the impact assessment methodology. The SIA guideline was released to support the preparation of SIAs for State significant Projects in NSW.

2.3 Strategic planning policies and strategies

The following section provides a summary of the relevant regional and local planning policies and strategic documents to the SEIA. These documents provide an overview of the strategic planning context of the local and regional area, as well as key priorities of local Councils and communities.

2.3.1 Regional planning

2.3.1.1 Regional Public Health Plan 2015. District Council of Ceduna, District Council of Elliston, District Council of Streaky Bay and Wudinna District Council

The health outcomes of the Regional Public Health Plan are explored in Chapter 6. The Plan outlines Ceduna's strategic role. Ceduna is emerging as the Far West Coast region's major business, industry and service centre, supporting a region which is renowned for its diverse agricultural, fishing, tourism and mining sectors. Further details of the strengths and challenges associated with the region are explored in the analysis of social, human and economic capitals later in this chapter.

The Revised Regional Public Health Plan was issued in 2021, and provides a review of the strategies, goals and outcomes identified in the 2015 Regional Public Health Plan, as per the SA *Public Health Act 2011*, which specifies that a 5 yearly review is undertaken by the partner Councils of the initial Regional Public Health Plan. The revised plan provides an overview of the region's key demographic and health indicators, which have been referenced within Chapter 6.

2.3.1.2 Yellabinna and Warna Manda Parks Management Plan (2019)

The Yellabinna and Warna Manda Parks Management Plan was developed by the Yumbarra Conservation Park Co-management Board – a partnership between the FWCAC and the South Australian Government. The Plan sets out the long-term management strategies, highlights the most important values and outlines the main threats to these values.

The Plan outlines the multiple legislation of relevance, reflecting the existence of an array of legislation for the management of the park. The Yellabinna Wilderness Protection Area is governed under the Wilderness Protection Act 1992 while all other Yellabinna and Warna Manda Parks fall under the National Parks and Wildlife Act 1972. The whole area sits within the provisions of the Native Title Act 1993, in which the Far West Coast (FWC) People, comprising of the Kokatha, Mirning and Wirangu Peoples, are the registered native title holders and Traditional Owners.

The Plan balances environmental protection and restoration, invasive species management, fire hazard management, cultural protection and the activity of extractive resources. Iluka's operations within the Eucla Basin are specifically mentioned, acknowledging:

- the careful nature of Iluka's approach within the reserve and Aboriginal site
- the employment opportunities generated for people in the region
- the opportunity for members of the FWCAC to work on country.

It is also noted that Iluka's activities at J-A legally abide by the Mining Act 1971 and involved liaison with stakeholders.

One of the strategies to achieving the objective of protecting and conserving the parks' natural environmental and rich Aboriginal and non-Aboriginal cultural heritage is to authorise and work with mining and extraction companies to ensure that the impact of any current or future resource development activities on the natural and cultural values of the parks is minimised (Department of Environment and Water, 2019, p.10).

Overall, the Plan reflects objectives that align with Iluka's operations within the Yellabinna Regional Reserve. The Plan is supportive of future extraction operations providing impacts and risks are sufficiently managed, and a respectful, cooperative and collaborative relationship between all parties is well established.

2.3.2 Local planning

2.3.2.1 Strategic Plan, District Council of Ceduna (2011-2014)

The Ceduna District Council Strategic Plan identifies the vision and future goals for the local area. The strategic plan focuses on:

- the need to support sustainable economic growth
- protect and maintain the areas local natural heritage
- community consultation and relationship building between council and residents
- improving community development services.

An important focus of the Plan is supporting and promoting economic growth. The need to support current industries, such as marine activities and roads, through improved physical infrastructure is identified as key to road usage. Similarly, the need to further develop other industries as part of a sustainable economy is outlined as a priority. This includes improved tourism infrastructure, supporting existing regional events and developing new ones, preserving natural and historic sites, and improving airport infrastructure and services.

2.3.2.2 Development Plan, District Council of Ceduna (2012)

The Development Plan outlines appropriate land use and associated zonings. It is the guiding document for development approval and land clearing. The Development Plan has six key objectives relating to mineral extraction in the Ceduna LGA. Relevant principles include screening and reducing visual impacts of operations including stockpiling. It is noted that this is particularly important if operations are close to scenic routes, destination or other tourism related activities.

Reducing social impacts relating to transport and access is a separate objective within the Plan. The objective aims to have *'a comprehensive, integrated, affordable and efficient air, rail, sea, road, cycle and pedestrian transport system'* that will *'have minimal negative environmental and social impacts'* (Ceduna Council, 2012, p. 86). This objective would include freight links between J-A and the Port, and the associated impacts.

2.3.2.3 Strategic Management Plan 2020–2025, Outback Communities Authority

The Outback Communities Authority (OCA) is a hybrid between local government and community self-management by the 4,500 people who make it their home. The OCA has been established to manage the provision of public services and facilities to outback communities within unincorporated SA.

Around 63% of SA is unincorporated, with a population of approximately 4,500 people who reside in a number of small townships and numerous smaller settlements including pastoral, farming and tourism enterprises (OCA, 2022). Communities within Unincorporated SA are not managed by any local council, and typically have a Progress Association (such as the Penong progress Association) to manage community needs and priorities and maintain facilities and services with the assistance and support of the OCA. Penong, Yalata, and Maralinga Tjarutja (Oak Valley) are all located within Unincorporated SA.

One of the Strategic Management Plan's objectives is to facilitate new opportunities and investment in the Outback, while promoting a shared vision for improving the 'liveability' of the Outback for those that live, work and visit. The Strategic Management Plan's also seeks to articulate the needs of Outback people and promotes the OCA's key role in decision making for the Outback.

3 Methodology

This technical report has been prepared in response to the Minerals Regulatory Guidelines (MG) 2a and Terms of Reference (TOR) 006 have been prepared by the Department of Energy and Mining (DEM) to assist the applicant to prepare a MLP and/or management plan (MP) required under the *Mining Act 1971* that must accompany an application for a ML or Miscellaneous Purposes Lease (MPL).

To obtain a ML an impact assessment must be undertaken and included in the application. This assessment must be done for elements relevant to the operation, which requires a detailed SIA. The TOR006 provides the minimum information which is required to be provided in an application. MG2a provides a structured framework for the MLP development, including assessment of impacts to the environment associated with the proposed mining operations to meet the TOR006.

An overview of the five key stages of this SIA is provided in Figure 3.1 and methodological details are provided below.

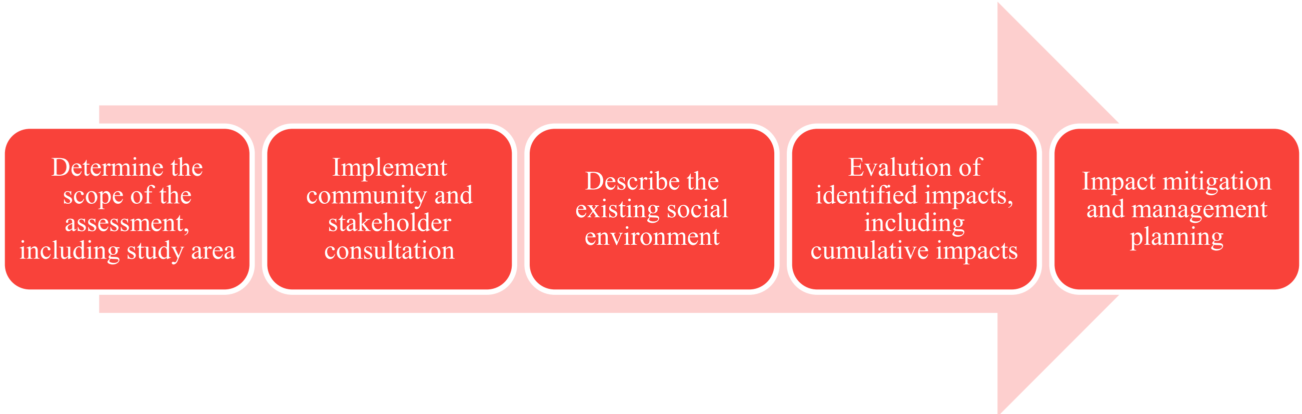


Figure 3.1 Overview of SIA approach

3.1 Scope of the assessment

Scoping is the first phase of undertaking an SIA. This is used to focus the SIA on the most relevant and important issues for the Project, ensure the scale of assessment required is proportionate to the importance of the expected impacts and inform the definition of the study area as described in Section 4.1.

The scoping of social issues has occurred through:

- determination of assessment scenarios: pre-construction, construction, operation and closure
- determination of social impact categories to be studied: Livelihoods, Community Wellbeing, Aboriginal Outcomes, Services and Infrastructure and Surroundings
- a review of J-A previous SIAs and management plans, including:
  - the 2020 J-A SIA
  - Parsons Brinckerhoff Atacama/Sonoran Typhoon Development Project SIA (2014)
  - 2020 J-A SMP
- consultations with the Iluka Atacama Senior Approvals & Environmental Specialist and J-A Environmental and Community Manager.

As a result of the scoping of social issues, the SIA study area encompasses the geographical areas in which direct and indirect impacts are likely to occur (see Figure 4.1).

The study area will refer to the following ABS geographical data boundaries:

- Statistical Areas Level 3 (SA3s)
- Suburbs and localities (SALs); and
- LGAs (see Section 4.1).

3.2 Community and stakeholder consultation

This SIA recognises that material impacts can arise from community and stakeholder perceptions and experiences, hence the importance of obtaining people's experiences, views, and perceptions to inform the assessment.

The objectives of consultation activities for the Project SIA are to:

- discuss outcomes expected to occur in relation to the Project and understand the interests and potential concerns of individuals and groups, as well as attitudes towards J-A and Iluka
- collect qualitative data, evidence and insights for assessing potential impacts and benefits in ways that maximise the diversity and representation of varying community and stakeholder viewpoints
- create synergies between other consultation and engagement activities to minimise potential consultation fatigue amongst key stakeholders and groups.

A targeted consultation plan was developed for this SIA. The plan was informed by former consultations conducted in the development of past SIA reports, current J-A engagement activities (see Appendix A) and by the Project Prefeasibility Stakeholder engagement plan.

A set of questionnaires guided consultations with key stakeholders (see Appendix B). A total of eight face-to-face consultations were conducted in Ceduna in August 2022, while two consultations took place via online and over the phone between August and September 2022.

Chapter 5 provides a summary of former SIA consultations and targeted consultation for this SIA.

3.3 Describing the existing social environment

The description of the existing environment (baseline) provides an understanding of the community composition, socio-economic trends and level of resilience or vulnerability of the Project's host communities. It also characterises the socio-economic values of locations, places, and areas.

The baseline provides balanced, objective, and concise information by gathering most social indicators via desktop research, using trusted sources of information, such as the ABS, and complementing data through primary data sources via community and stakeholder consultation.

3.4 Evaluation of identified social impacts

The methodology to assess the significance of each impact, included the following criteria:

- the four impact characteristics that demonstrate the material effect of the impact (extent, duration, severity, sensitivity) defined in Table 3.1, and how they are considered in determining magnitude is explained in Table 3.2.
- who specifically may be affected (directly, indirectly or cumulatively) and the level of concern they feel about the matter (high, medium, low), recognising that impacts may affect population groups or individuals differently
- when the potential impact is expected to occur (pre-construction, construction, operation, closure)
- defining likelihood as per the SIA guideline (DPE, 2021) and outlined in Table 3.3
- determining the significance of the potential impact pre-mitigation, as per matrix in Table 3.4.

Table 3.1 Characteristics of social impact magnitude

Characteristic	Definition
Extent	Who specifically is expected to be affected (directly, indirectly, and/or cumulatively), including any potential vulnerable people? Which location(s) and people are affected (e.g. near neighbours, local, regional)? Regional: Eyre Peninsula Local: Communities or settlements of Yalata, Penong, Kooniba, Ceduna, Smoky Bay, Streaky Bay, Ceduna and Thevenard
Duration	When is the social impact expected to occur? Will it be time-limited (e.g. over particular Project phases) or permanent?
Severity or scale	What is the likely scale or degree of change (e.g. mild, moderate, severe)? High: Social functions are severely altered – large number of directly impacted people/households Medium: Social functions are notably altered – medium number of directly impacted people/households Low: Social functions are slightly altered – small number of directly impacted people/households
Sensitivity or importance	How sensitive, vulnerable (or how adaptable/resilient) are affected people to the impact, or (for positive impacts) how important is it to them? This might depend on the value they attach to the matter; whether it is rare/unique or replaceable; the extent to which it is tied to their identity; and their capacity to cope with or adapt to change.
Level of concern/interest	How concerned/interested are people? Sometimes, concerns may be disproportionate to findings from technical assessments of likelihood, duration and/or severity. Concern itself can lead to negative impacts, while interest can lead to expectations of positive impacts.

Source: Adapted from SIA Guideline (DPE, 2021) and J-A SIA (2020)

Table 3.2 Defining magnitude levels for social impacts

Magnitude criteria	
Transformational	Substantial change experienced in community wellbeing, livelihood, amenity, infrastructure, services, health, and/or heritage values; permanent displacement or additional of at least 20% of a community.
Major	Substantial deterioration/improvement to something that people value highly, either lasting for an indefinite time, or affecting many people in a widespread area.
Moderate	Noticeable deterioration/improvement to something that people value highly, either lasting for an extensive time, or affecting a group of people.
Minor	Mild deterioration/improvement, for a reasonably short time, for a small number of people who are generally adaptable and not vulnerable.
Minimal	Little noticeable change experienced by people in the locality.

Source: SIA Guideline (DPE, 2021)

Table 3.3 Defining likelihood levels of social impacts

Likelihood level	Definition
Almost certain	Definite or almost definitely expected (e.g. has happened on similar projects)
Likely	High probability
Possible	Medium probability
Unlikely	Low probability
Very unlikely	Improbable or remote probability

Source: SIA Guideline (DPE, 2021)

Table 3.4 Social impact significance matrix

Magnitude		1 Minimal	2 Minor	3 Moderate	4 Major	5 Transformational
Likelihood Level	**A** Almost certain	Low	Medium	High	Very high	Very high
	B Likely	Low	Medium	High	High	Very high
	C Possible	Low	Medium	Medium	High	High
	D Unlikely	Low	Low	Medium	Medium	High
	E Very unlikely	Low	Low	Low	Medium	Medium

Source: SIA Guideline (DPE, 2021)

3.5 Impact mitigation and management planning

Recommended mitigation and enhancement strategies have been targeted to the potential impacts identified. These strategies have been informed by guidance provided in the SIA Guideline (DPE, 2021); Iluka; community and stakeholder feedback (see Chapter 5) and strategic directions of Council in the SIA study area (see Section 2.3).

Mitigation measures have been assigned to all unmitigated impacts from low to very high, noting that existing J-A controls will be continued and, in some cases, enhanced in response to some impacts. For potential impacts that have been given a low significance rating, Iluka would monitor for signs of social impact as part of the Social Management Plan Review and assess if additional management measures are required, as part of the adaptive management process outlined above.

New management measures proposed are proportional to impact ratings to ensure that all measures are effectively implemented. Opportunities to maximise benefits and make a positive difference to the social and economic development of the local communities are also defined.

An assessment of how significant the social impact remains, after the proposed mitigation measure or enhancement measure has been implemented.

3.6 Study limitations

Study limitations for this SIA included the following:

- The 2021 Census data is released by ABS in a phased approach beginning late June 2022. While the most recent data from the 2021 Census has been used throughout this SIA to inform the description of the existing social environment, some topics including employment and location-based variables were unavailable at the time of writing, and in these cases 2016 data was used.
- The Social impact significance matrix as shown in Table 3.4 may not reflect the changes of mitigated impacts into the overall significance rating. For some impacts where the continuation and enhancement of existing controls, and/or new management measure have been suggested, the residual significance rating may not change. This is particularly true of the low and medium ratings which have been assigned to most impacts. However, in all cases, either the likelihood or magnitude of the impact are reduced by suggested measures, and benefits are enhanced.
- There has been no site visit to the proposed Project site or J-A site as a part of this SIA, largely due to the remote location and the associated challenges traveling to and from the area. This limitation was addressed by reviewing previous social impact assessments and technical studies with site visits included as part of their respective methodologies.
- The Aboriginal Cultural Heritage Assessment Report (ACHAR) was unavailable for review and inclusion during the preparation of this report, due to pending negotiations with the FWCAC. The assessment has considered previous heritage assessments and findings for the Project and J-A sites, in addition to Iluka's existing operational and exploration heritage procedures, and the consideration of FWC Cultural Heritage as part of the NTMA negotiation process. FWCAC has been involved in consultation with Iluka regarding the proposed ACHAR study, and potential to cultural heritage.
- Only 10 stakeholders have been directly engaged as part of this SIA consultation. To mitigate this limitation, the SIA has been informed further by previous SIA reports and consultation findings from 2020 and 2014, as well as findings from Iluka's J-A grievance mechanisms.

4 Scope of the assessment

This chapter details the outcomes of the scoping process undertaken for this this SIA and provides an outline of the study area defined for this SIA.

4.1 Scoping of social issues

Scoping is the first phase of undertaking an SIA, it allows to focus the SIA on the most relevant and important issues for each Project, ensure the scale of assessment required is proportionate to the importance of the expected impacts and inform the definition of the study area.

Table 4.1 summarises the impacts scoped for this report. The scoped impacts below have guided the SIA consultation process and assessment methodology. The material social impacts assessed in Chapter 7, 8 and 9 have been updated and refined from the scoping phase, in response to consultation findings and other relevant technical assessments.

Table 4.1 Preliminary scoping of social impacts

Impact category	Phase	Project change from baseline	Potential impact	Where addressed in the SIA
Livelihoods	Construction & Operation	Increased direct and indirect employment opportunities during construction and operations (construction workforce of 50–90 over 12 months and operational workforce of 300–350, including contactors, during seven years). Extended J-A mine life, and continued employment of J-A employees for another four years.	Improved livelihoods as a result of: — increased economic activity and revenue for local businesses and other service providers — direct employment opportunities increase — upskilling and on-the-job training opportunities.	Section 7.1.1 and 7.1.2
Livelihoods	Construction & Operation	Increased technical or specialist workforce temporarily residing off-site during construction and operations.	— Impacts to accommodation availability.	Section 7.4.3
Livelihoods	Closure	Deferred closure of J-A and cessation of Project employment, local business engagement, and indirect economic opportunities following closure.	Detrimental effects to local livelihoods as a result of: — lower remunerations, increased unemployment and sustained unemployment — drop-in economic activity in local townships — rising cost of essential services e.g. fuel and accommodation services.	Section 9.1.1
Community Wellbeing	Construction & Operation	Construction workforce will predominantly be employed on a FIFO schedule similar to the current J-A operational workforce over a period of 12 months, and existing J-A employees will see an opportunity to continue working at the mine for another four years.	Impacts to workforce health and wellbeing associated with FIFO rosters.	Section 7.2.3

Impact category	Phase	Project change from baseline	Potential impact	Where addressed in the SIA
Community Wellbeing	Construction	Increase of Project related traffic and heavy vehicles using the haulage route (400–450 total deliveries to site during the construction phase, and an additional total of 20–40 vehicle movements to account for workforce travel during the construction phase, and 20–40 workforce vehicle movements per day during operations).	Diminished sense of safety (in Penong, Ceduna and Town Camp) during construction of the Project.	Section 7.2.1
Community Wellbeing	Construction & Operation	Increased number of construction-related traffic movements and extension of the life of mine of J-A.	Community health impact due to amenity disturbance including dust, noise, vibration along public roads – including Eyre Highway, train road noise in Ceduna, and fugitive dust pollutants from the Port Thevenard storage bunker.	Section 7.2.2
Community Wellbeing	Pre-Construction, Construction and Operation	Project stakeholder communications and engagement activities.	Impacts on procedural fairness and people's capacity to influence and understand changes that may affect their lives.	Section 7.2.5
Community Wellbeing	Construction & Operation	Four-year extension of J-A employment and community benefit payments and programs.	Enhanced community cohesion and wellbeing as a result of Iluka community benefit programs.	Section 7.2.7
Community Wellbeing	Pre-Construction, Construction and Operation	Four-year extension of J-A operation and Atacama project operation.	Unequal distribution of impacts and benefits to smaller communities, vulnerable groups and sensitive receivers. Non-FWCAC residents in the local study area may perceive employment opportunities to be unequally distributed.	Section 7.2.6
Community Wellbeing	Closure	Cessation of Project employment following closure.	Population decline in townships due to out-migration of former mine workers and their families.	Section 9.2.1
Community Wellbeing	Closure	Cessation of Project employment following closure.	Increased welfare dependency or increased demand for social services (public and non-governmental).	Section 9.2.1

Impact category	Phase	Project change from baseline	Potential impact	Where addressed in the SIA
Community Wellbeing	Closure	Cessation of Project employment, local business engagement, and indirect economic opportunities following closure.	Increased stress and anxiety across communities caused by loss of employment and business opportunities, which may lead to weaker family and community cohesion.	Section 9.1.1
Community Wellbeing	Closure	Cessation of community benefit payments and programs.	Reduced funding and sponsorship of community development programs.	Section 9.2.1
Aboriginal Outcomes	Construction and Operation	Four-year extension of the J-A FWCAC NTMA, FWC employment and business opportunities, cultural heritage management measures, FWC training programs, and community benefit payments and programs. New/updated NTMA relating to Atacama Project.	Increased organisational capacity of FWCAC due to annual payments/royalties leads to improved and longevity of services, land management, cultural heritage, self-determination efforts for the organisation and all members.	Section 7.3.2
Aboriginal Outcomes	Construction and Operation	Implementation of the FWCAC NTMA, FWC employment and business opportunities and FWC training programs.	Increased business opportunity for enterprises organised and represented by the FWCAC.	Section 7.3.1
Aboriginal Outcomes	Pre- and Construction and Operation	Negotiation and implementation of the FWCAC NTMA.	Detrimental effects to FWCAC community cohesion as a result of new negotiations to amend NTMA.	Section 7.2.7
Aboriginal Outcomes	Construction and Operation	Four-year extension Cultural awareness training for Project workforce.	Increased broader understanding of Aboriginal and FWC culture and improved reconciliation outcomes via Cultural Awareness Training.	Section 7.3.4
Aboriginal Outcomes	Construction and Operation	Four-year extension of the J-A FWCAC NTMA, and FWC employment. New/updated NTMA relating to Atacama Project.	FWCAC members employed as FIFO workers (living outside the local area) may cause disproportionate benefit between differing members of FWCAC and economic capital leaving area.	Section 7.3.4

Impact category	Phase	Project change from baseline	Potential impact	Where addressed in the SIA
Aboriginal Outcomes	Operation	Construction, mining, and rehabilitation of Project site.	Detrimental impacts on Aboriginal cultural heritage, values, wellbeing and spirituality due to permanent changes to landscape and reduced land access.	Section 7.3.5 and 7.3.6
Aboriginal Outcomes	Operation	Construction, mining, and rehabilitation of Project site and implementation of cultural heritage management measures.	Impacts to Aboriginal cultural value due to improper storage and preservation of artefacts.	Section 7.2.7 and 7.3.5
Aboriginal Outcomes	Closure	Cessation FWC employment, NTMA payments, and community benefit programs and payments.	Reduced revenue to FWCAC affecting capacity of cultural heritage and protection initiatives.	Section 9.3.1
Aboriginal Outcomes	Closure	Cessation of Project employment following closure.	Constraints to livelihoods of FWCAC as a result of: — increased unemployment among FWCAC members — fewer education or training opportunities for local residents.	Section 9.3.1
Service and Infrastructure	Construction and Operation	Increased direct and indirect employment opportunities during construction and operations (construction workforce of 50–90 over 12 months and operational workforce of 300–350, including contactors, during seven years).	Strain on local health services, including Ceduna Hospital, capacity due to increased demand.	Section 7.4.4
Service and Infrastructure	Construction and Operation	Increase of Project related traffic and heavy vehicles using the haulage route (400–450 total deliveries to site during the construction phase, and an additional total of 20–40 vehicle movements to account for workforce travel during the construction phase, and 20–40 workforce vehicle movements per day during operations).	Public highway and local roads damage and conditions deterioration.	Section 7.4.2

Impact category	Phase	Project change from baseline	Potential impact	Where addressed in the SIA
Service and Infrastructure	Operation	Increased direct and indirect employment opportunities during construction and operations (construction workforce of 50–90 over 12 months and operational workforce of 300–350, including contactors, during seven years).	A potential small increase in demand for childcare, hospital services, education, and emergency services.	Section 7.4.4
Service and Infrastructure	Closure	Cessation of Project employment, local business engagement, and indirect economic opportunities following closure.	Possible decommissioning of or reduction in services and infrastructure e.g. Ceduna Airport.	Section 9.2.1 and 9.4.1
Surroundings	Construction and Operation	Construction, mining, and rehabilitation of Project site.	Visual Amenity and landscape changes and perceived threat to and conflict with environmental conservation efforts and land management activities.	Section 7.5.1
Surroundings	Closure	Construction, mining, and rehabilitation of Project site.	Permanent changes to landscape affect aesthetic values of local communities and visitors to Yellabinna Parks.	Section 9.5

4.1 Definition of study area

The study area of the Project is comprised of the local and regional study areas, which include:

- **Local study area**: refers to the area expected to experience the most social change as a result of the Project. This local study area represents the immediate geographic area around the Project site, including surrounding settlements and communities nearest the mine; road transportation routes from J-A to Thevenard Port; townships that provide supplies of goods or services to the Project and J-A; and the fly-in-fly-out (FIFO) and drive-in-drive-out (DIDO) transfer locations of the Project workforce and Project contractor personnel. The local study area is made up of:
  - the Ceduna LGA, which encompasses the town of Ceduna and surrounding localities including Thevenard, Smoky Bay, Denial Bay, and Koonibba
  - key townships and communities outside the Ceduna LGA (within Unincorporated SA), including Yalata, Penong, Maralinga (Oak Valley), and Scotdesco.
- **Regional study area**: refers to the broader regional area in which the Project is located, which is unlikely to experience direct social impacts, but may be subject to secondary or indirect impacts associated with the Project. The regional study area also shares social and cultural links with communities in the local study area and would likely experience flow on economic impacts due to the Project's operational supply chain. Residents within the regional study area would be considered part of the local FIFO labour force. The regional study area is made up of:
  - Eyre Peninsula and Southwest Region ABS Statistical Area Level 3 (SA3).

South Australia has been included in the data gathering process as a benchmark for both the Ceduna LGA and the Eyre Peninsula and Southwest Region to provide a point of comparison and contextualise the Project in its state-level setting (see Chapter 6).

Figure 4.1 shows the SIA local and regional study areas in relation to the project site, as well as key social localities and infrastructure.

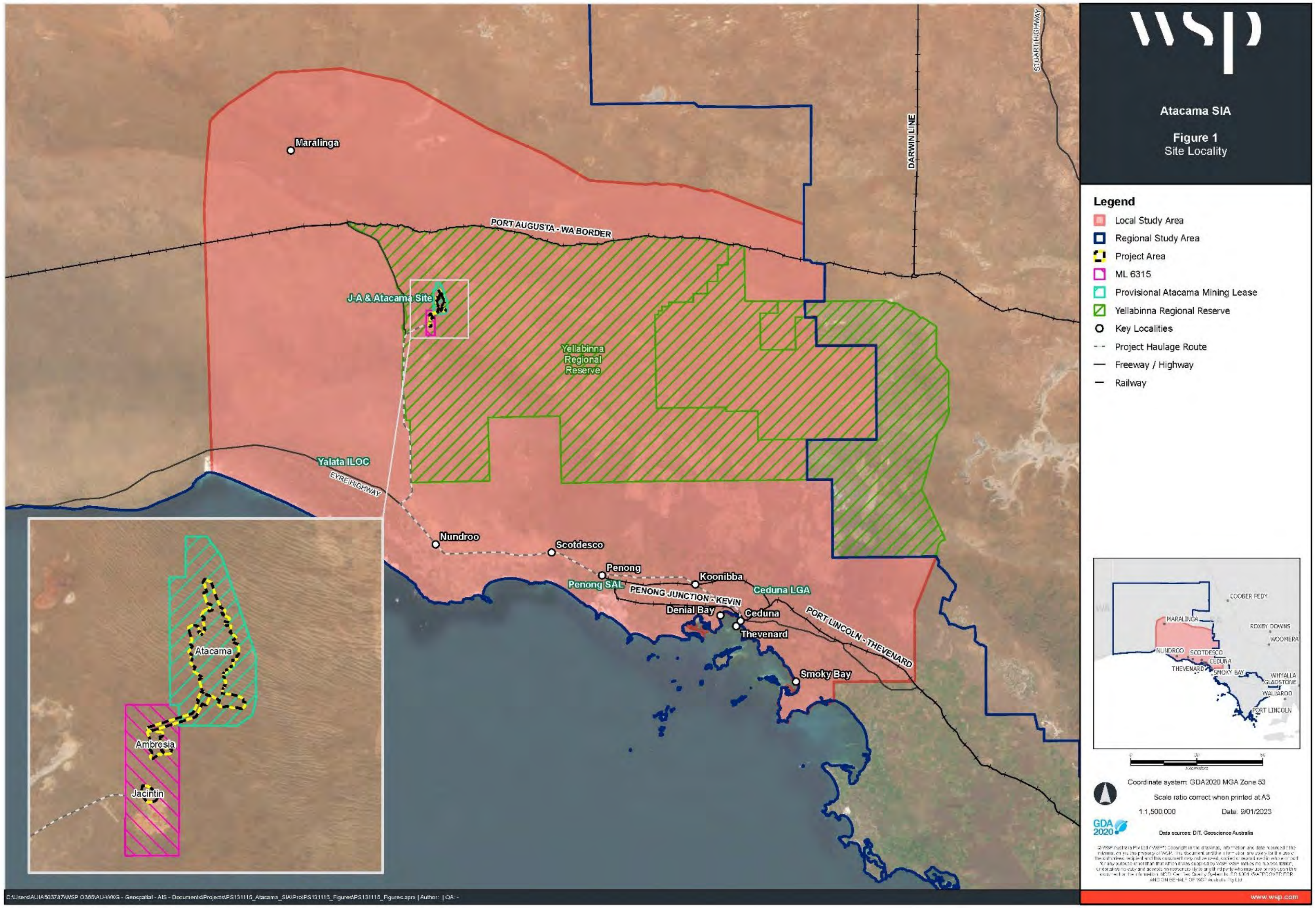


Figure 4.1 SIA local and regional study areas

5 Community and stakeholder consultation

This chapter provides a summary of the issues raised during consultation activities with community and stakeholders prior to and during preparation for the SIA for the Project.

5.1 Project stakeholder engagement

The Project team commenced engagement with key stakeholders in October 2021 (Iluka Resources, 2022). Engagement included meetings with government agencies such as DEM, Department for Environment and Water (DEW), EPA, and DAWE (now DCCEEW).

Early engagement was also conducted with FWCAC, Yumbarra Co-Management Board, Alinytjara Wilurara Landscape Board, and Native Vegetation Branch (NVB).

Engagement with the FWCAC commenced in November 2021 with a presentation to the Board that included a heritage clearance request for the Project, landscape and a heritage clearance requests for groundwater monitoring bores for J-A, and a Project introduction and overview of the Project's proposed scope.

Project studies and assessments that require ground disturbance, mechanised equipment and/or DEM approval require a valid heritage clearance from the FWCAC unless otherwise exempted by the FWCAC. Heritage clearance coordination with the FWCAC has been undertaken during the first half 2022. Quarterly updates to FWCAC on final landforms (at both the Project site and J-A) and the potential need for a test pit at the Project site have also been conducted.

5.2 SIA-specific consultation

Table 5.1 provides a summary of SIA consultation findings. SIA-specific consultation was undertaken during a three-day field campaign in August. A total of 10 interviews with key stakeholder and community representatives were conducted, including eight in-person interviews, and two online interviews. Stakeholders were briefed by Iluka prior to interviews to ensure participants were able to provide informed and considered feedback regarding the Project and its potential social impacts.

SIA consultation themes have been discussed in relation to both the Project, and existing J-A operations. Issues relating to the two projects have not been disaggregated, due to their inherent interconnectedness and associated potential impacts. For many stakeholders, potential impacts of the Project were understood and discussed in relation to existing J-A operations, as this was a point of familiarity for individuals to base their potential concerns and aspirations. Furthermore, given that the Project is anticipated to extend the mine life of the J-A operation, potential impacts associated with the Project would include the continuation of J-A activities that are already occurring within the local and regional social locality.

Table 5.1 SIA consultation summary

Social impact category	Stakeholder group	Stakeholder consultation findings	Where addressed in this SIA
Livelihoods	Businesses Community organisations	The current workforce at J-A is predominately FIFO and does not have much of a presence locally. FIFO workers do not interact with the town/community/local businesses often. Penong residents are of the view that there are not many Penong residents who work at J-A, potentially due to challenges of commuting to the mine site. Residents would likely either drive to Ceduna and fly to site or drive approximately 3 hours to site (and likely leave vehicle parked outside during shift). Introducing a shuttle/charter bus to and from Penong to transport local employees to the Project site could support people to work in the site.	Section 7.1.1
Livelihoods	Businesses	The expansion will create ongoing socio-economic security for the community, including increased/extended local employment and procurement opportunities for residents and small businesses. Local businesses may not have the capability or capacity to work on such a large-scale Project. Iluka has helped improve and expand local business capabilities due to the scale and requirements of the Project. Opportunities for Iluka to procure from local smaller scale services within the local community, such as plumbers and concreters, was identified as a key potential benefit. Additionally, the engagement of local business to supply smaller goods and services to the Project's camp was highlighted as an opportunity for increased local procurement.	Section 7.1.2
Livelihoods	Businesses	Perception that planned and unplanned shut-downs or quiet periods at J-A can impact local businesses that rely on Iluka operations. Often these shutdowns occur with little warning or prior communication.	Section 9.1
Livelihoods	Businesses	Mine closure may impact the community due to a reduction of employment opportunities and sponsorships, as well as impact local businesses such as Kalari.	Section 9.1
Livelihoods	Businesses Social services Indigenous organisations	Potential training and education programs for residents (particularly youth), including more opportunities for on-site apprenticeships. Opportunities to bring training resources into Ceduna (i.e., through the TAFE etc.) which could be utilised by other local businesses and help with youth retention in Ceduna.	Section 7.1.1 and 10.1.1
Livelihoods	Businesses Community organisations	Opportunities to increase local employment by incentivising relocation/employees moving to Ceduna. An increase in local residents and families would be beneficial for the community (potential increase in kids in sports clubs and schools, increased workforce). To mitigate local businesses losing employees to the Project, Iluka could sub-contract full time employees directly from local companies.	Section 7.1.1 and 10.1.1

Social impact category	Stakeholder group	Stakeholder consultation findings	Where addressed in this SIA
Livelihoods	Businesses Community groups Social services	To increase local employment, Iluka could advertise locally through Facebook (Ceduna Jobs page). Word of mouth is the most effective way to find employees in the community, as well as the local newspaper, and communicate opportunities through local representative in town. Continue promoting jobs locally through EyrePlus and explore other local advertisements methods such as the Ceduna Jobs Facebook page.	Section 7.1.1 and 10.1.1
Community Wellbeing	Businesses	On-site accommodation camp may have limited capacity, question of where any overflow workforce would stay or if camp expansions will be necessary.	Section 7.4.3
Community Wellbeing	Businesses Community organisations	Local residents are accustomed to large freight movements and trucks passing through town, noise and vibration are not currently a perceived impact for local residents, the 50 km speed limit through town is working well. Kalari bus drivers are polite and courteous on the roads and are mostly local drivers, unlikely to impact the community negatively.	Section 7.2.1 and 7.4.2
Community Wellbeing	Community organisations	Potential safety concerns associated with heavy vehicles and children crossing the road (particularly near the school). Increased signage, and awareness of children crossing for truck drivers passing through town could mitigate this risk. Road safety along the Eyre Highway in Highway and pedestrian safety concerns on One BP Station, nearby Penong Hotel, the Penong Pub and the Petrol Service Station and nearby rail tracks were raised. Since Kalari started using longer trucks there has been fewer trucks per day, reducing this safety concern.	Section 7.2.1
Community Wellbeing	Community organisations	Continuation of the existing operations is unlikely to result in new social impacts to the community. A number of interviewees raised that community benefits, investment and sponsorships have been beneficial for the community, the organizations and events sponsored have been positive. It was acknowledged by one interviewee that the application process/form to apply for Iluka sponsorships/community benefits is complex and could be improved, some of the questions are difficult to answer and discourage organisations from applying. Suggested simplifying sponsorship application process and questions.	Section 7.2.7 and 7.2.6

Social impact category	Stakeholder group	Stakeholder consultation findings	Where addressed in this SIA
Community Wellbeing	Businesses Community organisations Social services	There is a perceived lack of general communication and locally-appropriate Project information available to the community – local residents do not feel as though they have a good understanding of the Project and any updates. It was recommended that Iluka management have a stronger presence in town and employ an Iluka representative based in town full time to increase local engagement and connection. Improved communication and engagement with the local community and businesses regarding Project updates and key information – suggestions include holding community meetings/information sessions and dropping newsletters in resident mailboxes. Potential opportunities include advertising in the local newspaper (the Advocate), create a video walk through of the mine site, drop-in community information sessions, and controlled visitation to the J-A site for interested members of the community.	Section 7.2.5
Community Wellbeing	Businesses Community organisations	J-A workers feel disconnected with the community and town, and the community feel disconnected to J-A. Similarly, Iluka/J-A management does not have much of a local presence which has led to challenges communicating with the community and may limit local procurement and employment. Iluka does have workers volunteer days where some employees volunteer locally (i.e., Oyster Fest), however some workers do not take this seriously and don't commit to the volunteer work. Potential to increase community involvement and connection if this improves.	Section 7.2.3
Community Wellbeing	Businesses Social services	Questions regarding what the Project's mining method/technique will be. Expectation for more information regarding mining activities would be beneficial/of interest. As well as, ensuring community communication and awareness is upheld by Iluka approaching mine closure, remind residents about the Project's end of life phase and ensure there are no surprises. Increased information regarding closure and rehabilitation, including a better understanding of what Iluka will do with the land following closure is required.	Section 9.2
Aboriginal outcomes	Indigenous organisations	Potential impacts to Country and associated cultural values due to Project construction and operations. Stakeholders expressed that to adequately protect and respect Country, it is essential that Iluka does not leave any 'footprint' following mine closure. Some stakeholders stated that there was a concern that while revegetation was likely to occur, the Project site may not be rehabilitated back to its exact original state. It is important that the landscape is not damaged, as it holds cultural significance in relation to local Aboriginal stories, law, and hunting (for example).	Section 7.5.1, 7.3.6 and 9.5

Social impact category	Stakeholder group	Stakeholder consultation findings	Where addressed in this SIA
Aboriginal outcomes	Indigenous organisations Social services Businesses	There is enthusiasm and support for Iluka's existing 20% FWC employment target, but there are challenges limiting local opportunities. Opportunities to increase local Aboriginal training and employment, to grow the economy and wellbeing of the community. Many Aboriginal/FWC people working at J-A are in entry-level jobs and some have been for extended periods with little progression or opportunities for growth. It was recommended to increase Indigenous employment by extending 20% target to subcontractors.	Section 7.3.1
Aboriginal outcomes	Indigenous organisations Social services	Internal challenges for Aboriginal employees working at J-A, a perception that the work culture is not good/culturally appropriate for Indigenous employees, some of which have experienced discrimination in the workplace. Iluka's HR department is lacking and not as supportive as other aspects of their business. Health and wellbeing for Aboriginal employees is an area of concern (particularly working FIFO away from community). Iluka do not have systems in place to allow for cultural leave amongst Aboriginal employees.	Section 7.3.4
Aboriginal outcomes	Indigenous organisations Social services	Contractors are not required to adhere to the 20% FWC target, integrating Aboriginal employment opportunities into sub-contracting agreements would likely lead to an overall increase in Aboriginal employment in the local and regional area (at the airport, at the ports etc.). Engage smaller local businesses and suppliers engaged by Iluka, such as laundry services, catering etc.	Section 7.3.1
Aboriginal outcomes	Indigenous organisations	Engage FWC employees during the rehabilitation stage of the Project to enhance understanding of how to appropriately protect Country and uphold laws.	Section 7.3.6
Aboriginal outcomes	Indigenous organisations Social services	Increase/introduce robust succession planning and progression programs/systems for Aboriginal employees, including training and education opportunities (opportunities for management and more specialised/technical positions through supported scholarships and training). Opportunity to transition local employees into the tourism industry following closure (especially Aboriginal employees). Engage FWC employees during the rehabilitation stage of the Project to enhance understanding of how to appropriately protect Country and uphold laws.	Section 9.3

Social impact category	Stakeholder group	Stakeholder consultation findings	Where addressed in this SIA
Aboriginal outcomes	Indigenous organisations Social services	Cultural leave is not understood within Iluka (including leave for ceremonial/law purposes required to fulfill cultural obligations). Law does not allow for discrete dates and time, and this cannot be negotiated. FWC could help facilitate a conversation around cultural leave and help to implement the appropriate policies, including paid and unpaid leave, and succession/contingency planning for when employees do need to take leave.	Section 7.3.4
Service and Infrastructure	Community organisations	Concern that Kalari trucks will shorten the road life and accelerate deterioration, which may increase indirect damage/wear and tear on local vehicles. Question of who is responsible for repairing damaged roads.	Section 7.4.2
Service and Infrastructure	Community organisations Council	Re-use of on-site infrastructure within the local community following mine closure (such as donating solar panels etc.)	Section 9.4
Surroundings	Businesses	Potential impacts associated with increased groundwater use. Uncertainty regarding where Project water will be extracted from. Question of whether water will be coming from the Great Artesian Basin (GAB), and whether this would have cumulative impacts on the water supply (in conjunction with other extractive industries increasing groundwater take).	Section 7.5.1
Surroundings	Businesses Community organisations Indigenous groups	Mine closure is not anticipated to be an impact if rehabilitation is undertaken properly. There is confidence that the mine site will be left in a good condition following closure and that rehabilitation will be undertaken well. Iluka have a good track record with rehabilitation and the environment. The Project will inevitably leave a 'big hole' in the ground, rehabilitation will be important.	Section 9.5

6 Existing social environment

6.1 General context

6.1.1 South Australian mineral context

South Australia is home to a wide variety of active, inactive and prospective mine sites as well as various known resource deposits across the region. Major operating mines include gold, copper, iron, coal, zinc, silver, and graphite and are distributed across the state. Across SA mining contributes approximately $8.7bn corresponding to 7.9% of SA's total economic output, and 5.4% of total FTE employment across the state (BDO EconSearch, 2021; DEM, 2021). Mining is the second-highest export industry behind agriculture, forestry and fishing, with total mining exports valued at $5.5 bn, making up approximately 43% of South Australia's total exports (DEM, 2021).

J-A is considered the world's largest zircon mine, and one of the only two major mineral sands projects in the State, alongside the Mindarie Mineral Sands Project located approximately 150 km southeast of Adelaide (DEM, 2022; Iluka Resources, 2022).

The only operating mine within close proximity to the Project within the Eucla Basin is the Kevin Gypsum mine located approximately 144 km southeast of the Project site. All other major operating mines are located further East and are proximate to other LGAs and associated populated areas and do not share the same transport infrastructure as the Project. The Kevin Gypsum mine is located at Lake MacDonnell to the East of Ceduna and utilises transport and warehousing infrastructure in Ceduna.

6.1.2 Eyre Peninsula and Southwest Region

The Eyre Peninsula is made up of a number of designated conservation areas, national parks, recreational parks, wilderness protection areas, regional reserves as well as Indigenous Protected Areas (Healthy Environs, 2015). The Peninsula host over 100 parks, conservation areas and reserves (Eyre Peninsula Natural Resources Management Board 2009 in SA Water, 2010), including local government administrated land, land managed under the FWC Native Title determination and an Indigenous Protected Area. Towns and localities in the Eyre Peninsular include Port Lincoln, Whyalla, Ceduna, Coffin Bay and Cummins. The total resident population of the Eyre Peninsular and Southwest Region SA3 is 57,092. The total proportion of Aboriginal and/or Torres Strait Islander represents around 7% of the population (ABS, 2021).

The Eyre Peninsular generates over $4 billion in revenue each year, with key productive industries including agriculture, manufacturing, fishing and mining. The Eyre Peninsular is also one of the fastest growing tourism regions in the State, with employment in the sector growing almost 80% in the last decade (RDAEP, 2022). Mining in the region is largely centred on iron ore extraction, as well as heavy mineral sands which is predominately mined at the existing J-A operation. There are 69 hectares (accounting for 0.13% of total land area) categorised as mining land in the Eyre Peninsula Natural Resources Management Region, considered an emerging land use type (SA Water, 2010).

6.1.3 Ceduna LGA

Ceduna is the only LGA within the local study area, as the Project and surrounding localities sits within the unincorporated South Australia region, which is managed by the Outback Communities Authority (OCA). The Ceduna LGA encompasses the town of Ceduna and surrounding localities including Thevenard, Smoky Bay, Denial Bay, and Koonibba. The LGA covers a total area of 5,427 km^2 and has a total population of 3,505. Over half the population of the Ceduna LGA live in the Ceduna suburb area (ABS, 2021). The median age in the LGA is 40, which is one year younger than the SA median age, and the majority of residents (78%) are Australian born. Approximately 25% of the LGA's residents identify as Aboriginal and/or Torres Strait Islander, which is over 10 times higher as a percentage than SA more broadly. The most common language spoken at home other than English is Pitjantjatjara (2.1%).

More than half (59%) of residents in the Ceduna LGA work full-time and 29% work part-time. The most common industry of employment is Combined Primary and Secondary Education, which employs 6.1% of the LGA's population, followed by grain-sheep or grain-beef cattle farming (4.9%). Other notable specialized industries in the region include offshore longline and rack aquaculture, which employs 3.7% of the population. The Port of Thevenard and proximity to the Eyre Highway has bolstered Ceduna LGA's economy with key export industries, freight routes and tourists passing through the town. Ceduna's economy relies on major industries including agriculture, mining, aquaculture, and tourism (District Council of Ceduna, 2020).

6.1.4 Towns and communities

Relevant populated communities within the local study area described below in Table 6.1. As much of the regional area covers remote desert areas, these towns represent the areas where most of the population and services are concentrated.

Table 6.1 Key towns and communities surrounding Project site

Town	Description
Ceduna	Ceduna is a coastal community with a resident population of approximately 1,955 people (in the Ceduna ABS Suburb and Locality (SAL) area. It is located 290 km south-east of the Project site and is approximately eight hours drive west of the City of Adelaide, the capital of South Australia on the Eyre Highway or A1. It is governed by the District Council of Ceduna. The name 'Ceduna' is derived from the Aboriginal work 'Tjutjuna', meaning a place to sit down and rest (Ceduna Aboriginal Corporation, 2019). Ceduna is the major township within the Ceduna LGA representing 56% of the total LGA population which is approximately 3,505 people. Defining features of the Ceduna area include the A1, Port of Thevenard (described in further detail below) and an array of protected conservation parks including Wittelbee Conservation Park, Laura Bay Conservation Park, Yumbarra Conservation Park and Nullarbor National Park and Regional Reserve. Ceduna town is the closest economic 'hub' to J-A. Given Ceduna's position on the Eyre Highway, the town is considered the western gateway to the region and a key road transit and tourist route between Sydney and Perth. Ceduna has been a Dry Zone since 1988, meaning no alcohol can be consumed in public within the town's boundary and there are restrictions on the sale of certain types of alcohol. 'ID Tect systems' are installed in all takeaway premises which provide information to sales staff about whether the person purchasing has a barring order in place (i.e. should not be supplied with alcohol). The Dry Zone also applies to Thevenard and Smokey Bay (The District Council of Ceduna, 2020). Agriculture, forestry and fishing contribute significantly more to local output than any other industry in Ceduna LGA with a total output of $77m (economy.id, 2021). Other relatively significant industries in terms of output include mining, construction, wholesale trade, and transport postal and warehousing. It is likely mining supports these industries to some extent through the expenditure associated with ancillary services and operations.
Thevenard	Thevenard is a small port town located approximately 3 km from Ceduna and 195 km southeast of the Project site, with a population of 563. Port Thevenard is a deep-sea port that exports goods such as mineral sands (including from J-A), gypsum, salt and grain, whilst also servicing small fishing boats. The town features two fish processors, a supermarket, a hotel, and a Sports and Community Club (Ceduna Tourism, 2022). The town of Thevenard is governed by the District Council of Ceduna.

Town	Description
Penong	Penong is a township with a population of approximately 280 people. It is located 222 km south-east of the Project site. Penong is an unincorporated area (Government of South Australia, 2018). Penong is primarily a mix of farming and cropping area with the majority of residents living outside of the township itself. The area is known for its local beaches which are popular destinations for surfers (Outback Communities Authority, 2014).
Yalata	Yalata is a small Aboriginal community with a population of approximately 313 people. It is located 90 km south of the Project site. Yalata is an Indigenous Protected Area (IPA), governed by the Aboriginal Council of Yalata. Yalata was created in 1952 to accommodate people who had been displaced by the closure of the Ooldea United Aboriginal Mission adjacent to the Trans-Australian Railway. Aboriginal law and culture are a central focus in the community with many residents engaging in active cultural life, such as participating in traditional hunting activities around Yalata (National Indigenous Australians Agency, 2016). In recent years, there has been a trend of people moving back into the Yalata IPA as well as further north, particularly older people returning to traditional lands (Tullawon Health Services, 2020).
Koonibba	Koonibba is an Aboriginal community with a resident population of approximately 140–200 people (ABS, 2021; Koonibba Community Aboriginal Corporation, 2022). It is located 269 km south east of the Project site and 40 km north west of Ceduna. It is governed by the Koonibba Aboriginal Community Council Inc. In 1901 the Koonibba mission was established, which drew a number of Aboriginal people from three local language grounds, Wirangu, Kookatha and Mirning. The Mission was taken over by SA Government from the Church in 1963, before being transferred to the Aboriginal Land Trust in 1975. Today the town is governed by the Koonibba Aboriginal Community Council, and many families with historical and cultural connections to the Town continue to live in Koonibba (Koonibba Community Aboriginal Corporation, 2022). Koonibba is also in close proximity to the Eyre Highway.
Maralinga Tjarutja (Oak Valley)	Oak Valley, or Maralinga Tjarutja, is a remote Aboriginal community of the Maralinga Tjaratja People, with a resident population that ranges from 80 to 100 people. During cultural events and activities, the population of Oak Valley can increase to 1,500 people with visitors coming from neighbouring communities (Maralinga Tjarutja, n.d.). In recent years, the trend of residents moving back Maralinga and proximate traditional lands has increased, particularly older people returning to Country (Tullawon Health Services, 2020). Maralinga is located 245 km northwest of the Project site. It is governed by the Maralinga Tjarutja Aboriginal Council Government Area (Government of South Australia, 2018).
Scotdesco	Scotdesco is a small Aboriginal community located approximately 100 km west of Ceduna and 116 km southeast of the Project site, with a resident population of approximately 50 people (ABC News, 2019). The community is situated on 25,000 acres of property called Tjilkaba, which is open to the public offering camping and tourist activities with a focus on the Aboriginal culture and history of the area (Scotdesco Aboriginal Community, 2022).
Smoky Bay	Smoky Bay is a small township with a resident population of 216 people. It is located 340 km south-east from the Project site. It is governed by the District Council of Ceduna. The area is known for its high quality aqua-cultural products such as oysters as well as commercial and recreational fishing (Regional Development Australia: Whyalla & Eyre Peninsula, 2019). Smokey Bay has been a Dry Zone since 1988 and has the same restrictions in place as Ceduna (The District Council of Ceduna, 2020).

Town	Description
Streaky Bay	Streaky Bay is a township with a similar residential population to Ceduna, being approximately 1,436 people. It is located 405 km south-east from the Project site. Streaky Bay is governed by the District Council of Streaky Bay which shares its boundaries with the District Council of Ceduna in the north-west, Anangu Pitjantjatjara (APY) Lands in the north-east, Wudinna in the east and Elliston in the south. The total population of the Streaky Bay District Council area is approximately 2,165 people. In the Streaky Bay LGA, output and value-added are noticeably dominated by agriculture, forestry and fishing industries, with output valued at $113m and value-added of $59m in 2018/19 (Figure 33 and 34). This reflects the dominance of agriculture in the region and is expected given the geography of the region and low population.

6.2 Demographic overview

6.2.1 Population

6.2.1.1 Population change

In 2021, Ceduna LGA had a population of 3,505 residents. Between 2001 and 2016, the Ceduna LGA has experienced a population decrease of 7.8%, however from 2016 to 2021 the population increased slightly by 3%. This population decrease was not reflected in the Eyre Peninsula and Southwest Region or State level with both areas experiencing population growth. The Peninsula and South West Region saw an overall population increase of 19% from 2016 to 2021 (ABS, 2016; ABS 2021).

6.2.1.2 Age

Ceduna LGA is characterised by its relatively young population. Compared to the Eyre Peninsula and South West Region and the State, Ceduna LGA has a slightly lower median age (40 compared to 43 and 41 respectively).

Aboriginal and/or Torres Strait Islander communities within the Ceduna LGA are characterised by a high proportion of children (0–11 years of age) (28%) and fewer older residents, with only 22% of all Indigenous residents in the LGA aged over 50 (ABS, 2021).

6.2.1.3 Language

When considering 'language spoken at home' across the Ceduna LGA, Eyre Peninsula and South West Region and South Australia, there are similarities and differences which reflect social and cultural demographic characteristics of each area. Within the Ceduna LGA the top four languages other than English were Pitjantjatjara, Greek, Australian Indigenous Languages (undefined) and Punjabi. When considering the diversity of Australian Aboriginal languages spoken across the three areas Pitjantjatjara was the most common identified Australian Aboriginal language spoken, which was the top language other than English in Ceduna LGA (2.1%), and Eyre Peninsula and South West Region (0.7%). Notably, the proportion of residents who stated that they speak Pitjantjatjara in Ceduna LGA has more than doubled from 2016 to 2021 (ABS, 2021).

6.2.1.4 Social advantage and disadvantage

Ceduna LGA has an Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) decile rating of 2. There are 10 deciles evenly divided between 1 and 10, where 1 indicates relatively greater disadvantage and a lack of advantage in general, while 10 indicates a relative lack of disadvantage and greater advantage (Australian Bureau of Statistics, 2018). An IRSAD decile rating of 2 indicates that the Ceduna LGA is one of the more disadvantaged LGAs in Australia.

The remoteness of the region and the high proportion of Aboriginal communities within the population who face severe and adverse health and socio-economic conditions, place these communities in a vulnerable position. In particular, findings reflected that schools with below national average Index of Community Socio-Educational Advantage (ICSEA) and low education attainment create vulnerabilities related to future employment, skills development and career or vocational opportunities (MySchool, 2020).

6.2.2 Aboriginal and/or Torres Strait Islander people and culture

Almost a quarter of Ceduna LGA's population (24.8%) identified as Aboriginal and/or Torres Strait Islander in 2021. Between 2006 and 2016 the total number of Aboriginal and/or Torres Strait Islander residents decreased from 859 to 741, however increased again to 870 in 2021. This reflects similar population trends for the whole Ceduna LGA population. Compared to the Eyre Peninsula and South West Region and South Australia, Ceduna LGA has a significantly higher proportion of Aboriginal and/or Torres Strait Islander residents (6.7% and 2.4% respectively) (ABS, 2021).

The FWC Aboriginal Group are acknowledged as the Traditional Owners of lands and waters in the Ceduna LGA and surrounds. On 5 December 2013, the Federal Court of Australia granted a Consent Determination to recognise native title rights and interests in an area spanning 80,000 square kilometres known as the Yellabinna Parks. The Consent Determination includes the townships of Ceduna (principal regional centre), Penong, Fowlers Bay and Nundroo; and multiple Aboriginal Homeland Communities including Oak Valley, Yalata, Scotdesco, Koonibba, Koongawa Dundee, Bullinda, Tia Tuckia, Betts Corner, Yari-Lena, Dinahline, Warevilla and Munda and Wanna Mar.

The FWC Corporation represents members of six distinct cultural groups, which include the Wirangu people, Mirning Peoples, the Kokatha people, Yalata Peoples, Maralinga Tjaratja (Oak Valley) Peoples and the Descendants of Edward Roberts (FWAC 2022). All groups have spiritual connection and long history to the land, extending also to the Koonibba people, and Anangu people of Yalata and Oak Valley (Native Title Services South Australia, 2020; Reconciliation South Australia, 2014; Tullawon Health Services, 2020).

The Native Title Consent Determination provides rights to the members of the FWCAC, including:

- access to, hunt, fish, camp, gather and use natural resources
- deliver educational and learning initiatives on the land related to cultural heritage
- conduct cultural activities, meetings and traditional ceremonies on the land
- protect places or sites of cultural significance on the land.

6.2.3 Native title mining agreement

The FWCAC and Iluka hold a Native Title Mining Agreement (NTMA) for Production at J-A since 2007 for undertaking mining activities. The agreement aims to foster effective ongoing business relationships between FWC businesses and Iluka and describes priorities for local communities and members.

Under the current NTMA for J-A, the Traditional Owners of the J-A site granted Iluka permission to:

- proceed with mineral sands mining at J-A
- tap and pipe the underground water supply to the mine
- construct a sealed road from the Eyre Highway between Nundroo and Yalata to the mine (a distance of 92 km) (ATNS, 2007).

In addition, Iluka agreed to the following conditions of consent under the NTMA:

- Payments –including Milestone Payments and Production Payments. Milestone Payments include an initial payment and agreed annual payments. Iluka also pays the FWCAC Gross Project Revenue Percentage each year (Production Payment) (Finlaysons, 2008, pg. 19-20).
- Education, Training and Employment – for members of the FWCAC. This includes an employment target of 20% of FWCAC members in full time roles associated with the operation, structured on-site learning, work experience for school students, an Education Training and Employment Program, establishment of educational scholarship programs 'to be applied for in writing by members of the Claimants' (Finlaysons, 2008, pg. 21-25).
- Business Development – to provide guidance and assistance to FWCAC businesses in tendering for contracts and establishment of an Aboriginal Business Development Plan for J-A (Finlaysons, 2008, pg. 26-27).

The NTMA also acknowledges that the FWC people are the Traditional Owners of the land of which the J-A mine is situated and does not extinguish the Native Title interests held by the Native Title Group.

6.3 Labour force, income

In 2021, Ceduna LGA had the highest median weekly household income of the three comparison areas ($1,381). This was almost $99 more than the State median and $136 more than the median for the Eyre Peninsula and South West Region. This suggests that collectively in Ceduna LGA there is a higher proportion of high-income earning households, which increases the overall median.

Median household income for Aboriginal and/or Torres Strait Islander residents is lower across all three study areas than the median household income of the total population for these areas. Ceduna LGA has the largest gap between Aboriginal and/or Torres Strait Islander household income and median household income ($346). At a State level, the difference was notably smaller.

Healthcare and social assistance is the largest sector of employment in the local study area. Since 2001, employment in agriculture, forestry and fishing has fluctuated. Employment in this industry began increasing again in Ceduna LGA from 2011 onwards. There is limited longitudinal data for the Eyre Peninsula and South West Region, however available data does suggest that employment relating to agriculture, forestry and fishing is increasing but not as quickly as in the Ceduna LGA.

Mining accounts for 3.2% of employment in Ceduna with the majority of jobs in 'non-metallic mineral mining and quarrying' – such as sand mining (Economy.id, 2021). However, mining employs a higher proportion of residents across the Eyre Peninsula and South West Region, representing 6.2% of direct employment. Importantly, other jobs such as freight, warehouse management and export activities through ports can be linked to economic activity involving natural resources – such as wheat and mineral exports. Mining, while representing a lower proportion of employment in the Ceduna LGA, has gradually increased since 2001. While there has been growth in this industry, it has resulted in limited direct employment across the Ceduna LGA.

6.3.1 Unemployment rate

Over the past eight years, unemployment rates in the Ceduna LGA have ranged from 9.1% to 5.1%, with the highest rates of unemployment occurring in 2014 (9.1% compared to 5.4% in 2019). On average the unemployment rate is above that of the State which was an unemployment rates peak at 7.2% in 2014 compared to 5.9% in 2019.

In 2016, the proportion of unemployed Aboriginal and Torres Strait Islander residents was over three times as high as the Ceduna LGA more broadly (12.4% compared to 3.5%) (ABS, 2016). 44.4% of Indigenous residents worked full time and 34.4% worked part time in Ceduna (ABS, 2016).

6.4 J-A operations

The remote location of the J-A operation has necessitated the provision of suitable amenities to accommodate the entire J-A workforce. While rostered on shift, all employees are required to reside at the workforce accommodation camp. Since 2008, this has created a new population in an area that would otherwise be uninhabited.

In 2019, Iluka directly employed 99 people, 26 of which lived in the local study area. Additionally, Iluka employed 235 contractors across Australia, 21 of these reside in the local study area.

Table 6.2 Direct J-A workforce

Year	Iluka		Major contractors		Total J-A workforce		
	Total	Local area	Total	Local area	Total	Local area	Local area (%)
2011	65	33	66	33	131	66	50
2012	69	29	154	36	223	65	29
2013	70	36	93	36	163	72	44
2014	68	29	155	19	223	48	22
2015	76	31	165	20*	231	51	22
2016	77	26	35	5*	112	31	28
2017	45	15	187	23*	232	38	16
2018	67	19	223	26	290	45	15
2019	99	26	235	21	334	47	14

*Source: provided by Iluka Resources, 2020 * indicates estimate where data is not available*

Table 6.2 and Figure 6.1 illustrates how the place of residence of the J-A operation workforce has changed over time. It shows:

- a relatively small proportion of the J-A workforce FIFO from interstate locations. The proportion from within SA has increased from 83% of the workforce to 88% of the workforce in the last ten years of operations
- the majority (60%) of the J-A workforce live in Adelaide or its surrounding metropolitan suburbs. It is likely quite difficult for the small number of employees to commute from regional areas of SA to Adelaide or the study area
- of the 30% of the J-A workforce who reside in the local study area, the majority are based in Ceduna and Thevenard (61%), followed by Streaky Bay (23%). No employees were recorded from remote Aboriginal communities such as Yalata
- between 2014 and 2017 the total J-A operational workforce notably decreased. Internal consultation with Iluka highlighted that during these periods local workers were preferentially retained. Decreases in J-A workforce during this period may be due to the suspension of activities at the operation between April 2016 and December 2017, which was instated to allow for HMC inventory to be ‘drawn down during a time of subdued market demand’ (Australian Mining, 2017).

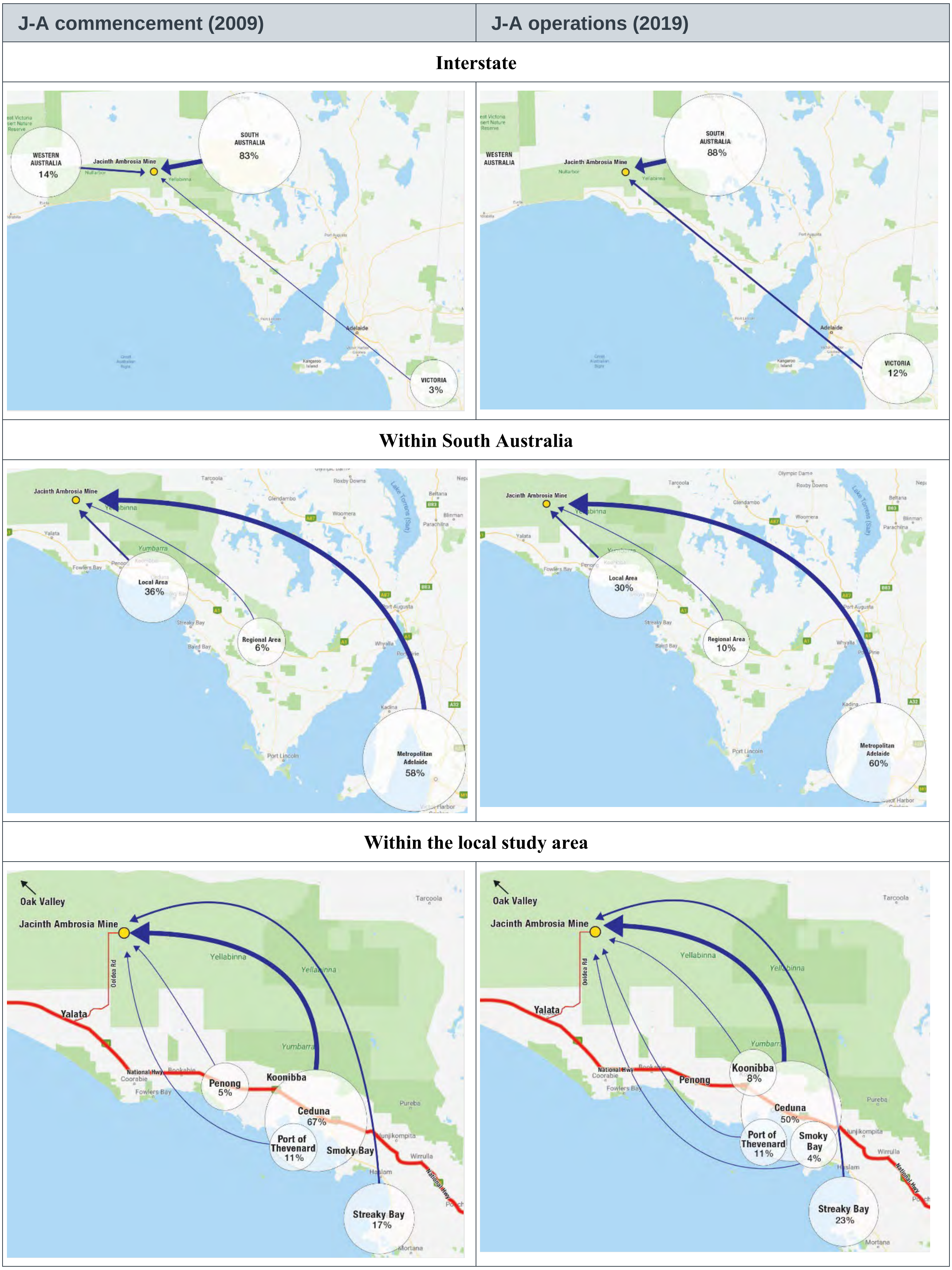


Figure 6.1 Residential address of J-A workforce 2009 and 2019

The following summarises both the indirect and direct employment impacts of J-A operations. A regionalised input-output model conducted by Acil Allen (2019) has been utilised that estimates the employment (as of 2018) resulting from employment at the mine, as well as indirect employment in other industries as a result of expenditure at J-A. These numbers reflect those directly employed by Iluka at the mine, as well as other employment in separate industries that have occurred as a result of capital and operational expenditure at J-A.

Job creation is measured in FTE and is derived from the direct employment by Iluka at the J-A mine and the indirect jobs created from the spending by Iluka on goods, services, community investments, wages, and taxation to operate the mine which then creates employment in other industries.

It is estimated that the direct and indirect employment and expenditure by Iluka support approximately 49 FTE jobs in the Far West Coast Region, and 12 FTE in the Eyre Peninsula as a result of J-A operations. Of these, 23 FTE of the 49 FTE jobs are in the Far West Coast Region and 10 FTE of the 12 FTE jobs from Eyre Peninsula are indirect, meaning that this proportion of employment occurs in ancillary industries and businesses located in the region (Acil Allen Consulting, 2020). Indirect and induced employment refers to indirect flow on economic benefits to local businesses and industries, that may result in additional employment.

Table 6.3 Total J-A employment impact

	Far West Coast	Eyre Peninsula	South Australia (total)	Australia (total)
Indirect and induced	23	10	604	816
Direct (Iluka FTE Employees)	26	2	76	89
Total job creation (FTE)	**49**	**12**	**680**	**905**

Source: Acil Allen Consulting 2020 Table 4.

6.5 Health and wellbeing

The Regional Public Health Plan (District Council of Ceduna, District Council of Elliston, District Council of Streaky Bay and Wudinna District Council) is the first and most recent health plan for the region published in 2015 and reviewed in 2020. Significant health issues face these four regional councils collectively, including premature mortality, smoking and smoking during pregnancy, chronic disease, and excessive drinking reflect health issues (Healthy Environs, 2014).

The region's remoteness and small and disperse population was identified as factors which amplified health impacts in communities and likely further disadvantages already marginalised communities. This has significant implications for the delivery and access of health services for residents, especially for emergency and/or critical care and especially across remote settlements. The need for culturally appropriate health services was also identified as a priority due to the significant proportion of Aboriginal residents (approximately 25%) in the Ceduna LGA, as well as a focus on closing the gap in Aboriginal health across the Ceduna LGA and across the Far West Coast. This requires delivery of services to target localised Aboriginal health issues as priority strategies. The Ceduna Health Service has also identified mental health services as a priority (Healthy Environs, 2015).

Aboriginal health services including Tullawon Health Services Inc, Ceduna Koonibba Aboriginal Services, Country & Outback Health, and Oak Valley Maralinga Health Service provide primary health care and chronic disease management to the local and regional Aboriginal community. These Aboriginal health services were born out of a need to provide healthcare to complex needs in ways that overcome cultural and physical barriers to accessing services. There are clinics in both settlements as well as administration offices (Tullawon Health Services, 2020).

The Tullawon Health Services Inc. is interested in growing and expanding their offerings and are currently looking into other remote area health services to examine ways in which we can assist in the development of a wider regional service for the Anangu people of the region (Tullawon Health Services, 2020).

During the 2022 calendar year, seven medical referrals for J-A staff were made of which only one attended the Ceduna hospital. Five attended Adelaide facilities and one attended a medical facility in Port Lincoln.

6.6 Transport and travel behaviour

Ceduna is an important transport and travel hub in the region, featuring several key pieces of transport capital and infrastructure that support commodity transport, freight and shipping across the region, including The Eyre Highway and the Port of Thevenard. These transport links play an important role in supporting a diverse economy in the Ceduna LGA and the broader region of the Eyre Peninsula and Southwest region.

6.6.1 Eyre Highway

The Eyre Highway (Highway A1) is a key freight route, and popular tourist drive for both domestic and international visitors (South Australia Tourism Commission, 2018; Regional Development Australia: Whyalla & Eyre Peninsula, 2019). When travelling east-west, Ceduna is the last major town before Perth on the Highway, acting as key service hub for travellers, workers and cargo passing through. The Eyre Highway is maintained by the South Australian Government with Federal Government funding contributions.

6.6.2 Port of Thevenard

The Port of Thevenard is the export gateway for the Ceduna LGA and broader region, being the second most active port in South Australia. The Port handles approximately 2,000,000 tonnes of cargo annually, including imports of fertiliser and exports of wheat, barley, oats, gypsum, salt and mineral sands (SHIPNEXT, 2022). The operation of the Port and its reliance on agricultural productivity and mineral extraction is an indirect employment benefit which is tied to the regions access to natural resources.

The Port of Thevenard is South Australia's busiest regional port. The presence of the Port in Ceduna is a tangible, visual and daily reminder for residents of the local economic activity in the region. Operated by Flinders Ports, cargoes handled in addition to the mineral sands produced by the Project are gypsum, grains and seeds, and salt. The port is vital to enabling export activities to occur, as demonstrated by temporary suspension of shipping in 2017 due to jetty damage. This event caused substantial community concern for local employment and necessitated the Project seeking alternate transport options for a period of around three months (McKay, 2017). However, as of October 2020, Flinders Ports completed upgrades including restoration works and improvements to the Thevenard jetty (Port Lincoln Times, 2020). These upgrades have enabled increased port capacity, and improved security of operations and associated employment (Flinders Ports, 2019).

6.6.3 Ooldea Road, Ooldea railway siding and Maralinga

Ooldea Road is a travel route that links the Eyre Highway to Yalata and Maralinga. It is maintained by the South Australian Government (with Federal Government funding contributions) and Iluka (between the Eyre Highway and the Project site).

The Ooldea railway siding is a water refill station along the Trans-Australian Railway. The Ooldea railway siding is located where Ooldea Road crosses the Trans-Australian Railway, roughly 76 km northwest from J-A (Maralinga Tours, 2015). It is located within an unincorporated area.

6.6.4 Ceduna airport

The Ceduna Airport is a small regional airport that provides two daily flights to and from Adelaide on weekdays and one on weekends. The airport is property of the District Council of Ceduna, who run and benefit from the airport's services. Charter flights and tours are also available from Ceduna. The airport features a passenger terminal, car park, and two runways (one gravel and one sealed).

Based on publicly available flight data, Rex is contracted to provide FIFO flights with Iluka, operating five weekly flights, corresponding to approximately 170 seats per week. All chartered Rex flights connect via Ceduna Airport to and from Adelaide and J-A.

6.6.5 Method of travel to work

There are limited public transport options for commuting in Ceduna LGA and the wider Eyre Peninsula and South West region. ABS travel to work data shows most residents rely on personal transport to travel to work.

A breakdown of the travel to work data set shows:

- the rate of people driving to work (as driver or passenger) is almost the same across the Ceduna LGA (72%) and the Eyre Peninsula and South West region (71%), which is similar to that across SA
- slightly higher rates of residents travelling to work as a passenger (carpooling) in the Ceduna LGA (5.7%) and Eyre Peninsula and South West Region (5.2%) than SA as a whole (4.6%)
- significantly lower rates of residents travelling to work by public transport in Ceduna LGA (0.8%) and Eyre Peninsula and South West Region (1.8%) than SA (7.2%), likely due to the lack of local public transport infrastructure
- slightly higher rates of residents walking to work in the Ceduna LGA (6.7%) and Eyre Peninsula and South West Region (5.1%) than SA (2.8%).

According to the 2020 J-A SIA and considering the 2022 SIA site visit, traffic conditions in Ceduna and Thevenard are consisting of:

- general high reliance by residents on private vehicles for daily activities such as work commute, school drop-off and other day-to-day activities
- presence of tourists and visitors, particularly those with caravans and off-road vehicles
- regular heavy vehicle movements associated with both the J-A, Port activities, and other local and regional industries
- daily gypsum train movements from the Kevin Gypsum mine to the Port of Thevenard.

6.7 Social infrastructure

The Ceduna, Thevenard and Denial Bay communities are serviced by two local schools and the region’s hospital, Ceduna Hospital. The Ceduna Area School is a primary, middle and high school catering to 424 students from Ceduna town and surrounding areas. Given the location of the school and regional communities, approximately 27% of students travel daily to and from school by bus (Ceduna Area School website, 2021). The Penong and Coorabie District School also services the regional community and is located in the town of Penong 78km west of Ceduna adjacent to the Eyre Highway along the Project’s transport route. There are 39 students currently enrolled at the primary school (MySchool, 2021). Other schools in the local study area include Streaky Bay Area School, Kooniba Aboriginal School and the Yalata Anangu School, which are included below in Table 6.4.

Most facilities and services available within the regional area are located in the Ceduna LGA. Major services and social infrastructure within the local study area is listed below in Table 6.4.

Table 6.4 Local social infrastructure

Service type	Name	Location
Health	Ceduna Hospital	3 Eyre Hwy, Ceduna
	Streaky Bay Hospital	1 Flinders Dr, Streaky Bay
	General Practice (GP) Plus Health Clinic in Ceduna	3 Eyre Hwy, Ceduna
	Ceduna Family Medical Practice	3 Eyre Hwy, Ceduna
	Ceduna Koonibba Aboriginal Health Service	1 Eyre Hwy, Ceduna
	Yalata Maralinga Health Service/Tullawon Health Services	303 Tullawon Sq, Yalata
	Oak Valley Maralinga Health Services	145 Wattle St, Oak Valley Community
Education	Ceduna Area School	3 May Cres, Ceduna
	Crossways Lutheran School	4 Smith Rd, Ceduna
	Streaky Bay Area School	109 Wells St, Streaky Bay
	Penong and Coorabie District School	Eyre Hwy, Penong
	Yalata Anangu School	Yalata
	Ceduna TAFE campus	Decres Bay Road, Ceduna
Transport	The Eyre Highway	Eyre Hwy
	Ceduna Airport	46307 Eyre Hwy, Ceduna
	Port of Thevenard	Thevenard Rd, Thevenard
	Trans-Australian Railway	N/A
	Rail line from Kevin to Thevenard	N/A

Residents living in remote communities further away from Ceduna are likely to have limited access to regional services. Issues regarding access to essential services compound for people in remote settlements, people with disabilities, young and aged people, Aboriginal people, and lower socio-economic households. Local Councils across the region also acknowledge the significant challenges they face due to the limited resources available to them and remoteness of populations across catchment areas (Healthy Environs, 2015).

6.7.1 Housing and accommodation

There is a relatively limited availability of rental and purchasable properties within the local study area. While house prices were considered comparatively low in the local area, there has been a notable increase in median house prices and rent over the past month, as demonstrated in Ceduna where prices have increased by 17% and rent has increased by 8.5%. In Ceduna, a slightly higher proportion of residents rent than in SA more broadly (37.3% and 27.5% respectively). While the proportion of residents that owned their home outright was similar to SA, a smaller percentage of residents owned their home with a mortgage in Ceduna LGA (24.8% and 35.6%) (ABS, 2021).

As of the 26 September 2022, a total of 29 properties were for sale in Ceduna, and the median house price was $280,500. An additional 5 houses were available in Thevenard and 0 houses were available in Penong. Within the Ceduna LGA the median monthly mortgage repayments were $1,247, compared to $1,500 across the State more broadly (ABS, 2021).

A total of 7 rental properties were available in Ceduna where the median rental price was $320 per week, and one rental was available in Thevenard. Given the proportion of residents who rent in Ceduna, this may indicate an overall shortage in rental accommodation supply.

6.7.2 Water infrastructure and availability

Social and economic development is closely correlated to the availability of potable water' (SA Water, 2010). The regional study area is one of the driest in Australia with scarce water resources (SA Water, 2010).

The Ceduna LGA does not have a sustainable or abundant water supply, due to the harsh biophysical setting of the area. Groundwater and River Murray water are the two main water sources across the Eyre Peninsula, with recycled water and dams being secondary sources. Across the Far West Coast Region, communities are predominantly reliant on groundwater, with available groundwater only available in areas proximate to the coastline. Groundwater resources surrounding the Project area are highly saline, and as such are not potable.

Currently, in Ceduna town, drinking water is sourced from one of two reticulated water systems; one in Koonibba known as 'Water West' and the second in Smoky Bay or the 'Smoky Bay Aquaculture Park' (Ceduna District Council, 2020). The former stops just 10 km from the settlement of Penong, resulting in the current service of drinking water being transported by truck to Penong. The District Council of Ceduna also operates two recycled water schemes for other water supply requirements across the LGA (Ceduna District Council, 2020). The District Council of Ceduna with SA Water has been in recent years making upgrades to the water infrastructure in the township, however it still remains an ongoing issue for future planning (West Coast Sentinel, 2018).

It can be inferred that there are ongoing issues for Ceduna and outlying communities related to water supply and demand. The existing reticulated systems are inadequate to support significant growth in industry, and water supply is not readily available for certain outlying communities without trucking services, which is costly and often unsustainable. Based on these factors, it is apparent that the current water infrastructure across the regional study area is inadequate to sustain future population and industrial growth (Natural Resources Committee, 2013).

Yalata, Oak Valley and other remote Aboriginal settlements rely on groundwater community wells built and maintained by SA Water. In recent years, drilling and water research Projects have been ongoing in Yalata among other remote communities to source new water supply options for sustained use (Department for Environment and Water, SA Government, 2020).

6.7.3 Telecommunications

In 2016, nearly a quarter of all residents in the Ceduna LGA (23.8%) could not access the Internet from their home, which was more than 5% higher than the State. Two phone networks service the regional; Telstra and Optus, however the latter is only available in Ceduna and Smoky Bay (Ceduna Tourism, 2022).

6.8 Community values

6.8.1 Community cohesion and resilience

During SIA consultation, Ceduna residents and community representatives described the community as resilient, with the ability to mobilise people in a uniformed way that achieves outcomes, with good local participation in community events. Sports are the 'social fabric' of the community, and not being able to attend sporting events due to COVID was challenging.

The Ceduna community was also described as active and involved – interested in fishing, camping, surfing and interacting with the surrounding natural environment.

Similarly Streaky Bay was described as community orientated and close knit. Recent growth in the community has somewhat impacted the sense of community, however there is still capacity for the area to grow further.

The Penong community also described Penong as having a strong sense of community, with a strong community understanding that all residents have a responsibility to help the Town progress. The Penong Progress Association was established due in part to the lack of a local Council with assistance/input from the Outback Communities Authority.

6.8.2 Community priorities

During SIA consultation, interviewees described the following as some of the key priorities of the community:

- employment, education and upskilling, early childhood to adult education, ensuring healthy and wealthy communities
- increasing Aboriginal employment is critical as it sets a precedent and creates role models for kids. A job in each house is the goal
- continued education amongst youth, as well as keeping young people in the community following their schooling.

6.8.3 Natural environment

The Project is located within the Yellabinna Regional Reserve, which is around 30 km north of Ceduna and approximately 20,000 km^2. Yellabinna is one of five regional reserves in SA, established as multiple-use reserves with a conservation function (DEW, 2022). As such, regional reserves promote the protection of wildlife, natural landscapes and cultural heritage, whilst also allowing for the utilisation and extraction of resources. Visitors are drawn to the reserve due to its unique landscape characterised by sparely vegetated red sand dunes, as well as its native wildlife which includes Major Mitchell Cockatoos, Scarlet Chested Parrots, Thorny Devils, Sand Hill Dunnarts and Malleefowl (NPWS SA, 2022).

Yellabinna Wilderness Protection area is located within the reserve, approximately 150 km from J-A. The Wilderness protection area hosts the majority of visitor activities within the reserve, including the Mount Finke Campground which features hiking tracks, birdwatching and 4WD access tracks (see Figure 6.2). There is minimal tourist infrastructure surrounding the J-A site.

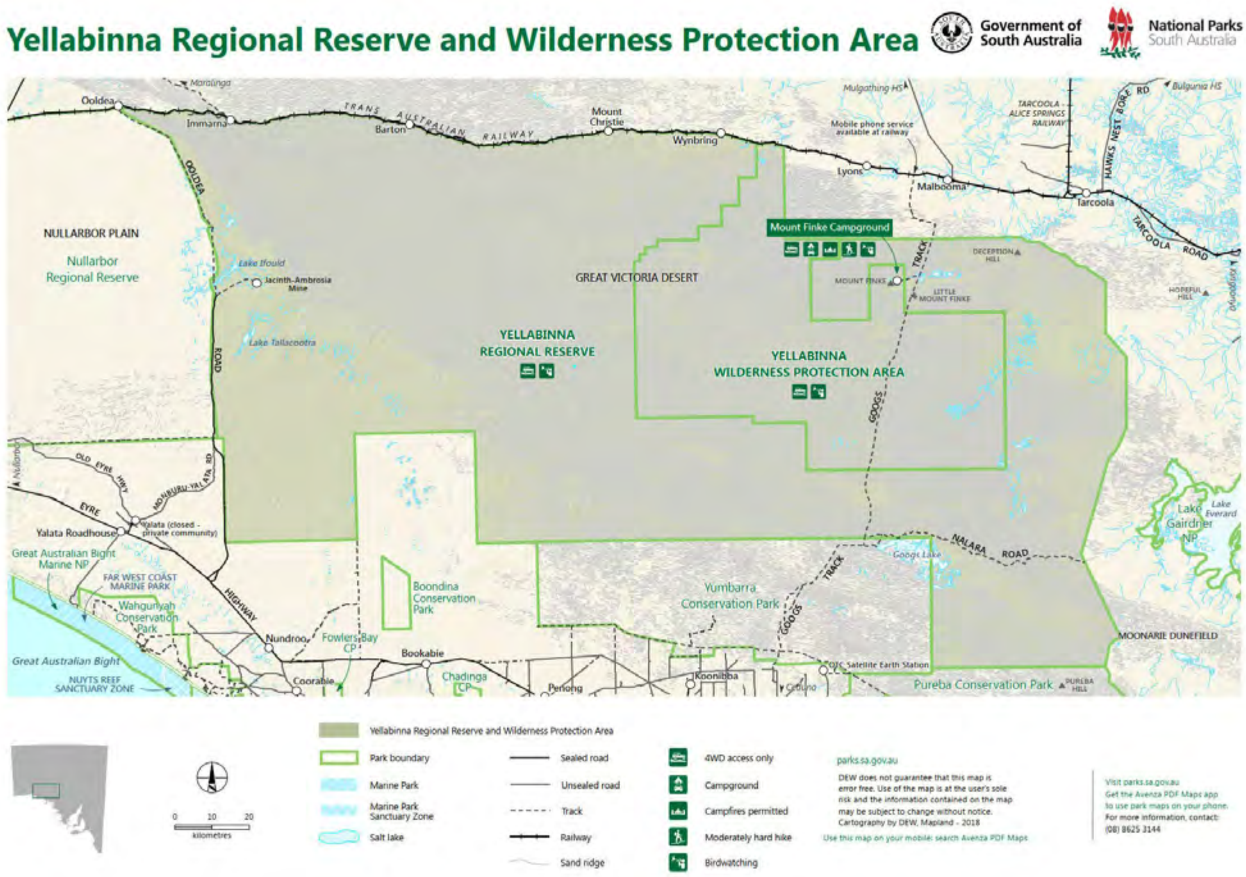


Figure 6.2 Yellabinna Regional Reserve and Wilderness Protection Area

6.8.4 Tourism

The local and regional study area attract a significant number of domestic tourists and visitors each year, including 'Grey Nomads' and other overland travellers driving from the east to west coasts of Australia. Ceduna is considered to be one of the last moderately sized towns before Perth, making it a popular destination for travellers to rest and stop for supplies. The tourism and hospitality industry represents a higher proportion of the local economy in Ceduna (5.2%) than the Eyre Peninsula and Southwest region (2.8%).

6.8.5 Community organisations

Ceduna is a hub for government and nongovernment services with many government departments and organisations having a head office in town, most of which service the wider region. This is reflected by the high proportion of residents employed in health care and social assistance, which was the second largest industry of employment in 2016 (15.6%), only 1% less than the largest industry of employment which agriculture, aquaculture and forestry (16.3%).

The number of government and non-government organisations in Ceduna suggests potentially higher levels of social disadvantage and/or need in the area. Ceduna was one of the five regions across Australia where the Federal Australian Government trialled the Cashless Debit Card Program. The Program aimed to "support people, families and communities in places where high levels of welfare dependence co-exist with high levels of social harm" (Department of Social Services, 2019). in August 2022 the Cashless Debit Card program was ended across Australia, with no new or voluntary participants are being accepted to this program (Department of Social Services, 2022).

Local or community-run organisations include:

- the Ceduna Aboriginal Corporation who supports and facilitate the Ceduna Youth Club and the Ceduna Arts and Cultural Centre as well as running upskilling and employment programs
- the FWCAC who represent the FWC Native Title claimants and have a range of assistance programs for members across the Far West Coast Region (see Section 6.2.2).

6.8.6 Challenges identified by community members

SIA consultation included interviews with community groups, local businesses, and local Traditional Owner representatives. During SIA consultation, interviewees identified the following challenges within the local study area:

- removal of the Indue cashless debit card which some stakeholders perceived to have had a positive impact on social issues including drinking and gambling
- regional flights are limited and expensive to and from Ceduna which causes challenges travelling to access services
- local trades are very busy and sourcing materials locally can be challenging
- vandalism in Ceduna
- finding local volunteers/members for organisation such as the Lions and Rotary Club
- barriers for locals upskilling or undertaking training/apprenticeships due to the required travel to and from Adelaide
- school attendance is a key issue which FWCAC has been targeting with youth programs, attendance has increased to around 78% with the program
- currently there is a trend of young people aged 15–25 leaving Ceduna to pursue work or study elsewhere, then returning later in life to settle down
- Streaky Bay house prices have increased significantly since the onset of COVID, which has had a positive impact on some local businesses. Very few/no rental properties available
- Penong has limited housing availability, short term accommodation fluctuates with key seasons (i.e. tourists and shearers).

7 Social impact assessment

This chapter describes and assesses the potential social impacts that are predicted as a result of construction and operation of the Project. The following analysis has been completed in accordance with the relevant guidance methodology described in Section 3.4.

7.1 Livelihoods

7.1.1 Increased employment opportunities for local residents

The Project will result in increased employment opportunities during construction and operations. Income derived from employment shapes many other aspects of people's lives such as housing, transport and health.

The Project will extend the life of mine of J-A, and as such existing J-A employees will see an opportunity to continue working at the mine for another four years, this is about 99 full time employees and fixed term contractors. There will be further prolonged employment opportunities, including an additional three years of product haulage, as well as rehabilitation activities. There are 235 third party contractors on a full-time equivalent basis who could also see work opportunities extended (89 lived in the Far West Coast region and 10 lived in the Eyre Peninsula region). The Project workforce is anticipated to increase by approximately 50–90 during construction and will almost double by approximately 300–350 workers during operations.

As described in Chapter 6, in 2019 Ceduna LGA the unemployment rate was 5.4% equating to approximately 189 people unemployed, while more than half (59%) of residents worked full-time and 29% worked part-time. The most common industry of employment in Ceduna LGA were health care, education, followed by grain-sheep or grain-beef cattle farming (4.9%), while mining accounts for 3.2% of employment.

J-A has implemented the following controls to maximise employment opportunities for local Aboriginal residents, noting that this focus is consistent with high presence of local residents who identify as Aboriginal and/or Torres Strait Islander (25%):

- 20% target FWCAC employment
- J-A FWC training and employment program
- influence labour hire providers – for local and FWC candidates
- FWC Work Experience program.

During SIA consultation, interviewees acknowledged that the expansion (via the Atacama Project) would create ongoing socio-economic security for the community, including increased/extended local employment and procurement opportunities for residents and small businesses, however also acknowledged that the current workforce at J-A is predominately FIFO and does not have much of a presence locally. In particular, Penong residents identified the challenge of commuting to the mine site as an employment constraint. It was suggested that introducing a shuttle/charter bus to and from Penong to transport local employees to site would enable more local opportunities. J-A consultations reported that employees who live locally are allowed to drive to site, having at least one employee from Yalata and Penong.

Given the constraints associated with the construction schedule and limited number of workers available with transferrable skills located within the local study area (see Table 7.1), there will likely be a portion of the construction workforce that comes from outside of the local and regional area. However, it is possible that an increase in employment opportunities will occur locally during construction, and this will have a moderate effect on the livelihoods of those residing in the local study area, resulting in a Medium benefit. During operations it is anticipated that existing J-A controls will continue for the Project and J-A, resulting in a High benefit locally.

Table 7.1 Assessment of increased employment opportunities for local residents

Social impact	**Improved livelihoods for those residing in the local study area due to increased employment opportunities.**	
Extent	Residents living in the local study area.	
Project phase	Construction	Operation
Assessment considerations	Approximately 50–90 workers would be employed during the construction program over approximately 12 months. Out of the 189 unemployed residents of the Ceduna LGA (inclusive of Indigenous residents) is it possible that a moderate proportion would require short to medium term training to be able to access to employment opportunities. Considering the fluctuation of unemployment figures in Ceduna, it is possible that a reasonable percentage of unemployed residents may be experiencing long term unemployment and would most likely not have access to construction employment opportunities. It is possible that part-time and full time employed residents who work in construction, transport or trade industries with transferrable skills may opt for Project employment opportunities.	It is anticipated that the total workforce at J-A will increase by 300–350 workers during operations due to the Project, including contractors. Given the continuous efforts of J-A to increase Aboriginal participation on site and via contractors, it is almost certain that local residents would see employment benefits. However, it is acknowledged that non-Aboriginal or non-FWCA members who are not targeted on existing controls may not see employment benefits to the same degree, resulting on a moderate benefit across all local residents.
Likelihood	Possible	Almost certain
Magnitude	Moderate	Moderate
Significance	Medium benefit	High benefit

7.1.2 Increased local procurement and business opportunities

During SIA consultation, it was acknowledged that local businesses may not have the capability or capacity to work on a large-scale contract. Procuring small services such as plumbers and concreters from the local community, and or increasing procurement opportunities by engaging local business to supply smaller goods and services to the camp were seen as potential opportunities and benefits of the Project.

These views are consistent with baseline data, where it was identified that there are a limited number of goods and services businesses available to support mine operations in the Ceduna LGA. J-A expenditure within the region and broader Eyre Peninsula region is significantly lower in comparison to SA and the rest of Australia/international expenditure with ranges between one and three million dollars per annum. In the Ceduna LGA local service expenditure on individual businesses averaged below $100,000 in under 10 years (2011–2019) (J-A SIA 2020), however in 2018, over $2.4 million was spent on goods and services purchased from businesses located in the Far West Coast region.

It was acknowledged by interviewees that Iluka has helped improve and expand local business capabilities due to the scale and requirements of the existing operation. Procurement opportunities have allowed local businesses to expand, for example buying new equipment and hiring additional staff and apprentices. As such, it is likely that the continuity of J-A operations and sourcing the needs of the Project, would likely see local business who have sourced J-A operations continue to benefit.

J-A also has implemented the following controls to maximise procurement opportunities for local Aboriginal businesses:

- Aboriginal business development plan
- contractor management plan.

Given that most businesses that could potentially service and supply the Project during construction are located outside of the local study area, it is possible that the realisation of this positive impact without any enhancement measures would cause a minor effect locally, resulting in a Low pre-enhanced benefit (see Table 7.2). As a result of the continuity of J-A's existing controls, it is likely that more local business would be engaged by the Project and J-A due to the increased supply needs associated with the Project, resulting in a Medium benefit during operation.

Table 7.2 Assessment of increased local procurement and business opportunities

Social Impact	**Enhanced livelihoods of local business owners and workers due to increased procurement opportunities.**	
Extent	Business owners and employees within the local study area, with benefits potentially extending to the broader community within the local study area.	
Project phase	Construction	Operation
Assessment considerations	Procurement benefits are most likely to occur at the regional and state level from provision of civil works, haulage of materials, supplying fuel and services. Local business may encounter opportunities in earthmoving, workforce transport and supporting some limited services or goods for the accommodation camp.	Trades and maintenance services local business are likely to continue to benefit. These businesses noted to varying extents that the level of employment they provide is driven by mining operations. Consultation suggests most business who procure from J-A have experienced a consistent positive economic impact.
Likelihood	Possible	Possible
Magnitude	Minimal	Moderate
Significance	Low benefit	Medium benefit

7.1.3 *Loss of local workforce from existing businesses to the Project*

During SIA consultation, concerns about increased local employment at the Project and J-A leading to a loss of workforce availability for local industries and businesses was raised, especially those on haulage, earthworks, management, construction, and specialised trades.

As of 2016, in the Ceduna LGA there was about 74 people working in construction, 101 in transport and warehousing, 49 in administrative work and 27 in manufacturing, equating to about 16.4% of the LGA active workforce (see Section 6.3).

While employment opportunities during construction will be short-term term, it is possible that local residents engaged in the construction, transport and trade industries may identify potential opportunities to gain ongoing employment from the Project during both the construction and operational phases, resulting in a Medium pre-mitigated impact during construction (see Table 7.3). Given the notable increase of employment opportunities during operation the pre-mitigated impact is Medium.

Table 7.3 Assessment of loss of local workforce to the Project

Social Impact	Reduction of local workforce availability for existing businesses due to increased Project employment	
Extent	Business owners within the local study area.	
Project phase	Construction	Operation
Assessment considerations	There will be between 50–90 additional workers during construction. Considering the short-term nature of construction opportunities, it is possible that mostly younger demographics and those unemployed at the moment of construction would seek opportunities. However, given the large number of operational employment opportunities, it is possible that the local active workforce will be incentivised to seek early employment through construction.	It is expected that total employee numbers will increase by 300–350, including contractors. As such, the notable increase of employment positions at J-A would have a minimal effect on workforce availability, while mining contractor workforce demand would possibly have a minor effect for other industries.
Likelihood	Possible	Possible
Magnitude	Minimal	Minor
Significance	Low impact	Medium impact

7.2 Community wellbeing

7.2.1 Diminished sense of safety

The Project may lead to perceived or material impacts to pedestrian and road user safety, including the heightened risk of a road accident resulting in injury or death. SIA consultation reported safety concerns associated with heavy Project vehicles frequently passing through populated areas. There are currently two School Zones along the Project Route, the Penong Primary School and the Ceduna Area School. In Penong, residents and school children frequently cross the highway on foot, many of which do not do so within the designated school zone. As described in the TIA, where the Eyre Highway's passes through Penong, the posted speed limited reduces from 110 km/h to 50 km/h. There is also a 25 km/h school zone with activated crossing lights.

Currently, HMC is transported from J-A to the Port of Thevenard storage facility by road using Kalari B-triple 96 tonne road trains, along sealed roads including Ooldea Road, and the Eyre Highway. Kalari's quad train fleet has been granted approval by the National Heavy Vehicle Regulator (NHVR) to use this route (HATCH, 2022).

During peak periods approximately 28 Iluka truck movements pass through this haulage route per day (including 14 loads and 14 return movements), passing through communities in the local study area including Thevenard, Ceduna, Penong, Scotdesco and Nundroo. The Project would utilise the same haulage route and road trains to transport product to Port, and there will be no anticipated change to the frequency of truck movements during operations. While there will be no increase in the frequency of truck movements during operations, the Project will prologue the use of the haulage route, and any related traffic impacts. Currently, J-A is anticipated to begin its wind down period in 2025, meaning that traffic volumes will reduce from 28 truck movements per day to 12 truck movements per day (HATCH, 2022). With the Project, the period in which there are 28 movements per day will be extended for an additional seven years, before reducing to 12 movements per day in 2032 (as shown in Table 7.4).

Table 7.4 Comparison of trucking profiles with/without the Project

Year	J-A without the Project			J-A with the Project		
	Loads per day	Loads per year	Comments	Loads per day	Loads per year	Comments
2022	14	5110	Business as usual	14	5110	J-A only
2023	14	5110		14	5110	
2024	14	5110		14	5110	
2025	6	2190	Wind down period	14	5110	J-A and Project
2026	6	2190		14	5110	
2027	6	2190		14	5110	
2028	6	2190		14	5110	
2029	0	0		14	5110	
2030	0	0		14	5110	
2031	0	0		14	5110	
2032	0	0		6	2190	Project only
2033	0	0		6	2190	
2034	0	0		6	2190	

Source: HATCH, 2022

During the Project's construction phase, there will be an additional 400–450 trucking movements to site, equating to around 9 more trucks per week (HATCH, 2022). The operational phase of the project is likely to result in an additional 20-40 vehicle movements per day along the Eyre Highway and Ooldea Road due to the anticipated increase in workforce, and during the construction phase there will be a total increase of approximately 20–40 light vehicle movements. This increase of light vehicle traffic is relatively minor in comparison to the annual average daily traffic (AADT) volumes along the proposed haulage route, ranging between 550 and 850 vehicles per day (vpd) along the Eyre Highway, with between 37.5% and 58% of traffic consisting of heavy vehicles. AADT volumes are higher on key roads in Ceduna town, ranging between 1,000 and 2,2000 vpd, with the proportion of heavy vehicles ranging between 18% and 33% (HATCH, 2022).

This increase in traffic volumes during construction of the project may compound with the existing J-A operational traffic, causing heightened safety concerns amongst the community. The TIA states that traffic volumes on key roads through Ceduna are considered relatively low by urban standards, however a relatively high percentage of the vehicles of the Port Thevenard Route are heavy vehicles (HATCH, 2022).

As discussed in Section 6.6 the Eyre Highway is a key freight route and popular tourist drive for both domestic and international visitors. The Eyre Highway connects many of the communities within the local and regional study area to Ceduna, which is a key regional hub providing access to goods, services and essential social infrastructure. As such, local and regional residents frequently utilise the Eyre Highway to complete daily activities such as work, education, shopping, recreation and accessing key services, as confirmed during consultation. Most people in the local and regional study area drive to work (see Section 6.6). As highlighted in the TIA, the Eyre Highway has been assessed by the Australian Automobile Association as being among the lowest risk highways in the country, based on total number of casualty crashes per kilometre (HATCH, 2022).

J-A operations have implemented the following controls to maintain road and pedestrian safety across the haulage route:

- Ooldea Rd – road maintenance and speed limit restrictions
- Travel restrictions – non-haulage traffic at daylight hours only
- Traffic Management Procedures, Kalari EHS Plan
- Journey Management Procedures, Fit for Work Procedures
- Emergency response plan and training, Emergency Response.

The following upgrades have been funded by Iluka to improve the Ceduna's road network in order to support existing operations at J-A:

- Eyre Highway/Kuhlmann Street intersection: Linemarking upgrades
- Thevenard Road/Davison Street intersection: Minor apron widening on southeast corner of intersection to facilitate left-turn movements into Davison Street
- Bergmann Drive/Davison Street intersection and level crossing: Intersection widening, pavement upgrades, new signage and linemarking
- Bergmann Drive widening: Minor widening to curve located west of Davison Street intersection.

Haulage contactor Kalari have also undertaken a Road Train Safety Program in partnership with Iluka. The program aimed to spread awareness and knowledge regarding the scale and potential risks associated with heavy vehicles within local schools and surrounding Aboriginal Communities (Kalari, 2020; Otrakdjian & Keeling, 2010). All Kalari vehicles are fitted with GPS tracking systems that provide drivers with audible alerts if designated speed limits are exceeded (Kalari, 2020). During SIA consultation it was reported that the Kalari's road safety programs have led to a significant decrease in near-miss incidents, particularly amongst Indigenous pedestrians travelling on road by foot. Some local community members that were engaged with during SIA consultation felt confident that Iluka logistics and transport is currently undertaken in a safe and considerate manor, referring specifically to haulage contractors Kalari as trusted members of the community.

As such, given the projected volumes of Project traffic, it is anticipated that reduced sense of safety as a result of haulage and Project related traffic would be a Medium impact during construction, and Medium impact during operations (see Table 7.5).

Table 7.5 Assessment of diminished sense of safety

Social Impact	Reduced sense of safety as a result of haulage and Project related traffic in Penong, and Ceduna	
Extent	Residents, businesses and services along the Project route, specifically in Thevenard, Ceduna, Penong, Scotdesco and Nundroo.	
Project phase	Construction	Operation
Assessment considerations	During the construction phase of the Project, there will be an additional 400–450 total deliveries to site across the 12-month period, resulting in around 9 trucks per week. There will also be a minor approximate 20–40 additional vehicle movements per day due to the increased construction workforce who will likely be travelling to site (HATCH, 2022). The Project's construction is anticipated to last approximately 12 months, beginning Q1 of 2024. During this phase, J-A daily product movements will continue in addition to construction related traffic to and from site, leading to an increase of Project related traffic and heavy vehicles using the haulage route. Consultation indicates that residents are accustomed to the haulage traffic from existing operations, and this increase is anticipated to be relatively minor and short-term.	Project operations will continue transportation of HMC product from the mine to Port Thevenard. The Project's mine life is anticipated to be approximately 7 years and will extend JA's total mine life by approximately 4 years. While truck movements are not anticipated to increase during Project operations, overall Project traffic will be extended for an additional 6 years. Community feedback regarding sense of safety demonstrated that existing J-A controls are considered effective. Hence, the continuity of operational traffic is unlikely to result in a major change to sense of safety. Closure and rehabilitation is also likely to result in an increase in construction and decommissioning related movements.
Likelihood	Possible	Unlikely
Magnitude	Moderate	Moderate
Significance	Medium impact	Medium impact

7.2.2 Detrimental effects to community wellbeing due to amenity impacts

During construction and operations, Project traffic from site to Port Thevenard may impact the amenity of communities within the local study area, including noise, vibration, and air quality impacts, potentially resulting in diminished health and wellbeing.

Construction and operation of the Project may result in dust air pollutant emissions due to:

- land clearing and stockpiling of topsoil and overburden
- mining operations
- rehabilitation works
- vehicle movements and wheel generated dust at the Project
- processing, tailings deposition and ongoing operations at the existing J-A
- wind erosion of stockpiles and open areas (Jacobs, 2022).

The Air Quality Impact Assessment (AQIA) (Jacobs, 2022) discusses potential impacts to residents and community members in the local study area, identifying Yalata as the nearest non-mining sensitive receiver. Given the significant distance between Yalata and the Project site (approximately 75 km), the AQIA states that the risk of air quality impacts to non-mining receivers has been assessed as low due to the distance between the Project site and community. The AQIA identifies the workforce accommodation village as the nearest mining sensitive receiver likely to receive dust and air quality impacts. Health and wellbeing impacts associated with dust and air quality amongst the onsite workforce have been addressed further in Section 7.2.4.

As per the Environmental Radiation Impact Assessment (ERIA) (Radiation Consulting Australia, 2022), orebodies at the existing J-A site and the Project site contain low levels of uranium and thorium mineralisation, which have the potential to cause radiological environmental impacts when mined and processed. However, as the ERIA states, 'The assessment has shown that the current and proposed operations at J-A, including proposed plans to mine, process and transport the Project's ore, and undergo rehabilitation, will result in negligible impact to workers and to members of the public'.

The 2018 Stakeholder Perception Survey recorded reduced amenity from Kalari truck movements as a key negative impact of Iluka Eucla Basin operations (KPMG, 2018). However, community consultation identified that local residents, businesses and organisations living and operating within the local study area are somewhat accustomed to existing amenity impacts associated with the Eyre Highway freight route and the Port of Thevenard and may have developed a heighted sense of resilience towards any related amenity impacts. As such, visual, noise and vibration were not raised as a detrimental aspect of the Project during SIA consultation, and it was stated that the current haulage route and enforced speed limits are relatively effective in minimising disruptions through Penong and Ceduna.

A review of Iluka grievance records identified only one community complaint in late 2021 regarding the noise from Kalari tucks in Ceduna between 11 pm and 6 am. The resident raised concerns regarding impacts to sleep, wellbeing and mental health associated with noise pollution caused by the truck movements. This complaint was actioned through communication with the resident, where Iluka provided an overview of traffic management in Ceduna.

As discussed in Section 7.2.1, there will be no anticipated annual increase in truck movements via the existing route from J-A to Port Thevenard during Project operations. However, during construction there will be an additional 400–450 movements in total, to site to deliver construction materials, resulting in around 9 trucks per week over the 12-month construction phase. This construction phase project traffic could exasperate amenity impacts amongst local sensitive receivers, due to increased noise, vibration and dust associated with passing heavy vehicles. Kalari's Journey Management Plan does state that "Drivers under no circumstance are to use engine brakes whilst traveling through any townships/built up areas along the planned driving route accept where emergency braking may be required". This may help to manage and mitigate noise impacts experienced by local residents. The TIA highlights that most of the roads along the Project haulage route are in relatively good condition, and can cater for oversized and over massed vehicles, stating that "provided the highway/route is routinely maintained, the Project's proposed traffic loading is not expected to affect the network's overall pavement performance" (TIA, 2022). As such, dust generated from poor quality roads is not anticipated as a result of the Project.

The Project would extend Iluka activities at Port Thevenard by approximately 6 years. During consultation, residents of the Thevenard area reported that current dust suppression measures for J-A stockpiles are considered largely effective. Current dust suppression measures include a sprinkler system around the enclosed bund, as well as participation in monthly meetings with Gypsum Resources Australia (GRA) and other third-party operators located at the Port to ensure continuous improvement of dust management.

Existing J-A controls include:

- J-A Grievance Procedure
- Iluka Port Thevenard Radiation and Waste Management Plan
- Iluka Port Thevenard Dust Management Plan
- dust deposition and radiation monitoring program
- bunker sprinkler suppression system.

As such, it is anticipated that detrimental effects to local resident health and wellbeing due to amenity disturbance, including dust, noise and vibration would be a Low impact during construction and Moderate during due to the extended duration of traffic and operations (see Table 7.6).

Table 7.6 Assessment of amenity impacts

Social Impact	Detrimental effects to local resident's health and wellbeing due to amenity disturbance including dust, noise, and vibration	
Extent	Residents, businesses and services along the Project route and surrounding the Port, specifically in Thevenard, Ceduna, and Penong.	
Project phase	Construction	Operation
Assessment considerations	As discussed above in Section 7.2.1, the Project will require 400–450 additional vehicle movements during the construction phase, as well as an additional 20–40 total workforce related traffic movements per day. This increase in traffic may result in a notable increase of noise, vibration and dust during constructions. Given the location and remoteness of the Project site, it is unlikely that amenity impacts associated with on-site construction would be experienced by sensitive receivers in the surrounding area.	As discussed in Section 7.2.1, the Project will extend current haulage activities for an additional 4 years, and there will be a minor increase of around 20–40 light vehicle movements per day. This increase will likely be minor in regard to anticipated amenity impacts. The AQIA demonstrates that there will be no change in dust deposition experienced at the on-site camp, however pollutant related impacts will be extended for an additional 4 years. All pollutants (dust, PM_{10}, $PM_{2.5}$, carbon monoxide and nitrogen dioxide) were recorded below the air quality objective at the camp, and it was determined that there is a low risk if air quality impacts due to nuisance dust and elevated airborne concentrations of PM_{10} and $PM_{2.5}$. Impacts to residents of Yalata (nearest non-mining sensitive receiver) are unlikely, and the risk of air quality impacts are overall low. As per the TIA, during the Project's mine life, 14 heavy vehicle movements (B-triple 96 tonne road trains) to and from site per day will continue to operate for an additional seven years, with an addition three years where there will be six movements per day.
Likelihood	Unlikely	Possible
Magnitude	Minor	Minor
Significance	Low impact	Medium impact

7.2.3 Impacts to community cohesion due to increased non-local workforce

Given the Project workforce requirements and limited local labour available, the Project will result in an increase of non-local workforce in the local study area. Both local and non-local workers will reside on site during their shift, due to the location and distance between the Project and towns within the local study area, and the potential health and safety risk associated with driving back and forth to the Project site. Iluka currently provide FIFO flights from that stop in both Adelaide and Ceduna. Due to the distance between Ceduna and the project site, workforce would be predominately FIFO to avoid safety, and logistical, risks associated with driving to and from site.

Population mobility, both incoming and outgoing, during construction and operation has the potential to impact community cohesion and wellbeing. J-A employment data shows that in 2019, 60% of J-A operational employees were located in Adelaide, and an additional 10% were located elsewhere outside of the local area. As such, approximately 287 out of 334 workers did not reside in the local study area.

During SIA consultation, the community described the existing non-local workforce as lacking any interaction with the local community and suggested that this may contribute to a feeling of disconnect between the J-A and community.

In addition, stakeholders raised concerns that several local residents employed by the J-A operations were perceived to have relocated to Adelaide as commuting to and from site was considered easier and more appealing from the city. It is noted that this assertion has not be verified through discussions with those who have actually relocated to Adelaide.

Opportunities for local residents to relocate to larger urban centres such as Adelaide through FIFO employment could be interpreted as a socio-economic benefit amongst individuals and families. Under the assumption that approximately 10% of the Project operational workforce would be local (30 to 35 people), it is possible that some of these workers may choose to relocate. As such, given the relatively small population of communities within local study area (2,290), and the historical population decline (see Section 6.2.1), a loss of local residents and their families has the potential to lead to impacts on community cohesion.

Iluka Resources implements community benefit programs to support community cohesion and support community wellbeing which are highly valued by the local community (further details provided in Section 7.2.7). These programs could mitigate to some extent the desire of local people to migrate out of town.

In addition, J-A implements a volunteering program to promote the contribution of its workforce to the broader society and formerly implemented a site visit program which provided the community with an opportunity to meet J-A operations and workers.

As such, it is anticipated that during construction the impact would be Low and during operations the impact would be Medium (see Table 7.7).

Table 7.7 Assessment of impacts to community cohesion due to increased non residential workforce

Social Impact	**Impacts to community cohesion due to increased non-residential workforce**	
Extent	Community members and residents within the local study are, specifically Ceduna and Penong.	
Project phase	Construction	Operation
Assessment considerations	The Project would require a construction workforce of 50–90 employees for 12 months. The majority of workforce would be FIFO and reside on site at the workforce accommodation camp.	The Project would require an additional 300–350 FTE operational employees for 7 years, including contractors. If 10% of the projects operational workforce are from the local area, this represents around 30–35 residents. The majority of workers would be FIFO and reside on site at the workforce accommodation camp.
Likelihood	Unlikely	Unlikely
Magnitude	Minimal	Minor
Significance	Low impact	Low impact

7.2.4 Impacts to workforce health and wellbeing

Extended shift work schedules and environments can also affect individual and family wellbeing and mental health. Currently, J-A staff work on rosters of no more than eight days on-shift during construction and operation, either on a 8:6 or 4:3 roster, which would be the model adopted for the Project workforce during operations (Piacentini & Son, 2022).

An international poll involving 1,056 respondents found that for FIFO workers, a roster of 8/6 is the preferred work lifestyle roster (Mining People International, 2017). Additionally, a study undertaken by the Centre for Transformative Work Design (CTWD) for the WA Mental Health Commission in 2018, demonstrated that "FIFO workers on even-time and shorter rosters (i.e. 2 weeks on/2weeks off, 8 days on/6 days off, 5 days on/2 days off) reported significantly better outcomes on all mental health and wellbeing measures compared to FIFO workers on longer rosters with less time for recovery".

FIFO work can provide financial benefits compared with other jobs locally (CTWD, 2018) and independence for worker and partner, extended time at home, ability to schedule appointments during leave, opportunities to meet new people, travel to new locations, and clear separation between personal and work life (Australian Institute of Family studies, 2014).

However, for members of the workforce who may not be accustomed to FIFO shift work and vulnerable or low represented groups, this work environment and schedule may lead to impacts on mental health and overall wellbeing. The CTWD 2018 study found that 'psychological distress (including feelings of anxiety and depression) scores were significantly higher for FIFO workers', outlining known psychosocial risk factors associated with FIFO work to include excessive work demands (emotional, mental, physical). Other key challenges that arise amongst FIFO workers include increased social support needs and difficulty managing multiple roles at work and at home. These impacts may extend to the families and social networks of workers.

During SIA consultation, impacts to workforce wellbeing as a result of the Project was raised as a concern, particularly in relation to Aboriginal workers (discussed in Section 7.3.3). Stakeholders also discussed the prevalence of mental health challenges in the local study area, given the remote and somewhat disconnected nature of living in the region, as well as the social stigmatisation of mental health, and the lack of accessible support and outreach services.

Iluka currently have an Employee Assistance Program (EAP) in place at J-A. The EAP is a confidential support service that includes confidential counselling and coaching, a manager hotline, assistance addressing work and personal challenges, and general 24/7 hotline support. The LifeWorks feature also provides resources to support mental, physical, social, and financial wellbeing. Additionally, the current workforce accommodation camp at J-A features a range of recreational facilities, including a swimming pool, which may contribute to improved workforce wellbeing and cohesion.

The EAP targets the following:

- strengthening relationships
- improving communication
- depression, anxiety, and stress
- children or family member concerns
- maximising performance
- addiction
- work life balance
- conflict and communication
- grief and bereavement
- retirement
- organisational changes.

Iluka require mental health awareness training for all J-A employees, and some members of the workforce have undertaken metal health first aid training, including contact officers and general employee volunteers.

In addition, it was found that physical environment and work conditions during project construction and operations has low risk of impacting employee health and wellbeing:

- The risk of air quality impacts has been assessed as low for mining (on-site) sensitive receivers (Jacobs, 2022).
- The risk of gaseous air pollutants nitrogen dioxide (NO_2) and carbon monoxide (CO), has been found insignificant for the accommodation village and camp (Jacobs, 2022).
- Radiation health impacts to workers have been found negligible to workers during construction, mining, processing and transportation (Radiation Consulting Australia, 2022).

As such, it is anticipated that impacts to workforce health and wellbeing associated with FIFO rosters, and work environment would be a Medium impact during construction due in part to the anticipated reduced duration of employment, and a Medium impact during operations, as operations would continue for approximately 7 years (see Table 7.8).

Table 7.8 Assessment of impacts to workforce health and wellbeing

Social Impact	**Negative impacts to workforce health and wellbeing associated with FIFO rosters**	
Extent	Project FIFO workforce and families, including workforce from the local and regional study area.	
Project phase	Construction	Operation
Assessment considerations	The construction workforce will predominantly be employed on a FIFO schedule, where shifts may be longer than the current J-A operational workforce schedule, over a period of 12 months.	Project work rosters consist of a maximum of eight days on-shift, with a 8:6 or 4:3 roster. FIFO workers travel to site via plane from Adelaide via Ceduna. There are some DIDO workers employed at J-A that drive their own vehicles to site, including residents from Yalata.
Likelihood	Likely	Possible
Magnitude	Minor	Moderate
Significance	Medium impact	Medium impact

7.2.5 *Procedural fairness and access to remedy*

A lack of stakeholder communications and engagement has the potential to impact procedural fairness and the community's ability to input feedback towards changes that may affect their lives. SIA consultation revealed that many key stakeholders and community members feel that they have limited awareness and understanding of the Project and relevant updates about J-A operations.

Community members felt that there is no easy way to ask questions or seek out information regarding the Project. When stakeholders were asked to describe their level of understanding regarding the Project, 33% responded low, 33% responded moderate and 33% responded high, with no stakeholders describing their level of understanding as either extremely low or extremely high. There was a notable desire for enhanced consultation, engagement and communication between Iluka and the local community, with suggestions including community drop in, Q&A and general information sessions, as well as the provision of newsletters and an overall increased presence of Iluka representatives in the local area. Some stakeholders noted that engagement has notably reduced since J-A operations first began in the region and expressed a desire to reinstate Iluka's local presence, which was also perceived to have reduced significantly over time.

The Project has developed a Pre-feasibility Stakeholder Engagement Plan to guide engagement and communication with key agency stakeholders and FWCAC. Upon SIA consultation feedback, the Pre-feasibility Stakeholder Engagement plan was updated, resulting in new communication and engagement activities focused on residents and key stakeholders within the local study area. New activities included:

- the delivery of a newsletter to all residents in Ceduna, Port Thevenard and Ceduna
- making information available in Iluka's Office located in Ceduna, including a Frequently Asked Question brochure
- coordination of drop-in sessions in the Ceduna office following public exhibition of the mining lease application
- follow up phone call to all SIA participants to inform about public exhibition of MLA.

Key activities implemented at the time of writing this report are outlined in Table 7.9.

J-A operations have implemented the following procedures and plans to address procedural fairness and community engagement, which will continue to be implemented:

- J-A Stakeholder Engagement Plan
- Iluka Grievance Mechanism Procedure
- recent re-establishment of an Iluka office in Ceduna which is regularly staffed.

As such, it is anticipated that procedural fairness impacts related to the community's understanding and awareness of changes that may affect their lives would be a Medium impact during both construction and operations (see Table 7.9).

Table 7.9 Assessment of procedural fairness and access to remedy

Social Impact	**Procedural fairness impacts related to the community's understanding and awareness of changes that may affect their lives.**	
Extent	Communities and residents within the local study area.	
Project phase	Construction	Operation
Assessment considerations	Stakeholder consultation and engagement during the pre-construction and planning phase of the Project has included: — SIA consultation with key community and stakeholder groups 2022 — NTMLA engagement with FWCAC commencing 2021 — Engagement with Yumbarra Co-Management Board, Landscape Board and Native Vegetation Branch	The Iluka grievance mechanism procedure (released in late 2017) is aligned with the United Nations Guiding Principles on Business and Human Rights (Iluka, 2018). As of December 2022, there have been 7 public complaints attributed to J-A operations since January 2009. All of these complaints were actioned by Iluka and have been 'closed'. Stakeholders recommended to reinstate visits to the operation and increase face to face communication.
Likelihood	Possible	Possible
Magnitude	Moderate	Moderate
Significance	Medium	Medium

7.2.6 Unequal distribution of impacts and benefits

Impacts are likely to be distributed throughout the local and regional study area unequally, and some stakeholders and communities will likely experience the effects of impacts to a greater degree due to proximity to the Project, and/or level of pre-existing vulnerability. The unequal distribution of Project impacts and benefits may consequently contribute to existing inequality and exacerbate pre-existing social issues in already vulnerable communities.

Project impacts such as diminished amenity are likely to increase in intensity in relation to proximity to the Project site and haulage route. While communities including Yalata and Penong are more likely to experience direct Project impacts, their remote location also leads to an inherently increased level of vulnerability due to isolation and distance between residents to services and infrastructure.

Residents in these communities are less likely to experience Project benefits such as access to employment and procurement opportunities. Penong residents identified challenges to commuting as an employment constraint. J-A consultations reported that employees who live locally are allowed to drive to site, with at least one employee from Yalata and Penong currently driving.

In regard to Iluka's community sponsorship program, potential inequity of sponsorship distribution for communities including Penong and Yalata was identified as a concern during SIA consultation. These views were consistent with sponsorship funding records, which reported that around 64% of Iluka's total J-A community benefit spending has been focused in the Ceduna area since 2013. Total spending in Penong represented 2.5% of community benefit spending, through the Western United Tigers Football Club grand final sponsorship, and contributions to the Penong Racing Club. In Yalata, the Yalata Festival was sponsored by Iluka in 2015, representing 0.5% of J-A community benefit spending.

During consultation, the complexity of sponsorship forms was raised as a constraint to obtain funding. This constraint may affect more heavily on those localities with higher level of vulnerability.

The following procedures and plans address distribution of community benefits at J-A:

- social investment plan and procedure
- social investment register and monitoring.

As such, it is anticipated that unequal distribution of impacts and benefits on vulnerable groups, communities and sensitive receivers within the local area would be a Medium impact during both construction and operations (see Table 7.10).

Table 7.10 Assessment of unequal distribution of impacts and benefits

Social Impact	**Unequal distribution of impacts and benefits on vulnerable groups, communities and sensitive receivers within the local area.**	
Extent	Communities and residents within the local study area, particularly smaller communities outside of Ceduna such as Penong, Koonibba, Scotdesco, and Yalata.	
Project phase	Construction	Operation
Assessment considerations	Yalata and Penong are more likely to experience direct Project impacts, their remote location also leads to an inherently increased level of vulnerability due to isolation and distance between residents to services and infrastructure. From 2013 to 2021, total J-A community sponsorship spending was $405,807.65, throughout the local study area. 64% of Iluka's total J-A community benefit spending has been focused in the Ceduna area since 2013, which may reflect the comparatively larger population in Ceduna town.	It is anticipated that community spending will continue throughout the Project's life, resulting in extended community spending for an additional 4 years. FWCAC provide community support and contributions to all communities within the FWC native title determination area, including Ceduna, Penong, Yalata, Nullarbor, Eucla, Deakin, Cook, Ooldea, Wynbring and Tarcoola. FWCAC provide and support a number of social services and programs across the region, including a number of workforce development partnerships, some of which are with Iluka.
Likelihood	Almost certain	Almost certain
Magnitude	Minor	Minor
Significance	Medium	Medium

7.2.7 Enhanced community cohesion and wellbeing as a result of Iluka community benefit programs

As discussed in Section 7.2.6 Iluka provides sponsorship to local community organisations, services, activities and businesses within the local area, enabling recipients to contribute to social and cultural activities within the community, as well as building social investment and capacity. It is anticipated that the Project would lead to continued and additional financial contributions within community through Iluka's existing community benefit programs. Existing community benefit programs funded by Iluka include:

- Iluka social investment program
- Iluka small grants program.

As part of these programs, Iluka have supported several reoccurring community activities, including the annual Ceduna Oysterfest from, annual NAIDOC day celebrations, as well as various reoccurring sporting events. The Project will result in the extension of J-A life of mine, which will see the continuity of Iluka sponsorship program locally. Some of the largest investments distributed by Iluka to external community organisations between 2018 and 2020 have included:

- Ceduna Council for the provision of a swimming enclosure off Ceduna Jetty in 2018
- Yadu Health as part of the Covid connections partnership in Ceduna in 2020
- Schoolplus Project with Ceduna Area School in 2018
- University of Adelaide STEM Outreach Program
- reoccurring NAIDOC and Oysterfest celebrations.

During SIA consultation, community members stated that any additional community sponsorships and investments as a result of the Project would likely be a major benefit. The social significance of reoccurring community events such as organised sport and Oysterfest was emphasised by stakeholders, with one individual stating that "sporting is the social fabric of the community".

As such, it is anticipated that Enhanced community cohesion, wellbeing and active lifestyles as a result of Iluka community benefit programs would be a High positive impact during both construction and operations (see Table 7.11).

Table 7.11 Assessment of enhanced community cohesion and wellbeing as a result of Iluka community benefit program

Social Impact	**Enhanced community cohesion, wellbeing and active lifestyles as a result of Iluka community benefit programs**	
Extent	Communities and residents within the local study area.	
Project phase	Construction	Operation
Assessment considerations	From 2013 to 2021, total J-A community sponsorship spending was $405,807.65, throughout the local study area. 64% of Iluka's total J-A community benefit spending has been focused in the Ceduna area since 2013.	From 2013 to 2021, total J-A community sponsorship spending was $405,807.65, throughout the local study area, in Ceduna, Thevenard, Streaky Bay, Penong, Coorabie, Maralinga, Yalata, Port Lincoln, Koonibba, and Adelaide. It is anticipated that community spending will continue throughout the Project life, being extended for an additional 4 years.
Likelihood	Likely	Likely
Magnitude	Moderate	Moderate
Significance	High	High

7.3 Aboriginal outcomes

7.3.1 Increased employment, education and business opportunities for FWC people

As discussed in Section 7.1.1, J-A currently has a target of 20% FWC employment which will be extended to the Project workforce during construction and operations. During SIA consultation, community members and stakeholders identified increase local Aboriginal employment as a key potential benefit associated with the Project, and voiced overall support for increased FWC training, education, business and employment opportunities.

In 2022 Aboriginal and Torres Strait Islander employment at J-A was approximately 22%, indicating that Iluka are successfully meeting their FWC employment commitment. As discussed in Section 6.2.2, there is a large Aboriginal population in the local study area. In Ceduna, Indigenous unemployment was more than three times higher than unemployment in Ceduna LGA more broadly. Given the comparatively large representation of Indigenous residents in the local study area, and the proportionally higher level of Indigenous unemployment, it is anticipated that additional Aboriginal employment opportunities associated the Project would provide a significant benefit to the community.

During consultation some stakeholders highlighted that the FWC employment target was significantly lower than the proportion of Indigenous people residing in the local study area and could be further enhanced to represent the large local Aboriginal population. However, during consultation it was acknowledge that initiatives such as the Iluka Work Experience Program (WEP) has been effective in enhancing local FWC workers experience and capability, for future employment at J-A or elsewhere. The WEP provides FWC employees with on the job paid training and work experience opportunities designed to help participants achieve full time employment at J-A.

Specific FWC training initiatives carried out by Iluka as part of the J-A operations have resulted in three FWC trade apprenticeships as well as a number of FWC participants receiving certificates including in resources and processing, Project management, Conservation and Ecosystem Management. FWC participants were also engaged in a pre-employment program at Ceduna TAFE supported by Iluka.

Furthermore, four FWC employees at J-A are currently engaged in the Engineering Leadership Program, targeted at progressing employee professional development and skills.

As a result of J-A NTMA, Iluka must prioritise preferential contracting to local businesses and enterprises under the FWCAC for local procurement requirements in order to contribute to the economic development of Aboriginal Businesses. Preferential contracting may apply to all elements of the supply chain of the Project, such as earth works, rehabilitation, vehicle supply and maintenance, drilling, catering, on-site maintenance, tourism ventures, transport operations and landscaping. Iluka's FWC Business Development program has contributed a total of $511,460 to local Aboriginal businesses and initiatives since 2009 (Iluka, 2022).

J-A operations have implemented the following procedures and plans to enhance FWC employment and economic opportunities:

- 20% target FWCAC employment
- J-A FWC training and employment program
- preferential labour hire for FWC candidates
- FWC Work Experience Program
- Aboriginal business development plan
- Contractor Management Plan
- Iluka FWC IYLP Scholarship funds
- Iluka Emerging Leadership Program
- Iluka, TAFE SA and EyrePlus partnership.

Given the existing partnership between FWCAC and Iluka, as well as the current FWC education, training, business and employment programs carried out as part of the J-A operations, FWC employment and business opportunities are likely to increased alongside the additional Project workforce. As such, it is anticipated that the positive impact would be High during both construction and operations.

Table 7.12 Assessment of increased business and employment opportunities for FWC people

Social Impact	Increased employment, education and business opportunities for FWC people	
Extent	FWC people in the local and regional study area, and across Australia more broadly.	
Project phase	Construction	Operation
Assessment considerations	It is assumed that Iluka will engage a minimum of 20% FWC employees during construction. Construction workforce will be 50–90, 20% of which would equate to approximately 10–18 FWC employees. As part of the current J-A NTMA agreement between Iluka and FWCAC, Iluka have agreed to establish a charitable trust for the purposes of improving living standards and enhancing education and employment opportunities for members of the Native Title Group.	It is assumed that Iluka will engage a minimum of 20% FWC employees during operations The Project's operational workforce will increase by approximately 300–350, 20% of which would equate to approximately 30–35 FWC employees. It is assumed that current J-A FWC training, employment and procurement programs and policies will apply extended to the Project. J-A FWC training and employment program has resulted in 8 FWC students into employment, of which three are onsite at J-A. In addition, 6 FWCA members have successfully completed apprenticeship programs at J-A and an additional 16 have completed pre-employment training programs and secured employment since 2017.
Likelihood	Likely	Likely
Magnitude	Moderate	Moderate
Significance	High benefit	High benefit

7.3.2 *Increased organisational capacity of FWCAC*

A NTMA for J-A operations has been in place with FWCAC since 2007. As part of the Project's MLA process, Iluka have been involved in further negotiations with FWCAC to update the current NTMA for the Eucla Basin, which includes J-A, as well as any future projects within the Project area. A key aspect of the existing J-A NTMA, and proposed Project NTMA would be direct payments and mining royalties, in the form of Milestone Payments and Production Payments. NTMA payments would be continued and extended for an additional 4 years as a direct result of the Project, and enhanced production potential associated with the Project would likely result in additional economic opportunities for FWCAC.

The revenue generated by payments made under the NTMA to the FWCAC have supported the overall financial viability and sustainability of the FWCAC, its commercial operations, organisational capacity and associated employment opportunities. The partnership between FWCAC and Iluka has been recognised as a model of how the resources sector can partner with local communities to deliver positive socio-economic outcomes, even when there are market downturns.

Future payments and financial benefits awarded to FWCAC through the Project would continue to be well implemented and lead to enhanced positive outcomes for the organisation and local FWC community. As such, it is anticipated that increased organisational capacity of FWCAC to annual payments would be a High positive impact during both construction and operations (see Table 7.13).

Table 7.13 Increased organisational capacity of FWCAC

Social Impact	**Increased organisational capacity of FWCAC due to annual payments, potentially contributing to community services, culture, health, wellbeing and overall progression of self-determination outcomes**	
Extent	FWCAC and members, as well as residents of communities including Ceduna, Yalata, Koonibba, Maralinga and Scotdesco.	
Project phase	Construction	Operation
Assessment considerations	FWCAC will be engaged by Iluka during the preparation of the ACHAR, and during site clearing and construction activities.	Under the NTMA, FWCAC will be entitled to royalty and lease payments from Iluka. It is assumed that current J-A FWC training, employment and procurement programs and policies will apply extended to the Project. J-A FWC training and employment program has resulted in 8 FWC students into employment, of which three are onsite at J-A. In addition, 6 FWCA members have successfully completed apprenticeship programs at J-A and an additional 16 have completed pre-employment training programs and secured employment since 2017.
Likelihood	Likely	Almost Certain
Magnitude	Moderate	Moderate
Significance	High benefit	High benefit

7.3.3 Procedural fairness

Under the *Native Title Act 1993,* mining activities invoke 'the right to negotiate', in which native title parties have the opportunity to enter into agreements with proponents, through mechanisms such as an Indigenous Land Use Agreements (ILUA) or a NTMA. As described in Section 1.3.1, Iluka are currently undertaking negotiations to enter a NTMA with the FWCAC to undertaking mining activities within the FWC Native Title Determination Area, which encompasses the Project site.

During consultation, some stakeholders raised concerns regarding the NTMA negotiation, including Iluka's process of information sharing and transparency regarding the current and proposed future operations of J-A and the Project. Stakeholders also perceived that preliminary NTMA negotiations had in some cases not demonstrated understanding of FWC culture and the social context of the Project and local communities.

The NTMA negotiation process is ongoing, and Iluka have committed to a good faith approach in reaching an agreement with the FWCAC. Iluka have engaged with the FWCAC during the planning and approvals phase of the Project, including Iluka's presentations to the FWCAC Board, regarding the proposed Project design and details. Iluka have also considered and incorporated feedback from key FWC stakeholders into future Project programs and policies.

Iluka have established the J-A FWC Liaison Committee to guide discussion, collaboration and engagement between Iluka and Traditional Owners, as part of the J-A NTMA. Additionally, Iluka currently employees an Aboriginal Liaison Officer who engages directly with the FWCAC in relation to current J-A operations, programs and employment, and will help to coordinate the Project's NTMA during negotiation and implementation stages.

As such, potential impacts to FWCAC access to procedural fairness has been assessed as a Low negative impact during both constructions and operations.

Following productive negotiations, a term sheet has been agreed in principle between Iluka and the FWCAC and drafting of a detailed agreement has commenced. The matter is planned to go to a community vote in Q1 2023 with agreement execution targeted by end Q2.

Table 7.14 Increased organisational capacity of FWCAC

Social Impact	**Impacts to procedural fairness**	
Extent	FWCAC and members, as well as FWC residents within the local study area.	
Project phase	Construction	Operation
Assessment considerations	Iluka are required to enter a NTMA with the FWCAC to undertaking mining activities within the FWC Native Title Determination Area. It is assumed that construction will take place only if agreement with FWC Traditional Owners has been reached. FWCAC will be engaged by Iluka during the preparation of the ACHAR, and during site clearing and construction activities.	It is assumed that operation will take place only if agreement with TO has been reached and existent controls will continue to operate.
Likelihood	Unlikely	Unlikely
Magnitude	Moderate	Moderate
Significance	Low	Low

7.3.4 Diminished wellbeing amongst Aboriginal employees

During SIA consultation, some stakeholders expressed concern regarding the health and wellbeing of FWC and/or Aboriginal employees working at J-A due to a lack of worker satisfaction, perceived discrimination, and a lack of cultural understanding.

Given existing commitments to increase the proportion of FWC employees at the J-A site, wellbeing impacts amongst Indigenous employees would potentially be enhanced or extended due to the Project. During SIA consultation undertaken in 2020, some stakeholders raised concerns regarding internal unresolved workforce grievances at J-A in relation to workforce discrimination experienced by Aboriginal employees, leading to an overall feeling of distrust and resentment between workers and Iluka as a whole.

Similar concerns were reiterated during SIA consultation including the perception of workplace discrimination and racism, as well as a lack of cultural competency regarding Aboriginal and Torres Strait Islander employees. A perceived lack of trust within the J-A work environment, in which employees were said to often feel uncomfortable openly communicating with managers or other co-workers, largely due to fears of negative repercussions. This feedback is to some extent consistent with the 2021 J-A workforce engagement survey, in which 2% of respondents (both Indigenous and non-Indigenous) stated that they had been the subject to discrimination, with an additional 6% stating they had witnessed discrimination. Of those respondents who stated they had either witnessed or experienced discrimination, 57% stated that they did not report it.

Additionally, stakeholder consultation raised concerns regarding a perceived lack of professional development and progression opportunities amongst FWC employees, which some identified as potentially being associated with discrimination, leading to dissatisfaction and overall diminished wellbeing amongst Aboriginal employees.

While Iluka have established development and continued education pathways for Aboriginal employees (as Discussion in Section 7.3.1), some stakeholders feel that these initiatives have not resulted in desired outcomes. Additional initiatives and programs provided by Iluka to encourage workforce progression are Iluka Leadership Acceleration Programs, leadership Coaching and Focus Programs, Iluka Leadership Community and Leadership Model Components.

Finally, lack of cultural provisions was identified as an additional element contributing to diminished wellbeing amongst Aboriginal employees. Cultural provisions include cultural leave for purposes such as ceremonial events or sorry business.

Currently Iluka provides Aboriginal Cultural Awareness training for all staff at J-A. If effective, this training may indirectly lead to improved workforce relations and understanding of Aboriginal culture. However, during consultation some stakeholders felt that training was not sufficient and had not contributed to meaningful outcomes.

Despite the existence of these programs and measures to encourage employee career progression and employee wellbeing as outlined in Section 7.2.4, it is anticipated that impacts on Aboriginal employee wellbeing due to perceived negative working environment and lack of Aboriginal cultural understanding would be a Medium impact during construction, and a High impact during operations (see Table 7.15).

Table 7.15 Assessment of diminished wellbeing amongst Aboriginal employees

Social Impact	**Impacts on Aboriginal employee wellbeing due to perceived negative working environment and lack of Aboriginal cultural understanding**	
Extent	Aboriginal Project employees, including FWC employees.	
Project phase	Construction	Operation
Assessment considerations	The construction workforce will predominantly be employed on a FIFO schedule similar to the current J-A operational workforce over a period of 12 months.	Project work rosters consist of a maximum of eight days on-shift, with an 8:6 or 3:4 roster. FIFO workers travel to site via plane from Adelaide via Ceduna. There are some DIDO workers employed at J-A that drive their own vehicles to site, including residents from Yalata. At the time of writing this report, there has not been a decision from Iluka with regard to changes to work shift and cultural leave for Aboriginal employees.
Likelihood	Possible	Likely
Magnitude	Moderate	Moderate
Significance	Medium	High

7.3.5 Disturbance or damage to Aboriginal material cultural heritage

Aboriginal cultural heritage within the Project area may hold value for a number of stakeholder groups, particularly the FWC Aboriginal people, but it also extends to other Indigenous and non-Indigenous people within the local and regional areas and individuals from the broader SA and/or Australian community. The extent of impacts to Aboriginal cultural heritage is largely related to the perceived significance, either culturally and/or historically, of a heritage item, site, or landscape.

The FWCAC 2018 Cultural Heritage Management Plan (CHMP) outlines the commitments of the FWCAC in the protection and preservation of FWC cultural heritage, and provides an overview of the legislative, agreement and policy framework of FWC cultural heritage management (FWCAC, 2018). The FWCAC CHMP defines FWC cultural heritage as the following:

> *'Aboriginal Cultural Heritage connects Far West Coast Aboriginal Peoples to this region. It includes tangible and intangible expressions of culture that link generations of people over time and into the future. It is ancient and modern. It is traditional and urban. It links the Far West Coast Aboriginal Peoples to this land. The Far West Coast Aboriginal Peoples express their cultural values through their relationships with country, people, beliefs, knowledge, law, language, symbols, ways of living, use of the sea, the land, sites, landscapes, totems and objects – all of which arise from Aboriginal spirituality, culture and connection to this land.' (FWCAC, 2018).*

Cultural heritage clearances have previously been obtained by Iluka to facilitate establishment and operation of the J-A. In addition, Iluka have developed and implemented a specific internal cultural heritage management plan and Heritage Discover and Clearance Procedure for the J-A operation. Control and management strategies have also been implemented to minimise any potential ongoing impacts to Aboriginal heritage. The 2020 J-A SIA found no evidence to suggest that there have been any social impacts on Aboriginal cultural heritage that are not being effectively managed and mitigated.

Atacama Project drilling campaigns and investigations have adopted the Heritage Discover and Clearance Procedure for the J-A operation. According to Iluka during those campaigns no Aboriginal findings have occurred.

An Aboriginal Cultural Heritage Assessment will be developed once NTMA is reached and will be in place prior to the PEPR submission and before any construction begins onsite.

As such, it is anticipated that impacts to FWC cultural values due to disruption and damage of Aboriginal material cultural heritage would be a High impact during construction, and a Medium impact during operations (see Table 7.16).

Table 7.16 Assessment of disturbance or damage to Aboriginal material cultural heritage

Social Impact	**Impacts to FWC cultural values due to disruption and damage of Aboriginal material cultural heritage**	
Extent	FWC people and organisations, potentially extending to the broader Indigenous and non-Indigenous people throughout the local and regional study area and State.	
Project phase	Construction	Operation
Assessment considerations	Atacama Project drilling campaigns and investigations have adopted the Heritage Discover and Clearance Procedure for the J-A operation. According to Iluka during those campaigns no Aboriginal findings have occurred. An ACHAR will be developed once NTMA is reached and will inform the MLA.	Iluka will continue implementation of J-A Cultural Heritage management plan and Heritage Discover and Clearance Procedure for the J-A. J-A's ACHR did not identify any significant impacts to Aboriginal Cultural Heritage that could not be effectively managed and mitigated. Current Cultural Heritage management plan and Heritage Discover and Clearance Procedure in place for the J-A.
Likelihood	Possible	Unlikely
Magnitude	Major	Major
Significance	High	Medium

7.3.6 Impacts to Aboriginal cultural landscapes and aesthetic values

The Project will result in noticeable landscape changes during operations, specifically through excavation of existing sand dune formations. These changes are anticipated to impact the local FWC Aboriginal Cultural Landscape of the area, as well as changing the aesthetic value of the area surrounding the Project site during operations (discussed in Section 7.5.1). Indigenous Cultural Landscapes are acknowledged as aspects of cultural heritage that extend beyond singular sites or objects, to encompass entire landscapes and environments. A cultural landscape may hold significance in terms of its cultural, historical, environmental, spiritual and social values.

During SIA consultation, the cultural significance of the Project site was discussed, specifically in terms of the natural sand dune ecosystems, as well as the length of time required for these features to form. The potential disruption and destruction of the landscape was a notable concern amongst stakeholders, with significant emphasis placed on the importance of well implemented rehabilitation practises.

One stakeholder stated that 'to protect Country, it is essential that Iluka do not leave any footprint' behind on the land. There was a concern that revegetation will likely be undertaken as part of the Project as is required, however the area will not be rehabilitated back to its exact original state. Stakeholders described the importance of avoiding any long-term or major changes to the landscape, as it may hold significance in regard to stories, law, song-lines and hunting areas. Additional concerns that FWC people will not be adequately consulted during the rehabilitation the process were also noted during consultation.

Concerns regarding temporary landform changes and mining during project construction and operations were minor amongst key stakeholders. However, permanent landform changes were raised as a key concern that would likely lead to significant, long-term implications for local Aboriginal cultural landscapes and values, due to the disturbance of intangible cultural heritage, and the impacts on FWC people in being able to fulfil their cultural obligation in maintaining the environment and restoring the land back to its original form. As such, it is anticipated that Impacts to Aboriginal cultural value due to permanent changes FWC Cultural Landscapes would be a Low impact during construction, and a Very High impact during operations and closure (see Table 7.17).

Table 7.17 Assessment of impacts to Aboriginal cultural landscapes and aesthetic values

Social Impact	**Impacts to Aboriginal cultural value due to changes to FWC Cultural Landscapes**	
Extent	FWC people and organisations, potentially extending to the broader Indigenous and non-Indigenous community within the local and regional study area and State.	
Project phase	Construction	Operation
Assessment considerations	The construction of the Project will result in landscape changes due to related construction activities. The Project's disturbance footprint will be smaller during construction, when compared to the proposed operational disturbance footprint.	Iluka will prepare a progressive landscape rehabilitation plan to consider FWC consultation and input into landscape design and revegetation. The Project's Sand Tailings stockpile will be constructed on the existing disturbance footprint. There will be a resultant landform change at Atacama which has been agreed to in principle by key external stakeholders and traditional owner groups.
Likelihood	Almost certain	Almost certain
Magnitude	Minimal	Major
Significance	Low	Very High

7.4 Services and infrastructure

7.4.1 Increased accessibility to infrastructure

The Project will utilise existing infrastructure within the local study area, which would likely contribute to the viability and upkeep of infrastructure that also supports other local industries. J-A operations heavily utilise existing infrastructure within the local study area, particularly transport infrastructure such as roads, shipping, and air transport. The Project will likely enhance and extend the use of these transport systems, which may contribute to the feasible operation of this infrastructure, while the fluctuations in output have the potential to influence pricing and availability of various forms of transport for business and community use.

Given the relatively small local population and remote location of communities in the local area, local and regional industries and residents may be more vulnerable to impacts on local infrastructure and services due to a lack of viable alternatives. The importance of infrastructure was highlighted during SEIA consultation, where stakeholders stated that connectivity and access to services was somewhat limited in the region. Specifically, flights to and from Ceduna were said to be difficult for residents to access due to pricing and availability constraints, with many residents relying on driving to access goods and services, or to seek out work outside the local study area. While Iluka utilise charter flights for 100% of their current FIFO transport to site, these flights utilise the existing infrastructure at Ceduna Airport.

The key infrastructure, services and facilities likely be utilised by the Project include:

- Ceduna Airport
- Port of Thevenard
- Eyre Highway
- local health and social services, including the Ceduna Hospital.

These services help to connect the local study area to the broader regional, State and nation-wide context, allowing for increased trade and mobility opportunities for key local industries, such as agriculture. As discussed in Section 6.6, Port Thevenard is an important piece of transport infrastructure for the local and regional community, allowing for the import of fertiliser to support agriculture in the region, as well as allowing product exports of wheat, barley, oats, gypsum, salt and mineral sands.

As such, it is anticipated that increased and extended utilisation and contributions to local services and infrastructure would be a Medium benefit during construction, and a High benefit during operations (see Table 7.18).

Table 7.18 Assessment of local infrastructure

Social Impact	**Increased and extended utilisation and contributions to local services and infrastructure**	
Extent	Residents, businesses and services within the local and regional study area.	
Project phase	Construction	Operation
Assessment considerations	Construction materials will be sourced from the local, regional and interstate context, and will primarily be transported via road to Project site. Construction workforce will be transported to Project site via existing Iluka Charter Flights from Adelaide via Ceduna.	The Project will transport product via road to Port Thevenard, where it will be shipped to Iluka's Narngalu processing facility in Western Australia. On site workforce will be transported to Ceduna Hospital in the case of required emergency care.
Likelihood	Almost certain	Almost certain
Magnitude	Minor	Moderate
Significance	Medium benefit	High benefit

7.4.2 Road damage and deterioration

As discussed in Section 7.2.2, residents in the local study area are somewhat accustomed to frequent and heavy traffic movements along the Eyre Highway and Project haulage route. The existing local presence of Kalari trucks have contributed to an awareness of J-A related traffic movements. While these movements are largely accepted within the community as an inevitable aspect of the Project, SIA consultation revealed concern regarding damage and deterioration of local roads and the Eyre Highway associated with Project traffic.

The majority of J-A related traffic movements are the B-triple 96 tonne road trains that transport product to Port Thevenard. As outlined in Section 7.2.1, approximately 28 of these heavy truck movements pass through sealed roads along the haulage route each day. It is anticipated that traffic volumes will remain the same during Project operations but will be extended for an additional 6 years (as shown in Table 7.4). Given the size, weight and frequency of Project related traffic movements, there is potential for the Project to contribute to road damage and deterioration during both construction and operations. Residents living along the Project route raised concerns regarding the current quality of the roads, and the potential for further deterioration contributing to loose gravel, potholes, and uneven road surface causing dust or damage to vehicles. Additionally, construction related traffic to and from site may further contribute to road deterioration, and lead to cumulative traffic related impacts for receivers along the Project haulage route. According to the TIA Ooldea Road is considered to be of a 'generally good standard and was upgraded by Iluka in 2008 to link the J-A mine site to the Eyre Highway (HATCH, 2022). Iluka are also responsible for any additional construction and maintenance of the current access road that connects the J-A to Ooldea Rd, which is currently open to the public (J-A SIA 2020).

As described in the J-A 2020 SIA, there is limited evidence to suggest that J-A operations have directly contributed to road damage. In 2018, Council minutes reported a road alteration to accommodate Kalari's 'Quad' trucks, which was funded by Kalari. Currently there are no anticipated road upgrades anticipated as part of the Project.

Despite community concern regarding road quality and degradation, the TIA states that "provided the highway/route is routinely maintained, the Atacama Project's proposed traffic loading is not expected to affect the network's overall pavement performance". This conclusion is supported by the following main findings within the TIA:

- project haulage vehicles feature 24 axles and wheels, which will spread the vehicles load to a large footprint and minimise impact on the road pavement
- the Project route currently experiences a large volume of freight movements and is being maintained by the State Road authority
- the overall traffic loading generated by this Project is considered insignificant, relative to existing traffic and road conditions (HATCH, 2022).

Existing J-A controls include:

- Ooldea Rd – road maintenance
- Ooldea Rd – speed limit restrictions
- Penong and Ceduna – speed limit restrictions through towns and residential areas
- Traffic Management Procedures, Kalari EHS Plan.

Additionally, Section 107 of the *Road Traffic Act 1961* (Damage to Road Infrastructure) requires drivers to immediately report full particulars of any damage caused to the road infrastructure (including roads, bridges and culverts, or interference with roadside furniture) to the Police or the SA Department of Infrastructure and Transport (DIT) (DPTI, 2012). As such, it is anticipated that increased and extended utilisation and contributions to local services and infrastructure would be a Medium impact during construction and Low during operations (see Table 7.19).

Table 7.19 Assessment of road damage and deterioration

Social impact	Damage and general deterioration of the Eyre highway and local roads due to Project traffic	
Extent	All road users sharing the Project transport route, including local and regional residents, businesses, service providers and tourists.	
Project phase	Construction	Operation
Assessment considerations	During the construction phase of the Project, there will be an additional 400–450 total deliveries to site. There will also be an approximate 20-40 total additional vehicle movements due to the increased construction workforce who will likely be travelling to site (HATCH, 2022).	As discussed above in Section 7.2.1, the Project will extend current haulage activities for an additional 6 years, and there will be a minor increase of around 20–40 light vehicle movements per day. Approximately 28 B-triple 96 tonne road train movements will occur daily during operations, transporting HMC from site to port Thevenard.
Likelihood	Possible	Unlikely
Magnitude	Minor	Minor
Significance	Medium impact	Low impact

7.4.3 Impacts to accommodation availability

Existing J-A operations utilise an on-site workforce accommodation camp to house 100% of operational FIFO workforce. The current capacity of the camp allows for up to 200 workers, and the Project will include an upgrade of the camp to allow for an additional 197 workers. it is anticipated that the Project will utilise the existing J-A camp to accommodate all Project workforce during construction and operation. Utilising existing infrastructure will help to reduce potential impacts associated with the construction of a new workforce camp, whilst also ensuring no additional burden is placed on the housing and accommodation supply in surrounding communities, such as Ceduna.

While it is unlikely that Project workforce would reside off-site, there is potential for short-term subcontractors, technical specialists, and Iluka management staff to use short-term accommodation locally while doing field work or working from the Ceduna Office. While this temporary and likely minor influx of Project related workforce is anticipated to only require a small number of accommodation units, there is potential for increased accommodation demand to impact availability and pricing for other accommodation users in the local study area. Given the local tourism Industry in and around Ceduna, and the volume of traffic that passes through the town via the Eyre Highway, a significant number of visitors pass through the town each year. As such, there is a relatively good supply of temporary tourism accommodation in Ceduna, with 5 caravan parks and 4 motels, as well as an additional supply of holiday homes and BnBs. The Ceduna Foreshore Hotel is the main hotel in the local area and would likely be considered the first preference for any staff staying in Ceduna. The hotel features a total of 57 double and single rooms.

During construction it is assumed that there could be up to 20 people who will require short term accommodation in Ceduna, including technical specialists, Project management staff, staff visiting Iluka's Ceduna office, and staff visiting the Port of Thevenard. Additionally, it is assumed that around five people will require short term accommodation in Ceduna during operations, to fulfil similar project management roles. Using these estimates, with the assumption that the construction and operational workforce will reside on site, and that no rental accommodation will be utilised, it is anticipated that the Ceduna Foreshore Hotel will have sufficient capacity to house any specialist workforce in Ceduna for short periods.

In the local study area, there is a limited availability of purchasable properties and an even smaller supply of rental properties, despite the comparatively high proportion of households that rent (as described in Section 6.7.1). Furthermore, both rent and mortgage prices have increased significantly in Ceduna over the past 12 months, which is somewhat consistent with overall trend across SA and Australia more broadly following the COVID-19 pandemic (KPMG, 2021). As such, Project use of rental or purchasable properties could have the potential to significantly impact local residents, including renters who may already be considered more vulnerable to housing stressors.

While consultation revealed that while there is a very limited supply of permanent housing in Penong, the Penong Caravan Park would likely have sufficient capacity to house any potential overview workforce associated with the Project, either in existing cabins or in demountables (dongas) located on powered sites. However, stakeholders stated that during peak seasons including December and April, temporary accommodation is often in high demand and can book out across the local study area. As identified in the 2020 J-A SIA, workforce data and worker place of residency from 2011 to 2019 does not suggest that the J-A operation has caused an increase in housing prices in Ceduna, despite the continued perception held by some local stakeholders.

As such, it is anticipated that reduced accommodation availability due to increased Project workforce would be a Medium impact during construction and a Low impact during operations (see Table 7.20).

Table 7.20 Assessment of impacts to accommodation availability

Social impact	**Reduced accommodation availability due to increased Project workforce**	
Extent	Project workforce, existing J-A workforce, accommodation providers, tourists and renters within the local study area.	
Project phase	Construction	Operation
Assessment considerations	The total construction workforce will consist of 50–90 FTE employees, who will reside on site during their shifts. Small increase in technical or specialist staff temporarily residing off-site during construction.	The workforce accommodation camp will be upgraded to accommodate an addition 197 workers. Increase of approximately 300–380 direct workforce, and potential further increases to indirect workforce. Small increase in technical or specialist workforce temporarily residing off-site during construction.
Likelihood	Possible	Unlikely
Magnitude	Minor	Minor
Significance	Medium impact	Low impact

7.4.4 Impacts to local health service capacity due to increased demand

As discussed in Section 6.5 Ceduna Hospital is the closest hospital to the Project, and the major healthcare provider within the regional area. Healthcare and social assistance is the largest sector of employment within the local study area, as highlighted in Section 6.3. However, as identified during consultation, local health and social services have had difficulties in attracting and retaining specialist staff, and typically rely on visiting or outreach models of service delivery as is common in regional and remote areas.

It is important to note that it is unlikely that Ceduna Hospital will experience a significant patient influx as a direct result of the Project. However, given the limited capacity and resources of the Hospital, as well as the significant regional and local community reliance on services, any Project related impacts are considered significant due to the vulnerability of hospital users and patients within the community (SA Health, 2022).

The J-A site has dedicated on-site medical facilities for Project personnel, including two onsite medics, which are anticipated to be utilised by the Project's additional workforce during construction and operations. It is likely that the Project would be able to provide basic on-site medical services, including general check-ups. However, according to Iluka, during the 2022 calendar year, of the 7 medical referrals that occurred, only one attended the Ceduna hospital. Five attended Adelaide facilities and one attended a medical facility in Port Lincoln.

The Ceduna Hospital features 15 acute overnight beds and four day-only beds. In the year 2020–2021, there were 1,680 admissions to Ceduna hospital, including 625 emergency admissions (AIHW, 2021). Any patients that are transported from the Project site to the Ceduna Hospital would likely spend a limited amount of time in the facility before either being discharged back to the Project site (in the case of more minor procedures) or transferred to Adelaide for anything more significant.

As such, it is anticipated that Impacts to local health service capacity due to increased Project workforce demand would be a Low impact during both construction and operations (see Table 7.21).

Table 7.21 Assessment of impacts to local health services capacity due to increased demand

Social Impact	**Impacts to local health service capacity due to increased Project workforce demand**	
Extent	Ceduna Hospital and residents within the local and regional study area who access these services.	
Project phase	Construction	Operation
Assessment considerations	There will be 2 onsite medics during the construction phase of the Project. The total construction workforce will consist of 50–90 FTE employees, who will reside on site during their shifts.	The J-A site has dedicated on-site medical facilities for Project personnel, including two onsite medics, which are anticipated to be utilised by the Project's additional workforce during construction and operations.
Likelihood	Very Unlikely	Unlikely
Magnitude	Minor	Minor
Significance	Low	Low

7.5 Surroundings

7.5.1 Impacts to the landscape and associated aesthetic values

As discussed in Section 7.3.6, Project construction and operations will require noticeable landform changes to access and extract product. The Yellabinna Regional Reserve is acknowledged as a valuable natural and aesthetic asset, and is a popular destination for tourists including campers, birdwatchers and 4WD drivers (see Section 6.8.3).

For certain community groups with a strong interest in environmental conservation, the Project may represent an overarching potential threat to perceived natural and aesthetic vales associated with the environment. It is possible that the Project may receive general opposition from tourists, environmental groups and community groups due to the perceived threat of mining activities to biodiversity and aesthetic values at any scale. Additionally, during consultation one stakeholder raised concern about the increased use of groundwater on site, due to the perceived threat and uncertainty to environmental and water related values in the region. The Native Vegetation Clearance footprint (or Disturbance Footprint), which refers to the new clearance of native vegetation related to the Proposed Action is 2,138 ha (Iluka Resources, 2022).

Despite proposed rehabilitation activities, which will include topsoil seeding, permanent landform changes would likely result in a change to the dune system, and a resultant reduction in dune crest vegetation associations. The Ecological Impact Assessment (Eco Logical Australia, 2022), states that the Project has the potential to cause impacts to native flora and fauna during construction and operations, and impacts of moderate significance are anticipated to occur due to the following Project activities:

- vegetation clearing
- pathogens or toxins – introduced or spread
- fire – changes to regimes or ignition sources
- erosion of soil – loss of topsoil and seedbank
- altered landforms – permanent changes prevent return to pre-mining conditions.

These permanent changes to the landscape, including landform changes, and loss of associated vegetation, are likely to alter the natural landscape of the Project site following closure. For those who ascribe social and cultural significance to the natural environment and biodiversity of this area, these changes may result in impacts to aesthetic and environmental values. Furthermore, given that the Project is located within a Regional Reserve, these impacts may be significant for a larger group of people who view the area as environmentally significant.

While acknowledging that impacts on conservation values by mining exist, this SIA found that impacts on the environment in relation to the Yellabinna Regional Reserve are being effectively managed through specialist environmental work, including rehabilitation activities. Also noted in the section above, the FWCAC provides cultural monitoring and observation activities as part of meeting its organisational objectives. This presents an opportunity for Iluka to raise awareness in the general community of its environmental management activities, to provide reassurance to any groups in the community that perceive the Project to be having a negative impact on the natural environment nearby the site. The position of the Project within the Yellabinna Regional Reserve is away from key camping and recreational areas and does not impinge on the Yellabinna Wilderness Protection Area. There is limited access to site aside from the mine access road, which has been constructed and maintained by Iluka during J-A operations and will continue to be maintained for the life of the Project.

As per the EIA, rehabilitation activities at the Project site are expected to be undertaken progressively, in conjunction with mining activities. This will see mined areas partially backfilled with waste materials, and at the completion of mining/processing activities, reserved loam and topsoils will be placed atop the pit and other previously disturbed areas to provide a soil profile for regeneration of vegetation (Eco Logical Australia, 2022).

Besides J-A's compliance requirements for on-site rehabilitation works, Iluka has made contributions related to Aboriginal cultural heritage initiatives and environmental conservation activities in the local study area – for example a financial contribution towards camel culling in the Yellabinna Regional Reserve in 2016. Significant planning and management for rehabilitation of land disturbed by the J-A operations has occurred and is also planned for several years post mine closure. Water required for Project operations is hyper-saline bore water, with no identified third-party concern around its extraction. The FWCAC is a co-manager of the Yellabinna Parks.

As such, it is anticipated that Impacts to landscapes and associated aesthetic value due to increased Project workforce demand would be a Medium impact during construction and High impact during operations (see Table 7.22).

Table 7.22 Assessment of impacts to the landscape and associated aesthetic values

Social Impact	**Impacts to the landscape and associated aesthetic values due to Project construction and operations**	
Extent	Local and regional residents, FWC community members, and broader State and national population.	
Project phase	Construction	Operation
Assessment considerations	The Native Vegetation Clearance footprint (or Disturbance Footprint), which refers to the new clearance of native vegetation related to the Proposed Action is 2,138 ha.	As per the EIA, Successful rehabilitation of the Project Area is a critical part of achieving the objective of minimising long-term impacts to native flora and fauna. Rehabilitation is well underway with promising early results in the adjacent J-A site (Eco Logical Australia, 2022). The J-A rehabilitation management plan will be updated to include the Project, and rehabilitation will be managed jointly between the two operations, with engagement and collaboration with key stakeholders to continue including the FWCAC.
Likelihood	Possible	Almost certain
Magnitude	Minor	Moderate
Significance	Medium	High

8 Cumulative impact assessment

Cumulative impacts refer to social impacts or benefits that arise due to the successive, incremental, and/or combined effects of a proposal when added to other existing, planned, and/or reasonable anticipated future Projects. The cumulative impacts of multiple proposals have the potential to 'add up', and may exacerbate the significance of Project activities, and/or intensify the socio-economic impacts experienced by receivers.

Projects considered to contribute to potential cumulative impacts alongside the proposal include:

- Gypsum Resources Australia (GRA) Keven Gypsum Mine, which is located near Lake Macdonnell, approximately 9 km from Penong and 65 km East of Ceduna. Considered Australia's largest gypsum mine, mining of Gypsum commenced in 1919 and the mine has been operational ever since. Product from the Keven Mine is transported to Port Thevenard by truck, using an assumed haulage route similar to that of the Project, as confirmed during SIA consultation. There are no anticipated upgrade or extension works planned for the Keven Gypsum Mine.

For the purpose of this SIA, the Project has been assessed as an extension of the existing J-A, and as such, the combined effects of J-A operations have been considered throughout Chapter 7. As the Project will extend J-A mine life for an additional 4 years, the assessment of social impacts has considered this extension a direct result of the Project. As such, the cumulative impacts of J-A are not discussed in this section but have been considered in the assessment of the Project's construction and operational impacts.

An assessment of the degree of impact arising from both the proposal and other nearby Projects is provided below.

8.1 Livelihoods

As discussed in Section 7.1.1, the Project may lead to an increase in local employment during operations, in line with an anticipated overall workforce increase of approximately 300–350 employees. While most of the operational workforce is anticipated to work on a FIFO roster, and to commute from outside the local and regional study area, some residents living in local communities may be employed by the Project, as has occurred previously during J-A operations. The Keven Gypsum mine has a majority local workforce, supporting around 40 jobs for local people, most of which live in Ceduna and Penong (Mining link, 2022).

As discussed in Section 7.1.3, an increase in Project related local employment may result in a loss of workforce availability and capability for other local industries. There is potential for the Project and Keven Gypsum Mine to cumulatively further contribute to a loss of workforce availability within the local study area, leading to impacts on other industries, businesses and livelihoods.

As such, cumulative impacts to workforce shortages associated with the proposal would be possible with a minor magnitude of change, resulting in a medium pre-mitigated impact during both construction and operations.

8.2 Community wellbeing

As discussed in Section 7.2.1, the Project will lead to an overall increase in vehicle movements during construction due primarily to the required transport of construction materials and machinery to site. Construction traffic would likely use the existing J-A operational haulage route. This increase in construction traffic may lead to amenity related impacts for those leaving near the haulage route, including increased noise, vibration, and diminished air quality. The Keven Gypsum mine currently utilises a similar haulage route to the Project to transport product from site to Port Thevenard. As such, it is anticipated that Project related traffic will share the road with traffic from the Keven Gypsum Mine for a small portion of the route along the Eyre Highway between Ceduna to Penong. This increase of Project related traffic during construction may lead to enhanced amenity impacts, specifically amongst residents and businesses located adjacent to the Project haulage route between Ceduna and Penong.

As such, cumulative community wellbeing as a result of amenity impacts, specifically amongst residents and businesses located adjacent to the Project haulage route between Ceduna and Penong would be possible with a moderate magnitude of change, resulting in a Medium pre-mitigated impact.

8.3 Aboriginal outcomes

As discussed in Section 7.3.5, the Project may impact Aboriginal cultural heritage sites or artefacts within the Project area. The Keven Gypsum Mine is located within the FWC Native Title Determination area, as is the Project. While the Keven Gypsum Mine has been operational since 1919, potential disruptions to existing Aboriginal Material Cultural Heritage may occur during operations as a result of mining activities. It is assumed that the Keven Gypsum Mine would have a current cultural heritage management plan in place to mitigate and manage impacts to material heritage, whilst also providing guidance as to stop work protocols for the identification of any unexpected heritage sites or objects.

Potential operational impacts to Aboriginal cultural heritage may however be enhanced or exacerbated due to the two Projects undertaking mining activities simultaneously within the FWC native title determination area.

As such, cumulative impacts to Aboriginal outcomes associated with the proposal would be possible with a moderate magnitude of change, resulting in a Medium pre-mitigated impact.

8.4 Services and infrastructure

As discussed above in Section 8.2, the Project is anticipated to result in an increase of construction related Project vehicle movements, which will utilise the existing Project haulage route. As discussed in Section 7.4.2, this increase in Project vehicle movements during construction may contribute to the deterioration and damage of local roads and the Eyre Highway. The Keven Gypsum Mine currently uses a similar haulage route to transport product from site to the Port of Thevenard. It is likely that both Projects will utilise the same route along the Eyre Highway between Ceduna and Penong, which may lead to a temporary increase of cumulative traffic during the Project's construction phase and exacerbate damage and deterioration of the road.

As such, cumulative damage and general deterioration of the Eyre highway and local roads due to Project traffic would be likely with a moderate magnitude of change, resulting in a High pre-mitigated impact.

8.5 Surroundings

Given that the Project and the existing J-A operation are the only current proposed and existing developments within the Yellabinna Regional Reserve, no cumulative impacts to surroundings are anticipated as a result of the Project.

8.6 Cumulative impact assessment results summary

Cumulative impacts are summarised below in Table 8.1.

Table 8.1 Potential cumulative impacts

Impact category	Impact	Likelihood	Magnitude	Pre-mitigated impact rating
Livelihoods	Cumulative impacts to livelihoods during construction and operation due to labour shortages	Possible	Minor	Medium
Community wellbeing	Cumulative community wellbeing impacts as a result of amenity impacts, specifically amongst residents and businesses located adjacent to the Project haulage route between Ceduna and Penong, during construction	Possible	Minor	Medium
Aboriginal outcomes	Cumulative impacts to Aboriginal outcomes	Possible	Moderate	Medium
Services and infrastructure	Cumulative impacts to road infrastructure	Likely	Moderate	High
Surroundings	Cumulative impacts to surroundings	No impact	No impact	No impact

9 Mine closure

This section focusses on the impacts and opportunities of mine closure. This SIA acknowledges that mine closure impacts take effect between pre-closure (closure planning), closure (rehabilitation, care and maintenance) and post closure (mine closure plan completed).

While analysis has not been undertaken for unplanned closure, it is assumed the impacts associated with unplanned closure would be the same as those identified and analysed in this chapter although impacts would be greater in severity and would occur over a shorter timeframe.

J-A Mine closure Plan

Iluka developed the J-A Mine Closure Plan (MCP) in 2017 which provides an overview of Iluka's approach to closure and completion of J-A mining operations. Mine closure planning is a continuous process throughout the life of the mine and the MCP is progressively reviewed by Iluka. As part of the existing MCP, the following is expected to occur when mining operations cease:

- Ooldea road will remain a public road
- the airfield and accommodation village will be removed and rehabilitated
- the site of mining operations and its associated borefield and access road will be rehabilitated.

Key process steps outlined in the MCP include:

- fulfil all statutory obligations and relinquish all relevant leases/tenements/licenses/authorities
- rehabilitate disturbed land to a condition that supports sustainable post-mining land use (i.e. regional reserve)
- address potential social implications of closure and enhance environmental values of the land where possible as part of a strategy to maintain Iluka's 'social license to operate' in the region
- closure activities are undertaken in a timely and cost-effective manner
- engage with relevant stakeholders during the closure process
- minimise social impacts related to closure where reasonably practical.

MCP identifies a number of preliminary impacts, plans and strategies to be undertaken upon mine closure, these are considered in the discussion of impacts and measures below.

The J-A MCP will be updated to include Atacama. At the time of writing this report and updated MCP is not available, and thus the assessment draws on the J-A MCP controls.

Atacama Progressive rehabilitation

Rehabilitation activities at Atacama are expected to be undertaken progressively, in conjunction with mining activities. This will see mined areas partially backfilled with overburden, and at the completion of mining/processing activities, reserved loam and topsoils will be placed on top and other previously disturbed areas to provide a soil profile for regeneration of vegetation (Eco Logical, 2022). Project tailings will be disposed of at J-A, predominantly within the mine footprint.

9.1 Livelihoods

9.1.1 Impacts

The J-A MCP identifies the following social impacts that are likely to affect local livelihoods due to:

- loss of employment opportunities
- reduced business opportunities.

Although the Eyre Peninsula offers multiple industries, including others that are more established in comparison to mining (e.g. agriculture, aquaculture and tourism) it is apparent that many ancillary businesses and services in nearby towns have grown as an indirect result of J-A's presence and the subsequent stimulation of local economic activity that the mine has brought. J-A and Atacama closure would result on the loss of approximately 99 jobs locally (including contractors) and approximately 23 jobs from flow on impacts. J-A and Atacama employees would see lower remunerations in alternative employment or inability to secure comparable employment opportunities across the region.

In the Ceduna LGA local service expenditure on individual businesses averaged below $100,000 in under five years (2011-2019) (J-A SIA 2020). Local businesses (suppliers and services) from nearby towns (Ceduna, Streaky Bay, Wudinna) reported to have grown, diversified and matured as a direct result of their ongoing work at J-A. This procurement experience has improved their capabilities and enhance their resilience to economic changes.

While some businesses based in the local area are commercially dependent on their contractual work with Iluka, there are others that would need to significantly alter their business operations and structures in order to remain commercially viable if their work at J-A and Atacama was to cease. Businesses in the latter scenario, would see a reduction in revenue and possibly a wind-down in their customer base, likely to result in a simplification of their continued work stream (i.e. servicing customers in town who only require minimal skilled tradespeople). During SIA consultation, local business shared the experience of how temporary (planned and/or unplanned) shut-downs or quiet periods at J-A (i.e. care and maintenance phases associated with decreased commodity prices) can majorly impact local businesses, especially if these shutdowns occur with little warning or prior communication.

According to 2020 J-A SIA, household level impacts related to financial security, health and wellbeing and family stability are the concerns held by employees at J-A (including contractors) around mine closure. During this SIA consultation there was a general understanding of how mine closure may impact the community due to reduction of employment opportunities and sponsorships, as well as impact local businesses such as Kalari.

The J-A MCP outlines the following activities as a minimum response to these potential impacts:

- provide support for employees including upskilling workforce to move to other jobs nationwide, counselling services, mentoring
- encouraging and supporting sustainable business strategies with local business
- share information with community and stakeholders including information sessions, notifications in local papers, meet with stakeholders
- prepare a social implementation plan (within 5 years of the end of production).

As such, given the existing controls established in the J-A MCP, it is possibly that those employed directly by J-A and Atacama, as well as local business and employees who largely depend on procuring from the mine site, would see a moderate deterioration on their livelihoods, resulting in a Medium impact during pre-closure and closure.

9.1.2 Opportunities

The following opportunities were identified during SIA consultation:

- opportunities for nature-based tourism utilising existing mine infrastructure
- opportunity to coordinate and align regional economic opportunities involving FWCAC, local government, local businesses
- opportunities for retraining and upskilling to support sustainable industries in the region.

9.2 Community wellbeing

9.2.1 Impacts

The J-A operation has caused an increase in mobility of people, both incoming and outgoing to and from the Eyre Peninsula. Skilled workers and their families have relocated due to the attractive 'lifestyle' towns such as Ceduna and Streaky Bay, and the employment opportunities presented at J-A. Similarly, local residents who 'skilled-up' from employment at J-A over the years, have in some cases moved to other parts of the state to work at other mining Projects. This includes relocation to Adelaide, as the only metropolitan city in the state, where families can access a wider range of services, infrastructure and connectivity.

Upon mine closure, it is possible that a number of the local skilled workers will relocate elsewhere across South Australia to continue their work in the mining sector. While some workers may be able to continue FIFO work based out of Ceduna, the distance and infrequency of flights in and out of Adelaide from Ceduna may constrain their opportunities, as highlighted during SIA consultation. As such, this would likely result in changes to population, particularly youth and family-rearing demographic groups.

In 2019, approximately 14% of the total J-A workforce (including contractors) resided in the local area. The Project will require an additional 300–350 workers, 14% of which would equate to around 42–49 local employees. Given the relatively small population of the Ceduna LGA (3,651), the permanent loss of even a small number of residents and their families would likely impact the local community, as highlighted during consultation. Services, sporting clubs and local businesses would likely be impacted by the loss individuals and families from the area. In addition, the cease of mining operations would result in a loss of funding to or sponsorship of community development programs which have contributed to maintain community cohesion and active lifestyle for families and youth.

Changes to population paired with loss of community funding, may result on increased welfare dependency or increased demand for social services (public and non-governmental). The decreased demand for educational services, sport and recreational facilities and community programs and social services, may led to:

- fewer aged and childcare facilities
- new and/or upgraded community infrastructure and sports facilities could become unfeasible
- reduced funding for health care services
- potential fewer school enrolments due to fewer families and fewer children residing in Ceduna, this ultimately impacts the provision of quality education negatively.

The preparation of a social implementation plan, within 5 years of the end of production, as established in J-A MCP, would be a key measure to mitigate those impacts, which should also be included in the updated J-A and Atacama MCP.

After implementation of the J-A MCP , changes to population paired with loss of community sponsorships are likely to result in moderate changes to wellbeing in the local community, resulting in a High impact.

9.3 Aboriginal outcomes

9.3.1 Impacts

The organisational capacity of the FWCAC has been strengthened and improved due to annual royalty payments received by Iluka as per the NTMA. These payments have been by far the most significant source of revenue for the organisation and have substantially helped the Corporation successfully achieve and continue working toward its objectives.

This has in turn improved the protection of rights and interests of FWC Aboriginal people, their autonomy, self-determination, and their management of land across the FWC Native Title region and the co-management of the Yellabinna Regional Reserve. The FWCAC has been able to improve services and their consistency to remote communities in the FWC Native Title region and their members residing elsewhere, through the Members Assistance

Program (all categories of assistance) and the Community Benefit Program through the FWC Aboriginal Community Charitable Trust. The FWCAC in more recent years has shifted its strategic focus to self-sustaining investments and long-term Projects (FWCAC Annual Report, 2017-2018, p. 33).

Several Aboriginal owned and run businesses have been established due to financial support targeting small businesses of FWCAC members through the FWC Investments (FWCI) Group, including the Far West Coast Mining and Civil Pty Ltd and the Munda Wana Wilurrara Pty Ltd. The FWCAC has in recent years been able to demonstrate on a national level the 'high community impact, self-determination and wealth creation for the FWC native title holders' through the success of multiple FWC businesses that service and support J-A (FWCAC Annual Report, 2017-2018, p. 27). It has been reported that the members of the FWCAC are committed to ensuring their investments are looking beyond the life of the J-A mine and proposed Atacama Project.

Aboriginal employment and the quota of 20% has resulted in 55 FWCAC members having jobs with Iluka since 2017 through the FWCAC Workforce Development Program and Labour Hire (FWCAC Annual Report, 2017-2018, p. 11). Of these jobs, 22 are positions with Iluka directly sourced through the Far West Coast Mining and Civil Pty Ltd.'s Labour Hire Program, while 9 are with mine contractor Piacentini and Son (p. 28). Piacentini and Son also employ 28 FWC people full-time.

J-A and Atacama closure could result on:

— loss of employment opportunities for FWCAC members and potentially on increased unemployment among FWCAC members
— fewer education or training opportunities for FWCAC members
— reduced revenue to FWCAC affecting organisational capacity for community service and cultural heritage protection.

As such, after J-A MCP implementation, it is possible that FWCAC members would see a moderate reduction in social benefits as a result of fewer employment and training opportunities, as well as reduced FWCAC revenue, resulting in a Medium impact.

9.3.2 Opportunities

During consultation the following opportunities were identified:

— opportunities for environmental or cultural tourism post mine closure
— potential employment and training opportunities for FWC people during rehabilitation, and through ranger training initiatives.

9.4 Services and infrastructure

9.4.1 Impacts

The presence of Iluka in the local study area has contributed to the local economy and key industries, and in turn has improved service provision (access to and availability of) and quality and consistency of services in nearby towns (e.g. fuel supply, road network, accommodation services etc.). This has benefited the broader population of towns in the local area, with many residents clearly understanding Iluka's role in contributing to this. As highlighted by the Sustainable Minerals Institute, 'social challenges associated with mine closure can include out-migration as direct and indirect mining jobs come to an end; maintaining social cohesion as community dynamics change; local government's capacity to continue providing services due to loss of revenue from mining companies; and loss of social services due to insufficient demand. Many communities and mining regions continue to lag socially and economically decades after mining has ceased' (Sustainable Minerals Institute, 2022).

In the case of Ceduna, currently J-A FIFO workforce comprise a moderate proportion of total flights from Ceduna, which suggests there could be risks in price changes and reduction in the availability of flights, associated with the loss of Iluka's expenditure at the Ceduna airport. In 2019 Iluka spent $3.7m on charter flights to the mine site, which are likely to provide a positive financial and employment contribution to regional airlines. As discussed in Section 6.4, as of 2019, J-A's total FTE job creation was around 49 in the Far West Coast region, with an additional 12 FTE positions generated in the Eyre Peninsula. Additionally, from 2013 to 2021, the total J-A community sponsorship spending was $405,807.65 throughout the local study area, highlighting the economic stimulus and contribution of Iluka to the local region.

Consequently, the loss of expenditure on local goods and services by Iluka and its employees, paired with negative changes to population, could result in an overall change to local economies and key industries. Loss of income and economic stimulus provided by Iluka may result in the reduced ability of local businesses and services to continue operating at the same capacity, which could potentially lead to the increased cost of goods and services in the local area.

The Port of Thevenard is frequently utilised by a range of local businesses and industries, with J-A operations comprising a relatively small proportion of the Port's total capacity. It is envisaged that the Port operations would remain sustainable even if mining at J-A and Atacama are ceased.

As such, after J-A MCP implementation it is possible that community members would see a moderate reduction of economic activity and expenditure in the local area, resulting in a Medium impact.

9.4.2 Opportunities

The following opportunities were identified during SIA consultation:

- opportunity to reuse existing mine infrastructure following closure (e.g. to support housing, new community, solar panels, utilities).

9.5 Surroundings

During SIA consultation, interviewees reported confidence regarding the rehabilitation work that J-A and the Atacama Project would undertake, based on Iluka track record with rehabilitation and environmental care.

Some interviewees indicated that to protect Country, it is essential that the area is rehabilitated back to its exact original state. Aboriginal interviewees indicated that it is important that the landscape is not damaged, as it can hold significance for stories, law, and hunting (for example).

Interviewees requested community communication and awareness is upheld by Iluka approaching mine closure, remind residents about the Project's end of life phase and ensure there are no surprise. Increased information regarding closure and rehabilitation, including a better understanding of what Iluka will do with the land following closure is required.

It was recommended that FWC employees are engaged during the rehabilitation stage of the Project to enhance understanding of how to appropriately protect Country and uphold laws. The progressive rehabilitation process may allow for enhanced opportunities for FWC people to engage in rehabilitation activities, and to provide ongoing and continues feedback.

As such, after J-A MCP implementation it is possible permanent changes to landscape would have a moderate effect on aesthetic values of local communities and visitors to Yellabinna Parks, resulting in a Medium impact.

9.5.1 Opportunities

During consultation the following opportunities were identified:

- potential employment and training opportunities for FWC people during rehabilitation, and through ranger training initiatives.

9.6 Summary of closure social impacts

Table 9.1 Summary of social impacts during the Project's closure phase

Impact category	Impact	Likelihood	Magnitude	Significance
Livelihoods	Detrimental effects on local livelihoods as a result of lower remuneration in alternative employment and drop-in economic activity in local townships.	Possible	Moderate	Medium
Community Wellbeing	Changes community wellbeing and cohesion as a result of a decline on active workforce and families, increased welfare dependency and loss of sponsorships.	Likely	Moderate	High
Aboriginal Outcomes	Deterioration of Aboriginal outcomes as a result of fewer employment and training opportunities, as well as reduced FWCAC revenue.	Possible	Moderate	Medium
Service and Infrastructure	Impacts to local economies and key industries due to reduced expenditure on local goods and services.	Possible	Moderate	Medium
Surroundings	Permanent changes to landscape affect aesthetic values of local communities, FWCAC and visitors to Yellabinna Parks.	Possible	Moderate	Medium

10 Recommended mitigation and management measures

This section details the key social impact mitigation and enhancement approaches. These align to Iluka existing controls for J-A operations and will be integrated into the Social Management Plan of the site.

The principles below informed the development of management measures:

- Informed by consultation. Stakeholders were consulted about how Iluka could manage the impacts and enhance the benefits of the Atacama Project; the input was considered when developing measures and management framework.
- Specific and relevant. Measures are designed to address the negative social impact.
- Enhance social outcomes. Identification of opportunities to make a positive difference to the social and economic development of the local communities.

It is recommended that existing J-A controls are continued and strengthened by an adaptative management process, so that the outcomes of existing controls are monitored, measured and changes to controls are made if needed.

For potential impacts that have been given a low significance rating, Iluka would monitor for signs of social impact as part of the Social Management Plan Review and assess if additional management measures are required, as part of the adaptive management process outlined above.

Some improvement has been proposed to relevant J-A controls, and additional measures are outlined in the Project's Social Management Plan.

10.1 Livelihoods

10.1.1 Construction and operation measures

Continuity and enhancement of local employment programs

The continuity and enhancement of J-A local employment programs during pre-construction, construction and operations is recommended to:

- maximise the benefits increased employment opportunities for local residents
- mitigate workforce shortages.

Local employment programs, such as the Iluka work experience and apprenticeship programs, could be broadened to include local residents, with a particular focus on under-represented groups, including Indigenous people (FWC and non-FWC), women and youth from Ceduna, Yalata, Penong and Oak Valley.

To mitigate loss of active and qualified employees working for local businesses, Iluka could expand its Education Training and Employment Program to the above-mentioned groups, and where possible, continue to establish subcontracting agreements with local businesses.

Iluka will promote employment opportunities and requirements using local communication channels, such as the Ceduna Jobs page, the Penong notice board and EyrePlus. This could include providing printed information for display at FWCAC office and or at Ceduna Aboriginal Corporation's office.

Procurement management plan

The development of a local procurement plan is recommended to maximise procurement opportunities for local businesses, and would:

- identify the capacity of local and Indigenous businesses and suppliers to be ready for potential demand
- contain strategies to ensure contract requirements are known and understood (financial and administrative)
- provide opportunities for local businesses, including Indigenous businesses, to know more about business opportunities via Business Development expo or other type of tailored meet- the-contractor events.

10.1.2 Closure

Dependency assessment

It is recommended that Iluka assesses the degree of dependency of the local and regional community on J-A and Atacama operations. The assessment would include the identification of:

- local workforce dependency on J-A and Atacama, workforce needs for closure and post-closure employment opportunities in existing and/or emerging industries
- local businesses dependency on J-A and Atacama
- services dependency on J-A and Atacama (example Ceduna Airport).

This assessment will inform the social implementation plan, which is due to be prepared within 5 years of site closure.

10.2 Community wellbeing

10.2.1 Construction and operations

Road safety and awareness campaign

A road safety campaign prior to and during construction is recommended. Iluka could explore opportunities to reintroduce aspects of previous effective road safety campaigns, such as the Kalari's road safety program, and the inclusion of new signage in sensitive areas, such the Penong town centre and Penong Public School.

Continue and enhance the Employee Assistance Program and mental health awareness training

It is recommended that Iluka include information pertaining to the Employee Assistance Program and mental health awareness training as part of the standard induction package. Iluka contractual conditions require major contractors to provide the services of an EAP, or similar, for their employees. Iluka provide smaller contractors who may otherwise not have the capability to do so, access to the Employee Assistance Program (EAP).

It is recommended that Iluka continues to monitor and evaluate the effectiveness of the Employment Assistance Program and mental health awareness training.

Continue and enhance communication with key stakeholders

Building on the existing Atacama and J-A Engagement Plans, it is recommended that new strategies are incorporated to ensure community representatives and other key stakeholders clearly understand the Project key activities, its impacts, benefits and management measures at every stage of the Project (pre-construction, construction and operations).

New strategies may include:

- utilise the Iluka Ceduna office for Drop-in sessions and sharing informational materials
- staff Iluka's Ceduna office with a community relations staff during construction and operation
- explore opportunities for re-instating in-person mine tours for key stakeholders or virtual tours in the Ceduna Office during operations.

It is recommended that prior to construction, Iluka communicates and coordinates with key service providers Ceduna Airport, Port of Thevenard and Local health services.

Continue to implement and enhance social investment

The continuation of the existing J-A social investment plan is recommended with consideration of an assessment of ways to make more accessible the existing application process for sponsorships to all groups within the local study area. This may include simplifying application form and provide opportunities for applicants to ask questions and seek assistance (through communication channels such as the Ceduna office).

Continue to implement and evaluate the effectiveness of volunteering program

It is recommended that during operations Iluka evaluates the effectiveness of the volunteering program, to ensure there is a positive relationship between local residents and J-A and Atacama employees. It is recommended that the volunteering program is reviewed every five years.

10.2.2 Closure

Pre-closure social investment strategy

There is limited detail on the social implementation plan to be implemented as part of J-A MCP. It is recommended that the social implementation plan develops a pre-closure social investment strategy to contributes to the future of the local study area in a post-closure scenario. The strategy will be informed by the dependency assessment and mine infrastructure repurpose assessment.

The pre-closure social investment strategy will focus on moving to more strategic sponsorships through existing community foundations or organisations in the region. Funding usage can then be determined with autonomy from Iluka in working toward organisational sustainability and be directed to programs with a future-focus.

Pre-closure and closure Community and Stakeholder Engagement Plan

It is recommended that Iluka consider revising the existing Community and Stakeholder Engagement Strategy and Plan to be a robust tool during the pre-closure phase and extend to post closure, providing clear and consistent information to the public and key stakeholders.

It is recommended to follow ICMM Mine closure Tool 5: key messages for social transition for the development of the pre-closure and closure community and stakeholder engagement plan.

10.3 Aboriginal outcomes

10.3.1 Construction and operations

Review and continue to implement Cultural Heritage management plan and Heritage Discover and Clearance Procedure

It is recommended that Iluka review the Cultural Heritage Management Plan, and Heritage Discover and Clearance Procedures in collaboration with the FWCAC, to identify opportunities for improvement and update accordingly.

Opportunity to present all cultural heritage findings and data to FWCAC and natural resource bodies with consideration of cultural requirements.

Enhance cultural awareness training

It is recommended that Iluka reviews the effectiveness and outcomes of the Cultural Awareness Training to ensure the desired outcomes are being achieved and identify ways to enhance cultural awareness at the site.

Cultural provisions for all Indigenous employees

Consider introducing flexible cultural leave policies for all Indigenous employees, in consultation with FWCAC. The purpose of cultural leave is to enable Indigenous employees to respond to cultural responsibilities, to care for country, and to participate in cultural ceremonies or law.

Enhance rehabilitation by actively involving and consulting FWCAC members

It is recommended that Iluka, enhances rehabilitation controls by:

- supporting programs to enhance opportunities for Ranger Programs, land management, and tourism initiatives
- support formal rehabilitation training programs with FWC members to build specialised knowledge and capability.

10.3.2 Closure

Support FWC businesses in transitioning

It is recommended that Iluka consider supporting FWCAC by collaborating with peak bodies such as Indigenous Business Australia (IBA) to ensure transition support, self-sufficient businesses and diversified skills and training opportunities are available to FWC businesses currently dependent on the mine (e.g. Far West Coast Mining and Civil Pty Ltd).

It is also recommended that Iluka maximises involvement of FWC businesses in pre-closure, closure and post-closure work requirements.

Financial planning of the FWCAC

Mine closure will likely result in significantly reduced revenue for the FWCAC. It is recommended that Iluka work with the FWCAC to identify potential mechanisms to establish pre-closure to maintain their financial viability post-closure of J-A and Atacama.

Support FWCAC in adopting the management of Aboriginal cultural heritage in the project sites

It is recommended that Iluka work closely with the FWCAC to transfer cultural heritage information collected during J-A and Atacama construction and operation, this includes documentation about Aboriginal objects and sites. In addition, it is recommended that Iluka supports FWCAC in returning to Country any objects that have been relocated during operations.

10.4 Services and infrastructure

10.4.1 Construction and operations

Avoid use of private rental housing during construction

It is recommended that Iluka monitors short-term accommodation availability during construction. Iluka will request contractors avoid the use of private rental housing for workforce accommodation.

Monitor local health service capacity during construction

It is recommended that Iluka monitors local health services capacity during construction to ensure there are no constrains to servicing local residents during the construction period. It is recommended that Iluka communicates with local services yearly to determine if they have experienced any significant changes on demand.

10.4.2 Closure

Mine infrastructure audit and repurpose assessment

The repurposing of mine infrastructure and existing equipment provides an opportunity to replace or enhance limited or aging physical infrastructure in local Aboriginal communities. As such, it is recommended that Iluka undertakes an audit of mine infrastructure and existing equipment to then commission a technical assessment of repurposing options leading up to closure. The assessment will include:

- the economic viability of retaining infrastructure, including the dentification of the maintenance and operational cost of infrastructure
- legal requirements for transferring and operation, and liabilities associated with goods or services
- partnership arrangements required
- parties responsible for care and maintenance.

The assessment may consider future FWCAC ownership of and community usage of power, water and housing infrastructure on-site, usage of roads, water pipeline infrastructure and other moveable or non-moveable buildings. This could be aligned to the existing programs across the Yellabinna Regional Reserve and FWC Native Title area. The assessment also needs to consider existing community services or infrastructure that may cease due to mining cessation, such as emergency services across the region and ongoing maintenance of Ooldea Road.

10.5 Surroundings

10.5.1 Operations and closure

Site visits to rehabilitated land

Continue to provide site visits to the broader FWC and non-FWC community during closure phase to establish continued feedback, and collaboration regarding land management and change processes.

10.6 Mitigation and management measures summary

Table 10.1 provides a summary of management measures assigned to Medium and High pre-mitigated impacts. Low pre-mitigated impacts will be monitored and enhancement to existing controls will be implemented if unanticipated changes occur.

Table 10.1 Summary of recommended mitigation and management measures

Impact category	Impact significance	Measure	Phase	Type	Residual impact significance
Livelihoods	Medium	Continuity and enhancement of local employment programs	Construction and Operation	Continuity and enhancement	Low impact
	Medium	Procurement management plan		New measure	Low impact
	Medium	Dependency assessment	Closure	New measure	Medium impact

Impact category	Impact significance	Measure	Phase	Type	Residual impact significance
Community Wellbeing	Medium	Road safety and awareness campaign	Construction and Operation	New measure	Low impact
	Medium	Continue and enhance communication with key stakeholders	Construction and Operation	Continuity and enhancement	Low
	Medium	Continue and enhance Employee Assistance Program and mental health awareness training	Construction and Operation	Continuity and enhancement	Low
	Medium	Continue and enhance social Investment mechanisms	Operation	Continuity and enhancement	Low
	Medium	Continue to implement and evaluate volunteering program	Operation	Continuity and enhancement	Low
	High	Pre-closure social investment strategy	Closure	New measure	Medium
	High	Pre-closure and closure Community and Stakeholder Engagement Plan	Closure	New measure	Medium
Aboriginal Outcomes	Very High	Review and continue to implement Cultural Heritage management plan and Heritage Discover and Clearance Procedure	Construction and Operation	Continuity and enhancement	Medium
	High	Enhance cultural awareness training	Operations	Continuity and enhancement	Medium
	High	Cultural provisions for all Indigenous employees	Operations	New measure	Medium
	Very High	Enhance rehabilitation by actively involving and consulting with FWCAC members	Operations	New measure	Medium
	Medium	Support FWC businesses in transitioning	Closure	New measure	Medium
	Medium	Engage with the FWCAC to identify and establish mechanisms to support the Corporation's transition financial planning	Closure	New measure	Medium
	Medium	Support FWCAC in adopting the management of Aboriginal cultural heritage at the Project site	Closure	New measure	Medium

Impact category	Impact significance	Measure	Phase	Type	Residual impact significance
Service and Infrastructure	Medium	Avoid use of private rental housing during construction	Construction	New measure	Low
	Low	Monitor local health service capacity during construction	Construction	New measure	Low
	Medium	Mine infrastructure audit and repurpose assessment	Closure	New measure	Medium
Surroundings	Very high	Site visits to rehabilitated land	Operations and Closure	Continuity and enhancement	Medium

10.7 Assessment of residual social impacts

The following tables identify the recommended mitigation or enhancement measures for each social impact and details a specific mitigation measure that would address the identified social impact.

The residual social impact rating has been determined after implementation of the recommended mitigation or enhancement measure, including measures determined in technical papers listed in Section 1.1.

The methodology employed is as detailed in Section 3.4 above.

10.7.1 Construction residual impact rating

Table 10.2 Residual impact rating of construction impacts

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
Livelihoods	Increased employment opportunities for local residents (+)	Possible	Moderate	Medium	Continuity and enhancement of local employment programs	Likely	Moderate	High benefit
	Increased local procurement and business opportunities (+)	Possible	Minimal	Low	Continue and enhance monitoring of potential social changes Local procurement plan	Likely	Minimal	Low benefit
	Loss of local workforce to the Project (-)	Possible	Minimal	Low	Monitor, continue and enhance local employment programs	Unlikely	Minimal	Low impact
Community Wellbeing	Diminished sense of safety (-)	Possible	Moderate	Medium	Road safety and awareness campaign Development and implementation of a Construction Traffic Management Plan Continue and enhance communication with key stakeholders	Unlikely	Moderate	Low impact
	Detrimental effects to community wellbeing due to amenity impacts (-)	Unlikely	Minor	Low	Monitor, continue and enhance communication with key stakeholders	Possible	Minimal	Low impact
	Impacts to community cohesion and wellbeing due to increased non-residential workforce (-)	Unlikely	Minimal	Low	Monitor, continue and enhance communication with key stakeholders	Unlikely	Minimal	Low impact

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
	Impacts to workforce health and wellbeing (-)	Likely	Minor	Medium	Continue and enhance Employee Assistance Program and mental health awareness training	Unlikely	Minor	Low impact
	Procedural fairness and access to remedy (-)	Possible	Moderate	Medium	Continue and enhance communication with key stakeholders	Very Unlikely	Moderate	Low impact
	Unequal distribution of impacts and benefits (-)	Almost certain	Minor	Medium	Continue to implement and enhance social Investment	Unlikely	Minor	Low impact
	Enhanced community cohesion, wellbeing and active lifestyles as a result of Iluka's sponsorship program (+)	Likely	Moderate	High	Enhance social Investment mechanisms	Almost certain	Moderate	High benefit
Aboriginal Outcomes	Increased employment, education and business opportunities for FWC people (+)	Likely	Moderate	High	Continuity and enhancement of local employment programs Implement and monitor updated NTMA	Likely	Major	High benefit
	Increased organisational capacity of FWCAC (+)	Likely	Moderate	High	Implement and monitor updated NTMA Increase communication and engagement with FWC stakeholders	Almost certain	Moderate	High benefit
	Procedural fairness, and duty of care to FWCAC stakeholders (-)	Unlikely	Moderate	Low	Implement and monitor updated NTMA Monitor communication and engagement with FWC stakeholders	Unlikely	Minimal	Low impact

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
	Diminished wellbeing amongst Indigenous employees (-)	Possible	Moderate	Medium	Enhance cultural awareness training Cultural provisions for all Indigenous employees Continue and enhance Employee Assistance Program and mental health awareness training	Very Unlikely	Moderate	Low impact
	Disturbance or damage to Aboriginal material cultural heritage (-)	Possible	Major	High	Implement and monitor updated NTMA Review and continue to implement Cultural Heritage management plan and Heritage Discover and Clearance Procedure	Unlikely	Major	Medium impact
	Impacts to Aboriginal cultural landscapes and values (-)	Almost certain	Minimal	Low	Monitor rehabilitation with active involvement of FWCAC members Implement and monitor updated NTMA Monitor, review and continue to implement Cultural Heritage management plan, and Heritage Discover and Clearance Procedure	Likely	Minimal	Low impact

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
Services and Infrastructure	Increased accessibility to local infrastructure (+)	Almost certain	Minor	Medium	Maintain communication with key stakeholders about service needs	Almost certain	Moderate	High benefit
	Constrains to access to services due to road damage and deterioration (-)	Possible	Minor	Medium	Development and implementation of a Construction Traffic Management Plan	Unlikely	Minor	Low impact
	Impacts to accommodation availability (-)	Possible	Minor	Medium	Avoid use of private rental housing during construction	Very Unlikely	Moderate	Low impact
	Impacts to local health service capacity due to increased demand (-)	Very unlikely	Minor	Low	Monitor local health service capacity during construction Continue and enhance monitoring of potential social changes	Very Unlikely	Moderate	Low impact
Surroundings	Impacts to the landscape and associated aesthetic values (-)	Possible	Minor	Medium	Increase communication with key stakeholders	Possible	Minimal	Low impact

Note: (+) indicates a positive impact/benefit, and (-) indicates a negative impact.

10.7.2 Cumulative residual impact rating

Residual cumulative impacts are summarised below in Table 10.3.

Table 10.3 Residual impact rating of cumulative impacts

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual impact rating
Livelihoods	Cumulative impacts to livelihoods during construction and operation due to labour shortages	Possible	Minor	Medium	Continuity and enhancement of local employment programs	Unlikely	Minor	Low impact
Community wellbeing	Cumulative community wellbeing impacts as a result of amenity impacts, specifically amongst residents and businesses located adjacent to the Project haulage route between Ceduna and Penong, during construction	Possible	Moderate	Medium	Continual and enhanced communications Continuity and enhancement of Traffic Management Plan	Unlikely	Minor	Low impact
Aboriginal outcomes	Cumulative impacts to Aboriginal outcomes	Possible	Moderate	Medium	Review and continue to implement Cultural Heritage management plan and Heritage Discover and Clearance Procedure	Possible	Moderate	Medium impact
Services and infrastructure	Cumulative impacts to road infrastructure	Likely	Moderate	High	Continuity and enhancement of Traffic Management Plan	Likely	Minor	Medium impact

10.7.3 Operational residual impact rating

Table 10.4 Residual impact rating of operational impacts

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
Livelihoods	Increased employment opportunities for local residents (+)	Almost certain	Moderate	High	Continuity and enhancement of local employment programs	Almost certain	Major	Very high benefit
	Increased local procurement and business opportunities (+)	Possible	Moderate	Medium	Local procurement plan	Likely	Moderate	High benefit
	Loss of local workforce to the Project (-)	Possible	Minor	Medium	Continuity and enhancement of local employment programs	Possible	Minimal	Low impact
Community Wellbeing	Diminished sense of safety (-)	Unlikely	Moderate	Medium	Road safety and awareness campaign Continue implementation of J-A Traffic Management Plan	Very Unlikely	Moderate	Low impact
	Detrimental effects to community wellbeing due to amenity impacts (-)	Possible	Minor	Medium	Increase communication with key stakeholders via Community and Stakeholder Engagement Plan	Unlikely	Minimal	Low impact
	Impacts to community cohesion and wellbeing due to increased non-residential workforce (-)	Unlikely	Minor	Low	Evaluate and monitor the effectiveness of volunteering program (every 5 years) Maintain substantial separation distances between the mining and minerals processing areas and the nearest sensitive receptor (accommodation village)	Unlikely	Minimal	Low impact

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
	Impacts to workforce health and wellbeing (-)	Possible	Moderate	Medium	Evaluate and monitor the effectiveness of the Employee Assistance Program and mental health awareness training. (every 5 years)	Unlikely	Moderate	Low impact
	Procedural fairness and access to remedy (-)	Possible	Moderate	Medium	Continue and enhance communication with key stakeholders via Community and Stakeholder Engagement Plan	Very Unlikely	Moderate	Low impact
	Unequal distribution of impacts and benefits (-)	Almost certain	Minor	Medium	Continue and enhance communication with key stakeholders Continue to implement and Enhance social Investment mechanisms	Unlikely	Minor	Low impact
	Enhanced community cohesion, wellbeing and active lifestyles as a result of Iluka's sponsorship program (+)	Likely	Moderate	High	Continue and enhance communication with key stakeholders Enhance social investment mechanisms	Likely	Major	High benefit
Aboriginal Outcomes	Increased employment, education and business opportunities for FWC people (+)	Likely	Moderate	High	Continuity and enhancement of local employment programs Implement and monitor updated NTMA	Almost certain	Moderate	Very High benefit
	Increased organisational capacity of FWCAC (+)	Almost certain	Moderate	High	Assistance of FWCAC financial planning Implement and monitor updated NTMA Increase communication and engagement with FWC stakeholders	Almost certain	Major	Very High benefit

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
	Procedural fairness to FWCAC stakeholders (-)	Unlikely	Moderate	Low	Implement and monitor updated NTMA Monitor communication and engagement with FWC stakeholders	Very unlikely	Minor	Low impact
	Diminished wellbeing amongst Indigenous employees (-)	Likely	Moderate	High	Enhance cultural awareness training Cultural provisions for all Indigenous employees Evaluate and monitor the effectiveness of the Employee Assistance Program and mental health awareness training (every 5 years)	Unlikely	Moderate	Medium impact
	Disturbance or damage to Aboriginal material cultural heritage (-)	Unlikely	Major	Medium	Implement and monitor updated NTMA Implement and monitor Aboriginal Cultural Heritage Management Plan	Very Unlikely	Major	Medium impact
	Impacts to Aboriginal cultural landscapes and aesthetic values (-)	Almost certain	Major	Very High	Enhance rehabilitation by actively involving and consulting with FWCAC members Implement and monitor updated NTMA Implement and monitor Aboriginal Cultural Heritage Management Plan Implementation of the Rehabilitation Management Plan	Possibly	Moderate	Medium impact

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
Services and Infrastructure	Increased accessibility to local infrastructure (+)	Almost certain	Moderate	High	Maintain communication with key stakeholders about service needs	Almost certain	Major	Very High benefit
	Road damage and deterioration (-)	Unlikely	Minor	Low	Continue and enhance monitoring of potential social changes Continue to implement Traffic management plan	Very unlikely	Minor	Low impact
	Impacts to accommodation availability (-)	Unlikely	Minor	Low	Continue and enhance monitoring of potential social changes Continue and enhance communication with key stakeholders	Very unlikely	Minor	Low impact
	Impacts to local health service capacity due to increased demand (-)	Unlikely	Minor	Low	Continue and enhance monitoring of potential social changes Maintain communication with key stakeholders about service needs	Very unlikely	Minor	Low impact
Surroundings	Impacts to the landscape and associated aesthetic values due to Project operations (-)	Almost certain	Moderate	High	Enhance rehabilitation by actively involving FWCAC members	Possible	Moderate	Medium impact

Note: (+) indicates a positive impact/benefit, and (-) indicates a negative impact.

10.7.4 Mine closure residual impact rating

Table 10.5 Residual impact rating of mine closure impacts

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
Livelihoods	Detrimental effects on local livelihoods as a result of lower remuneration in alternative employment and drop-in economic activity in local townships. (-)	Possible	Moderate	Medium	Dependency assessment Pre-closure and closure Community and Stakeholder Engagement Plan Pre-closure social investment strategy	Possible	Minor	Medium impact
Community Wellbeing	Changes community wellbeing and cohesion as a result of a decline on active workforce and families, increased welfare dependency and loss of sponsorships. (-)	Likely	Moderate	High	Pre-closure social investment strategy Pre-closure and closure Community and Stakeholder Engagement Plan	Possible	Minor	Medium impact
Aboriginal Outcomes	Deterioration of Aboriginal outcomes as a result of fewer employment and training opportunities, as well as reduced FWCAC revenue. (-)	Possible	Moderate	Medium	Support FWC businesses in transitioning Financial planning of the FWCAC Enhance rehabilitation by actively involving FWCAC members	Possible	Minor	Medium impact
Service and Infrastructure	Impacts to local economies and key industries due to reduced expenditure on local goods and services. (-)	Possible	Moderate	Medium	Mine infrastructure audit and repurpose assessment	Possible	Minor	Medium impact

Impact category	Impact	Likelihood	Magnitude	Significance	Management measures	Residual likelihood	Residual magnitude	Residual significance
Surroundings	Permanent changes to landscape affect aesthetic values of local communities, FWCAC and visitors to Yellabinna Parks. (-)	Possible	Moderate	Medium	Enhance rehabilitation by actively involving FWCAC members Site visits to rehabilitated land Implementation of the Rehabilitation Management Plan Site-specific closure framework that includes progressive rehabilitation Support FWCAC in adopting cultural heritage management at Project site	Possible	Minor	Medium impact

Note: (+) indicates a positive impact/benefit, and (-) indicates a negative impact.

11 Conclusion

This report provides the results of a SIA for the Atacama Project. The Project has been assessed as an extension of the existing J-A Mine, and as such, the combined effects of J-A operations have been considered throughout this report.

This report contains a description of the existing social baseline conditions for local and regional areas potentially affected by the proposal, an assessment of the potential likelihood and magnitude of the predicted direct, combined and cumulative social impacts on those communities during the construction, operation and closure of Project, and the list of recommended mitigation and enhancement measures associated with each identified social impact.

The continuity and enhancement of existing controls, in addition to the implementation of new measures, will bring the impacts identified as High and Very High to a Medium and Low level of significance, and in some cases, bring High benefits to a Very High level of significance. Mitigation measures suggested include a Social Management Plan in order to establish the ongoing monitoring and evaluation of social impacts with an adaptive management approach to identify any emerging impacts.

The potential positive social benefits expected during construction and operation of the Atacama Project are as follows:

- increased employment opportunities for local residents
- increased local procurement and business opportunities
- enhanced community cohesion, wellbeing and active lifestyles as a result of the continuation of the Iluka sponsorship program
- increased employment, education and business opportunities for FWC people
- increased organisational capacity of FWCAC
- increased accessibility of local infrastructure.

Four pre-mitigated High or Very High negative social impacts were identified to potentially occur during construction and operation of the Atacama Project, which would all be reduced to a medium level of significance given the continuation and implementation of suggested measures. The negative social impacts with a Medium residual significance are summarised below, with all other construction and operation impacts receiving a Low residual impact rating:

- diminished wellbeing amongst Indigenous employees
- disturbance or damage to Aboriginal material cultural heritage
- impacts to Aboriginal cultural landscapes and values
- impacts to the landscape and associated aesthetic values.

The potential social impacts with a Medium residual significance rating that may occur during closure of the Atacama Project are summarised below:

- detrimental effects on local livelihoods as a result of lower remuneration in alternative employment and drop-in economic activity in local townships
- changes to community wellbeing and cohesion as a result of a decline on active workforce and families, increased welfare dependency and loss of sponsorships
- deterioration of Aboriginal outcomes as a result of fewer employment and training opportunities, as well as reduced FWCAC revenue
- reduced accessibility to services, goods and infrastructure as a result of increased prices; and
- permanent changes to landscape affect aesthetic values of local communities, FWCAC and visitors to Yellabinna Parks.

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Appendix A

Former SIA consultation

A1 Former SIA consultation

Table A.1 details consultation participants in 2014 and 2020 for SIAs. During both SIAs the District Council of Ceduna and Iluka Resources staff were interviewed. Both SIA's consultation together provide diversity in representation of stakeholder groups consulted throughout the last 7 years. Only in the 2020 SIA, Traditional Owners were interviewed.

The outcome of these consultation is considered, as much as practicable, to minimise duplication and respondent fatigue.

Table A.1 Previous 2014 and 2020 J-A SIA consultation participants

2014 AST Development Project SIA	2020 J-A SIA
— District Council of Ceduna — Department of Environment, Water and Natural Resources (DEWNR) — Alinytjara Wilurara Natural Resources Management Board — Gypsum Resources Australia — Environment Protection Authority (EPA) — Penong Progress Association (PBTA) — Ceduna Business and Tourism Association (CBTA) — Iluka Resources staff including Community Relations Advisor and Site Manager	— District Council of Ceduna, CEO — FWCAC CEO and Corporate affairs — Ceduna Can & Bottle Pty General Manager — Streaky Bay Plumbing, Owner and General Manager — West Coast Welding, Owner and General Manager — Thevenard Residents Association, Member — Ceduna Aboriginal Corporation, CEO — Iluka Resources staff including Community Relations Advisor and Site Manager

Table A.2 details the key issues and interests raised by stakeholders during former SIA consultations and where is addressed in this report.

Table A.2 Key issues and interests raised by stakeholders during 2014 and 2020 SIA consultation

Social Impact category	Stakeholder consultation outcomes	Where addressed in this SIA
Livelihoods	Positive economic outcomes as part of J-A operations, including employment and procurement opportunities. Roadhouses, petrol stations, supply stops, and short-term accommodation have benefited due to freight logistics and exploration teams.	Section 7.1
Livelihoods	Concerns over increase of house, rental and goods prices based on immigrational speculation.	Section 7.1
Livelihoods	Mine closure was associated with reduced work within the region, instability in workflows, uncertain income streams and revenue, and possible staff reductions, as well as deterioration in local infrastructure and public services affecting the broader public would be expected.	Section 7.1
Community Wellbeing	Concerns over dust and noise from haulage and the Port Thevenard operation.	Section 7.2
Community Wellbeing	Expectations of increased communication and engagement methods.	Section 7.2

Social Impact category	Stakeholder consultation outcomes	Where addressed in this SIA
Community Wellbeing	Road safety along the Eyre Highway in Highway and pedestrian safety concerns on One BP Station, nearby Penong Hotel, the Penong Pub and the Petrol Service Station and nearby rail tracks were raised. Since Kalari started using longer trucks there has been fewer trucks per day, reducing this safety concern.	Section 7.2
Aboriginal outcomes	It was positively recognised the geo-location work of Aboriginal cultural heritage artefacts on existing tenements; however, concerns were raised about record keeping, location of storage and existing processes in place.	Section 7.2.7
Aboriginal outcomes	Concerns over environmental disturbance of access, conservation efforts Yellabinna Regional Reserve and land access	Section 7.2.7
Aboriginal outcomes	Aboriginal employment targets required as a condition of consent under the NTMA is understood to be met by Iluka Resources but not consistently adhered to by Project contractors. Challenges in sourcing workers with the required skill set, training and industry experience is recognised. Aboriginal worker retention and the difficulty in managing worker absenteeism in FIFO rosters was raised.	Section 7.2.7
Aboriginal outcomes	Issues relating to racial discrimination onsite was also raised. Comments relating to the Cultural Awareness Training that is active onsite was around how it can be improved to act as a tool to address this concern.	Section 7.2.7
Aboriginal outcomes	FWCAC royalty payments over the years have allowed the organisation to grow, strengthen and mature and has meant that the FWCAC has been able to provide ongoing and consistent funding to an extensive number of programs such as aged care, funeral support, remote health services, youth school support and remuneration for when members turn 50 and 60.	Section 7.2.7
Aboriginal outcomes	It is well understood by the FWCAC that mine closure and the cessation of royalty payments will have a significant adverse implications for the organisation in continuing to grow and in sustaining their range of community services. It is expected that onsite Aboriginal workers could relocate to other mine sites across the state, while Aboriginal subcontractors would either need to reduce their business size, adapt to find other streams of work.	Section 7.2.7 and 9.3
Service and Infrastructure	Concern over the impact of trucks along the Eyre Highway, on the road networks and road conditions.	Section 7.4
Surroundings	In 2014, Stakeholders recognise there is a need to improve the visual amenity at Port Thevenard and are open to the possibility of working with investors to create a community friendly environment.	Section 7.5

Appendix B

Consultation questionnaires

B1 Consultation questionnaires

Table B.1 SIA consultation questionnaire

Stakeholders	Engagement method	Questionnaire

Local and regional government bodies	Individual meeting	— What are the current issues/challenges facing your community and organisation?
		— What local services and facilities are important to you and your organisation?
		— How would you describe your level of understanding of the Atacama Project (on a scale of 1-5, where 1=extremely low and 5=extremely high)? When answer is Low: What areas are still unclear?
		— What potential Project benefits and impacts during ***construction*** has your organisation identified?
		— What potential Project benefits and impacts during ***operation*** has your organisation identified?
		— How do you think the Project may impact or provide benefit to (further exploratory questions – in case issue is not raised in the two questions above):
		    — the local housing/accommodation market?
		    — The Project area's land access, usages, and associated values?
		    — Cohesiveness of the community?
		    — Wellbeing impacts: noise, dust, safety
		    — Environmental impacts / water quality?
		— Are there any vulnerable members of the community that may be particularly impacted by the Project?
		— How can Iluka Resources manage or reduce potential impacts during construction and operation?
		— How can Iluka Resources manage or increase potential benefits to the community?
		— What potential Project benefits and impacts during closure has your organisation identified?
		— How would you like to see Iluka Resources and your organisation prepare for mine closure in the future?
		— How would you describe your experience of engagement with Iluka Resources for the Atacama Project (on a scale of 1-5, where 1=extremely poor and 5=extremely positive)? Could you explain why?
		— On the whole, how do you feel about the Atacama Project? (on a scale of 1-5, where 1=extremely negative and 5=extremely positive)? Could you explain why?
		— Thank you for your time, are there any final comments you would like to make?

Stakeholders	Engagement method	Questionnaire
Traditional Owners	To be decided by stakeholder: alternatives include meeting within established forums or scheduling a separate meeting	***Procedural Fairness in NTMA process (Directed at FWCAC)*** — Were you involved in the NTMA agreement making? How? — How familiar did you feel with the Atacama Project before entering NTMA? — So far, do you feel that your organisation has been adequately informed about the Atacama Project and associated outcomes during NTMA process? — So far, do you feel that your organisation has been able to have a say in the NTMA process to achieve positive outcomes? — Are there any ways you would like to see this process improved? — How do you think the NTMA agreement-making process would impact the community (either positive or negatively)? Has the group experienced changes to sense of community, cohesion or culture? ***Atacama Project Impacts (Directed at FWCAC and FWCA Liaison Committee)*** — How would you describe your level of understanding of the Atacama Project (on a scale of 1-5, where 1=extremely low and 5=extremely high)? When answer is Low: What areas are still unclear? — How do you think the Atacama Project could impact (both positively and negatively) the Far West Coast Native Title Group? (any concerns about: local Indigenous heritage, history and cultural values, employment and wellbeing) — Any particular concerns during construction, operation? — What are the long-term changes that you think the Project will bring to Country – either positive or negative? — How could Iluka Resources mitigate, manage or enhance those impacts and/or benefits? What has worked well with J-A / what could be improved? — What would you like to see come to the local community as a result of the Atacama Project? — Are there groups within FWC group that would be or have been impacted or benefited differently? How? Is there anyone within FWC group do think should be also interviewed? — How would mine closure affect Traditional Owners, what are your priorities for mine rehabilitation – to what extent do you perceive your priorities have been taken into consideration? — Thank you for your time, are there any final comments you would like to make?

Stakeholders	Engagement method	Questionnaire

First Nation Groups	Individual meeting	— What are the current issues/challenges facing your community?
		— How would you describe your level of understanding of the Atacama Project (on a scale of 1-5, where 1=extremely low and 5=extremely high)? When answer is Low: What areas are still unclear?
		— What Project benefits and impacts during **construction** has your organisation identified?
		— What Project benefits and impacts during **operation** has your organisation identified?
		— Are there any vulnerable members of the First Nation groups that may be particularly impacted/benefited by the Project?
		— How do you think the Project may impact or provide benefit to (further exploratory questions – in case issue is not raised in the two questions above):
		  — The Project area's land access, usages, and associated values?
		  — Cohesiveness of the community?
		  — Wellbeing impacts: noise, dust, safety
		— How can Iluka Resources manage or reduce potential impacts during construction and operation, and bring benefit to the community?
		— What Project benefits and impacts during **closure** has your organisation identified?
		— How could Iluka Resources and your organisation prepare for mine **closure in the future**?
		— How would you describe your experience of engagement with Iluka Resources for the Atacama Project (on a scale of 1-5, where 1=extremely poor and 5=extremely positive)? Could you explain why?
		— On the whole, how do you feel about the Atacama Project? (on a scale of 1-5, where 1=extremely negative and 5=extremely positive)? Could you explain why?
		— Thank you for your time, are there any final comments you would like to make?

Stakeholders	Engagement method	Questionnaire

Community stakeholders
Social service providers
	Individual or group meetings.
	Face to face or online, as required by stakeholder.
		— What are the current issues/challenges facing your community/organisation?
		— How would you describe your level of understanding of the Atacama Project (on a scale of 1-5, where 1=extremely low and 5=extremely high)? When answer is Low: What areas are still unclear?
		— What Project benefits and impacts during **construction** has your organisation identified?
		— What Project benefits and impacts during **operation** has your organisation identified?
		— Are there any vulnerable members of the community that may be particularly impacted/benefited by the Project?
		— How do you think the Project may impact or provide benefit to (further exploratory questions – in case issue is not raised in the two questions above):
		  — the local housing/accommodation market?
		  — The Project area's land access, usages, and associated values?
		  — Cohesiveness of the community?
		  — Wellbeing impacts: noise, dust, safety
		— How can Iluka Resources manage or reduce potential impacts during construction and operation, and bring benefit to the community?
		— What Project benefits and impacts during **closure** has your organisation identified?
		— How could Iluka Resources prepare for mine **closure in the future**?
		— How would you describe your experience of engagement with Iluka Resources for the Atacama Project (on a scale of 1-5, where 1=extremely poor and 5=extremely positive)? Could you explain why?
		— On the whole, how do you feel about the Atacama Project? (on a scale of 1-5, where 1=extremely negative and 5=extremely positive)? Could you explain why?
		— Thank you for your time, are there any final comments you would like to make?

Stakeholders	Engagement method	Questionnaire

Local Businesses and Suppliers	Individual or group meetings.
	Face to face or online, as required by stakeholder.
		— How would you describe your level of understanding of the Atacama Project (on a scale of 1-5, where 1=extremely low and 5=extremely high)? When answer is Low: What areas are still unclear?
		— What Project benefits and impacts during **construction** has your organisation identified?
		— What Project benefits and impacts during **operation** has your organisation identified?
		— Are there any vulnerable members of the community that may be particularly impacted/benefited by the Project?
		— How do you think the Project may impact or provide benefit to (further exploratory questions – in case issue is not raised in the two questions above):
		    — the local housing/accommodation market?
		    — Wellbeing impacts: noise, dust, safety, amenity
		— Are there additional opportunities for local communities to benefit economically from this Project (employment, procurement etc. and how)?
		— How can Iluka Resources manage or reduce potential impacts during construction and operation, and bring benefit to the community?
		— What Project benefits and impacts during **closure** has your organisation identified?
		— How could Iluka Resources and your organisation prepare for mine **closure in the future**?
		— How would you describe your experience of engagement with Iluka Resources for the Atacama Project (on a scale of 1-5, where 1=extremely poor and 5=extremely positive)? Could you explain why?
		— On the whole, how do you feel about the Atacama Project? (on a scale of 1-5, where 1=extremely negative and 5=extremely positive)? Could you explain why?
		— Thank you for your time, are there any final comments you would like to make?

Appendix C

Local businesses

C1 Local business

Table C.1 Consolidated local and regional contractors

Vendor	Registered location	Product/service
COWELL ELECTRIC SU	Region	Trades and utilities
COMPLETE PERSONNEL RECRUITMENT	Region	Labour hire
MAX CRANES AND EQUI	Region	Equipment hire
WEST COAST WELDING (SA) PTY LT	Local	Engineering and machinery maintenance
FAR WEST MINING & CIVIL PTY LT	Local	Equipment hire and earth works
CEDUNA BULK HAULIERS &	Local	Transport and freight
CEDUNA CAN & BOTTLE PTY LTD	Local	Waste services
CEDUNA METAL SOLUTIONS	Local	Manufacturing
CEDUNA STEEL FABRICATIONS PTY	Local	Manufacturing
CEDUNA MACHINERY PTY LTD	Local	Equipment hire
HOCKO'S AUTO REPAIRS & MECHANI	Local	Maintenance and repair
CEDUNA PAINT & PANEL	Local	Maintenance and repair
WESTLAKE CONTRACTING	Local	Labour hire and trades
STREAKY BAY PLUMBING SERVICE &	Local	Trades and utilities
STREAKY BAY AIR CONDITIONING	Local	Camp services
EP ANALYSIS PTY LTD	Region	Environmental monitoring

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Atacama Ecological Impact Assessment

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Executive Summary

The Atacama Project (the Project) is located approximately 5 km north-east from Iluka's operational Jacinth-Ambrosia (J-A) Mine, approximately 200 km north-west of Ceduna on the Eyre Peninsula. The Atacama Project is expected to have a maximum 2,057 ha footprint (including a 50 m buffer around the project limits), with 128 ha of additional clearing to occur at Jacinth-Abrosia (J-A) mine (ML6315 and MLP111). The Project isocated in the Yellabinna Regional Reserve.

In accordance with SA Government requirements, this ecological impact assessment (EIA) applied a Source-Pathway-Receptor (S-P-R) approach to identify whether there were project-related changes in elements of the environment (Sources) that could trigger events (Pathways) that lead to adverse effects on ecological values (species and vegetation associations) in the existing environment (Receptors). As part of this approach Pathways linking Sources and Receptors were validated before the whole S-P-R mechanism (i.e., impact event) was assessed.

The following activities were identified as having potential impacts on ecology as a result of the Project:

- Vegetation clearing;
- Vehicle strike;
- Pathogens or toxins;
- Pests and weeds;
- Changes in fire regime;
- Erosion of soil;
- Altered landforms;
- Noise, light and dust;
- Changes in surface water flows.

Potential Receptors were identified using ecological database searches and results of surveys undertaken by ELA and EBS Ecology across the proposed Atacama ML and surrounding area. A likelihood of occurrence assessment was undertaken to assess the likely presence of species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the South Australian *National Parks and Wildlife Act 1972* (NPW Act). Listed species identified as known or likely to occur within the proposed Atacama ML and immediate surrounds that are considered as potential Receptors susceptible to Project impact events includes the following species:

Listed Fauna

- *Acanthiza iredalei* (Slender-billed Thornbill) - Rare NPW Act;
- *Apus pacificus* (Fork-tailed Swift) – Migratory EPBC Act;
- *Ardeotis australis* (Australian Bustard) – Vulnerable NPW Act;
- *Cinclosoma castanotus (*Chestnut Quail Thrush*)* – Rare NPW Act;
- *Falco peregrinus* (Peregrine falcon) – Rare NPW Act;
- *Hieraaetus morphnoides* (Little Eagle) – Vulnerable NPW Act;
- *Leipoa ocellata* (Malleefowl) –Vulnerable NPW act and Vulnerable EPBC Act;
- *Lophochroa leadbeateri* (Major Mitchell's Cockatoo) – Vulnerable NPW Act;

- *Myiagra inquieta* (Restless Flycatcher) - Rare NPW Act;
- *Neelaps bimaculatus* (Western Black-naped Snake) Rare NPW Act;
- *Neophema splendida* (Scarlet-chested Parrot) - Rare NPW Act;
- *Pachycephala inornata* (Gilbert's Whistler) – Rare NPW Act;
- *Sminthopsis psammophila* (Sandhill Dunnart) – Vulnerable NPW Act and Endangered EPBC Act.

Listed Flora

- *Corynotheca licrota* (Sand Lily) – Rare NPW Act;
- *Gratwickia monochaeta* – Rare NPW Act;
- *Hibbertia crispula (*Ooldea Guinea-flower) – Vulnerable NPW Act and Vulnerable EPBC Act;
- *Melaleuca leiocarpa* (Pungent Honey-myrtle)- Rare NPW Act;
- *Santalum spicatum* (Sandalwood) – Vulnerable NPW Act.

An assessment of the potential impacts of the Project on the native ecology (non-listed), NPW Act listed species, and EPBC Act listed species was completed. Control measures are recommended to avoid and minimise the listed impacts, and proposed outcomes show the expected level of impact (if any) post mitigation for all Impact Events identified. Post mitigation, potential impacts are deemed to be 'as low as reasonably practicable (ALARP).

A Significant Residual Impact was conducted in accordance with the *Matters of National Environmental Significance Significant impact guidelines 1.1* for EPBC listed species with a known or likely likelihood of occurrence within the ML area. This assessment showed that there are no significant residual impacts on EPBC listed species expected as a result of the Project.

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Abbreviations

Abbreviation	Description
AHD	Australian Height Datum
ALA	Atlas of Living Australia
ALARP	As low as reasonably practicable
BGL	Below Ground Level
BOM	Bureau of Meteorology
CE	Critically Endangered
DEM	Department for Energy and Mining
DEW	Department of Environment and Water
ELA	Eco Logical Australia
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FWCAC	Far West Coast Aboriginal Corporation
FWCLC	Far West Coast Liaison Committee
FWCNTG	Far West Coast Native Title Group
GDE	Groundwater Dependent Ecosystem
HMC	Heavy Metal Concentrate
Iluka	Iluka Resources Limited
J-A	Jacinth-Ambrosia
MG2a	Minerals Regulatory Guidelines MG2a: Preparation of a mining application for metallic and industrial minerals
Mining Act	South Australian Mining Act 1971
ML	Mining Lease
MLP	Mining Lease Proposal
MNES	Matters of National Environmental Significance
MP	Management Plan
MPL	Miscellaneous Purpose Licence
MUP	Mining Unit Plant
MW	Mega Watts
NORM	Natural Occurring Radioactive Material
NPW	National Parks and Wildlife
NTMA	Native Title Mining Agreement
NV	Native Vegetation (act)
NVF	Native Vegetation Fund
NVIS	National Vegetation Information System
PEPR	Program for Environment Protection and Rehabilitation
PFS	Pre-Feasibility Study
PMST	Protected Matters Search Tool
RO	Reverse Osmosis
RR	Regional Reserve

SEB	Significant Environmental Benefit
TOR006	Terms of Reference 006: Mineral mine lease/licence application

1. Introduction

1.1 Project description

The Project involves mining of the Atacama Deposit, to produce heavy mineral sand concentrates. The deposit is adjacent to the existing Iluka Jacinth-Ambrosia (J-A) mine located on Mining Lease (ML) 6315. The deposit will be developed as a satellite mine to J-A making use of existing facilities and disturbance footprint at J-A for processing and deposition of new tailings. Mining activity has occurred at J-A mine since 2009. J-A is operated by Iluka in accordance with the *Mining Act* (1971) under an approved PEPR.

The Project is located in the Yellabinna Regional Reserve (YRR) on the far-west coast of South Australia, at the edge of the Great Victoria Desert. The nearest regional centre is Ceduna, located about 200 km to the south-east. YRR land uses include mineral exploration and extraction, tourism, and wildlife conservation.

A summary of the key project elements is included in Table 1-1.

Table 1-A Proposed Mining Lease key project elements

Project element	Description
Project location	The Project is located within the Yellabinna Regional Reserve, approximately 800 km north-west from Adelaide and 290 km north-west of the Port of Thevenard. It is located approximately 5 km north-east of the existing J-A mine site.
Project disturbance	The project footprint (Figure 1.1), including buffers, occupies up to 2,057 ha within the Project Area, and an additional 128 ha extension of the existing J-A site.
Mining method	Dry mining of three open pits with the following dimensions: • Pit 1 (Western Pit): approximately 5,000 m long, 350 m wide and 60 m deep. • Pit 2 (Central Pit): approximately 3,900 m long, 290 m wide and 45 m deep. • Pit 3 (Eastern Pit): approximately 5,800 m long, 470 m wide and 75 m deep. There is also a small satellite pit to the south which may be mined at the end of the mine life which is <700 m in length.
Mining rate	Approximately 185 Mt of overburden and 25 Mt of ore. Approximately 4.1 Mt of Heavy Mineral Concentrate (HMC) will be produced for transport by ship to Iluka's WA processing facilities.
Mine life	Approximately seven (7) years including overburden stripping and backfilling of voids. J-A's total mine life will be extended by approximately four (4) years by inclusion of processing of this deposit.
Commodities	Zircon, ilmenite and rutile.

Project element	Description
Processing	Material will be trucked or slurry pumped via a Mining Unit Plant (MUP) from Atacama to J-A for processing through gravity concentration and magnetic separation. This Atacama ore will likely be blended with Ambrosia ore through the existing MUP located at the Ambrosia deposit which may be temporarily relocated to Atacama deposit for discrete stages of the mining life.
Tailings storage facility	A self-supported Sand Tailings stockpile will be constructed at J-A for the storage of tailings material from Atacama which will be processed through the J-A Mine processing plant. The Sand Tailings stockpile will be constructed on the existing disturbance footprint at J-A. Fine tailings (<53 micron) will be blended with similar material from Ambrosia and placed in voids consistent with the current approved J-A backfill plan.
Power demand and supply*	Power will be sourced from the onsite (diesel/ solar) power station at J-A. Additional solar capacity is being investigated. The instantaneous power demand at Atacama will be approximately 4 MW greater than the J-A peak demand. Based on average consumption, this would equate to approximately 17,000 MWh of additional power each year.
Water demand and supply**	Water will be sourced from the existing wellfield used for the J-A mine site, located approximately 40 km from the J-A mine site. The wellfield has a design capacity of approximately 360 L/s or 1,200 m^3/h. Current (2022) water use for J-A is approximately 100 L/s (or 360 m^3/h). The additional capacity required for the Atacama project is incremental for processing purposes. For dust suppression purposes, an additional 9 L/s (or 34 m^3/h) of potable water is expected to be required for the project. With the efficiency of a new RO plant at J-A, this would amount to approximately 175 m^3/h of saline consumption, resulting in a total water requirement across both projects of approximately 550 m^3/h.
Operating hours	Mining will occur 24/7, 7 days a week, with progressive rehabilitation, and processing through the J-A Mine processing plant.
Transport and logistics	Production life at J-A will be extended but there will be no annual increase in truck movements via the existing route from J-A to Port Thevenard. The same trucking route will be used. Changes to the bunker at Port Thevenard are not expected, however if required, will broadly be within the existing site footprint.
Workforce	It is expected that total staff numbers at J-A will increase by up to 350 full time equivalent (FTE) depending on the roster patterns. This will be spread across the current site rosters. Accommodation for the workforce will be at the existing J-A camp, which will require upgrades.

Project element	Description
Radiation	The following levels of radiation are expected due to naturally occurring radioactive minerals (NORMs) in the deposit: Ore: between 0.16 to around 0.54 Bq/g Mine tailings: between 0.01 to 0.1 Bq/g Magnetic concentrate (open storage prior to trucking off site): between 0.6 to 1.7 Bq/g Non-magnetic concentrate (open storage prior to export): between 3.7 to 5.0 Bq/g

*** Power consumption will change through the course of the study as design definitions improve**

**** Water use will change through the course of the study as design definitions improve**

The Project will progress as a concurrent development with the existing J-A Mine. Disturbance at Atacama will be limited to mining, roads, and stockpiles by using the existing processing and storage facilities and expanding the existing tailings facilities at the J-A mine.

Project activities will occur in three phases - construction, operation, and closure/rehabilitation phases. These activities are listed below:

- Construction
  - Clearing of vegetation;
  - Stripping and stockpiling topsoil and subsoil;
  - Stripping and stockpiling overburden;
  - Building roads and supply infrastructure.
- Operation
  - Clearing of vegetation;
  - Stripping and stockpiling topsoil and subsoil;
  - Stripping and stockpiling overburden;
  - Mineral sand extraction;
  - Screening, separation and slurrying or trucking of ore to J-A;
  - Stripping and stockpiling topsoil and subsoil;
  - Stripping and stockpiling overburden.
- Closure/rehabilitation
  - Progressive backfilling of the mine void with overburden and then progressively rehabilitating with placement of subsoil and topsoil followed by revegetation.

The open pit voids will be progressively rehabilitated, infilled with overburden and soil material up to the elevation level of the existing swales. Rehabilitation success will be monitored.

PROPOSED DISTURBANCE FOOTPRINT

The Project footprint, including buffers, occupies up to 2,057 ha. The disturbance footprint includes:

- Roads (access and haulage);
- Pits;
- Stockpiles;
- Mining unit plant (MUP).

Supporting infrastructure will be constructed and installed at the proposed Atacama ML to support these activities, including ablutions, crib room, office, communications room and tower, mining contractor’s area and vehicle carpark, workshop, and a wastewater treatment plant.

Wherever possible, supporting infrastructure has been placed between dune crests to minimise changes to the landscape. The project has some flexibility and will seek to implement avoidance and mitigation measures to avoid complete clearance of native vegetation within the Project footprint.

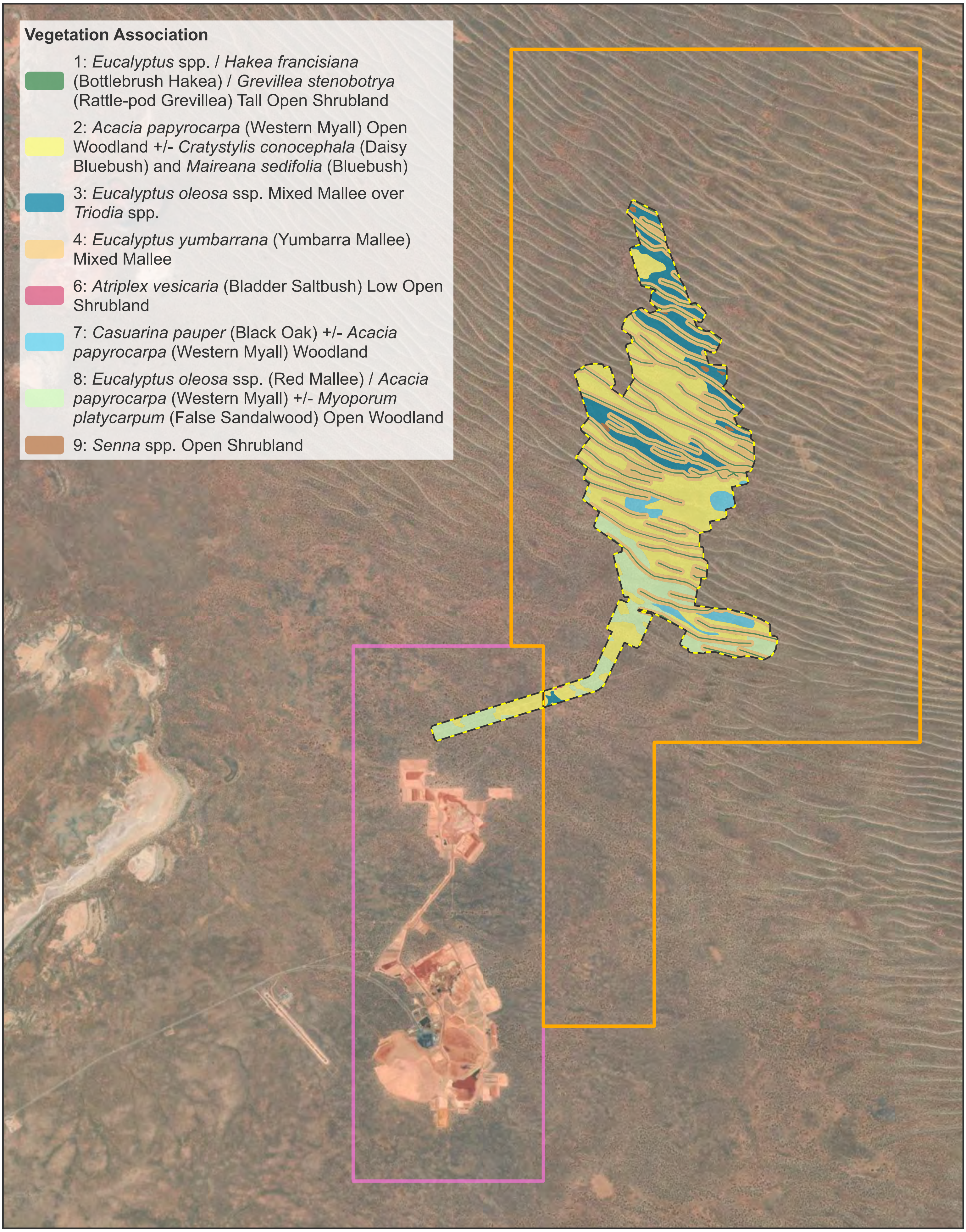

Figure 1-1: Proposed disturbance footprint

Project Area
Conceptual Footprint
ML 6315

N

0 2 4
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 53

Project: 20409-OK Date: 27/10/2022

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1.2 Scope of this assessment

This impact assessment is focussed on terrestrial ecology, specifically native flora and fauna, and threatened biota listed under the State *National Parks and Wildlife Act 1972* (NPW Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The purpose of this ecological impact assessment is to assess the nature of impacts that will occur as a result of the project activities during the construction, operation and rehabilitation phases of the Project.

This report will use the following definitions:

- Conceptual Footprint: This is an area of 2,057 ha within which the Project will occur. All direct impacts such as vegetation clearing will occur inside of this footprint;
- Project Area: This is an area of 13,789.14 ha which allows for the consideration of indirect impacts such as noise, dust and light outside of the direct disturbance Conceptual Footprint and associated buffer

1.3 Legislative context

The Commonwealth and State legislative frameworks relevant to the ecological impact assessment are summarised here.

1.3.1 State legislation

National Parks and Wildlife Act 1972 (NPW ACT)

The NPW Act provides for the establishment and management of reserves for public benefit and enjoyment and to provide for the conservation of wildlife in a natural environment (Department of Environment and Water (DEW 2021)). The NPW Act is for the protection of representative areas of the state's ecosystems, ecological communities, habitats and species and their populations.

Native Vegetation Act 1991 (NV Act)

The *Native Vegetation Act 1991* controls the clearance of any native vegetation. For any clearance of native vegetation undertaken a Significant Environmental Benefit (SEB) offset liability must be implemented in accordance with the Policy for a Significant Environmental Benefit (DEW 2020). Should the proponent choose to satisfy SEB liability by creating an on-ground SEB offset then this must provide an environmental gain over and above the impacts of an approved clearance. The SEB may be established via a number of different options, including monetary contribution to the Native Vegetation Fund (NVF) and management of native vegetation for conservation purposes. The use of SEB is discussed further in Section 6.

Mining Act 1971

The *Mining Act 1971* regulates and controls mining operations throughout South Australia. The Mining act has a two-stage assessment and approval process to enable any new mining operation to commence:

- Stage one: assessment of mining lease application and mining proposal, this stage either results in a grant of a new mining lease or refusal; and
- Stage two: submit a Program for Environment Protection and Rehabilitation (PEPR) for approval for operations to commence.

In accordance with the South Australian Government mining approvals framework, this assessment is required to understand impacts to terrestrial ecology associated within the construction, operation and post-closure rehabilitation phases of the Atacama Project. The impact assessment will focus on understanding how the Project may interact with the existing biodiversity values, and provides an opportunity for Iluka to mitigate, manage and reduce environmental risks associated with the Project. The results from this ecological impact assessment will feed into the development of the Mining Lease Proposal (MLP) and Program for Environmental Protection and Rehabilitation (PEPR) for the Project and are therefore compliant with the Terms of Reference 006 (TOR006) and Minerals Regulatory Guidelines MG2a (MG2a).

1.3.2 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC ACT)

The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places, which are known under the Act as Matters of National Environmental Significance (MNES). The Act requires that if an action has, will have, or is likely to have a significant impact on MNES, it must be referred to the Australian Government Minister for the Environment for consideration.

The Proposed Action was referred to DCCEEW under the EPBC Act and the Minister for the Environment and was determined the Proposed Action to be a Controlled Action under Section 75 of the EPBC Act on 9 November 2022 [ref. EPBC 2022/09289]; therefore, it requires further assessment, and approval, under the EPBC Act before it can proceed. The relevant controlling provision of the EPBC Act is 'listed threatened species and communities' (Section 18 and 18A of the EPBC Act). DCCEEW's decision on referral determined that the Proposed Action may have, or is likely to result in a significant impact to:

- *Leipoa acellata* (Malleefowl);
- *Sminthopsis psammophila* (Sandhill Dunnart);
- *Hibbertia crispula* (Ooldea Guinea-flower).

The State is assessing the Proposed Action as an Accredited Assessment on behalf of the Commonwealth, under Section 87 of the EPBC Act. This assessment provides for a single environmental assessment process conducted by the State, with DCCEEW providing comment on the MLP during the public comment period and reviewing the Response to Submissions. At the completion of the assessment, the MLP report is provided to DCCEEW to assess the likely impacts of the Proposed Action on MNES.

The Commonwealth Minister for the Environment will make an approval decision. On approval, a Decision Notice will be issued, including implementation conditions to be applied to the Proposed Action.

The EPBC Act Offsets Policy (2012) outlines the Australian Government's approach to environmental offsets. Under this policy, offsets are required to compensate for unavoidable significant residual impacts to MNES and should only be applied after all other measures to avoid and reduce impacts have been implemented. Key tenants of the policy are that:

- Offsets must be delivered for the matters that will be impacted (i.e., be like-for-like); and
- Offsets must be built around direct (i.e., land-based) offsets that are proportionate to the size and scale of impact.

1.3.3 Approved Conservation Advice and Recovery Plans

For MNES there are established Approved Conservation Advice and Recovery Plans which must be taken into consideration when conducting an impact assessment. These guidance documents detail the objectives, critical habitat, important populations, key threats, and priority management actions for each species. The impact assessment has considered this advice as impacts are not to contradict the Recovery Plans or Conservation Advice. Available approved conservation advice is displayed in Table 1-2.

Table 1-B Conservation advice and recovery plans for threatened species

Guidance	Primary objective	Specific objectives
National Recovery Plan for the Malleefowl (Benshemesh 2007)	Secure the existing populations across the species range and lower the EPBC listing within 20 years.	Manage populations through reducing permanent habitat loss, grazing pressures, fire threats, predation, isolation of fragmented populations and mortality on roads, as well as the promotion of Malleefowl friendly agricultural practices. Further planning, research and monitoring into the distribution, adaptation, abundance, and fertility to inform regional planning. Community involvement to raise public awareness and project coordination to manage the recovery process and facilitate communication.
National Recovery Plan for the Sandhill Dunnart (Churchill 2001)	Over five years expand distribution, species knowledge, to inform how to conserve and manage rehabilitation efforts	Prevent further habitat loss due to land clearance on the Eyre Peninsula. Further surveys: • Conduct biological on the Eyre Peninsula; • Further surveys of the Great Victoria Desert; • Detailed population surveys on the Eyre Peninsula; and • Deep pitfall trap surveys in central Australia and northern regions of the Great Victoria Desert (encourage). Experimental burns in suitable habitat should be conducted to promote the growth of spinifex, a key habitat forming species, on the Eyre Peninsula. Study the reproductive biology of the species through captive individuals. Implement monitoring programs for the key populations.

Guidance	Primary objective	Specific objectives
Approved Conservation advice for the Night Parrot (DCCEEW 2016)	The interim conservation strategy is to secure the only known extant population by eliminating or minimising key local threats, improving knowledge of habitat, identifying effective survey methods, and identifying and securing further populations.	The current conservation advice is subject to revision at any time, the current advice is focused on reducing impacts of • Invasive species; • Fire; • Disease; • Impacts of domestic species. Additionally, the advice calls for improved stakeholder engagement via promotion of survey and monitoring participation, identifying, and informing collaboration partners and implementing a communication strategy with relevant stakeholders.
Approved Conservation advice for *Hibbertia crispula* (DEHWA, 2008)	No specific National Recovery plan with primary objectives	EPBC Act 1999 Approved Conservation Advice for *H. crispula* conservation actions: • Manage and mitigate the loss and damage of habitat within areas of vegetation that have populations or remnants of *H. crispula;* • Develop and implement a management plan for weeds, stock movement, feral species, fire, disease, and parasite threats; • Cooperation with traditional owners to raise public awareness; • Enable the recovery of sites and populations; and Support local priority actions.

1.4 Background

This ecological impact assessment is largely based on the outcomes of baseline surveys as well as results of updated desktop searches (PMST/ NatureMaps – conducted October 2022). The baseline surveys were conducted in 2014, 2019 and 2021 and were reported as follows:

- *Atacama Baseline Flora and Fauna Assessment - 2014* (EBS 2015);
- *Baseline Environmental Investigations Atacama Project* (EBS 2019a);
- *Targeted Malleefowl Survey Atacama* (EBS 2019b);
- *Atacama Project EPBC assessment report* (2019c);
- *Atacama Threatened Species Assessment Spring 2021* (ELA 2021).

2. Assessment framework

This assessment framework aligns with MG2a and TOR006, ensuring the assessment meets the requirements of the Mining Act 1971 and Mining Regulations 2020. The framework has been developed to identify the potential impacts to native ecology present in and around the proposed development footprint in a transparent and comprehensive manner.

The ecological impact assessment for impacts to native flora and fauna including species listed under NPW Act was undertaken with the following objectives:

- Identification of potential impacts based on a defined source-pathway-receptor connection;
- Identification of likely receptors within the Project Area;
- Consideration of potential impacts on likely receptors;
- Recommendations for control measures;
- Statement of proposed outcomes including draft measurement criteria.

2.1 Identification of potential impact events

The assessment framework for potential impacts is based on an S-P-R model, where a:

- **Source** is a project component or process that can affect and interact with the environment;
- **Pathway** is a medium by which the effect reaches a receptor from a project source for example air or water; and
- **Receptor** is a discrete, identifiable attribute or environmental element that can be impacted by from a project source via a pathway.

Pathways have been grouped into three key categories:

- Land – vegetation, habitat, soil, landscape;
- Air – emissions, climate, noise, light, pollution; and
- Water – quality and quantity of surface water and groundwater.

Receptors (ecology) include the following two categories:

- Native ecology (non-threatened flora and fauna); and
- Listed flora and fauna (under NPW Act and/or EPBC Act).

This assessment has considered Project activities throughout construction, operation, and closure.

When a S-P-R linkage is confirmed an assessment of impact on receptors is undertaken. Where there is confidence that a linkage does not exist no further impact assessment for that aspect is necessary.

2.2 Likelihood of occurrence assessment

Assessments are completed to consider the likelihood of listed flora and fauna (under both the NPW Act and the EPBC Act) occurring within the Project Area. This is completed using the results of the extensive previous surveys completed within the Project Area, together with the results of ecological database searches.

2.3 Impact assessment

Assessments are completed to consider potential impacts of the known impact events on likely receptors within the Project Area (from the likelihood of occurrence assessment). The confirmation of the presence of source, pathway and receptors for each impact event confirms the impact events subsequently requiring control and management strategies. The impact assessment identifies whether the impact is likely and also the consequence of the impact as determined by how a receptor's value may reasonably be expected to be impacted by a source, taking into account the sensitivity of the receptor.

2.4 Control measures

For each impact event, a series of control measures is proposed to effectively manage the impact to the greatest practicable extent. The control measures may manage, limit or remedy each impact event and are commensurate with the potential impacts, achieve compliance with other applicable statutory requirements and are technically and economically viable. Each impact is managed using the 'hierarchy of control' applied in the following order:

1 – Elimination and prevention;
2 – Design / Engineering (physical) controls;
3 – Management systems (procedural) controls.

2.5 Proposed environmental outcomes

A statement of environmental outcomes is developed for the identified environmental impacts. These statements indicate the impact on the environment caused by the proposed mining activities, followingcontrol strategies being implemented. They need to be reasonable and realistically achievable, acceptable to affected parties and meet legislative requirements.

2.6 EPBC Act listed species significance assessment

For Commonwealth listed species, there is an approval process under the EPBC Act requiring an assessment of the significance of any residual impact (post controls) of the Project on MNES.

The Significant Impact Guidelines (DoE 2013) provide overarching guidance on determining whether an action is likely to have a significant impact on a matter protected under the EPBC Act. In accordance with this Guideline, the following key concepts will be assessed during the impact significance assessment:

- Habitat critical to the survival of a species;
- A population – this relates particularly to groups of Endangered or Critically Endangered listed species under the EPBC Act;
- An important population – this relates particularly to species listed as Vulnerable under the EPBC Act;
- Important habitat for migratory species;
- Ecologically significant proportion of the population of a migratory species.

The meaning of these concepts is defined in Table 2-1 (DoE 2013).

Table 2-A Significant impact concepts for MNES

WHAT IS HABITAT CRITICAL TO THE SURVIVAL OF A SPECIES?

Habitat critical to the survival of a species refers to areas that are necessary:

- *for activities such as foraging, breeding, roosting, or dispersal;*
- *for the long-term maintenance of the* species *or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators);*
- *to maintain genetic diversity and long-term evolutionary development; or*
- *for the reintroduction of populations or recovery of the species or ecological community.*

Such habitat may be but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/ or habitat listed on the Register of Critical Habitat maintained by the Minister under the EPBC Act.

WHAT IS A POPULATION OF A SPECIES?

A 'population' is an occurrence of the species in a particular area. In relation to critically endangered, endangered or vulnerable threatened species, occurrences include but are not limited to:

- *a geographically distinct regional population, or collection of local populations; or*
- *a population, or collection of local populations, that occurs within a particular bioregion.*

WHAT IS AN IMPORTANT POPULATION OF A SPECIES?

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- *key source populations either for breeding or dispersal;*
- *populations that are necessary for maintaining genetic diversity; and/or*
- *populations that are near the limit of the species range.*

WHAT IS AN IMPORTANT HABITAT FOR A MIGRATORY SPECIES?

An area of 'important habitat' for migratory species is:

- *habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species; and/or*
- *habitat that is of critical importance to the species at particular life-cycle stages; and/or*
- *habitat utilised by a migratory species which is at the limit of the species range; and/or*
- *habitat within an area where the species is declining.*

WHAT IS AN ECOLOGICALLY SIGNIFICANT PROPORTION?

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species (each circumstance will need to be evaluated). Some factors that should be considered include the species' population status, genetic distinctiveness and species-specific behavioural patterns (for example, site fidelity and dispersal rates).

Impact assessment was undertaken for MNES recorded (known) or considered likely, or with potential to occur in the Project Area after implementation of control measures, to provide an assessment of the significance of the residual impact.

3. Existing environment

This section presents an overview of the existing environment for the Project.

3.1 Topography and landscape

The Project is on the western fringe of the Yellabinna Dunefield, which consists of parallel dunes with a predominant northwest-southeast direction. Aeolian processes (wind) are the dominant morphology controller of this landscape with little influence from fluvial (water) processes.

Across the Yellabinna region, dune height varies from 5-30 m, with dune length ranging from less than 1 km to tens of kilometres. Dune crests in this region are mobile but are generally fixed by vegetation (Copley and Kemper 1992).

The linear dunes typically consist of terminal catchments (i.e., small, isolated catchments that are typically delineated by dunes) bounded by a dune crest to the north and south, and low, rounded, ridgelines that are perpendicular to the dunes. Almost all catchments end in a terminal pan.

CDM Smith (2022) describes the Project Area landscape as having a gradational change from north to south. Parallel steep sided dunes in the north grade to dunes with broader swales and with a concurrent change of vegetation, which then grade to the gentle slopes and plains associated with bluebush and saltbush in the south.

In the south-west corner of the Project Area where the access road will be located to connect Atacama with the J-A, the dune system transitions into an interdunal landscape. The topography of this corner is largely different to the rest of the Project Area, reflecting the dendritic network found throughout the J-A catchment which is dominated by fluvial processes.

3.1.1 Surrounding land use

The Project Area is located within the YRR. The YRR is bordered by the Nullarbor Regional Reserve to the west and the Yumbarra and Pureba Conservation Parks to the south. All these reserves and conservation parks are predominantly covered in mallee vegetation which has largely remained undisturbed (DEWNR, 2022).

Under the NPW Act, Regional Reserves were formed to provide a conservation function while allowing for the development of multiple land uses (including mining and exploration). Within the YRR there is the existing J-A mine (ML6315, 4500 ha) which has operated since 2009 and several exploration leases targeting heavy mineral sand deposits.

The nearest population centre is Ceduna, located approximately 200 km to the south-east (approximately 270 km by road). Existing land uses in the region are mineral exploration and extraction, tourism, and wildlife conservation activities.

3.1.2 Ecology

3.1.2.1 Vegetation communities

The Project is located within the Yellabinna environmental association, within the Great Victoria Desert bioregion and Yellabinna subregion, as per the Interim Biogeographical Regionalisation for Australia

(IBRA). Approximately 99% of the Yellabinna subregion has been mapped as remnant native vegetation, with 55% of this area under conservation (EBS 2019a). Although formally within the Yellabinna subregion, the Atacama Project is situated in the transition zone between two biological subregions: the Yellabinna dunes to the north-east and the shrublands of the Nullarbor subregion to the south-west. The Nullarbor Plain is predominately a karst plain with low shrubland and occasional areas of taller vegetation where depressions occur and allow for deeper soils. Low open woodland dominated by *Acacia papyrocarpa* is present towards the east where the Nullarbor meets the Yellabinna dunes, which comprise predominately of mallee woodland.

Ecological studies undertaken in 2014 (EBS 2015) identified nine broad vegetation associations present within the Project Area (refer Figure 1-1). Across all associations, vegetation was generally described as being diverse, intact native vegetation largely in pre-European condition, with little to no weed infestation (EBS 2019a). Vegetation communities were dominated by mallee associations, especially in the north, with vegetation association *Eucalyptus yumbarrana* (Yumbarra Mallee) Mixed Mallee most dominant within the landscape. *Acacia, Alectryon* and *Casuarina* Woodlands, and *Senna* and chenopod Shrubland vegetation associations were more prevalent in the south.

The vegetation present across the Project footprint and survey area represent the vegetation in the broader region and no vegetation associations had any noticeable elevated diversity of flora species.

3.1.2.2 Flora and fauna

A total of 136 flora species from 32 families have been observed within the Project Area, composing 133 native species and three weed species (EBS 2019a). The most widespread flora species were *Salsola australis* (Buckbush), *Ptilotus obovatus* (Silver Mulla Mulla), *Atriplex vesicaria* (Bladder Saltbush), *Brassica tournefortii* (Wild Turnip (weed species)), *Senna artemisioides ssp. artemisioides x ssp. coriacea* (Desert Senna) and *Pittosporum angustifolium* (Native Apricot), which were recorded in a at least seven of the nine recorded vegetation associations. Three weed species were recorded in very low densities (refer Section 4.2)

Across the survey area 52 bird species have been recorded, representing 28 different families (EBS 2019a). The Meliphagidae family (Honeyeaters) recorded the highest number of species with six representatives identified, with the most abundant birds recorded including *Melopsittacus undulatus* (Budgerigar), *Smicornis brevirostris* (Weebill), *Phylidonyris albifrons* (White-fronted Honeyeater) and *Lichenostomus ornatus* (Yellow-plumed Honeyeater).

One Nationally threatened bird species (*Leipoa ocellata* (Malleefowl)) was recorded within the project area (refer Section 4.4.2.1) with five State threatened bird species directly observed.

A total of 20 mammal species from 11 families have been recorded as occurring across the survey area, including 15 terrestrial mammals, five microbat species and five introduced species (EBS 2019a). The most abundant species were the introduced House Mouse (*Mus musculus*), *Sminthopsis dolichura* (Little long-tailed Dunnart) and *Pseudomys hermannsburgensis* (Sandy Inland Mouse). Large native mammal species were restricted to Kangaroos and Dingo.

One Nationally threatened mammal species was recorded within the Project Area, the *Sminthopsis psammophila* (Sandhill Dunnart) and evidence of the formerly State threatened mammal species, *Notorcytestyphlops* (Southern Marsupial Mole) was also observed.

Thirty-eight (38) reptile species from nine families were recorded, with the *Scincidae* family (skinks) having the greatest number of species with 12 representatives. No reptile species with a National or State conservation rating were recorded in the survey area.

A more detailed description of the flora and fauna listed species known to occur or likely to occur within the Project Area is shown in Section 4.

3.1.2.3 Water dependent ecosystems

No groundwater or surface water dependent ecosystems were found to occur within the Project Area.

3.1.2.4 Plant pathogens

There was no evidence of plant pathogens during any field investigations and Atacama is not located in a high-risk *Phytophthora cinnamomi* (root-rot fungus), or Mundulla Yellows area due to the low annual rainfall (root-rot fungus occurs in areas where average annual rainfall is greater than 400 mm) and minimal human disturbance.

3.1.2.5 Subterranean communities

Studies in 2006 (Parsons Brinckerhoff 2007) investigated the presence of subterranean fauna, including stygofauna and troglofauna, prior to water abstraction from the production wellfield to service operations at the approved J-A Project. No subterranean fauna was identified, with conditions deemed unsuitable to support subterranean fauna within the project area due to the depth of the fractured rock aquifer and the highly saline nature of the groundwater environment.

3.1.3 Geology and soils

The Project Area is located within the Eucla Basin which consists of Cainozoic marine limestone deposits which overlay the crystalline basement of the Gawler Craton.

Five soil units have been identified within the Atacama Project Area based on 25 soil test pits of 1.5 m (CDM Smith 2019). The soil units identified on site include two parallel dune systems, two gently undulating systems and one system with level swale depressions. The northern section of the Project area is predominantly dune systems that are characterised by sand or loamy sand topsoils 20-40 cm deep, with inter-dune swales that are up to 200 m wide (CDM Smith 2019).

The northern section of the Project Area was predominantly Unit 1 - parallel dunes with narrow *Triodia* (spinifex) swales. This unit was characterised by sand or loamy sand topsoils that were 30 to 40 cm deep and covered by *Eucalyptus* spp. and *Triodia* spp. on the dune and the inter-dune swale. The inter-dune swale was usually less than 100 m wide, with dune slopes of 5 to 25% (CDM Smith 2019). There were isolated pockets of level swale depressions within the dune-swale systems, that had 10 cm of loamy topsoil. Towards the southern portion of the Project Area, gently undulating rises were dominant. Topsoils were generally 20 cm thick and comprised loamy sand, sandy loam and light sandy clay (CDM Smith 2019).

3.1.4 Climate

The climate of the Yellabinna region is arid with mild winters and hot summers (Copley and Kemper 1992). The seasonal distribution of rainfall varies across the Yellabinna region, with Ceduna receiving predominantly winter rains, but Tarcoola (200 km east of the Atacama Project) and Maralinga (100 km north of the Atacama Project) receiving on average, equal rainfall across all seasons (Copley and Kemper 1992). The nearest long-term weather station to the Project is located at Tarcoola (Steggles et al. 2016).

The average annual rainfall for this region is 177.5 mm, with mean annual rainfall ranging from approximately 60 mm to 300 mm across years. In 2021, the highest monthly rainfall was recorded in November with 50.2 mm, followed by June with 23 mm (BOM 2022). The timing of rainfall events can be highly variable, but over the past 20 years, the months that have received the highest average rainfall are February (21.3 mm), followed by November (21.4 mm) and December (19.9 mm) (BOM 2021). Rainfall during winter and spring is generally composed of many small rainfall events, whereas rainfall during summer and autumn tends to be less frequent but larger (Steggles et al. 2016; BOM 2019). The mean annual temperature for the region is approximately 28°C. The hottest month is January with an average temperature of 36.6°C, with the average monthly temperatures for November to March all exceeding 30°C (BOM 2022).

BoM weather stations which were reviewed from the regional area summarise seasonal winds within the vicinity:

- summer: Dominant southerly or south-easterly winds, but less pronounced than for coastal sites;
- autumn: Southerlies become less dominant and wind speed reduce overall;
- winter: Dominant wind is not pronounced, but may be northerly;
- spring: Returning to summer pattern with more southerly winds; wind speeds increasing (Jacobs, 2022).

3.1.5 Air quality

The existing ambient air quality in the Project Area is typical of an arid environment with dust being generated by wind erosion of exposed surfaces from unsealed roads and tracks, sand dunes and potentially through bushfire ash.

DUST DEPOSITION

No dust deposition data has been collected at the Project Area. Instead, proxy data from the nearby J-A Mine (approximately 5 km to the south-west) has been used for the baseline analysis. In accordance with AS/NSZ 5380.10-1, four J-A monitoring stations set up for assessing background conditions were selected for baseline conditions at Atacama dust deposition. The air quality baseline assessment methods and data selections were discussed and agreed with an SA EPA air quality specialist. Given that dust deposition rates decrease rapidly as distance increases from the dust source, the background sites for J-A Mine provide an acceptable approximation for Atacama baseline conditions (Jacobs 2022).

Data obtained over a ten-year period (2009 to 2019) was considered., a peak in measured dust deposited is observed around summer, and a minimum during the winter months, as such background values were determined for those two periods separately. Conservative, high estimates for background deposited dust, typically used as input to a modelling assessment, are the 90th percentile monthly averages.

A proxy for PM_{10} data was used with data from Whyalla-Schulz Reserve monitoring station (located in Whyalla, approximately 550 km south-east of the Project). Data was analysed over the span of hourly rates for three years (2016 to 2018) using the Tapered Element Oscillating Microbalance (TEOM) method. Overall, the PM_{10} concentrations were higher in spring and summer due to higher wind speeds. Given the seasonal differences in the measured PM_{10} at Whyalla-Schulz, adoption of winter and non-winter background values was considered beneficial, otherwise particulate impacts may be overstated in the winter months due to the elevated background. Typically, based on their experience on other projects in South Australia, Jacobs find that background 24-hour PM_{10} values to be less than 25 µg/m3, which is consistent with the extrapolated baseline data for the Project.

Similarly, a $PM_{2.5}$ proxy (EPA's Port Augusta monitoring station) was used for the development of the baseline. Data was analysed from 2017 to 2019. The estimated background 24 average $PM_{2.5}$ concentrations for the Project Area were 10 µg/L or less for the non-winter and winter months.

3.1.6 Surface water

Part of the Project Area is located within an ephemeral tributaries system of the Lake Ifould catchment. These tributaries are controlled by rainfall (intensity and duration), soils, vegetation, and topography. Rainfall is infrequent and irregular (spatially and temporally) across the region.

The drainage system occurs along the dune swales but there are no defined watercourses throughout the Project Area, and no large watercourses. Alluvium completed a hydrology study using the River Styles framework and were able to determine that the dune swale system is overwhelmingly the most dominant River Style in the Project Area. This is largely in reflection of the proximity to the Yellabinna Dunefield and dominant aeolian processes (Alluvium 2019).

Terminal pans are a feature across the Project Area, they are smaller and more elongated than those found to the south of Atacama. This is largely due to the small and elongated catchments which have formed due to the linear dunes within the dunefield.

The south-western corner of the Project Area is located within the upper J-A catchments, which are part of the dendritic network. The watercourses are largely undefined in the upper reaches, however, there are several from the Jacinth North Creek, and Ambrosia South.

Stream flow data is unavailable for the Atacama area, and only two stream flow events have occurred since mining operations at J-A began in the region (2008 and 2014). In 2009 and 2011 smaller intermittent flow events were reported.

3.1.7 Groundwater

Groundwater levels for the Project have been measured via three newly installed wells in the Project Area, and data from other Iluka Projects within the Eucla Basin.

Flow direction is interpreted to be from east to west, with groundwater levels approximately 91.7 to 93.4 mAHD at Atacama, approximately 100 mAHD at the adjacent J-A Mine and becoming shallower (20 mAHD) at the palaeochannel borefield (EMM 2022a). The inferred groundwater discharge point is Lake Tallacootra and Lake Ifould. There is an interpreted fault to the south of the Atacama deposit that runs along the eastern boundary of the adjacent J-A Mine.

Mining has occurred at the J-A Mine since 2009, and seepage from the disposal of wet tailings in the off-path tailings storage facility has led to the development of a groundwater mound. This mound has reached more than 40 m above pre-mining water table elevations, though it is closer to 20 m in currently. The mound has caused large perturbations in groundwater flow directions compared to the inferred pre-mining levels at some locations, with groundwater inferred to flow northward towards Ambrosia before returning to the regional east-west gradient. These impacts do not extend to groundwater within the Project Area. The tailings produced as a result of processing mineral sands derived from the Project Area will be disposed within J-A and not impact the Project Area in relation to groundwater.

East of the fault, the groundwater system is interpreted to be isolated from the effects of tailings induced mounding, due to the fault potentially acting as barrier to groundwater flow and compartmentalising the groundwater system (EMM, 2022). The mound is expected to eventually reach Lake Ifould; but has not done so as of June 2021.

Groundwater recharge from rainfall is expected to be low, due to low annual rainfall and high potential for evapotranspiration. Topographic low points, Lake Ifould and Lake Tallacootra, may act as temporary recharge sources following high rainfall events, however as noted in EMM (2022) the pre-mining groundwater contours do not appear to show significant zones of high recharge in these locations.

Regionally, there are no permanent surface water features, however, there are a number of salinas in topographic low points. Dependent on the depth to groundwater, these salinas may act as groundwater discharge zones via capillary rise of groundwater, and subsequent evapotranspiration due to the observation of high salt content at the surface.

3.1.8 Groundwater dependent ecosystems

There are no aquatic GDEs located within close proximity of the Project Area, with the closest being an unnamed low potential GDE approximately 7 km south of Atacama (EMM 2022).

Terrestrial GDEs (i.e., those that rely on the sub-surface presence of groundwater) are identified in the Project Area. These include eucalyptus Mallee forest and Mallee woodland rated as low and high potential GDE's. However, considering the shallowest groundwater encountered in the Project Area is 75 m BGL, it is considered that the terrestrial species are likely to rely on episodic rainfall and soil moisture rather than groundwater.

3.1.9 Radiation

A baseline radiation survey was conducted in 2016 (SA Radiation). The survey initially included collecting measurements of soil samples, implied uranium and thorium in the soil, and gamma does rates at ground level, from 219 sampling locations within the Project Area. Approximately 20-50 g of surface soil was collected using a hand trowel to a depth of approximately 100 mm at each of the 219 sampling locations.

Samples were selected for testing, based on a range of factors, for uranium, thorium and radon. Passive dust samples were also subjected to uranium and thorium testing and gamma doses were recorded at ground level at the 219 locations.

The data obtained throughout the baseline radiation survey for the Project Area show that:

- Thorium concentrations were typical when compared to the background concentrations in Australia;
- Uranium concentrations were lower than typical concentrations in Australia;
- Isotopic Radon (Rn222 and Rn220) concentrations in the air, and uranium and thorium levels in dust were very low, with some measurements below minimum detectable levels;
- Thorium concentrations in airborne dust were also consistent with concentrations found in soil samples;
- Average terrestrial radiation dose rate (16.6 nSv/h) in the Project Area is low compared to the average in Australia (69 nSv/H[5]).

4. Likelihood of occurrence assessment

4.1 Native non-listed species

The Project Area and greater region contains high quality habitat which is largely undisturbed and is home to a diverse range of flora and fauna.

Using the Biological Database of South Australia (BDBSA) search tool for the Project Area recorded 163 fauna species, comprising 79 bird, 62 reptile and 22 mammal species (EBS, 2019a). Previous fauna surveys conducted by EBS between 2008 and 2014 have identified 110 fauna species present within the Project Area (EBS 2019) including 52 bird species, 20 mammals and 38 reptiles. ELA (2021) identified 66 native fauna species as described in Section 3.1.2.2.

4.2 Pest fauna and flora species

During the desktop assessment twenty invasive species were identified as being likely to occur within the Project Area (eight species from BDSB and an additional two species from EBS' survey). Out of the nine species identified, seven of these were exotic fauna species, comprising:

- *Camelus dromedarius* (Camel);
- *Canis lupus familiaris* (Dog);
- *Felis catus* (Cat);
- *Mus musculus* (House mouse);
- *Oryctolagus cuniculus* (European rabbit);
- *Vulpes* (Red fox); and
- *Bos Taurus* (European Cattle).

Three weed species have been previously recorded in very low densities by EBS (2019a):

- *Acetosa vesicaria* (Rosy dock) was present in areas of run off collection such as ephemeral drainage lines, swales and the edges of some vehicle tracks;
- *Brassica tournefortii* (Wild turnip) occurred on a range of landforms but predominantly on sandy sites;
- *Carrichtera annua* (Ward's weed) was the least common all weed species and was found in small, dense patches surrounding dead trees in areas subject to runoff.

No weeds of National Significance or priority weeds listed under the *Landscape South Australia Act 2009* (LSA Act) for the Alinytjara Wilurara Landscape Management Region have been recorded within the project area.

4.3 NPW Act listed species

Note that any species listed under both Commonwealth (EPBC Act) and State (NPW Act) legislation will be assessed under the EPBC Act to the extent that it prevails.

EBS (2019) reported an extraction from the Biological Databases of South Australia (BDBSA) was obtained to identify flora and fauna species that have been recorded within 50 km of the Project Area (DEW 2019, accessed 11/04/2019, Record set number DEWNRBDBSA190121-1). The BDBSA is comprised of an integrated collection of species records from the South Australian (SA) Museum, conservation organisations, private consultancy companies, Birds SA, Birdlife Australia, and the Australasian Wader Study Group, which meet DEW standards for data quality, integrity and maintenance. The BDBSA search highlighted 12 flora and 12 fauna species of State conservation significance with previous records within the Project Area (EBS 2019a).

An assessment to determine the likelihood of occurrence for state threatened species and ecosystems within the Project Area was conducted (Appendix A). Each of the threatened species and ecosystems identified by the BDBSA data extract were assigned a rating (highly likely, likely, possible, and unlikely), which described their likelihood of occurrence with the Project Area. Criteria for likelihood include date of records, proximity of records, landscape conditions, vegetation associations, knowledge of species and habitat preferences.

4.3.1 Flora

The likelihood assessment in Appendix A, aligns with the findings of the EBS baseline survey (2019) and finds the following flora species are known, possible or likely to occur within the Project Area:

- *Corynotheca licrota* (Sand Lily) – Rare NPW Act – possible;
- *Gratwickia monochaeta* – Rare NPW Act – known in patches of 30-100 individuals in disturbed areas;
- *Melaleuca leiocarpa* (Pungent Honey-myrtle)- Rare NPW Act – known as a single or small cluster in areas adjacent to low dune crests;
- *Santalum spicatum* (Sandalwood) – Vulnerable NPW Act – possible.

4.3.2 Fauna

The likelihood assessment in Appendix A and EBS baseline survey (2019) found the following fauna species of current State conservation status were known, possible or likely to occur within the Project Area:

- *Acanthiza iredalei* (Slender-billed Thornbill) – Rare NPW Act – Likely;
- *Ardeotis australis* (Australian Bustard) – Vulnerable NPW Act – known;
- *Cinclosoma castanotus (Chestnut Quail thrush)* – Rare NPW Act;
- *Falco peregrinus* (Peregrine falcon) – Rare NPW Act – known;
- *Hieraaetus morphnoides* (Little Eagle) – Vulnerable NPW Act – likely;
- *Lophochroa leadbeateri* (Major Mitchell’s Cockatoo) – Vulnerable NPW Act – likely;
- *Myiagra inquieta* (Restless Flycatcher) – Rare NPW Act – known;
- *Neelaps bimaculatus* (Western Black-naped Snake) Rare NPW Act – possible;
- *Neophema splendida* (Scarlet-chested Parrot) – Rare NPW Act – known;
- *Pachycephala inornata* (Gilbert’s Whistler) – Rare NPW Act – likely.

Section 5 will consider the potential impacts of the Project on these listed species.

4.3.3 Threatened ecological communities

None of the vegetation associations recorded are listed as Threatened Ecological Communities under the Provisional list of threatened ecosystems of South Australia (EBS 2019a).

4.4 EPBC Act listed species

The PMST outputs (EBS 2019a and ELA 2021) indicated that four listed fauna species, three listed flora species and seven migratory species may be present within a 50km buffer of the Project Area. Appendix A shows the assessment of the likelihood that each of these species occurs within the Project Area and concludes that the following species should be considered further:

- two threatened fauna species:
  - *Sminthopsis psammophila* (Sandhill Dunnart)- (Endangered EPBC Act & Endangered NPW Act);
  - *Leipoa ocellata* (Malleefowl) – (Vulnerable EPBC Act & Vulnerable NPW Act).
- one threatened flora species:
  - *Hibbertia crispula* (Ooldea Guinea-flower) – (Vulnerable EPBC Act & Vulnerable NPW Act).
- one migratory species:
  - *Apus pacificus* (Fork-tailed Swift) – migratory marine.

None of the vegetation associations observed are consistent with key diagnostic criteria for Threatened Ecological Communities (TEC) listed under the EPBC Act.

4.4.1 Flora

Hibbertia crispula (Ooldea Guinea-flower) has been recorded within 1.5 km of the north-eastern boundary of the Project Area (approximately 5.5 km from the Conceptual Footprint) during previous surveys (EBS 2015 EBS 2019a, ELA 2021).

Despite extensive survey effort including transect surveys on 4 km of potential habitat, and ramble surveys over 94 km of dune habitat), Ooldea Guinea-flower has not been recorded within the Project Area. In 2014 a total of 283 individual plants were recorded in five separate patches with the closest record located approximately 5.5km from the Conceptual Footprint (refer Figure 4-1).

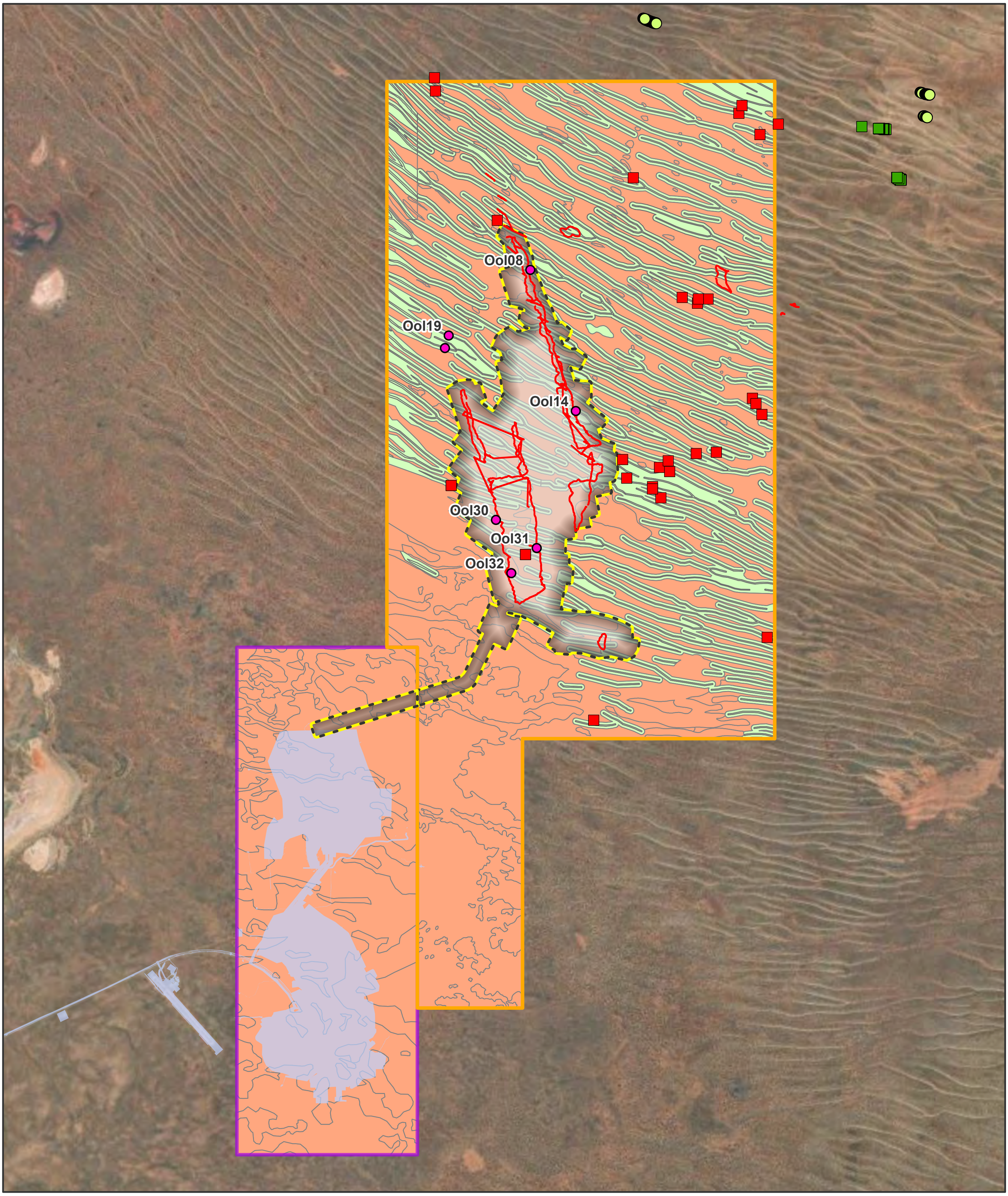

Figure 4-1: Potential Ooldea guinea-flower habitat

Ooldea Guinea-flower was recorded outside of the Project Area on tall dune crests dominated by tall shrubland of *Hakea francisiana* (Bottle-brush Hakea) and *Grevillea stenobotrya* (Sandhill Spider-flower) with emergent *Callitris verrucosa* (Mallee Cypress-pine) over *Bossiaea walkeri* (Cactus Pea), *Thryptomene elliottii, +/- Leptospermum coriaceum* (Green Tea-tree), *Triodia basedowii* (Lobed Spinifex) and *Triodia lanata* (ELA 2021).

It is noted that the habitat in the north of the Project Area is more suitable for this species as it contains the deep dunes that appear to be key habitat features. These dune crests have some suitable habitat including the occurrence of *Leptospermum coriaceum* (Green tea-tree), however the co-associated *Eucalyptus capitanea* (Desert ridge-fruited mallee) is absent, as is the presence of fire scars that may be required for germination. The habitat to the south of the Project Area is suboptimal for this species as it lacks the presence of suitable dune crest habitat as has often been replaced by the interdune habitat that has covered the dune crests.

Due to the significant survey effort returning no records, and because the required co-associated species and fire scars are not present within the Conceptual Footprint, the species is considered unlikely to occur. However, Ooldea Guinea-flower is known to occur within 1.5 km of the Project Area and so potential impacts on this species will be considered in Section 7.1.1.

4.4.2 Fauna

4.4.2.1 Malleefowl

The survey effort for Malleefowl has been significant, with targeted fauna surveys using a multitude of methodologies including bird counts, helicopter survey, LiDAR survey, targeted habitat surveys, songmeter surveys, camera trapping and searches for scats and tracks since 2014.

Sixteen Malleefowl mounds have been recorded within the Project Area within the dune complex to the north and east of the Conceptual Footprint. Of these, two were recorded in 2014, an additional two in early 2019, an additional 11 in late 2019 and an additional one in 2021. The majority of these mounds were old and/or inactive and cannot be confirmed to have been used for successful breeding attempts. Within the Conceptual Footprint only one inactive mound has been recorded, and the Conceptual Footprint was noted to lack the deep rafts of leaf litter that are strongly associated with the active nests located within the Project Area. Evidence of Mallefowl presence (track) has been recorded within the south of the Conceptual Footprint, but there is no evidence of breeding activity in this area (refer Figure 4-2).

The Conceptual Footprint for the Proposed Action is located on the ecotone between Mallee dominated sand dunes, and the casuarina woodland and shrubland of the Nullarbor plains. The survey results show that the breeding mounds for this species show a strong association with the more defined dune and mallee systems within the northeast of the Project Area. Public records of Malleefowl locations are also shown to be located to the north-east of the Project area within the better-quality habitat in Yellabinna Regional Reserve. Malleefowl have a home range of up to 5 km^2 and habitat potentially suitable for foraging and traversing is likely to be found across the northern section of the Conceptual Footprint.

Whilst it is most likely that low numbers of this species only use the suboptimal habitat in the Conceptual Footprint transiently, potential impacts on Malleefowl will be considered further in Section 7.1.2.

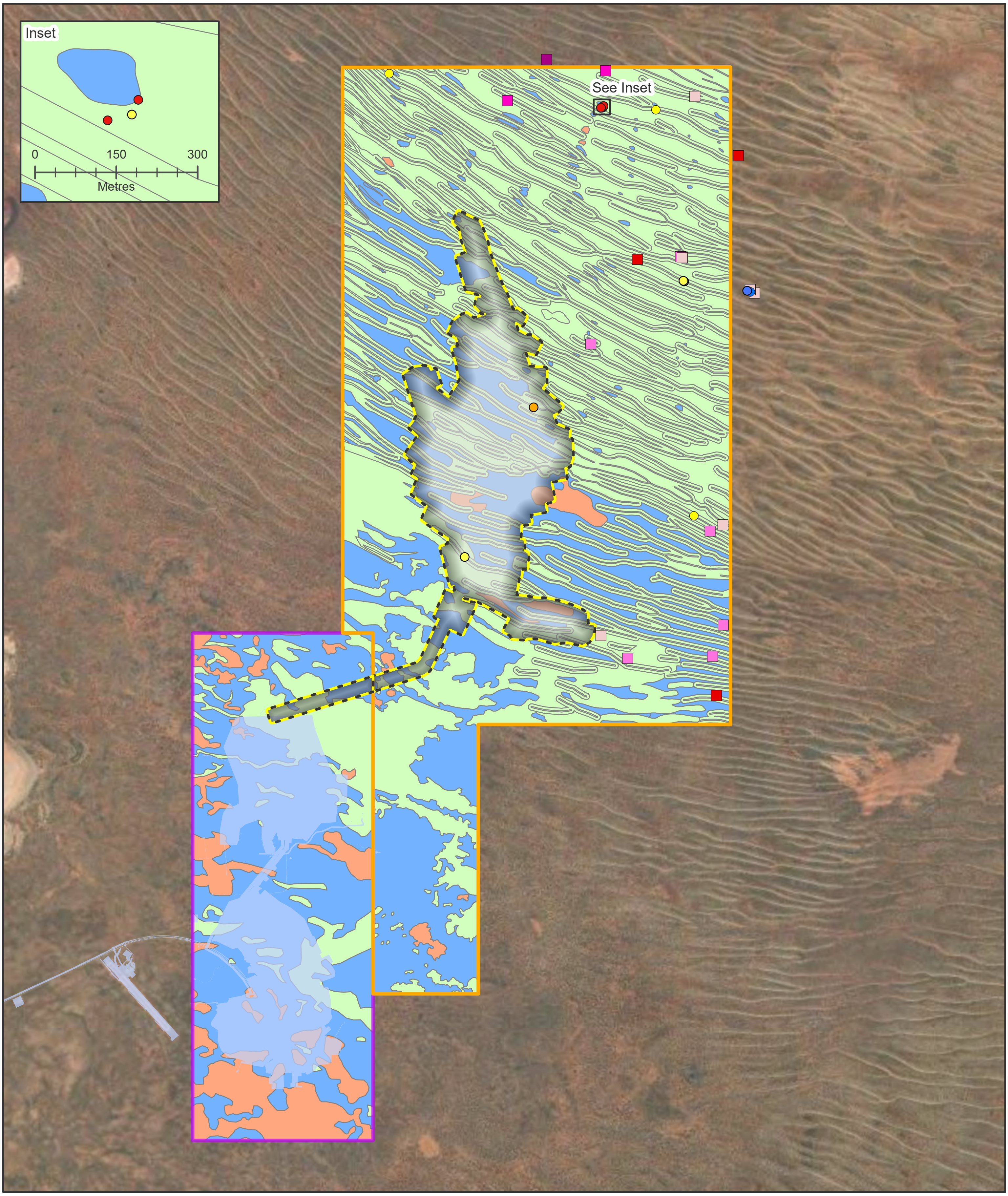

Figure 4-2: Potential Malleefowl habitat

4.4.2.2 Sandhill Dunnart

There are no records of Sandhill Dunnart recorded within the Conceptual Footprint despite targeted surveys for this species consisting of 1,666 trap nights since 2014. One old disused burrow potentially belonging to a Sandhill Dunnart was recorded on the north-eastern boundary of the Conceptual Footprint in 2021 (refer Figure 4-3).

The species was recorded within the larger Project Area in 2014 and is known to occur in Yellabinna Regional Reserve in low numbers where the density of Triodia is greater than within the Conceptual Footprint. The Triodia within the Conceptual Footprint was recorded as sparse during on-ground surveys. Whilst the exact requirements for optimal species habitat have not yet been confirmed, the presence of relatively dense and continuous Triodia is known to be necessary for both breeding and foraging (Landscape SA, 2022). Hence although all the habitat within the Conceptual Footprint is suboptimal, the vegetation to the north contains mallee-spinifex vegetation and hence is more suitable than that to the south of the Conceptual Footprint. Whilst it is most likely that low numbers of this species only use the suboptimal habitat in the north of the Conceptual Footprint transiently, potential impacts on Sandhill Dunnart will be considered further in Section 7.1.3.

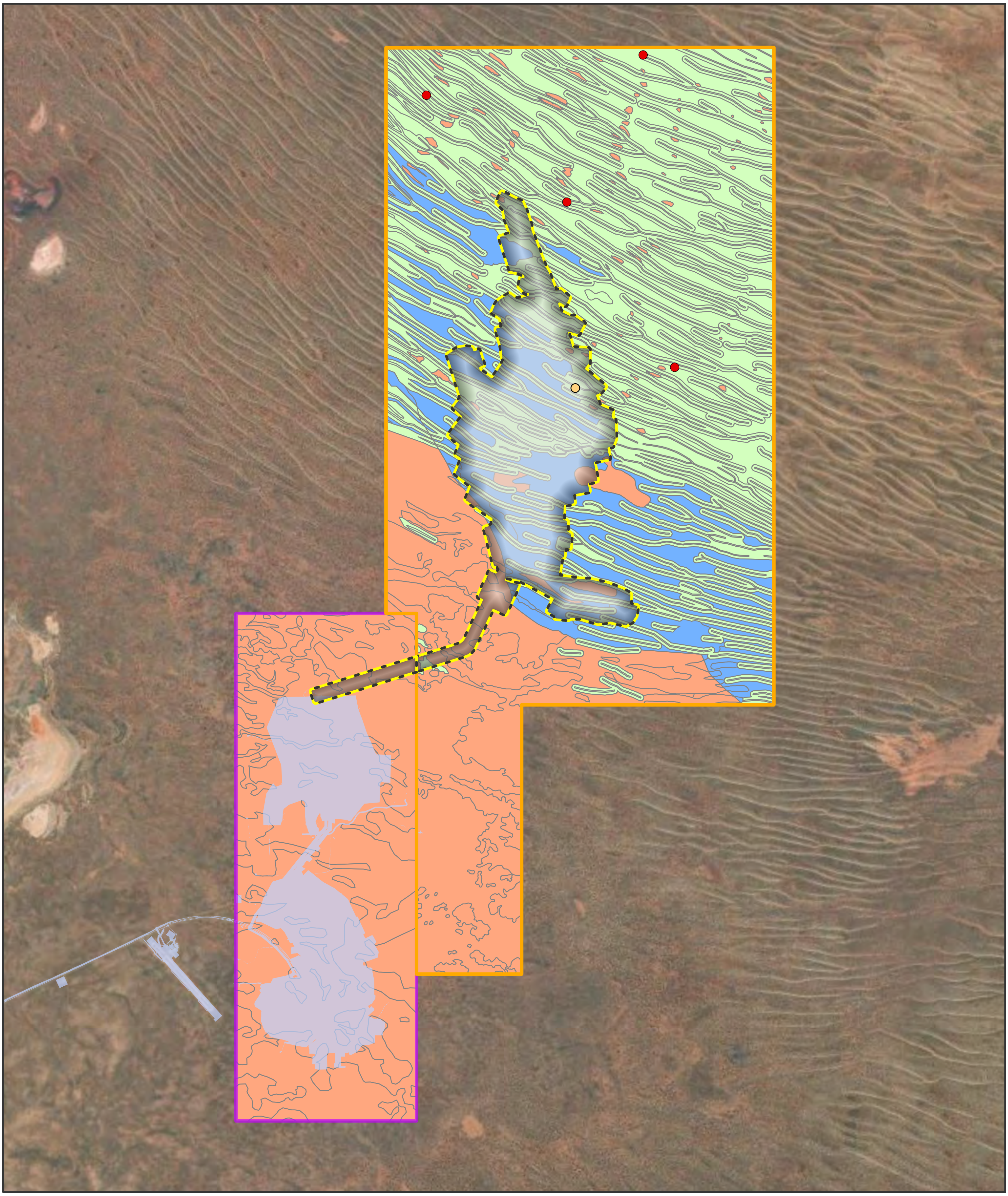

Figure 4-3: Potential Sandhill dunnart habitat

Project Area
ML 6315
ML 6315 Disturbance Footprint
Conceptual Footprint

Potential Habitat
Yes (mallee-spinifex vegetation)
Yes (marginal)
No

Threatened Species Observations
Sandhill Dunnart (old nest - unconfirmed)
Sandhill Dunnart Records (EBS Ecology 2014)

0 2 4
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 53

20409-OK/SH Date: 23/12/2022

N

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4.4.2.3 Fork-tailed swift

One migratory species, the fork-tailed swift, was assessed as possibly occurring in the Project Area, however it was not recorded during surveys of the proposed project site (EBS 2015 & 2019a; ELA 2021). Suitable habitat is present in the Project Area; however, this habitat is not considered unique or of limited extent across the region. In addition, the fork-tailed swift is likely to be present within the proposed Atacama ML as an aerial fly-over species only (ELA 2021).

4.4.3 Threatened ecological communities

None of the nine vegetation associations observed within the Project Area meet the diagnostic criteria for TECs listed under the EPBC Act (ELA 2022).

5. Potential Impacts

There are no water courses within the Project Area and groundwater will not be intercepted or impacted by the Project, on this basis aquatic ecology is not considered to be relevant receptor for impact events associated with the Project and has not been considered further.

5.1 Native ecology impact assessment

Effects on ecological values due to changes to surface and groundwater, air quality and land environment, including pest flora and fauna impacts, have been considered. The screening impact assessment tables are in included in Appendix B. Where an S-P-R linkage has been identified, the potential impact event has been further considered below.

Prior to controls and mitigation, the Project has the potential to result in direct and indirect impacts to native flora and fauna species. Table 5-1 shows a summary of the potential impact events identified and considered for S-P-R linkages.

Table 5-A Potential impact events

Impact	Is the Linkage confirmed? Y/N	Impact ID
Vegetation clearing – clearing of native vegetation and habitat impacts flora and fauna	Yes	L1, L3
Interaction with vehicle and machinery – Risk of collisions between native fauna with vehicles and machinery	Yes	L2, L4
Increased weed density – Creations of habitat conditions for weed species during construction, operation, and rehabilitation	Yes	L5
Fauna pests – Creation of conditions which favour predatory or herbivorous pest species	Yes	L6, L7
Pathogens and toxins – Introduction or increased spread of pathogens and toxins to the area	Yes	L8, L9, L10
Fire – Potential for accidental fires from fire ignition sources and altered fire regimes	Yes	L11
Chemical spills – accidental spills result in impacts to flora and fauna	No	L12
Erosion of soil – potential for increased erosion of topsoil due to increased surface activity, stockpiling and rehabilitation efforts	Yes	L13
Altered landforms - potential for final landforms to not sustain pre-mining flora and habitat.	Yes	L14
Discharges and emissions – potential for dust deposition from land clearance and ore movement.	Yes	A1, A2
Discharges and emissions – potential for machinery/engine emissions impact flora and fauna	No	A4
Radiation – increased radiation due to HMC extraction, transport and stockpiling impact flora and fauna	No	A3
Light – Increase in light due to 24 hr mining activity impact flora and fauna	Yes	A5

Sound – Increase in sound and vibration as a result of 24 hr mining activity	Yes	A6
Changed surface water flow regimes – Mining and infrastructure reduce/change flows to native vegetation (flora and habitat)	Yes	W1
Redistribution of groundwater – Mining activity reduces groundwater levels, or recharge rates, impacting native vegetation (flora and habitat)	No	G1

5.1.1 Land

5.1.1.1 Vegetation clearing

The bulk of vegetation clearing will be undertaken during the operations phase, the areas cleared will be utilised for mine infrastructure, transport routes and mine pits. Table 5-2 quantifies the vegetation associations will be subject to clearing as a result (and includes a 50 m buffer around the Project disturbance footprint).

Table 5-B Vegetation associations to be cleared within the disturbance footprint

ID	Vegetation association	Total area to be cleared (ha)
1	*Eucalyptus* spp. / *Hakea francisiana* (Bottlebrush Hakea) / *Grevillea stenobotrya* (Rattle-pod Grevillea) Tall Open Shrubland	159
2	*Acacia papyrocarpa* (Western Myall) Open Woodland +/- *Cratystylis conocephala* (Daisy Bluebush) and *Maireana sedifolia* (Bluebush)	610
3	*Eucalyptus oleosa* ssp. Mixed Mallee over *Triodia* spp.	223
4	*Eucalyptus yumbarrana* (Yumbarra Mallee) Mixed Mallee	797
5	*Alectryon oleifolius* (Bullock Bush) Shrubland	0
6	*Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland	0.8
7	*Casuarina pauper* (Black Oak) +/- *Acacia papyrocarpa* (Western Myall) Woodland	69
8	*Eucalyptus oleosa* ssp. (Red Mallee) / *Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) Open Woodland	191
9	*Senna* spp. Open Shrubland	7
	Total area	**2,057**

Relevant impact events: L1, L3

LOSS OF FLORA SPECIES

A direct impact of vegetation clearing is the loss and reduction of flora species and population sizes.

Within the arid and semi-arid environments many species have developed a variety of characteristics including lifespans of greater than 30 years. The long lifespan and perennial nature of the dominant overstorey and reliance on adequate rainfall to allow germination results in a longer recovery time for many arid plants/habitats.

The vegetation communities in the Project Area are dominated by *Eucalyptus* (mallee) associations, particularly in the northern portion, but *Acacia*, *Alectryon* and *Casuarina* woodlands, and *Senna* and chenopod shrublands are present in the southern portion (EBS 2015 & 2019a). The vegetation associations are diverse with little weed infestation and all associations are considered to resemble pre-European condition (EBS 2015).

In total, 136 flora species were recorded by EBS during their 2014 survey, which was comprised of 133 native species and three weed species (EBS 2015). The most widespread native species were *Salsola australis* (Buckbush), *Ptilotus obovatus* (Silver Mulla Mulla), *Atriplex vesicaria* (Bladder Saltbush), *Senna artemisioides* ssp. X *coriacea* (Desert Senna) and *Pittosporum angustifolium* (Native Apricot) (EBS 2019a).

Vegetation in the Project Area has been divided into nine different associations. Vegetation associations were defined by the soil and substrate types present within the area surveyed. Soils varied depending on the landform and these consisted of clay loams in the lowest elevation zones through to deep sands on the dune crests (EBS 2015). On average, 40 different species were recorded per vegetation association, but this ranged from 14 species in the lowest diversity association to 89 species in the highest diversity association. Species often occurred across a number of different associations. Seven of the nine vegetation communities that were defined occur within the disturbance footprint and 132 of the native species recorded have the potential to occur within this area.

HABITAT LOSS

The clearing of vegetation will result in a reduction in the availability of suitable habitat for flora and fauna species which are known or likely to occur within the Project Area. The habitat loss may include areas which are utilised for breeding, roosting, foraging or dispersal. Habitat loss may have a localised impact on species which utilise the Project Area for breeding purposes as it may disrupt the breeding cycle.

The amount of habitat lost as a result of Project-related activities is unlikely to result in a local extinction or decrease in population size of a species which has generalist habitat requirements and/or is highly mobile as there is extensive similar habitat within the YRR.

HABITAT FRAGMENTATION

The relevance, extent, and severity of the potential impact through habitat fragmentation is different for each species and needs to be considered case-by-case.

The proposed mining operations consist of open-cut pits (largest being approximately 5,800 m long, 470 m wide) within the linear dune system. This size is likely to cause only a local scale barrier effect with associated fragmentation.

Flora and some fauna species which are found within arid and semi-arid ecosystems have evolved to traverse or disperse over large distances, and fragmented distribution is common. The scale of habitat fragmentation associated with the proposed mining operations is unlikely to result in a local extinction or decrease in population size of such species with large home ranges.

Fauna species which have a smaller home range are more likely to be affected by a localised habitat fragmentation, such as linear clearing for roads. These species are commonly smaller mammals, reptiles, and invertebrates. Vegetation clearing associated with construction of roads and exploration tracks may interfere through inhibiting movement patterns and result in a ‘barrier’. This barrier effect has the potential to cause a fragmentation of populations resulting in reductions in breeding and genetic diversity, dispersal and foraging opportunities. Overall, these factors further increase pressures on small or vulnerable populations and have the potential to result in a decline in population size.

For all fauna species, movements across areas of cleared vegetation to reach suitable habitats for breeding, roosting and foraging can result in an increase of predation.

Habitat fragmentation also results in an increase of the distance of the 'edge' of a habitat. The 'edge effect' associated with vegetation clearing and site disturbance can lead to increased opportunities for weeds and pest species to invade a native vegetation community. An increase in weed distribution may also be the result of increased vehicle movement and foot traffic.

The scale of fragmentation as a result of Project related activities will not be significant for most species as the disturbance footprint is only relatively small with larger scale habitat still remaining connected to the north-east. There are large amounts of available and suitable habitat to the east and north which will allow any animals that are able to traverse large distance to disperse outside the disturbance footprint (refer Table 5-3).

Table 5-C Extent of vegetation communities within the conceptual footprint as a % of extent within YRR

Vegetation community	Description	Extent within CF	Extent within YRR	CF extent as a % of YRR extent
GV005 – Casuarina / acacia low woodland. Casuarina +/- Acacia low woodland, over Senna / Triplex shrub	Casuarina pauper, +/-Acacia papyrocarpa low woodland over Senna artemisioides ssp. petiolaris, +/-Senna cardiosperma ssp. gawlerensis mid sparse shrubland over Atriplex vesicaria ssp., +/-Maireana sedifolia, +/-Cratystylis conocephala low open shrubland. Plain; sandy loan; plain to dunefield	211	83,155	0.25%
GV0010 - Eucalyptus mid mallee woodland. Eucalyptus mid mallee woodland\Dodonaea shrub\Triodia hummock grass	Eucalyptus concinna+/-Eucalyptus socialis ssp.+/-Myoporum platycarpum ssp. platycarpum\tree mallee,tree Dodonaea viscosa ssp. angustissima+/-Senna artemisioides ssp. petiolaris+/-Acacia ligulata+/-Acacia colletioides+/-Bossiaea walkeri\shrub Triodia sp.+/-Lomandra leucocephala ssp. robusta+/-Aristida contorta\hummock grass, forb+/-tussock grass. Sandy plain; sand; sand plain	1,481	1,368,415	0.01%
GV0011 – Eucalpytus mid mallee woodland Eucalyptus mid mallee woodland / Acacia shrub / Atriplex (mixed) shrub	Eucalyptus oleosa ssp. oleosa, +/-Eucalyptus brachycalyx, +/-Eucalyptus concinna mid mallee woodland over +/-Acacia nyssophylla, +/-Cratystylis conocephala mid sparse shrubland over Atriplex vesicaria ssp., Maireana radiata, Maireana pentatropis low sparse shrubland. Dune / consolidated dune to swale; sand; dunefield	101	165,667	6.10%
GV0015 – Acacia / Dodonaea tall open shrubland Acacia tall open shrubland over Aristida tussock grass	Acacia ligulata, +/- Dodonaea viscosa ssp. Angustissima, +/- Acacia ramulosa var tall open shrubland over +/- Aristida holathera var. holathera, +/- Aristida contorta low sparse tussock grassland. Plain; skeletal soil; dunefield	343	137,459	0.25%

CF: Conceptual Footprint

A secondary impact from habitat fragmentation is the creation of more edge regions, known as the 'edge effect'. Some species benefit from edge regions more than others, such as weeds. This edge effect can result in a rapid increase in invasive weeds and consequently a decrease in native species.

See Sections 5.2 and 5.3 for specific species impacts.

5.1.1.2 Interaction with vehicles and machinery

Throughout the mine life there will be an increase of human activity and the use of vehicles and machinery. During the construction and vegetation clearance stage individual animals have the potential to be injured through interactions with machinery, which may also result in the fatality of individuals. Fauna species which are at the greatest risk during this stage are species which burrow into the soil, nest amongst shrubs/grasses, and are slow moving.

The transportation of personnel between J-A site and Atacama also increases the potential for vehicle strike of fauna. During the night when visibility is at the lowest there is an increased risk of collision as many arid species forage during the cooler hours.

Relevant impact events: L2, L4

5.1.1.3 Increased weed density

The disturbance of land through throughout the life of the mine creates habitats that are favourable for weed species to become establish and grow. Weeds can leave to a decrease in the habitat quality and out-compete native species. There are a variety of different distribution vectors for weeds, including:

- Wind;
- Vehicles and earthmoving equipment;
- Animals (native and introduced); and
- Surface water flows.

Three introduced flora species have been observed within the Project Area: *Acetosa vesicaria* (Rosy Dock), *Brassica tournefortii* (Wild turnip) and *Carrichtera annua* (Ward's weed). These species were observed at low densities and are not listed as Weeds of National Significance or Priority weeds under the LSA act for the Alinytjara Wilurara Landscape Management Region

The most likely mechanism for weeds to be transported to the Project Area is via vehicles and equipment moving into the Project Area. If not controlled, it is likely there will be an increase in diversity or abundance within the new ML. Table 5-4 shows the weeds which have been recorded at the J-A mine and/or within the YRR and therefore have a potential for spread and establishment within the Project Area.

Table 5-D Weeds found within the region and Project Area

Scientific Name	Common Name	Yellabinna Regional Reserve	J-A mine site	Atacama Project Area
Acetosa vesicaria	Rusy Dock		✓	✓
Arcotheca calendula	Cape Weed		✓	
Avena barbata	Wild Oats	✓	✓	
Brassica tournefortii	Wild Turnip	✓	✓	✓

Scientific Name	Common Name	Yellabinna Regional Reserve	J-A mine site	Atacama Project Area
Bromus rubens	Red Brome	✓	✓	
Buglossoides arvensis	Sheep Weed	✓		
Bupleurum semicompositum	Hare's Ear	✓		
Cardaria draba	Hoary Cress	✓		
Carrichtera annua	Ward's Weed	✓	✓	✓
Carthamus lanatus	Woolly Star Thistle	✓		
Centaurea melitensis	Maltese Cockspur	✓		
Chenopodium sp.	Fat Hen		✓	
Citrullus colocynthis	Colocynth	✓	✓	
Cucumis myriocarpus	Paddy Melon	✓		
Cynodon dactylon	Couch Grass	✓	✓	
Diplotaxis muralis var. muralis	-	✓		
Dittrichia graveolens	Stinkwort	✓		
Echium plantagineum	Salvation Jane	✓		
Erodium aureum	Stork's Bill	✓	✓	
Erodium botrys	Long Stork's Bill	✓		
Erodium cicutarium	Cut Leaf Stork's Bill	✓	✓	
Erodium moschatum	Musky Stork's Bill	✓		
Gypsophila tubulosa	Chalkwort	✓		
Heliotropium europaeum	Potato Weed	✓		
Hordeum sp.	Barley Grass	✓	✓	
Hypochaeris glabra	Smooth Cat's Ear	✓		
Lactuca serriola	Wild Lettuce		✓	
*Lycium ferocissimum**	African Boxthorn	✓		
Malva parviflora	Small Flower Marshmallow	✓		
Marrubium vulgare	Horehound		✓	
Medicago sp.	Medic	✓	✓	
Mesembryanthemum aitonis	Angled Iceplant	✓	✓	
Mesembryanthemum crystallinum	Iceplant	✓	✓	
Neatostema apulum	Hairy Sheep Weed		✓	
Nicotiana glauca	Tree Tobacco	✓		
Onopordum acaulon	Stemless Thistle	✓		
Parapholis incurve	Curly Ryegrass	✓		
Plantago bellardii	Hairy Plantain	✓		
Polycarpon tetraphyllum	Allseed	✓		
Prunus dulcis	Almond	✓		
Raphanus raphanistrum	Wild Radish		✓	
Reichardia tingitana	False Sow Thistle		✓	

Scientific Name	Common Name	Yellabinna Regional Reserve	J-A mine site	Atacama Project Area
Rostraria cristata	Annual Cats Tail	✓		
Rostraria pumila	Tiny Bristle Grass	✓	✓	
Schinus areira	Pepper Tree	✓		
Schismus arabicus	-	✓		
Schismus barbatus	Mulga Grass	✓		
Sisymbrium erysimoides	Smooth Mustard	✓		
Sisymbrium irio	London Rocket	✓		
Sisymbrium orientale	Wild Mustard	✓	✓	
Solanum nigrum	Blackberry Nightshade	✓	✓	
Sonchus oleraceus	Sow Thistle	✓	✓	
Sonchus tenerrimus	Clammy Sow Thistle	✓		
Spergularia diandra	Lesser Sand-Spurrey	✓		
Tribulus terrestris	Yellow Vine	✓		
Urtica urens	Stinging Nettle	✓		
Vulpia muralis		✓		
Vulpia myuros	Rat's Tail Fescue	✓		

* *Weed of National Significance*

Relevant impact events: L5

5.1.1.4 Fauna pest species

The introduction of fauna pest species can result in the decline of some species through predator or competition. The following pest species have been recorded within the Project Area or at the neighbouring J-A mine:

- *Camelus dromedarius* (Camel);
- *Canis lupus familiaris* (Dog);
- *Felis catus* (Cat);
- *Mus musculus* (House mouse);
- *Oryctolagus cuniculus* (European rabbit);
- *Vulpes* (Red fox); and
- *Bos Taurus* (European Cattle).

The introduction of the European rabbit inflicts damage on a variety of ecological assets, native flora and fauna, vegetation communities, and landforms. Due to the rabbit's high reproductive rates and ability to survive in a variety of habitats they become established in areas rapidly, considered to be one of the fasted colonizing mammals in the world (CoA, 2016). The direct impacts which may result with in the Project Area as a result of the introduction of rabbits include:

- Competition with native wildlife for sources (food and shelter);
- Preventing plant regeneration;
- Overgrazing and general damage to plant species;

- Reversing the normal processes of plant succession;
- Altering ecological communities and changing soil structure and nutrient cycling, leading to significant erosion; and
- Removal of critical habitat for arboreal mammals and birds, leading to increased predation and reduced reproduction.

The Domestic cat (cat) is a threat to native fauna primarily through predation as well as competition and disease transmission (refer to Section 5.1.1.5). Cats in Australia have contributed to the extinction of many small to medium-sized mammals and ground nesting birds in the arid zone previously (CoA, 2015). Reptiles are also a food resource for cats in the arid zone but are not as greatly affected.

The European fox (fox) is another introduced predator which poses a major threat to many native Australia animals. They are listed on the Worlds Conservation Union's list of the 100 worst invasive species (DEWHA, 2008). Due to their rapid reproduction rate and high survival rate of cubs they colonise areas rapidly within a short period of time. Like the cat, they prey upon small to medium sized mammals and ground-nesting birds.

The cat and fox both have the potential to decrease species populations significantly within the area through increased predation. There is an increased risk of this occurring from the construction to operation phase as they can be attracted to areas with human activity. Areas which have undergone vegetation clearance are known to attract predators as it exposes prey when they are traversing open areas. They have also been observed roaming along roads which provide them with easy access corridors.

These pest species are known to be established in the area and no new species have been recorded as being introduced to the area since the inception of the J-A mine's fauna monitoring program.

J-A operates in accordance with a Pest Species Management Plan (Iluka Document No. 0016-940010196-373). The plan details known pest species, impacts of pest species in relation to operational activities and pest control and management strategies. The pest management strategies are accompanied by detailed monitoring procedures and requirements, with documented responsibilities and reporting requirements to ensure compliance and review

Mitigation measures include prohibition of domestic animals, restriction of pest access to food and water sources, waste management controls, inspections, monitoring of pest sightings and abundance to implement suitable and timely control strategies, targeted baiting of pest animals, ad hoc rapid response programs as required.

These monitoring and mitigation programs will be extended to Atacama to mitigate pest animal risks.

Relevant impact events: L6, L7

5.1.1.5 Pathogens and toxins

Pathogens and toxins can be fatal to some species of native flora and fauna.

Pathogens are biological agents which can cause disease or illness to the host, including reducing their ability to reproduce. Within South Australia three species (Mundulla Yellow, *Austropuccinia psidii* (Myrtle rust) and *Phytophthora cinnamomi* (Phythophora) are known to have the potential to impact native flora and fauna. However, there was no evidence of plant pathogens during field investigations at J-A or Atacama and the Project Area is not located in a high-risk *Phytophthora cinnamomi* (root-rot fungus), or Mundulla Yellows area due to the low annual rainfall (root-rot fungus occurs in areas where average annual rainfall is greater than 400 mm) and minimal human disturbance.

Cats are potential hosts to disease-causing agents including the Toxoplasma which is a threat to many native Australian mammals. A possible impact of the Toxoplasma disease on native animals is the loss of fear, increasing vulnerability to predators or vehicles (CoA, 2015).

Toxins are used as a method for pest control, including rabbit and rodent control through baiting and weed spraying. Through these methods it is not guaranteed that the target species will be the only that are killed, native species may ingest the toxins or through secondary poisoning be affected. Depending on the method of exposure to the target species will depend on the risk to other species.

At J-A mine there are pest management plans in place, including:

- Rodent baiting;
- Rabbit baiting;
- Weed spraying;
- Insect bait stations; and
- Snail baiting.

Rabbit and rodent baiting can be fatal to predators including birds of prey which hunt these species as a primary food resource. This can have an impact on population numbers; however the risk is mitigated through appropriate pest management control strategies.

Weed spraying has the potential to kill native flora species within the area. It may also secondarily poison native herbivores and lead to soil contamination. If soil contamination does occur, it can have localised impacts to the affected area.

J-A operates in accordance with a Pest Species Management Plan (Iluka Document No. 0016-940010196-373). The plan details known pest species, impacts of pest species in relation to operational activities and pest control and management strategies. The pest management strategies are accompanied by detailed monitoring procedures and requirements, with documented responsibilities and reporting requirements to ensure compliance and review

Mitigation measures include prohibition of domestic animals, restriction of pest access to food and water sources, waste management controls, inspections, monitoring of pest sightings and abundance to implement suitable and timely control strategies, targeted baiting of pest animals and treatment of pest plant species, ad hoc rapid response programs as required.

These monitoring and mitigation programs will be extended to Atacama to mitigate pathogen and toxin risks.

Relevant impact events: L8, L9, L10

5.1.1.6 Fire

The introduction of human activity into an area can lead to a change in the natural fire regime. It may decrease the frequency and intensity of fires via control measures and/or increase accidental fires caused through the introduction of ignition points (i.e., vehicles and machinery).

Species that are sensitive to fire may be impacted through Project-related activities if they lead to an increase in frequency. This process could lead to disturbance outside of the Project footprint involving repetitive loss of the dense shrub layer that forms critical habitat for species. If this were to occur, it has potential to:

- reduce the area of occupancy the species can inhabit in the region;
- fragment populations as fire isolates remaining suitable habitat; and
- if it occurred on a sufficiently large scale could:
  - disrupt the breeding cycle;
  - impact habitat to the extent that the species is likely to decline and subsequently reduce the population size of the species.

J-A operates in accordance with a Fire Management Plan (Iluka Document No. 0016-940010196-389). The plan includes a detailed fire risk assessment for the operational area including specific details of vegetation and bushfire risk to minimise the potential for uncontrolled fires as a result of mining operations. The fire management strategies are accompanied by detailed monitoring procedures and requirements, with documented responsibilities and reporting requirements to ensure compliance and review.

Mitigation measures include adherence to fire ban rules, maintenance of fire breaks, provision and training of emergency crews, emergency procedures, restricting vehicle access to approved tracks and areas.

These monitoring and mitigation programs will be extended to Atacama to mitigate fire risks.

Relevant impact events: L11

5.1.1.7 Erosion of topsoil and loss of organic matter and seedbank

Topsoil that is stockpiled during the operations phase of the Atacama Project for later use, is the source for organic matter and seedbank necessary for rehabilitation of the Project Area. Long term stockpiling of soils can result in a loss of organic matter and viable seed within the stockpiles leading to the potential to impairment of rehabilitation activities through reducing the availability of viable seed for germination and nutrients provided for plant regeneration.

During the construction and operational phases of the Project there will be an increase in topsoil movements, stockpiling and in vehicle and machinery activity which can result in increased erosion (through surface water and/or wind dispersion) of soils. This may also increase when rehabilitation activities to replace the removed soil are underway. Increased erosion of topsoils can negatively affect soil/habitat stability and deplete the available seed resource from topsoil. This may lead to inhibited growth of native plants and consequently the rehabilitation promoted habitat may not replicate pre-mining conditions.

Mineral sands mining and subsequent rehabilitation activities require soil handling, movement and stockpiling, and these activities can alter the composition, structure, and chemistry of soils. As a result, consideration of post-mining soils is an important consideration when planning restoration works and deciding on the vegetation communities to be replaced (Herath et al. 2009; Golos et al. 2016). Reconstructed soils can lack the necessary soil characteristics needed to support the development and survival of seedlings, with issues including poor soil structure, compaction, low water retention, inadequate levels of organic matter, nutrients, and microbial activity (Kneller et al. 2018).

This may have direct impacts on flora as it impairs their ability to grow or may limit development of subterrestrial symbiotic relationships, as well as indirect impacts on fauna as it may impact restoration of habitat.

The soil surface is fragile, with the high percentage of fine sand particles in the surface (and some regolith) being particularly susceptible to wind erosion. Soil strength measurements at J-A indicate that weak soil crusts develop within the topsoil material which offers some protection from wind erosion. Wind erosion potential is variable according to soil type (particle size and weight), cover and moisture content with significant wind erosion generally occurring at the Project Area at speeds in excess of 20 km/h (DERM 2011).

Rehabilitation activities are a focus of Iluka's mine planning phase; and where possible are progressively implemented in conjunction with mining operations. Before mining commences, vegetation, topsoil and overburden is removed from the disturbance area. Exhausted pits will either be immediately reinstated with appropriate soil profiles for rehabilitation and vegetation regeneration or utilised for stockpiling topsoil, loam soils or mineral sands materials ahead of rehabilitation works. In either scenario topsoil stockpiles will be mitigated from uncontrolled erosion via appropriate siting and monitoring for evidence of erosion with soil stabilisation methods implemented if required.

As each soil horizon is reinstated during rehabilitation, the layer is ripped to prevent compaction and uncontrolled erosion of the soils. The depth of profile varies with the vegetation association to be reinstated. Subsoil and topsoil, sourced from stockpiles or the mining face, is then reinstated to an approximate profile thickness of 0.15 m and 0.05 m respectively. The final topsoil layer is ripped on the contour to assist in erosion control.

J-A has well documented practices for the movement, management, and replacement of soils for stockpiling and rehabilitation practices. Soil specific practices will be employed at Atacama.

Relevant impact events: L13

5.1.1.8 Final landforms

Rehabilitation activities at Atacama are expected to be undertaken progressively, in conjunction with mining activities. This will see mined areas partially backfilled with overburden, and at the completion of mining/processing activities, reserved loam and topsoils will be placed atop the pit and other previously disturbed areas to provide a soil profile for regeneration of vegetation. Loam is to be direct returned from the mining areas to the greatest extent practicable. Soil horizons are to be ripped to prevent compaction and erosion of soils and the depth profile with vary with the vegetation association to be reinstated.

Outside of pit areas, disturbance for mining infrastructure has been positioned to utilise existing disturbances and/or avoid dune crests as far as possible to reduce cuts.

The net extraction of material and soil movements will result in changes to the topography, compared to pre-mining conditions and surrounding dunes. The pits cut across the existing regional dunes. The rehabilitated landforms will be shaped to blend with the surrounding landforms, but the dune crests are unlikely to be continuous in height. While care is expected to be taken to replicate soil profiles, the changes to landforms can be expected to result in impacts or changes to vegetation associations that regenerate within the disturbed footprint areas in comparison to those present in pre-mining conditions.

Relevant impact events: L14

5.1.2 Air quality

5.1.2.1 Discharges and emissions

Open areas such as open pits increase the opportunity for dust generation. Increases in dust within the atmosphere can result in adverse effects on vegetation through smothering the plant and inhibiting their ability to photosynthesis. Resulting in reduced plant growth or cause death to existing vegetation, consequently, decreasing the quality habitat.

Without dust management strategies it is possible for the adverse impact on vegetation to occur. The extent of vegetation exposed to heavy dust is restricted to areas within close proximity to the site. Therefore, the impact to vegetation within the Yellabinna reserve would be minor as the disturbance footprint is relatively small.

While the Atacama deposit is being mined, process water will be deployed for dust suppression. The salinity of the process water is in the range of 40,000 to 60,000 TDS. Vegetation types within the Project area are tolerant of saline conditions, with plants naturally equipped to distribute soil-borne salts through leaf surfaces. The continuous exposure to saline water in periods of high evaporation may exceed the tolerance of the vegetation. The actual impact area is likely to be limited to the immediate border of roads for which a 50 m buffer has already accounted for as part of disturbance accounting.

An air quality impact assessment for the Project was conducted (Jacobs 2022a), this assessment found:

..there is a low risk of air quality impact due to nuisance dust and elevated airborne concentrations of PM10 and PM2.5.

Recommendations for dust mitigation measures centred around: substantial separation distances between the mining and minerals processing areas and the nearest sensitive receptor (Camp); use of water carts on unpaved roads to minimise wheel-generated dust by haul trucks; rehabilitation of mined areas by earthworks, stabilisation of stockpiles using suppressant (enhancing surface crusting), and revegetation of rehabilitated areas.

With respect to *flora and fauna impacts, the recommendations for dust mitigation for the protection of human health and amenity are generally considered to be adequate for the protection of flora and fauna surrounding the mine site boundaries.*

Relevant impact events: A1, A2

5.1.2.2 Radiation

An environmental radiation impact assessment has been conducted (Emes 2022), and found the following:

Deposition of radionuclides within the Atacama study area is expected to be considerably lower, even in the event that material is stockpiled prior to being trucked to the process plant (assuming similar controls to that of the J-A site are implemented regarding the stockpiling and trucking of material). The material contains considerably lower radionuclide concentrations than HMC (0.26 Bq/g Th^{232} and 0.39 Bq/g U^{238} in ore based on assays conducted by Iluka, compared to up to 1.93 Bq/g Th^{232} and up to 2.78 Bq/g U^{238} in HMC), so considerably larger quantities need to be released into the environment to give rise to doses greater than or equal to the doses that have been estimated at the J-A site. Even if we assume that dust deposition in the vicinity of stockpiling activities at Atacama is double what it is at the most affected site at J-A (23.58 g/m2/month) for the anticipated mining life of 6.5 years, plus an additional 4 years of processing (for a total of 10.5 years), this will result in a total deposition of 2971 g/m2. If we conservatively assume that 50% of all of the dust is attributable to Atacama ore (J-A dustablility studies suggest 44% from ore), which has approximate Uranium and Thorium concentrations of 31 ppm and 63 ppm respectively, the total deposited activity can be calculated to be 359 Bq and 239 Bq of U^{238} and Th^{232} respectively.

If we again conservatively assume that all of the material (no material is redeposited elsewhere) mixes with the top 10 mm of soil over time (consistent with dust deposition data in Australian soil (Kaste, Heimsath and Bostick, 2007)), and assuming a soil density of 1500 kg/m3, the total activity in the soil can be determined. The activity concentrations can be determined to be 0.035 Bq/g Th^{232} and 0.046 Bq/g U^{238} (equivalent to approximately 8.5 ppm and 3.6 ppm respectively) remain comparable to the typical average soil concentrations of thorium and uranium in soils, the worldwide average thorium concentration being approximately 9 ppm, and with the worldwide average uranium concentration being approximately 3 ppm.

… estimated doses based on the combined radiological impact of future approved operational activities and the radiological impact of Atacama derived ore and product (yet to be approved) are below 10 µGy/h at the most impacted site near the J-A process plant, indicating that there are likely to be no impacts from a radiological perspective to non-human biota due to continued mining, processing, stockpiling and transport of HMC.

No impacts are expected via radiation.

Relevant impact events: A3

5.1.2.3 Light

During the operational phase at Atacama, operation will be 24 hours per day, seven days a week. Operation will require constant light sources. This may have impact on native fauna species through increased risk of predation, disruption of circadian rhythms, disorientation, attraction to light sources increasing injury and mortality risk and may have negative impacts on breeding and migration. There is also the potential for changes to vegetation growth and flowering patterns.

Relevant impact event: A4

5.1.2.4 Sound

Noise at Atacama is expected to increase from current ambient noise levels during the construction and operation phases of the mine. During these phases, increased noise is likely to occur in short, intense pulses from mobile plant equipment as well as in the form of more prolonged noises with consistent vibration, pitch and volume due to generators, excavators, pumps and vehicles. During operation mining activities will occur 24/7, which may cause avoidance of adjacent areas in the wider YRR, interference with species' calls, increased risk of predation and interference with circadian rhythms.

Relevant impact event: A5

5.1.3 Surface water

5.1.3.1 Alteration to flow regimes

There are no defined watercourses throughout the Project Area, and no large watercourses.

To prevent flow or collection of surface water around or within the Project footprint the surface water flows may be redirected. This has the potential to result in connections between previously discrete catchments or altered positioning of terminal catchments. Secondarily leading to increased infiltration of surface water into the soil and heighted soil water retention which may impact the health (positively or negatively) of flora species.

Available water from rainfall events is likely to be short lived with high evapotranspiration rates and would not impact significantly on existing vegetation communities within the Project Area. The disruption of these flows due to infrastructure siting is unlikely to pose a significant risk to the abundance and diversity of flora and fauna.

Assessment of surface water impacts found '*Other than within terminal pans which intersect mining activities, runoff in the dune field is unaffected by mining activities*' (EMM 2022a) and *'The proposed mine layout is primarily contained within the dune land scape. When rainfall runoff occurs, mining influences on runoff would be contained to dune swales in the immediate vicinity of the activity'* (EMM 2022a).

Post-closure erosion of topsoil will be minimised through contouring, ripping, soil crusts and re-establishment of landscape function through soil cover and vegetation regrowth. Infrequent run-off events are expected to result in little impact to surrounding vegetation.

Relevant impact event: W1

5.1.4 Groundwater

5.1.4.1 Drawdown

Impact due to mining of mineral sands is not expected as water table is not expected to be intercepted during mining, and there is no extraction planned within the Project Area.

EMM (2022a) indicates creeks in the Project Area are ephemeral, flowing only in response to rainfall, and do not receive groundwater discharges. Groundwater is known to discharge at Lake Ifould, a terminal salina.

No aquatic groundwater dependent ecosystems (GDE) were located within proximity of the Project Area. Terrestrial GDEs in the Project Area include Mallee forest and Mallee woodland, it is noted that the lack of shallow groundwater (shallowest being 75 m BGL) suggests these ecosystems are more likely to rely on episodic rainfall and soil moisture rather than groundwater.

Target ore deposits sit above the natural groundwater table. This precludes the requirement to dewater the natural in-situ aquifer to facilitate mining; dewatering will only be required if/where tailings seepage losses to the underlying aquifer result in localised groundwater rise and a threat to the environment. Tailings are not expected to be deposited within the Atacama Project site and as such any impacts from tailings are expected to be addressed from within the J-A site.

Relevant impact event: G1

5.2 NPW Act listed species impact assessment

NPW ACT LISTED SPECIES

Nine birds, one reptile and four plant species listed under the NPW Act have been recorded within the Project Area or are likely or possible to occur through the available suitable habitat (refer Section 4.3). An additional three species that are listed under both the EPBC Act and the NPW Act will be considered under the EPBC Act in Section 5.3 and are hence excluded from discussion here.

A summary of the potential impacts to the NPW Act listed flora and fauna prior to mitigation and control are detailed in Table 5-5: Potential impacts on NPW Act listed species. Control measures and Environmental Outcomes will be discussed in Section 6 and Section 7 respectively.

Table 5-E Potential impacts on NPW Act listed species

NPW	Potential Threats	Impact Profile
***Ardeotis australis* (Australian Bustard)**		
V	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species L10 - There is a small potential for poisoning via consumption of prey that have consumed baits, this is unlikely to cause species decline due to likely distance from baiting stations and limited proportions of available baited prey L11 - Any increased frequency and spread of fire is not expected to impact this species, which is said to move readily in response to fire (Ziembicki 2010). A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 – Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area.
***Cinclosoma castanotus* (Chestnut Quail Thrush)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	L2 & L4 – The species is ground-based and more likely to run than fly, hence is more likely to be subject to vehicle strike than aerial bird species. L3 – Given the abundant presence of suitable habitat for this species across the broader, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species L10 – This species is omnivorous and unlikely to consume poisoned prey.

NPW	Potential Threats	Impact Profile
		L11 – This species may be impacted by an increase in frequency of fires as a result of mining-related activities as this process could lead to disturbance outside of the mining footprint involving repetitive loss of the dense shrub layer that forms critical habitat for the species. Fire is known to affect population densities which have been shown to be lower when the fire interval is less than two years. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 – Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area.
***Pachycephala inornata* (Gilbert's Whistler)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	L2 & L4 – The species is ground-based and more likely to run than fly, hence is more likely to be subject to vehicle strike than aerial bird species. L3 – Given the abundant presence of suitable habitat for this species across the broader, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species L10 – This species is omnivorous and unlikely to consume poisoned prey. L11 – This species may be impacted by an increase in frequency of fires as a result of mining-related activities as this process could lead to disturbance outside of the mining footprint involving repetitive loss of the dense shrub layer that forms critical habitat for the species. The species is known to affect population densities which have been shown to be lower when the fire interval is less than two years. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 – Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area.
***Hieraaetus morphnoides* (Little Eagle)**		
V	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8)	L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species.

NPW	Potential Threats	Impact Profile
	• Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. Little Eagle are known to rely heavily on the rabbit population as a food source, hence an increase in rabbit numbers would not negatively impact this species. L10 - There is a small potential for poisoning via consumption of prey that have consumed baits, this is unlikely to cause species decline due to likely distance from baiting stations and limited proportions of available baited prey L11 - Any increased frequency and spread of fire is not expected to impact this species, which is likely to move readily in response to fire. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 - Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area
Lophochroa leadbeateri mollis **(Major Mitchell's Cockatoo)**		
V	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	The absence of hollow bearing trees within the Project Area excludes impacts to nesting and breeding, with habitat only suitable for foraging. L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. L10 - This species is omnivorous and unlikely to consume poisoned prey. L11 - Any increased frequency and spread of fire is not expected to impact this species, which is likely to move readily in response to fire. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 - Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area

NPW	Potential Threats	Impact Profile
***Falco peregrinus* (Peregrine Falcon)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) Surface water (W1)	L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. Little Eagle are known to rely heavily on the rabbit population as a food source, hence an increase in rabbit numbers would not negatively impact this species. L10 - There is a small potential for poisoning via consumption of prey that have consumed baits, this is unlikely to cause species decline due to likely distance from baiting stations and limited proportions of available baited prey L11 - Any increased frequency and spread of fire is not expected to impact this species, which is likely to move readily in response to fire. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 - Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area
***Myiagra inquieta* (Restless Flycatcher)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. L10 - This species is omnivorous and unlikely to consume poisoned prey.

NPW	Potential Threats	Impact Profile
		L11 - Any increased frequency and spread of fire is not expected to impact this species, which is likely to move readily in response to fire. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 - Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area
***Neophema splendida* (Scarlet-chested Parrot)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1)	The absence of hollow bearing trees within the Project Area excludes impacts to nesting and breeding, with habitat only suitable for foraging. L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. L10 - This species is omnivorous and unlikely to consume poisoned prey. L11 - Any increased frequency and spread of fire is not expected to impact this species, which is likely to move readily in response to fire. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 - Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area
***Acanthiza iredalei* (Slender-billed Thornbill)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6)	L2 & L4 – The species is highly mobile and unlikely to be subject to vehicle strike. L3 - The abundant presence of suitable habitat for this species across the broader landscape and given the nomadic tendency of this species allowing for movement into this suitable connected habitat, it is suggested dispersal of the species into unaffected areas in the broader Yellabinna Regional Reserve will prevent any potential impacts to population size, risk of habitat fragmentation or restriction of the area of occupancy for the species. This indicates that the proposed land to be cleared is neither critical habitat for the species' survival nor likely to lead to a decline in the species.

NPW	Potential Threats	Impact Profile
	• Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1).	L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. L10 - This species eats mainly insects and is unlikely to consume poisoned prey. L11 - Any increased frequency and spread of fire is not expected to impact this species, which is likely to move readily in response to fire. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 - Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area
Neelaps bimaculatus **(Western Black-naped Snake)**		
R	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1).	L2 & L4 – this species may be impacted by vehicle strike as it is nocturnal and cold-blooded and do not move quickly enough to escape fast moving vehicles. L3 – the exact habitat requirements, distribution and range of this species is not well known. It is likely to be limited in the distance that it can move to escape disturbance. L5 - Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this species. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. L10 – This species may be affected by poisoning as it may eat poisoned vermin. L11 - Any increased frequency and spread of fire may impact this species, which is unlikely to be able to move over long distances in response to fire A5 – This species is mainly nocturnal and may be impacted by changes in light regimes A6 – This species response to noise is unknown. W1 – Due to the transient nature of the short duration event-based surface water within the Project Area, the species is unlikely to rely solely on this as a water source.

NPW	Potential Threats	Impact Profile
Gratwickia monochaeta		
R	• Vegetation clearing (L1) • Weeds (L5) • Pests (L7) • Pathogens (L9) • Toxins (L10) • Fire (L11) • Dust deposition (A1 & A2) • Light (A5) • Surface water (W1)	Very limited information is available for *G. monochaeta*. L1 – There are no records of *G. monochaeta* within the Conceptual Footprint. Given limitations on information about the species it cannot be certain the proximity of the Atacama Project won't disrupt the reproductive cycle of the population as the disturbance footprint occurs between different records of the species in the region which may reduce potential for cross-pollination. However given that the species is known to exist in disturbed areas, it may recolonise post-disturbance. L5 – The invasion of ecosystem changing weeds may impact on this species through competition. L7 – It is unknown whether this species is palatable to pest herbivore species. L9 – Pathogens are unlikely to spread into the arid environment of the Project Area. L10 – Due to the location of the records of G. monochaeta outside of the Project Area, there is unlikely to be contact between any toxins and this species. L11 – The response of this species to fire is unknown A1, A2 & A5 - There is the potential for the impacts from dust and constant lighting of the area to impact plants to the extent that there is a decrease in population size (Olszyk & Tingey 1984; Farmer 1993). W1 – there is no known correlation between *G. monochaeta* and the availability of surface water.
***Melaleuca leiocarpa* (Purple Honey-myrtle)**		
R	• Vegetation clearing (L1) • Weeds (L5) • Pests (L7) • Pathogens (L9) • Toxins (L10) • Fire (L11) • Dust deposition (A1 & A2) • Light (A5) • Surface water (W1)	Very limited information is available for *M. leiocarpa* L1 – There are no records of *M. leiocarpa* within the Conceptual Footprint. Given limitations on information about the species it cannot be certain the proximity of the Atacama Project won't disrupt the reproductive cycle of the population as the disturbance footprint is close to the records of this species in the region which may reduce potential for cross-pollination. L5 – The invasion of ecosystem changing weeds may impact on this species through competition. L7 – It is unknown whether this species is palatable to pest herbivore species. L9 – Pathogens are unlikely to spread into the arid environment of the Project Area. L10 – Due to the location of the records of *M. leiocarpa* outside of the Project Area, there is unlikely to be contact between any toxins and this species. L11 – The response of this species to fire is unknown A1, A2 & A5 - There is the potential for the impacts from dust and constant lighting of the area to impact plants to the extent that there is a decrease in population size (Olszyk & Tingey 1984; Farmer 1993). W1 – there is no known correlation between *M. leiocarpa* and the availability of surface water.

NPW	Potential Threats	Impact Profile
***Corynotheca licrota* (Sand Lily)**		
R	• Vegetation clearing (L1) • Weeds (L5) • Pests (L7) • Pathogens (L9) • Toxins (L10) • Fire (L11) • Dust deposition (A1 & A2) • Light (A5) • Surface water (W1)	Very limited information is available for *C. licrota.* L1 – There are no records of *C. licrota* within the Conceptual Footprint, with the closes record over 14km north of the Project Area. Given the distance between the Conceptual Footprint and the nearest record, there will be no direct impacts on this species. L5 – The invasion of ecosystem changing weeds may impact on this species through competition. L7 – It is unknown whether this species is palatable to pest herbivore species. L9 – Pathogens are unlikely to spread into the arid environment of the Project Area. L10 – Due to the location of the records of *C. licrota* outside of the Project Area, there is unlikely to be contact between any toxins and this species. L11 – The response of this species to fire is unknown A1, A2 & A5 – Given the distance between the Project Area and the nearest record, there will be no impacts on this species as a result of changes in the lighting regime. W1 – Given the distance between the Project Area and the nearest record, there will be no impacts on this species as a result of changes in the surface water in the immediate Project Area.
***Santalum spicatum* (Sandalwood)**		
	• Vegetation clearing (L1) • Weeds (L5) • Pests (L7) • Pathogens (L9) • Toxins (L10) • Fire (L11) • Dust deposition (A1 & A2) • Light (A5) • Surface water (W1)	Limited information is available for *S. spicatum*, therefore key threats are unknown. L1 – There are no records of Sandalwood within the Conceptual Footprint. Given limitations on information about the species it cannot be certain the proximity of the Atacama Project won't disrupt the reproductive cycle of the population as the disturbance footprint is close to the records of this species in the region which may reduce potential for cross-pollination. L5 – The invasion of ecosystem changing weeds may impact on this species through competition. L7 – Sandalwood is known to be very palatable to herbivores, hence any increase in herbivore numbers is likely to impact on this species. L9 – Pathogens are unlikely to spread into the arid environment of the Project Area. L10 – Due to the location of the records of Sandalwood outside of the Project Area, there is unlikely to be contact between any toxins and this species.

5.3 EPBC Act listed species impact assessment

A summary of the potential impacts to the EPBC Act listed flora and fauna is detailed in Table 5-6.

Table 5-F Potential impacts on EPBC listed species

EPBC	NPW	Potential Threats	Impact Profile
Leipoa ocellata (Malleefowl)			
V	V	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8) • Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1).	L2 & L4 – The species is ground-based and more likely to run than fly, hence is more likely to be subject to vehicle strike than aerial bird species. L3 –Tracks within the Conceptual Footprint suggests that small numbers of Malleefowl may transiently use the Conceptual Footprint and hence prior to mitigation there may be potential impacts due to habitat loss. L5 – Weeds are unlikely to invade the Project Area to the extent that they will alter the habitat so that it that it becomes unsuitable for this generalist species.. L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. Increase in herbivore pest numbers (i.e. cats and goats) may impact on this species as they may compete for food and prevent regeneration of plants, greatly slowing recovery after fire. L10 – This species forages on a variety of seeds and is unlikely to consume poisoned prey. L11 –This species may be impacted by an increase in frequency of fires as a result of mining-related activities as this process could lead to disturbance outside of the mining footprint involving repetitive loss of the dense shrub layer that forms critical habitat for the species. The species is known to require deep rafts of leaf litter which need time to build after fire, hence fire could potentially impact on this species. A5 – The species diurnal and unlikely to be significantly affected by increased light A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 – Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area.
Sminthopsis psammophila (Sandhill Dunnart)			
E	V	• Vehicle strike (L2 & L4) • Habitat loss (L3) • Weeds (L5) • Pests (L6) • Pathogens (L8)	L2 & L4 – This terrestrial mammal has the potential to be impacted by vehicle strike. L3 –Although this species has not been recorded within the Conceptual Footprint, the presence of one potential (old abandoned) burrow site and the presence of some suboptimal habitat provides the potential for small numbers of Sandhill Dunnart to transiently use the Conceptual Footprint and hence prior to mitigation there may be potential impacts due to habitat loss. L5 –. Should Buffel grass invade the Project Area, it may outcompete the native Triodia that Sandhill Dunnart requires, which would potentially impact on this species

EPBC	NPW	Potential Threats	Impact Profile
		• Poisons (L10) • Fire (L11) • Light (A5) • Noise (A6) • Surface water (W1).	L6 & L8 - Wild cats are already recorded within the Project Area hence there will be no increased risk of toxoplasmosis as a result of the Project. Predators of risk are already present in the habitat and therefore will not be introduced due to the Atacama Project, however any increase in numbers of these predators may impact on this species. Increase in herbivore pest numbers (i.e. cats and goats) may impact on this species as they may reduce the quality and quantity of habitat available for this species. L10 – This species is carnivorous, however eats only small insects and is unlikely to consume poisoned prey. L11 – This species may be impacted by an increase in frequency of fires as a result of mining-related activities as this process could lead to disturbance outside of the mining footprint involving repetitive loss of the Triodia that forms critical habitat for the species. The species is known to require mature Triodia of an age where the middle of the clump has started to decay, therefore there would be a delay between a fire and the time when mature Triodia suitable for use by Sandhill Dunnart is available. A5 – The species nocturnal and there is some potential for individuals to be affected by increased light. A6 – Due to the mobile nature of this species, individuals are likely to disperse into the surrounding Yellabinna Regional Reserve before they are significantly impacted by an increase in noise. W1 – Due to the mobile nature of this species, they are unlikely to rely on the short duration event-based surface water within the Project Area.
Hibbertia crispula (Ooldea Guinea-flower)			
V	V	• Vegetation clearing (L1) • Weeds (L5) • Pests (L7) • Pathogens (L9) • Toxins (L10) • Fire (L11) • Dust deposition (A1 & A2) • Light (A5) Surface water (W1)	L1 – Despite extensive surveys, Ooldea Guinea-flower has not been recorded within the Conceptual Footprint, with the closest record 5.5km to the north-east. L5 – The invasion of ecosystem changing weeds may impact on this species through competition. Buffel grass is known to be a key threat to Ooldea Guinea-flower (DEWHA, 2008). L7 –Increased grazing pressure from rabbits and feral goats is a key threat to Ooldea Guinea-flower (DEWHA, 2008). L9 – Pathogens are unlikely to spread into the arid environment of the Project Area. L10 – Due to the location of the records of Ooldea Guinea-flower outside of the Project Area, there is unlikely to be contact between any toxins and this species. L11 – Fire is likely to be required for the seed germination of this species. A1, A2 – The reaction of this species to dust deposition is unknown. A5 – Due to the location of the Ooldea Guinea-flower records 5.5km outside of the Conceptual Footprint, there will be no impacts as a result of increased lighting on this species. W1 – there is no known correlation between Ooldea Guinea-flower and the availability of surface water.

6. Control measures (mitigation)

Control measures describe how each impact event is proposed to be effectively managed during the lifetime of the mine, and post completion. The proposed control measures are shown in Table 7-1. The hierarchy of control has been used and applied in the following order of preference:

1. Elimination;
2. Design / engineering (physical) controls;
3. Management system (procedure) controls.

The key control and management strategy for the residual vegetation clearing (once avoidance and minimisation has been achieved), is the provision of an SEB offset. The detail as to how this offset will be provided will be covered in a separate report.

7. Proposed Environmental outcomes

The environmental outcome indicates the impact on the environment caused by the propose mining activities subsequent to control strategies being implemented. The proposed environmental outcomes are shown in Table 7-1.

Table 7-A Control measures, outcomes, and criteria

Impact ID	Impact	Control measures	Proposed outcome	Draft Outcome Measurement Criteria
L1	Land clearance. Impact on flora	• Implementation of a Native Vegetation Management Plan • Implementation of a Rehabilitation Management Plan • Progressive rehabilitation of disturbed area, commencing within first few years of operations • Provision of a Significant Environmental Benefit (SEB) • Landscape Function Analysis • Comparison of annual aerial photography to ensure vegetation clearance is within approved internal permit limits • Restricting access to undisturbed areas not required during operations.	All clearance of native vegetation is authorised under appropriate legislation	• Annual GIS comparison of approved clearance boundary and actual clearance boundary demonstrates vegetation is within authorised clearance boundaries (annual SEB reconciliation report) • Annual vegetation health survey demonstrates vegetation clearance is within authorised boundaries (annual SEB reconciliation report). Survey to measure (in consideration of baseline conditions (EBS 2014, 2019, ELA 2021)): - Plant mortality - New growth - Evidence of flowering and fruiting - Extent of dust smothering and - Evidence of saline stress
			Post mining ecosystem and landscape function is resilient, self-sustaining and indicating that the pre-mining ecosystem and landscape function will ultimately be achieved	• Landscape Function Analysis monitoring (at DEM agreed intervals post rehabilitation and closure) to show rehabilitated areas are trending towards pre-disturbance landscape function based on comparison with control sites.
L2	Vehicle strike during construction	• Implementation of Fauna Management Plan • Maintenance of a fauna sightings and deaths register • Fauna handling and euthanasia procedures • Fauna caution traffic signage on haul road • Speed limits on roads used for Project activities • Personnel forbidden from feeding or harassing wildlife.	All sick and injured fauna are managed as per the requirements of the Animal Welfare Act 1985	• Opportunistic visual observations and reporting of dead or injured fauna, with incident investigation (recorded within Iluka Incident Management System, Cintellate) of the occurrence of dead or injured fauna demonstrate compliance with the requirements of the Animal Welfare Act where animal is sick or injured as a result of mining operations.
			No net adverse impacts from site operations on native fauna abundance or diversity within the lease areas and adjacent areas	• Mine records and investigations (recorded within Iluka Incident Management System, Cintellate) of fauna deaths demonstrate that the Mine Operator did not cause or could not have reasonably prevented injuries or deaths from occurring.
L3	Land clearance. Impact on fauna	• Implementation of Fauna Management Plan • Fauna handling and euthanasia procedures • Implementation of a Native Vegetation Management Plan • Provision of SEB • Fauna proof fencing installed around long-term open water storage areas • Avian fauna proof screen installed on freshwater tanks • Fauna escape matting or exit ramps installed in all open water areas • Daily inspection of potential fauna traps within Project Area e.g. ponds and trenches • Personnel forbidden from feeding or harassing wildlife. • Maintenance of a fauna sightings and deaths register • Fauna monitoring as per the Fauna Management Plan • Progressive rehabilitation of disturbed areas, commencing within first few years of operation. • All open water storage facilities infilled and closed at mine closure	No net adverse impacts from site operations on native fauna abundance or diversity within the lease areas and adjacent areas	• Biennial fauna surveys demonstrate fauna diversity and abundance in impact areas Is comparable with control sites, in consideration of baseline conditions (EBS 2014, 2019, ELA 2021). • Mine records and investigations (recorded within Iluka Incident Management System, Cintellate) of fauna deaths demonstrate that the Mine Operator did not cause or could not have reasonably prevented injuries or deaths from occurring.

Impact ID	Impact	Control measures	Proposed outcome	Draft Outcome Measurement Criteria
L4	Vehicle strike during operation	As per L2	As per L2	As per L2
L5	Increase in weed diversity and/or abundance	• Inspect for pest plants ahead of vegetation clearance to prevent transfer of pest plants to stockpiles • Minimisation of disturbance areas • Ensure road building material is not brought in from an area where pest plants may be present • Implementation of vehicle and equipment hygiene / wash down procedure • Regularly monitor disturbance areas for presence of pest plants • Reporting of pest plant sightings via internal reporting system and reporting requirements highlighted in site induction program • Implement targeted pest species management for observed significant increases in distribution or abundance or presence of new pest species • Implementation of Pest Species Management Plan	No introduction of new weeds, plant pathogens or pests, nor increase in abundance of existing weed or pest species in the lease area and adjacent areas caused by mining operations	• Annual weed survey (after winter rainfall) undertaken, demonstrates no introduction of new weeds, plant pathogens or pests, nor increase in abundance of existing weed or pest species in the lease area and adjacent areas caused by mining operations, in comparison to baseline conditions (EBS 2014, 2019, ELA 2021). • Monthly field monitoring for the presence of weed species in disturbance areas (including soil stockpiles, road edges and mining infrastructure) demonstrates no introduction of new weeds, plant pathogens or pests, nor increase in abundance of existing weed or pest species in comparison to baseline conditions (EBS 2014, 2019, ELA 2021). • Opportunistic visual observations of weed species demonstrates no introduction of new weeds, plant pathogens or pests, nor increase in abundance of existing weed or pest species in comparison to baseline conditions (EBS 2014, 2019, ELA 2021). *Leading Indicator Criteria: Annual review of the pest flora survey and weed management register (comprising results of field monitoring and visual observations) considering trends that could indicate population increase or introduction of new weed species.* *Closure criteria: Following completion of active rehabilitation, and annually for a minimum of five years, a weed survey demonstrates weed species diversity and abundance at closure to be consistent with control sites in consideration of post-rehabilitation LFA surveys and baseline conditions (EBS 2014, 2019, ELA 2021).*
L6	Increase in pest predator species diversity and/or abundance	• Waste storage infrastructure is designed and maintained to prevent access by pest animal species • Ensure all waste and food storage containers are adequately sealed • Domestic animals prohibited on site • Prohibit feeding of wildlife • Reporting of pest plant sightings via internal reporting system and reporting requirements highlighted in site induction program • Implement targeted pest species management for observed significant increases in distribution or abundance or presence of new pest species • Implementation of Pest Species Management Plan	No increase in abundance of pest animal species in the lease area and adjacent area caused by mining operations	• Biennial fauna survey demonstrates no increase in abundance of pest animal species in the lease area and adjacent area caused by mining operations, in comparison to baseline conditions (EBS 2014, 2019, ELA 2021). • Monthly field monitoring of the presence of pest animal species, including warrens and tracks (including soil at stockpiles, road edges and mining infrastructure) demonstrates no increase in abundance of pest animal species in the lease area and adjacent area caused by mining operations, in comparison to baseline conditions (EBS 2014, 2019, ELA 2021). • Opportunistic visual observations of the presence of pest species demonstrates no increase in abundance of pest animal species in the lease area and adjacent area caused by mining operations, in comparison to baseline conditions (EBS 2014, 2019, ELA 2021). *Leading Indicator Criteria: Annual review of register of pest animal sightings considering trends that could indicate population increase.* *Closure criteria: Following completion of active rehabilitation, and annually for a minimum of five years, a weed survey demonstrates pest animal abundance at closure to be consistent with control sites in consideration of baseline conditions (EBS 2014, 2019, ELA 2021).*

Impact ID	Impact	Control measures	Proposed outcome	Draft Outcome Measurement Criteria
L7	Increase in pest herbivore species diversity and/or abundance	As per L6	As per L6	As per L6
L8	Increased pathogens risk to fauna	• Monitor for signs of pathogens	As per L3	As per L3
L9	Increased pathogens risk to flora	As per L8	As per L5	As per L5
L10	Risk to flora and fauna resulting from baiting	• Use of sealed baiting stations • Regular checks of bait stations	As per L2	As per L2
L11	Risk to flora and fauna resulting from increased frequency and/ or intensity of fire	• Implementation of a Native Vegetation Management Plan • Maintenance of firebreaks • Implementation of a Fire Risk Management Plan • Observation of fire ban rules • Hot works permitting system • Annual vegetation fire load and bushfire risk assessment • Annual field based site fire risk audit • Fire suppression systems installed • Site based emergency response team and firefighting equipment.	No uncontrolled fires caused by mining operations	• Fire incidents caused by mine operations are recorded in Iluka incident management system (Cintellate) with trends reviewed annually and investigated as required. • Mine records and investigations (recorded within Iluka Incident Management System, Cintellate) of fires demonstrate that the Mine Operator did not cause or could not have reasonably prevented fires from occurring.
L13	Erosion	• Implementation of Native Vegetation Management Plan • Implementation of Rehabilitation Management Plan • Implementation of Dust and Air Quality Management Plan • Implementation of Surface Water Management Plan • Progressive rehabilitation of disturbed area commencing within first few years of operation • Annual stockpile monitoring • Restricting access to stockpiles • Prohibiting topsoil and subsoil stripping when winds exceed 20km/h	Soil profile and function is restored and capable of supporting agreed land use	• Annual GIS comparison of approved clearance boundary and actual clearance boundary demonstrates vegetation is within authorised clearance boundaries (annual SEB reconciliation report) • Annual report demonstrates progressive rehabilitation • Mine records (Cintellate) demonstrate soil stripping has not been conducted during high wind periods (>20km/h)
L14	Final landforms do not support landscape function	• Implementation of a Rehabilitation Management Plan • Procedures for stockpiling and stockpile maintenance • Direct return of topsoil and subsoil where possible • Restricting access to stockpiles • Direct seeding of rehabilitated areas	As per L13	• Monitoring records show that all disturbed land has topsoil reinstated and is revegetated progressively to achieve the aims of the Mine Rehabilitation Plan.

Impact ID	Impact	Control measures	Proposed outcome	Draft Outcome Measurement Criteria
A1	Dust during clearing	• Dust and Air Quality Management Plan • Native Vegetation Management Plan • Mineral Stockpiles Management Plan • Rehabilitation Management Plan • Weather forecast and field suppression plans • Traffic management restrictions • Suppression and stabilisation procedures • Suppression and stabilisation using potable water, reclaimed B-class wastewater, saline water, clay slimes and commercial sealants • Procedures for progressive rehabilitation of disturbed areas • Procedures for vegetation clearance and removal of soil profiles for stockpiling or direct return • Procedures for stabilisation of rehabilitation areas and soil stockpiles • Gravimetric dust deposition monitoring • Vegetation Clearance Procedure • Timing and management of clearance to minimise erosion • Minimisation of open areas through stage clearing • Site induction inclusive details on dust risks and management • Dust and air quality awareness training • Loss Control reporting system	As per L1 All clearance of native vegetation is authorised under appropriate legislation	As per L1
A2	Dust during operation	As per A1	As per A1	As per A1
A5	Artificial lighting	• Start with natural darkness and only add light for specific purposes • Light only the object/areas intended – keep lights as close to the ground as possible, directed and shielded to avoid unnecessary light spill • Use the lowest intensity lighting appropriate for the task	As per L3	Periodic inspections of lighting are undertaken as required to ensure controls are adequate. As per L3
A6	Increased noise	• Equipment to be turned off or throttled down when not in use • Noise reduction devices such as mufflers will be fitted and will operate effectively • Equipment will be serviced regularly and equipment in need of repair will not be used	As per L3	As per L3
W1	Affect on surface water	• Implementation of Rehabilitation Plan to ensure progressive rehabilitation of landform • Separation of overland surface water flows originating from undisturbed areas of the Project away from disturbed areas. • Sumps will be used to capture and hold stormwater within a working pit	Post mining ecosystem and landscape function is resilient, self-sustaining and indicating that the pre-mining ecosystem and landscape function will ultimately be achieved	Annual monitoring records show no vegetation community change as a result of changes to surface water flows.

8. EPBC Act listed species – significant residual impact assessment

This section discusses the potential for significant residual impacts (SRI) on MNES to remain after all mitigation / control measures discussed in Section 6 have been applied. The method of this SRI assessment is as per the MNES Significant Impact Guidelines 1.1 (DoE, 2013).

8.1 Ooldea Guinea-flower

Table 7-2 shows an assessment of the potential SRI on Ooldea Guinea-flower. This assessment shows that there are no significant residual impacts to Ooldea Guinea-flower expected as a result of the Project.

Table 8-A Assessment of significant residual impacts on Ooldea Guinea-flower

Significant impact criteria for a Vulnerable species	Assessment of impact to Ooldea Guinea-flower
Lead to a long-term decrease in the size of an important population of a species?	**No.** There is no population of this species within the Project Area. Pre-clearance inspections will ensure that no previously unrecorded individuals of this species are directly impacted during vegetation clearance. The nearest patch of Ooldea Guinea-flower is approximately 1.5 km from the edge of the Project Area, and 5.5km from the edge of the Conceptual Footprint. No indirect impacts such as light or dust are expected to reach this location. Control of feral animal species will be undertaken to ensure that there is no increase in grazing pressure as a result of the Proposed Action.
Reduce the area of occupancy of an important population?	**No.** The AOO of the population is located outside of the Project Area will not be impacted by the Proposed Action.
Fragment an existing important population into two or more populations	**No.** There are two sub-populations to the northeast of the Project Area. The Proposed Action will not impact on, nor fragment these two populations.
Adversely affect habitat critical to the survival of a species	**No.** The area of disturbance within the Conceptual Footprint is not considered to be habitat critical to the survival of the species as it does not currently contain Ooldea Guinea-flower and does not contain all the habitat elements to support the species. Land to the northeast of the Project Area would be considered critical to the survival of the species and whilst this will not be directly impacted, indirect impacts on this habitat have been considered. The mitigation measures discussed in Section 6 including weed control (with a focus on Buffel grass) will ensure that there are no adverse impacts on this critical habitat.
Disrupt the breeding cycle of an important population	**No.** The nearest population is outside of the Project Area and the Proposed Action will not disrupt the breeding cycle of that population.

Significant impact criteria for a Vulnerable species	Assessment of impact to Ooldea Guinea-flower
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** The Proposed Action will result in the loss of a maximum of 797 ha of potentially suitable (but suboptimal) habitat for Ooldea Guinea-flower. This represents approximately 0.12% of the suitable habitat within the region. The loss of such a small proportion of suitable habitat will not cause the species to decline.
Result in an invasive species that are harmful to a vulnerable species becoming established?	**No.** A weed control program will be undertaken to ensure that there is no increase in the type or abundance of weed species within the Project Area. Particular attention will be paid to the control of Buffel grass which is a known competitor to Ooldea Guinea-flower.
Introduce disease that may cause the species to decline	**No.** There are no known diseases that affect the species.
Interfere substantially with the recovery of the species	**No.** There is no current management plan or recovery plan for the species.

8.2 Malleefowl

The EPBC Act Significant Impact Guidelines require that a consideration the definition of an 'important population' for species listed as Vulnerable. However no particular populations or general areas is deemed of greater importance for the long-term survival of Malleefowl than any other at this stage (Benshemesh, 2007). Hence for this assessment the phrase 'important population' is considered to refer to any population of this species.

Table 7-3 shows an assessment of the potential SRI on Malleefowl. This assessment shows that there are no significant residual impacts to Malleefowl expected as a result of the Project.

Table 8-B Assessment of significance of potential impacts to Malleefowl

Significant impact criteria for a Vulnerable species	Assessment of impact to Malleefowl
Lead to a long-term decrease in the size of an important population of a species?	**No.** As discussed above, there are no particular populations of Malleefowl that are considered to be an 'important population' for this species (Benshemesh, 2007). Targeted surveys have shown a low density of breeding mounds to the northeast of the Conceptual Footprint in the mallee dominated sand dunes. The only record of historical breeding within the Conceptual Footprint is one inactive nest at the northeastern extent (close to the better-quality habitat outside of the disturbance area). The only record across the rest of the disturbance area is a track in marginal habitat in the centre of the Conceptual Footprint. Assuming that breeding habitat suitable for this species can be recreated during rehabilitation, the clearing of the vegetation within the Conceptual Footprint (and when including cumulative impacts from JA) would cause the temporary removal of 1,632 ha of habitat potentially suitable for nesting Mallefowl, and 1,717 ha of marginal habitat suitable for foraging and dispersal. However, as discussed, the Conceptual Footprint is on the ecotone of the habitats that provide good quality breeding habitat (mallee associations on sand dunes), and those that are not optimal for breeding (open woodlands and tall shrub). To the northeast of the Proposed Action there is extensive areas of mallee covered sand dunes with greater cover and depth of leaf litter that would provide greater quality breeding habitat. Hence the clearing of the habitat within the Conceptual Footprint is likely to cause movement of any individuals using this area into the surrounding higher quality habitat. Due to the low density and transient nature of this species, this movement is unlikely to cause disturbance to the population in the surrounding area. Hence the size of the local population in the region will not be impacted by the short-medium term loss of habitat. Potential indirect impacts include the possibility of vehicle strike during clearing, construction and operational phases of the Proposed Action. Due to the low numbers of Mallefowl expected to be transiently within the Conceptual Footprint, and the shy nature of this species, it is considered unlikely that they will encounter vehicles on the access roads, however mitigation measures such as speed limits and fauna sighting registers will be implemented (refer to Section 6). Care will be taken to ensure that Malleefowl are not impacted during clearing activities, including a pre-clearance inspection and presence of a spotter-catcher during clearing (refer to Section 6).

Significant impact criteria for a Vulnerable species	Assessment of impact to Malleefowl
Reduce the area of occupancy of an important population?	**No.** The AOO for Malleefowl within a 40 km buffer of the Conceptual Footprint is 5,112 ha (ALA, 2022). This entire area is outside of the Conceptual Footprint therefore the clearing of this habitat would not reduce the AOO of the local population. There are signs of Malleefowl that have been recorded within the Conceptual Footprint (tracks and one inactive mound) that are not considered within the AOO assessment as they are not direct records for the species. If these were used as data points for the calculation, then there would be a small temporary decrease in the AOO due to clearing. As no population of Malleefowl is considered more important than any other, and as any reduction in habitat would be temporary, this is not considered a significant impact.
Fragment an existing important population into two or more populations	**No.** There is confirmed presence of Malleefowl to the north-east of the Proposed Action within the mallee dominated sand dunes. However, the Conceptual Footprint is located on the edge of this habitat type and partially within the adjacent habitat of Nullabor plains habitat. There are no records of this species within the Nullabor habitat type. Hence any disturbance as a result of the Proposed Action would occur on the edge of the population extent and hence will not fragment a population.
Adversely affect habitat critical to the survival of a species	**No.** Whilst habitat critical to the survival of the species is not formally defined for Malleefowl, in the context of the Proposed Action it is reasonable to conclude given the higher quality of the habitat to the northeast of the Conceptual Footprint with associated deep leaf litter rafts, that would be the critical habitat, rather than the more marginal habitat within the footprint itself. The loss of habitat for the local population would not be permanent as the rehabilitation will aim to recreate the mallee dominated vegetation that they require for breeding. The species is known to prefer mature mallee that has not been impacted (e.g., by fire) for at least 30 years as breeding habitat due to the availability of leaf litter and shrub density. The short -medium term loss of suboptimal habitat for the species will not affect the survival of the species as the species is likely to temporarily re-locate to the optimal habitat to the northeast until the revegetation is suitably mature.
Disrupt the breeding cycle of an important population	**No.** As discussed above, the optimal breeding habitat for this species is located to the northeast in the mallee dominated sand dunes. The breeding habitat within the Conceptual Footprint is likely suboptimal in the north and unsuitable in the south due to the lack of the required deep leaf litter rafts. Movement of Malleefowl during the breeding season is likely to be restricted to within 1 km of the nest chamber (Stenhouse & Moseley, 2018), hence the Proposed Action is unlikely to impact on the individuals using the habitat to the northeast of the area of disturbance. Whilst some tracks have been found within the Project Area, it is unlikely that these are important dispersal corridors as they lead to the unsuitable plains areas. The birds are more likely to disperse to the northeast to more suitable habitat.

Significant impact criteria for a Vulnerable species	Assessment of impact to Malleefowl
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** There will be a short – midterm reduction in the availability of the suboptimal habitat available within the Conceptual Footprint. Rehabilitation will progressively reinstate the same mallee dominated habitats as those that currently occur on the land so there will be no long-term permanent loss, modification or isolation of habitat. However, it is known that Malleefowl preferentially use habitat that has not been impacted for 30 or more years and hence there may be a time lag between the revegetation of the land and use by the species. Multiple surveys within the Project Area have shown that the Conceptual Footprint is suboptimal habitat for Malleefowl and is likely to be used transiently by a small number of individuals. The temporary loss of 1,632 ha of potential habitat across both the Proposed Action and adjacent J-A mine is unlikely to affect breeding, as 1,505,874ha of potentially suitable habitat is available adjacent to the Project Area. As Malleefowl are known to use a wide variety of food resources that are transient, widespread and patchily distributed, the cumulative loss of 0.11% of suboptimal habitat will not cause a decline in the species.
Result in an invasive species that are harmful to a vulnerable species becoming established?	**No.** Invasive species are known to be a key threat to Malleefowl. Species such as foxes and to a lesser extent feral cats predate on the species, whilst introduced herbivores such as feral goats and rabbits compete for food resources. Foxes, feral cats and rabbits are all established and have been recorded within the Conceptual Footprint. The Proposed Action is unlikely to increase the abundance of these species and may decrease their numbers due to the mitigation measures implemented. Whilst increased light may increase predation, the mitigation measures discussed in Section 6 will ensure that the impacts of lighting are minimised. A weed control program will be undertaken to ensure that there is no increase in the type or abundance of weed species within the Project Area. Particular attention will be paid to the control of Buffel grass which is a potential threat to Malleefowl habitat.
Introduce disease that may cause the species to decline	**No.** There is no information on disease in Malleefowl populations (DCCEEW, 2019).
Interfere substantially with the recovery of the species	**No.** The Malleefowl Recovery Plan objectives are to reduce habitat loss, reduce grazing pressures, reduce fire threat, reduce predation, reduce isolation and fragmentation and reduce mortality on roads. All of these factors have been considered within this table and has been concluded that they will not have a significant impact on this species. There has been considerable research and monitoring of Malleefowl populations which has shown that the rate of decline in numbers has decreased, but overall numbers continue to fall (DCCEEW, 2019). The temporary loss of a small area of suboptimal habitat (0.10%) will not interfere substantially with the recovery of the species.

8.3 Sandhill Dunnart

Table 7-4 shows an assessment of the potential SRI on Sandhill Dunnart. This assessment shows that there are no significant residual impacts to Sandhill Dunnart expected as a result of the Project.

Table 8-C Assessment of significance of potential impacts to Sandhill Dunnart

Significant impact criteria for an Endangered species	Assessment of impact to Sandhill Dunnart
Lead to a long-term decrease in the size of a population of a species?	**No.** Several targeted surveys have failed to record Sandhill Dunnarts within the Conceptual Footprint. Although the species is known to be trap-shy, they were caught outside of the Conceptual Footprint during the 2014 survey (four individuals). There was one old burrow that may have been that of Sandhill Dunnart (unconfirmed) recorded within a Triodia clump on the northern edge of the Conceptual Footprint in 2021. Surveys for Sandhill Dunnart completed within the adjacent Yellabinna Regional Reserve indicate that they are likely to be restricted to the northwest portion which is northeast of the Project Area in areas of relatively dense and continuous Triodia cover. Assuming that habitat suitable for this species can be recreated during rehabilitation, the clearing of the vegetation within the Conceptual Footprint would cause the temporary removal of 1,179 ha of potentially suitable habitat, and 800 ha of marginal habitat for Sandhill Dunnart. However, as discussed, the Conceptual Footprint is on the ecotone of the habitats that provide good quality breeding habitat (mallee associations over spinifex on a sandy substrate), and those that are not optimal for breeding (open woodlands and tall shrub lacking spinifex understorey). To the northeast of the Proposed Action there are extensive areas of sand dunes with spinifex cover that would provide greater quality breeding habitat and are known to support Sandhill Dunnart due to surveys completed within the Reserve. Hence the clearing of the habitat within the Conceptual Footprint is likely to cause movement of any individuals using this area into the surrounding higher quality habitat. Due to the low density and transient nature of this species, this movement is unlikely to cause disturbance to the population in the surrounding area. Hence the size of the population in the region will not be impacted by the short-medium term loss of habitat. Potential indirect impacts include the possibility of vehicle strike during clearing, construction and operational phases of the Proposed Action. Due to the low numbers of Sandhill Dunnart expected to be transiently within the Conceptual Footprint, and the shy nature of this species, it is considered unlikely that they will encounter vehicles on the access roads, however mitigation measures such as speed limits and fauna sighting registers will be implemented (refer to Section 6). Care will be taken to ensure that Sandhill Dunnart are not impacted during clearing activities, including a pre-clearance inspection, staged vegetation clearing and presence of a spotter-catcher during clearing (refer to Section 6).

Significant impact criteria for an Endangered species	Assessment of impact to Sandhill Dunnart
Reduce the area of occupancy of a species?	**No.** The closest record for the Sandhill Dunnart is from 2014 located approximately 2 km to the northeast of the Conceptual Footprint. Whilst it is acknowledged that Sandhill Dunnarts can move up to 2 km in two hours if required, their known foraging range is only 200-300 m. The species has more often been recorded in the habitat to the northeast of the Project Area within Yellabinna Regional Reserve and the Conceptual Footprint is more likely to be suboptimal foraging habitat due to the sparsity of Triodia coverage. The temporary loss/ short-medium term loss of 1,979 ha of suboptimal foraging habitat that is well connected to better quality habitat is unlikely to permanently reduce the AOO of the species.
Fragment an existing population into two or more populations	**No** The population of Sandhill Dunnart is located primarily to the northeast of the Conceptual Footprint within Yellabinna Regional Reserve where there are more records of the species. The Conceptual Footprint is a discrete area and as such will not fragment habitat in the same way that linear infrastructure would. Sandhill Dunnart are highly mobile, and can circumnavigate the Concept Footprint if required.
Adversely affect habitat critical to the survival of a species	**No.** Due to the availability of better-quality habitat to the northeast of the Project Area within Yellabinna Regional Reserve, it is unlikely that the habitat within the Conceptual Footprint is critical to the survival of the species due to the sparsity of Triodia coverage 1,979 ha of potential habitat may be impacted by the Proposed Action, including 1,179 ha of good quality habitat and 800 ha of marginal habitat. This habitat occurs as patches between and on top of dunes, interspersed with habitat that is not considered suitable for the species. Assuming that targeted revegetation of habitat for Sandhill Dunnart is successful, the short – medium term loss of this habitat which represents 0.12% of that available in the surrounding area, is unlikely to adversely impact the species.
Disrupt the breeding cycle of a population	**No.** Despite targeted surveys since 2014, there is no evidence that Sandhill Dunnart is breeding within the Conceptual Footprint with only one old disused burrow (unconfirmed as being that of Sandhill Dunnart) recorded on the northeastern boundary of the Conceptual Footprint.

Significant impact criteria for an Endangered species	Assessment of impact to Sandhill Dunnart
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** Ground-truthed vegetation mapping indicates potentially suitable *Triodia* (spinifex) habitat for Sandhill Dunnart is located throughout much of the Project Area where the dunal areas persist, grading to unsuitable in the southwestern areas where the dunal areas grade to the plains. However the density of Triodia is sparse and does not constitute the dense and continuous Triodia coverage required by the species. Habitat that is potentially suitable for the species occurs as discontinuous patches both between and on the top of dune crests, interspersed with non-sandy habitat types that are unsuitable for the species. When considered in the context of the 1,534,082ha of suitable habitat within Yellabinna Regional Reserve, the temporary short-midterm loss of 1,979 ha of suboptimal habitat (0.12%) is unlikely to cause a decline in Sandhill Dunnart.
Result in an invasive species that are harmful to an endangered species becoming established?	**No.** A weed control program will be undertaken to ensure that there is no increase in the type or abundance of weed species within the Project Area. Particular attention will be paid to the control of Buffel grass which is a known threat to Sandhill Dunnart habitat. Invasive species are known to be a key threat to Sandhill Dunnart. Species such as foxes and to a lesser extent feral cats predate on the species. Foxes, feral cats and rabbits are all established and have been recorded within the Conceptual Footprint. The Proposed Action is unlikely to increase the abundance of these species and may decrease their numbers due to the mitigation measures implemented. Whilst increased light may increase predation, the mitigation measures discussed in Section 6 will ensure that the impacts of lighting are minimised.
Introduce disease that may cause the species to decline	**No.** Feral cats are known to be established within the Project Area and hence although toxoplasmosis and sarcoptic mange have the potential to impact Sandhill Dunnart, the Proposed Action is unlikely to introduce disease that is not already present within the Project Area.
Interfere substantially with the recovery of the species	**No.** There is a recovery plan in place for the Sandhill Dunnart and few of the recovery actions in that plan are relevant to the Project. The approved conservation advice for the species lists conservation and management actions, none of which are contradictory with the Project. The loss of habitat associated with the Project is small relative to what is available and of higher value in the Project Area and region and no individuals of the species have been recorded near the Conceptual Footprint. Therefore, the Project is not considered likely to interfere substantially with the recovery of the species

9. Conclusion

This assessment shows that the Project has the potential to cause impacts to native flora and fauna. The mechanisms by which these may occur include:

- Vegetation clearing;
- Vehicle strike;
- Pathogens or toxins;
- Pests and weeds;
- Changes in fire regime;
- Erosion of soil;
- Altered landforms;
- Noise, light and dust;
- Changes in surface water flows.

There are nine birds, one reptile and four plant species listed only under the NPW Act (excluding those that are listed under both the NPW Act and EPBC Act) that may be impacted by the above potential impacts, whilst one bird, one mammal and one plant listed under the EPBC Act may also be impacted.

Control measures including avoidance, minimisation and control measures will be used to reduce the risk of impacts on flora and fauna species. When implemented, the risk of impacts to native ecology (including NPW listed species) is reduced to an acceptable level as shown in Table 7-1. There are no potential impacts that cannot be reduced to an acceptable level by the use of the control measures.

A Significant Residual Impact assessment under the EPBC Act Guidelines was completed for the three EPBC-listed species. This assessment concluded that there are no significant residual impacts on any of the three listed species expected as a result of the Project.

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Appendix A Likelihood of occurrence assessment

An assessment of the likelihood of occurrence was undertaken for the threatened and migratory species identified from the database search. This assessment was undertaken for the search area only. It was based on database or other records and presence of suitable habitat (or absence).
Information within this assessment is based on combination of NatureMaps, ELA and EBS Ecology surveys and the ELA prepared Atacama EPBC referral.

The terms used for likelihood of occurrence are defined below:

- Known = the species was or has been observed within the search area;
- Likely = a medium to high probability that a species uses the area;
- Potential = suitable habitat for a species occurs within the search area, but that is insufficient information to categorise the species as likely to occur, or unlikely to occur;
- Unlikely = a very low to low probability that a species occurs within the search area; and
- No = habitat within the search area and surrounding areas is unsuitable for species.

Key to the table:

- CE = Critically Endangered;
- E = Endangered;
- Ex = Extinct;
- R = Rare;
- V = Vulnerable; and
- M = Migratory (EPBC Act).

Table A 1: Likelihood assessment for the Commonwealth (EPBC) and State (NPW) listed fauna and flora species within the Project Area.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Birds									
Aves	*Acanthiza iredalei iredalei*	Slender-billed Thornbill (western)		R	12	2014	*Sclerophyll* heathland and *chenopod* shrubland dominated by samphire, *Maireana* spp. (bluebush) or *Atriplex* spp. (saltbush)	Likely	Recorded within 20 km buffer to south-west on 3 occasions in 2014
Aves	*Actitis hypoleucos*	Common Sandpiper	M		0	-	Mainly inhabits wetlands found on the coast, but occasionally will also inhabit inland wetlands. Commonly found in areas of muddy margins or rocky shores where they forage with protection of obstacles from varying substrates.	Unlikely	Typical wetland habitats are absent from the Project Area and there are no records of the species within the proposed Atacama ML or a 20 km buffer area surrounding the proposed ML.
Aves	*Apus pacificus*	Fork-tailed Swift	M		0	-	As an almost exclusively aerial birds, flying from < 1 m to at least 300 m above ground, the Fork-tailed Swift occurs mostly over inland plans, but also sometimes above foothills or coastal area. Their habitat tends to be dry and opens, including riparian woodlands and tea-tree swamps, low scrubs, heathland or saltmarsh treeless grasslands and sand plains covered with Spinifex, open farmlands and inland and coastal sand dunes.	Potential (aerial fly-over only)	Suitable habitat is available with the proposed Atacama ML, but the aerial tendency of the species is considered to result in it flying over only.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Aves	*Ardeotis australis*	Australian Bustard		V	17	2014	May occur in tussock grassland, *Triodia* hummock grassland, grass woodlands, low shrublands or savannas. May also occupy structurally homogeneous manmade habitats or wetlands, but these habitats are of lesser importance. Dense vegetation recently exposed by recent burning also used and boundaries between open grasslands and denser shrublands and woodlands used for laying eggs.	Known	Recorded within proposed ML and 20km buffer in 2014.
Aves	*Calidris acuminata*	Sharp-tailed Sandpiper	M		-	-	Muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland. They also occur in salt works and sewage farms and use flooded paddocks, sedge lands and other ephemeral wetlands, but leave when they dry. They use intertidal mudflats in sheltered bays, inlets, estuaries and seashores, and also swamps and creeks lined with mangroves. They tend to occupy coastal mudflats mainly after ephemeral terrestrial wetlands have dried out, moving back during the wet season.	Unlikely	Typical wetland habitats are absent from the Project Area and there are no records of the species within the Atacama ML or a 20 km buffer area surrounding the ML.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Aves	*Calidris melanotos*	Pectoral Sandpiper	M		-	-	Either fresh or saline shallow wetlands, usually in coastal or near-coastal habitats. Prefers areas with low, emergent, or fringing vegetation with open fringing mud flats. During the non-breeding season, the species occurs mainly in the eastern part of Australia.	Unlikely	Typical wetland habitats are absent from the Project Area and there are no records of the species within the Atacama ML or a 20 km buffer area surrounding the ML.
Aves	*Charadrius veredus*	Oriental Plover	M		-	-	Outside of breeding grounds, this species prefers coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands.	Unlikely	No suitable habitat occurs in the Project Area and there are no records of the species within the Atacama ML or a 20 km buffer area surrounding the ML.
Aves	*Cinclosoma castanotus*	Chestnut Quail thrush		R	1	2019	*C. castanotus* is largely mallee-dependent and is found in the Great Victoria Desert (GVD) into the central Australian Ranges chiefly on sandy substrates (Black and Walker 2006).	Known	Recorded by EBS in 2019 within the project area
Aves	*Falco hypoleucos*	Grey Falcon	V	R	-	-	The species occurs in arid and semi-arid Australia, including the Murray-Darling Basin, Eyre Basin, central Australia and Western Australia (Marchant and Higgins 1993). The Grey Falcon occurs at low densities across inland Australia (BirdLife International 2019). The species frequents timbered lowland plains, particularly *Acacia* shrublands that are crossed by tree-lined water courses.	Unlikely	Species in not know from records within 50km of the Project Area. It is unlikely that the species would utilise the project area for breeding or frequent utilisation.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Aves	*Falco peregrinus*	Peregrine Falcon		R	1	2014	Occurs across a range of habitats ranging from woodlands to open grasslands and coastal cliffs, but infrequent in desert regions.	Known	Recorded with Project Area in 2014
Aves	*Hieraaetus morphnoides*	Little Eagle		V	5	2014	Occur in woodlands and open forests extending into the arid zone.	Likely	Records within ML and 20 km buffer in 2012 and 2014 with suitable habitat in the ML for the species.
Aves	*Leipoa ocellata*	Malleefowl	V	V	9	2019	Semi-arid or arid shrublands and low woodlands, preferentially when dominated by mallee and/or acacias. Sandy substrates and abundant leaf litter are requirements for breeding.	Known	Species or species habitat known to occur within area, was recorded during survey (EBS 2019a).
Aves	*Lophochroa leadbeateri*	Major Mitchell's Cockatoo		V	3	1987	Occur in various timbered habitats in semi-arid and arid regions. Inhabit mallee *Eucalyptus* – *Callitris* – *Casuarina* assemblages, stands of riparian *Eucalyptus camaldulensis* or *E. largiflorens*, sandplains. Dunes, *Acacia* shrubland with *Triodia*, grassland savanna, open saltbush, bluebush or *Chenopod* shrublands or *Banksia* heathlands.	Likely	Suitable habitat in the Project Area and historical records for the species within the 20 km buffer, but not in the ML.
Aves	*Motacilla cinerea*	Grey Wagtail	M		-	-	Fast-flowing mountain streams and river with riffles and exposed rocks or shoals (often in forested areas).	Unlikely	Typical wetland habitats are absent from the Project Area and there are no records of the species within the Atacama ML or a 20 km buffer area surrounding the ML.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Aves	*Motacilla flava*	Yellow Wagtail	M		-	-	Damp or wet habitats with low vegetation including damp meadows, waterside pastures, marshes and grassy tundra.	Unlikely	Typical wetland habitats are absent from the Project Area and there are no records of the species within the Atacama ML or a 20 km buffer area surrounding the ML.
Aves	*Myiagra inquieta*	Restless Flycatcher		R	3	2014	Open forest and woodlands and frequently occurring on farmland.	Known	Recorded within the project area in 2014 (EBS 2015).
Aves	*Neophema splendida*	Scarlet-chested Parrot		R	3	2014	Opens woodlands of E*ucalyptus*, she-oak and mulga with a spinifex and saltbush understorey.	Known	Recorded within ML in 2014
Aves	*Pachycephala inornata*	Gilbert's Whistler		R	1	2013	Often occurs in mallee shrublands associated with an understorey of spinifex and low shrubs such as wattles, hakeas, sennas and hop-bushes, but also found in box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests. In woodlands habitats this species is often found with areas containing dense patches of shrubs in the understorey, particularly where *Callitris* pine regrowth occur in thickets. *Exocarpus* parasitic species or other dense shrubs such as Lignum and wattles also appear to be important in Belah and Red Gum communities.	Likely	Recorded outside proposed ML to west in 2013

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Aves	*Pezoporus occidentalis*	Night Parrot	E	E	0	-	Limited information is available, but most records indicate they occur in *Triodia* dominated grasslands or *chenopod* shrublands in arid and semi-arid regions, but they have also been observed in association with *Astrebla* spp., *shrubby samphires*, chenopod associations, scattered trees and shrubs, *Acacia aneura woodland*, treeless areas, bare gibber, *Triodia longiceps* dominated slopes and *duricrust* plateau margins or with *Sclerolaena* spp., *Maireana* spp., *Ptilotus* spp., small areas of *Triodia longiceps* and occasional watercourse with surrounding *Acacia cambagei*.	Unlikely	There are no records of this species within 300 km of Project Area and no detection during targeted surveys. EPBC assessment has presumed absent within area.
Mammals									
Mammalia	*Sminthopsis psammophila*	Sandhill Dunnart	E	V	110	2014	Semi-arid and arid zone with sandy substrate in southern central Australia, especially where sand dunes containing vegetation dominated by *Triodia* occurs.	Known	Species and species habitat known to occur within area, species recorded during surveys (EBS 2019a).
Reptiles									
Reptilia	*Neelaps bimaculatus*	Western Black-naped Snake		R	1	2012	May occur in temperate forests and temperate, subtropical or tropical dry shrublands and grasslands where these occur on sandy substrate. Also found in coastal dune and the Great Victoria Desert.	Potential	Recorded within 20 km buffer in 2012 to the south.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Reptilia	*Varanus brevicauda*	Short-tailed Pygmy Goanna		R	1	2010	Ground-dwelling fossorial species predominantly inhabiting sandy desert areas covered by spinifex grasses, but which may also be supported by suitable subtropical or tropical dry grassland habitat.	Unlikely	Recorded near edge of 20 km buffer to north in 2010, however this is now considered likely to have been incorrectly identified based on discussions with the South Australia Museum (M. Hutchinson, pers comm, 2012). Other records are limited to far north South Australia.
Flora									
Equisetopsida	*Corynotheca licrota*	Sand Lily		R	1	2013	Grows on sand dunes or sand plains in association with *Triodia* and mallee communities.	Potential	Recorded once north of the ML within a 20km buffer area.
Rosopsida	*Gratwickia monochaeta*	-		R	9	2014	Predominantly found in red and yellow sandy soils of sand planes, swales and sand ridges, but also may be found in sandy loam, calcareous clay soils of plains and hillsides, sandy soils surrounding salt lakes, clay soils associated with granite outcrops and rocky creek beds and *Acacia aneura* and *Acacia papyrocarpa* woodlands and *Chenopod* shrubland.	Known	Recorded four times in the proposed ML and five times within a 20 km buffer around the proposed ML.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Magnoliopsida	*Hibbertia crispula*	Ooldea Guinea-flower	V	V	251	2014	Grows on red sand and known to occur in two disjunct locations in the Lake Everard region and the Ooldea region of South Australia. Potentially suitable habitat for the *Hibbertia crispula* includes the presence of mallee vegetation on dune crests and slopes.	Unlikely	Not recorded in the native vegetation clearance footprint or the survey area (EBS 2015, 2019a), or during extensive on ground searching of dune crest habitat within the proposed pit shell areas (proxy for land disturbance, as assessed in 2021, ELA 2022). Known from only two disjunct locations in South Australia, the Lake Everard region and the Ooldea region of South Australia. Local populations (approximately 3 km north and 9 km east of the survey area) occur on large, deep sand dunes (16-18 m), dominated by tall shrubland of *Hakea francisiana* and *Grevillea stenobotrya* with emergent *Callitris verrucosa* and *Eucalyptus capitanea*, over *Bossiaea walkeri*, *Thryptomene elliottii*, +/- *Leptospermum coriaceum, Triodia* spp. Only a few large, deep sand dunes in survey area (north-east, outside of the Proposed Action Area) grading down to low, flat broad sand dunes (2-5 m, south-west survey area), dominated by same dune crest community but with absence of *E. capitanea*, which local Ooldea Guinea-flower populations are known to co-occur with.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Equisetopsida	*Maireana suaedifolia*	Lax Bluebush		R	1	2010	Found on raised areas around salt lakes and on alluvial plains.	Unlikely	Recorded once north of the ML within a 20km buffer area and no suitable habitat in the Project Area.
Equisetopsida	*Melaleuca leiocarpa*	Pungent Honey-myrtle		R	2	2014	Grows in rocky, lateritic soils and red sand on hillslopes, outcrops and sandplains.	Known	Recorded twice in the ML by EBS in 2014.
Orchidaceae	*Pterostylis xerophila*	Desert Greenhood	V	V	-	-	Little is known of the precise habitat requirements of *P. xerophila*. In South Australia, *P. xerophila* occurs in dry woodland (mainly mallee) on fertile red loamy soils (Bates & Weber 1990), on or around granite or quartzite rock outcrops (Jessop & Toelken 1986).	Unlikely	3 plants known from Yellabinna Regional Reserve (Duncan 2010) however vegetation associations within the project are unlikely to support this species.
Equisetopsida	*Santalum spicatum*	Sandalwood		V	13	2012	Hemi-parasitic plant reliant on other plants roots that may grow on red sandy soils, among rocks. Occurs in various forest type ranging from woodlands to low open-woodlands and on loamy soils among rocks in woodland and tall shrubland.	Potential	Recorded thirteen times within a 20km buffer outside the ML, generally in the south west quadrant of the area; however, these 13 records are all recorded within 5 clustered populations.

Class	Scientific name	Common name	EPBC	NPW	# of records	Date of last record	Preferred habitat	Likelihood of occurrence	Rationale
Fabaceae	*Swainsona pyrophila*	Yellow Swainson-pea	V	R	-	-	The Yellow Swainson-pea occurs in mallee vegetation communities on a variety of soil types including well-drained sands, sandy loams and heavier clay loams. The only detailed habitat information is from South Australia, where the species was recorded from mallee woodland with *Eucalyptus species* including *E. brachycalyx, E. calycogona, E. dumosa, E. gracilis, E. incrassata, E. leptophylla, E. oleosa and E. socialis*, sometimes with *Broombush Melaleuca uncinata* tall shrubland.	Unlikely	No records within 50km of the Project Area, it is unlikely that the project area contains suitable habitat to support this species.

Information within this assessment is based on combination of NatureMaps, ELA and EBS Ecology surveys and the ELA prepared Atacama EPBC referral.

Appendix B Screening impact assessment

Environmental Element	Mine life phase	Potential impact event	Source	Pathway	Environmental Receptor	Impact ID	Sensitivity to Change	S-P-R linkage (Y/N)	Summary
LAND									
Native flora	Construction, Operation, Closure	Land clearance for construction of project infrastructure and/or rehabilitation causes a reduction of abundance and diversity of native flora.	Mining and rehabilitation	Land	Flora	L1		Yes	To enable the construction of the Project approximately 2,057 ha of native vegetation is proposed to be cleared, across nine vegetation associations. This may result in a decrease of abundance and/or diversity of native flora species. Threatened flora species recorded within the Atacama survey area will potentially be impacted by the vegetation clearance during the construction phase as suitable habitat for listed species occur within development footprint.
Native fauna	Construction, Operation, Closure	Use of machinery and vehicles during construction of project infrastructure and/or rehabilitation causes direct impacts to native fauna.	Mining and rehabilitation	Land	Fauna	L2		Yes	There is a potential for fauna species (including listed species) to be injured or killed due to vegetation clearance and soil removal operations if suitable habitat occurs within the disturbance footprint.
Native fauna	Construction, Operation, Closure	Land clearance for construction of project infrastructure and/or rehabilitation causes a loss of habitat and reduction of abundance and diversity of native fauna	Mining and rehabilitation	Land	Fauna	L3	Species may move to and from disturbance area during fluctuations in environmental conditions.	Yes	To enable the construction of the Project approximately 2,057 ha of native vegetation that provides habitat for a range of fauna species will be cleared. Potential habitat for threatened fauna species is present within the proposed disturbance footprint.
Native fauna	Operation	Transport of mineral extracts and personnel during mining activities causes direct impacts to native fauna.	Mining and rehabilitation	Land	Fauna	L4		Yes	There is a potential for fauna species (including listed species) to be injured or killed due to vehicle strike due to increased vehicle movements during mine operation.
Weeds	Construction, Operation, Closure	The project increases weed density, causing a reduction in the abundance and diversity of native flora.	Mining and rehabilitation	Land	Flora	L5		Yes	There are already a number of established weeds within the Project Area and surrounds. Project-related activities could result in an increase in the abundance and/or diversity of weeds, resulting in a decrease in habitat quality and potential impacts on listed species.
Pests	Construction, Operation, Closure	Altered landscapes allow for migration of pest species that out compete or predate native fauna reducing the abundance and diversity of native fauna species.	Mining and rehabilitation	Land	Fauna	L6		Yes	Project-related activities could result in an increase in the abundance and/or diversity of pest species within the ML. These pest species would impact on a range of fauna species (including listed species) due to the increased predation pressure.
Pests	Construction, Operation, Closure	Altered landscapes allow for migration of herbivore pest species consume native flora reducing the abundance and diversity of native flora species.	Mining and rehabilitation	Land	Flora	L7		Yes	Project-related activities could result in an increase in abundance and/or diversity of pest species in the area. These pest species would impact on a range of flora species (including listed species) due to increased grazing pressure. .

Environmental Element	Mine life phase	Potential impact event	Source	Pathway	Environmental Receptor	Impact ID	Sensitivity to Change	S-P-R linkage (Y/N)	Summary
Pathogens	Construction and operation	Human activity and/or increased pest species introduce pathogens or diseases leading to a reduction in the abundance and diversity of native flora and/or native fauna	Workforce	Air	Fauna	L8		Yes	Increased risk of pathogens transported into the Project Area through vehicle movement or increased pest species.
					Flora	L9		Yes	Project-related activities have the potential to increase the risk of pathogen transport into new areas.
Toxins/poison	Construction, operation and closure	The use of toxins as a method of pest control results in a reduction in the abundance and diversity of native flora and/or native fauna.	Hazardous materials	Land	Fauna and Flora	L10		Yes	The toxins used for these control measures can be fatal to flora and fauna species through direct contact or secondary poisoning. Pest control which uses toxins and poison as a method which are implemented at J-A and likely Atacama include: • Rodent baiting; • Rabbit baiting; • Weed spraying; • Insect bait stations; and • Snail baiting.
Fire	Construction and operation	Project related ignition sources result in accidental fires and in a reduction in the abundance and diversity of native flora and/or native fauna. Project construction results in changed fire regime leading to a reduction in the abundance and diversity of native flora and/or native fauna.	Unplanned events	Land	Fauna and flora	L11		Yes	Fire regimes important for habitat of many native fauna and flora species. Accidental fires or fire management practises can change the intensity and frequency of fires within the region and impact on the composition of vegetation communities.
Soil	Construction and operation	Chemical spills or leaks result in impacts to soils and a reduction in the abundance and diversity of native flora and/or native fauna.	Hazardous materials	Land	Flora and fauna	L12		No	Chemical spills or leaks, such as hydrocarbon spills, may result in a localised impact to soil quality and potentially native vegetation and fauna species which are in the immediate vicinity.
Surface water	Construction, operation and Closure	Erosion of topsoil (stockpiles, cleared areas) affecting habitat.	Mining and rehabilitation	Land/Surface water	Listed fauna and flora	L13		Yes	Erosion impacts habitat stability, development and can lead to dust deposition which impact existing habitat. Loss of seed resources in the topsoil can compromise rehabilitation success (e.g. succession of flora and in turn landscape stability).
Final landform	Closure	Final landforms do not support rehabilitation causing a permanent and on-going change to abundance and diversity of native flora and fauna.	Mining and rehabilitation	Land	Listed flora and fauna	L14		Yes	Some flora and fauna species require niche habitats with a series of key habitat requirements. It may not be possible to ensure that all of these habitat niches are reinstated in the landscape post mine closure.

Environmental Element	Mine life phase	Potential impact event	Source	Pathway	Environmental Receptor	Impact ID	Sensitivity to Change	S-P-R linkage (Y/N)	Summary
AIR									
Air quality	Construction and operation	Dust deposition during land clearance, extraction and processing of mineral resource cause reduction in the abundance and diversity of native flora.	Mining and rehabilitation	Air	Flora	A1		Yes	Open areas within the Project Area and Project-related activities will present an opportunity for dust generation. Increased dust generation within the atmosphere has the potential to smother vegetation which can reduce the plant growth or cause death to the existing vegetation (decreasing habitat quality).
Air quality	Operation	Dust deposition generated from mine site vehicles (including heavy vehicles) cause reduction in the abundance and diversity of native flora.	Mining and rehabilitation	Air	Flora	A2		Yes	Increased anthropogenic sources of dust via vehicle movement, may lead to the increase of dust particles in the air. This can adversely affect flora species through smothering and inhibiting the ability to photosynthesize.
Radiation	Construction and operation	Increased airborne radionuclides due to Heavy Mineral Concentrate extraction, transport and stockpiling cause reduction in the abundance and diversity of native flora and/or native fauna.	Mining and rehabilitation	Air	Flora and fauna	A3		No	It should be noted there is limited published data regarding the effects of radiation on non-human biota.
Air quality	Construction and operation	Increase in emissions due to vehicle and machinery use cause reduction in the abundance and diversity of native flora and/or native fauna.	Mining and rehabilitation	Air	Flora and fauna	A4		No	Vehicle emissions due to fuel combustion are not expected to occur at a level where there would be negative affects to flora or fauna, as guided by general descriptions in the Evaluation distance for effective air quality and noise management (EPA 2016).
Light	Construction and operation	Anthropogenic sources of light at night due to 24 hr operation. Interruption to foraging and circadian rhythms of native fauna.	Artificial lighting	Air	Flora and fauna	A5		Yes	Operations at Atacama will be running 24 hours a day and will therefore require artificial lighting on site at all times. This may result in a disturbance to foraging, breeding and circadian rhythms of native fauna in close proximity to the Project Area. Additionally, predatory species can monopolise the use of artificial lighting at night in their hunt for food resources.
Sound	Construction and operation	Anthropogenic sources of noise due to 24 hr operation. Interruption of foraging and circadian rhythms of native fauna	Mining and rehabilitation	Air	Fauna	A6		Yes	The continuous operation schedule will result in increased noise in the Project Area which may cause a disruption to the foraging, breeding and circadian rhythms of nearby fauna species.
WATER									
Surface water	Construction and operation	Redistribution of surface water resulting in impacts to vegetation growth and survival	Mining and rehabilitation	Surface water	Flora and fauna	W1		Yes	The surrounding topography may be altered to prevent flow or collection of surface water around the Project Area, potentially resulting in changed surface water flow regimes. Changes in surface water flow could also potentially lead to change in nearby habitats.
Groundwater	Construction and operation	Redistribution of groundwater due to mining impacts	Mining and rehabilitation	Groundwater	Flora and Fauna	G1		No	Impacts due to mining of mineral sands, however, this is not expected as the mineral sand deposit sits entirely above the water table (i.e. the water table is not expected to be intercepted during mining).

Appendix C Flora species list

Species Name	Common Name	Pot'l dist	Vegetation Association						
		Ha	1	2	3	4	7	8	9
Acacia acanthoclada ssp. acanthoclada	Harrow Wattle	223			✓				
Acacia ligulata	Umbrella Bush	956	✓			✓			
Acacia nyssophylla	Spine Bush	1970		✓	✓	✓	✓	✓	
Acacia oswaldii	Umbrella Wattle	1180		✓	✓		✓	✓	✓
Acacia papyrocarpa	Western Myall	1180		✓	✓		✓	✓	✓
Acacia rigens	Nealie	230			✓				✓
Adriana tomentosa var. hookeri	Mallee Bitter-bush	1179	✓		✓	✓			
Alyogyne pinoniana var. pinoniana	Sand Hibiscus	459			✓			✓	
Amphipogon caricinus var. caricinus	Long Grey-beard Grass	1020			✓	✓			
Aristida contorta	Curly Wire-grass	957		✓			✓	✓	✓
Atriplex vesicaria	Bladder Saltbush	1180		✓	✓		✓	✓	✓
Austrostipa nitida	Balcarra Spear-grass	950		✓			✓	✓	
Austrostipa platychaeta	Flat-awn Spear-grass	1020			✓	✓			
Beyeria opaca	Dark Turpentine Bush	1256			✓	✓		✓	
Billardiera cymosa ssp.		868		✓	✓				
Boronia coerulescens ssp. coerulescens	Blue Boronia	1256			✓	✓		✓	
Bossiaea walkeri	Cactus Pea	956	✓			✓			
Brachyscome sp.	Native Daisy	223			✓				
Callitris verrucosa	Scrub Cypress Pine	956	✓			✓			
Calotis lappulacea	Yellow Burr-daisy	1179	✓		✓	✓			
Calytrix sp.	Fringe-myrtle	1179	✓		✓	✓			
Cephalipterum drummondii	Pompom Head	645		✓					
Chrysocephalum apiculatum	Common Everlasting	2060	✓	✓	✓	✓		✓	
Codonocarpus cotinifolius	Desert Poplar	1179	✓		✓	✓			
Coopernookia strophiolata	Sticky Coopernookia	1179	✓		✓	✓			
Cratystylis conocephala	Bluebush Daisy	881		✓				✓	
Cynanchum floribundum	Desert Cynanchum	459			✓			✓	
Dampiera dysantha	Shrubby Dampiera	1179	✓		✓	✓			
Dampiera lanceolata var. lanceolata	Grooved Dampiera	1179	✓		✓	✓			
Daviesia ulicifolia ssp.		956	✓			✓			
Dianella revoluta var. divaricata	Broad-leaf Flax-lily	1256			✓	✓		✓	
Dicrastylis beveridgei var. lanata	Woolly Sand-sage	1179	✓		✓	✓			

Species Name	Common Name	Pot'l dist	Vegetation Association						
		Ha	1	2	3	4	7	8	9
Dicrastylis lewellinii	Purple Sand-sage	1179	✓		✓	✓			
Dicrastylis verticillata	Whorled Sand-sage	1179	✓		✓	✓			
Dillwynia uncinata	Silky Parrot-pea	159	✓						
Dodonaea stenozyga	Desert Hop-bush	1020			✓	✓			
Dodonaea viscosa ssp. angustissima	Narrow-leaf Hop-bush	645		✓					
Enchylaena tomentosa var.	Ruby Saltbush	1173		✓	✓		✓	✓	
Eremophila alternifolia	Narrow-leaf Emubush	459			✓			✓	
Eremophila crassifolia	Thick-leaf Emubush	618	✓		✓			✓	
Eremophila gibsonii	Gibson's Emubush	1020			✓	✓			
Eremophila glabra ssp.	Tar Bush	459			✓			✓	
Eremophila macdonnellii	Macdonnell's Emubush	1179	✓		✓	✓			
Eremophila maculata ssp.	Spotted Emubush								
Eremophila paisleyi ssp. paisleyi		797				✓			
Eremophila scoparia	Coccid Emu-bush	1977		✓	✓	✓	✓	✓	✓
Eriochiton sclerolaenoides	Woolly-fruit Bluebush	957		✓			✓	✓	✓
Eriochlamys behrii	Woolly Mantle								
Eucalyptus brachycalyx	Gilja	881		✓				✓	
Eucalyptus capitanea	Desert Ridge-fruited Mallee	159	✓						
Eucalyptus oleosa ssp. oleosa	Red Mallee	1104		✓	✓			✓	
Eucalyptus pimpiniana	Pimpin Mallee	1020			✓	✓			
Eucalyptus yumbarrana	Yumbarra Mallee	1179	✓		✓	✓			
Exocarpos sparteus	Slender Cherry	459			✓			✓	
Frankenia serpyllifolia	Thyme Sea-heath	645		✓					
Geijera linearifolia	Sheep bush	1027	✓	✓	✓				
Glischrocaryon behrii	Golden Pennants	1020			✓	✓			
Goodenia glauca	Pale Goodenia	223			✓				
Goodenia havilandii	Hill Goodenia	1020			✓	✓			
Goodenia varia	Sticky Goodenia	223			✓				
Grammosolen truncatus	Shrubby Ray-flower	1256			✓	✓		✓	
Gratwickia monochaeta		223			✓				
Grevillea huegelii	Comb Grevillea	1020			✓	✓			
Grevillea juncifolia ssp. juncifolia	Honeysuckle Grevillea	1020			✓	✓			
Grevillea stenobotrya	Rattle-pod Grevillea	956	✓			✓			
Gyrostemon thesioides	Broom Wheel-fruit	956	✓			✓			

Species Name	Common Name	Pot'l dist	Vegetation Association						
		Ha	1	2	3	4	7	8	9
Hakea francisiana	Bottlebrush Hakea	956	✓			✓			
Halgania andromedifolia	Scented Blue-flower	382	✓		✓				
Haloragis gossei	Gosse's Raspwort	1179	✓		✓	✓			
Leptospermum coriaceum	Dune Tea-tree	956	✓			✓			
Logania nuda (Orianthera nuda)	Leafless Logania	956	✓			✓			
Lomandra collina	Sand Mat-rush	223			✓				
Lomandra leucocephala ssp. robusta	Woolly Mat-rush	1179	✓		✓	✓			
Lycium australe	Australian Boxthorn	645		✓					
Maireana pentatropis	Erect Mallee Bluebush	1173		✓	✓		✓	✓	
Maireana radiata	Radiate Bluebush	1173		✓	✓		✓	✓	
Maireana sedifolia	Bluebush	881		✓				✓	
Maireana trichoptera	Hairy-fruit Bluebush	881		✓				✓	
Maireana villosa	Silky Bluebush	236						✓	
Melaleuca eleuterostachya	Hummock Honey-myrtle	1179	✓		✓	✓			
Melaleuca leiocarpa	Pungent Honey-myrtle	956	✓			✓			
Minuria leptophylla	Minnie Daisy	223			✓				
Myoporum platycarpum ssp. platycarpum	False Sandalwood	950		✓			✓	✓	
Newcastelia bracteosa		1179	✓		✓	✓			
Nicotiana velutina	Velvet Tobacco	652		✓					✓
Olearia exiguifolia	Lobed-leaf Daisy-bush	797				✓			
Olearia lepidophylla	Clubmoss Daisy-bush	1179	✓		✓	✓			
Olearia muelleri	Mueller's Daisy-bush	1665		✓	✓	✓			
Olearia pimeleoides	Pimelea Daisy-bush	1020			✓	✓			
Pimelea microcephala ssp.	Shrubby Riceflower	459			✓			✓	
Pimelea trichostachya	Spiked Riceflower	223			✓				
Pittosporum angustifolium	Native Apricot	1116	✓	✓			✓	✓	✓
Podolepis capillaris	Wiry Podolepis	1901		✓	✓	✓		✓	
Prostanthera striatiflora	Striated Mintbush	1256			✓	✓		✓	
Ptilotus incanus/obovatus	Silver Mulla	1977		✓	✓	✓	✓	✓	✓
Ptilotus nobilis ssp. nobilis	Yellow-tails	1020			✓	✓			
Ptilotus polystachyus	Long-tails	305					✓	✓	
Rhagodia candolleana ssp. argentea	Silver Sea-berry Saltbush	881		✓				✓	
Rhagodia crassifolia	Fleshy Saltbush	881		✓				✓	
Rhagodia preissii ssp. preissii	Mallee Saltbush	881		✓				✓	

Species Name	Common Name	Pot'l dist	Vegetation Association						
		Ha	1	2	3	4	7	8	9
Rhagodia spinescens	Spiny Saltbush	1173		✓	✓		✓	✓	
Rhagodia ulicina	Intricate Saltbush								
Rhodanthe floribunda	White Everlasting	714		✓			✓		
Salsola australis	Buckbush	1339	✓	✓	✓		✓	✓	✓
Santalum acuminatum	Quandong	1173		✓	✓		✓	✓	
Santalum spicatum	Sandalwood	645		✓					
Sarcozona praecox	Sarcozona	1104		✓	✓			✓	
Scaevola depauperata	Skeleton Fanflower	956	✓			✓			
Scaevola humilis	Inland Fanflower	223			✓				
Scaevola spinescens	Spiny Fanflower	1734		✓	✓	✓	✓		
Schoenus subaphyllus	Desert Bog-rush	223			✓				
Sclerolaena diacantha	Grey Bindyi	888		✓				✓	✓
Sclerolaena parviflora	Small-flower Bindyi	1020			✓	✓			
Sclerolaena patenticuspis	Spear-fruit Bindyi	645		✓					
Senecio gregorii	Fleshy Groundsel	645		✓					
Senna artemisioides ssp. artemisioides x ssp. coriacea	Desert Senna	1977		✓	✓	✓	✓	✓	✓
Senna artemisioides ssp. petiolaris		1180		✓	✓		✓	✓	✓
Senna cardiosperma ssp. gawlerensis	Gawler Ranges Senna	76					✓		✓
Senna pleurocarpa var. pleurocarpa	Stripe-pod Senna	223			✓				
Solanum coactiliferum	Tomato-bush	1179	✓		✓	✓			
Swainsona sp.	Swainson-pea	223			✓				
Templetonia egena	Broombush Templetonia	459			✓			✓	
Thryptomene elliottii		1020			✓	✓			
Thysanotus exiliflorus	Inland Fringe-lily	1179	✓		✓	✓			
Triodia basedowii	Hard Spinifex	1179	✓		✓	✓			
Triodia lanata	Woolly Spinifex	1179	✓		✓	✓			
Velleia connata	Cup Velleia	223			✓				
Vittadinia dissecta var. hirta	Dissected New Holland Daisy	1020			✓	✓			
Westringia rigida	Stiff Westringia	1256			✓	✓		✓	
Xerochrysum bracteatum	Golden Everlasting	1020			✓	✓			
Zygophyllum apiculatum	Pointed Twinleaf	1104		✓	✓			✓	
Zygophyllum aurantiacum ssp.		1180		✓	✓		✓	✓	✓

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Atacama Project – Air Quality Impact Assessment

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Iluka Resources
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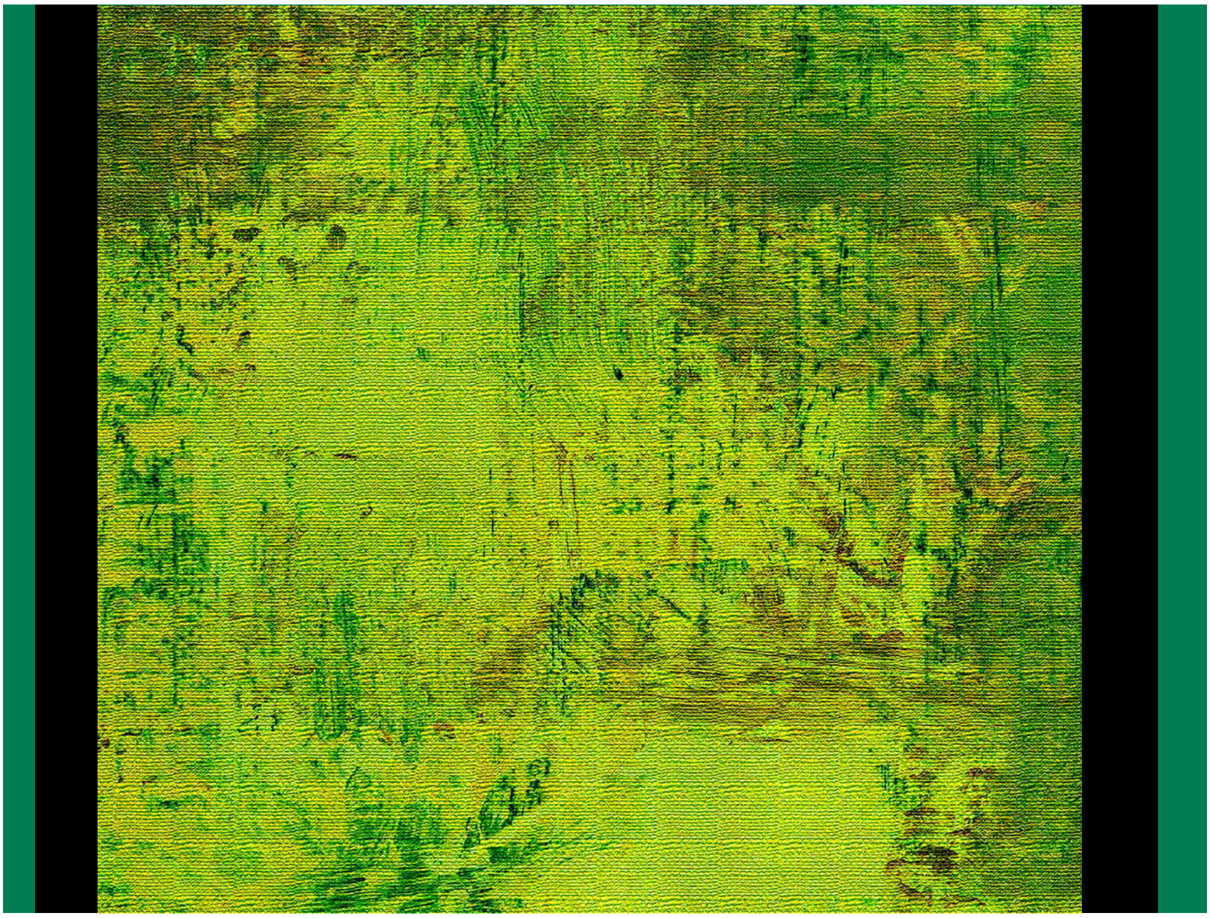
Atacama Project
22 November 2022



Atacama Project – Air Quality Impact Assessment

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Executive summary

This report details an Air Quality Impact Assessment (AQIA) undertaken for the proposed Iluka Atacama mining operation (the Project), including the cumulative effects of the associated and adjacent Jacinth-Ambrosia (J-A) mine site. The AQIA was based on meteorological modelling and air dispersion modelling of air pollutant emissions, and included a review of the previous Katestone (2008) air quality assessment for the J-A site.

Meteorological, dust, and other monitoring data collected by Iluka Resources Limited (Iluka) during the operation of J-A to date were used as inputs into this assessment. Also, radionuclide dispersion modelling was completed to provide inputs for a separate radiation assessment.

The AQIA was conducted to address Government of South Australia Terms of Reference 006 (TOR006) *Mineral mine lease/ licence applications* requirements detailing potential impacts to air quality resulting from the proposed mining of the Atacama deposit, and a plan for managing these impacts. Recommended avoidance, mitigation and management measures were set out, focussing on dust mitigation measures due to mining and minerals processing activities. Interpretation of the residual impacts; i.e., as shown by the modelling results including dust mitigation measures, formed the major part of the assessment.

Also, the AQIA was conducted in accordance with the Environment Protection Authority South Australia (EPA SA) 2016 guideline, *Ambient air quality assessment*, with reference to the design Ground Level Concentrations (GLCs) set out in SA's Environment Protection (Air Quality) Policy 2016 (GSA, 2022b). EPA SA (2016) sets out EPA's general risk assessment strategy and other details pertinent to air dispersion modelling.

The development and operation of the Project will result in air pollutant emissions due to land clearing and stockpiling of topsoil and overburden; mining operations; rehabilitation works and vehicle movements at the Atacama Mining Lease (ML); and processing and tailings deposition at the existing J-A ML 6315. The on-going operations at J-A will contribute to these air emissions; all emissions were assessed cumulatively.

The existing Iluka J-A mining activities and the adjacent, proposed Atacama mining operation are remote: the nearest (non-mining) sensitive receptor is Yalata township, approximately 70 km to the south-west. The nearest (mining) sensitive receptor is the Iluka accommodation village (Camp) located adjacent to the airstrip, located approximately 3 km north-west of the existing J-A mine and approximately 8 km south-west of Atacama.

A summary of the modelling assessment results for the worst-case (nearest) sensitive receptor to the existing and proposed operations (the Camp), is provided in the following points:

The results for deposited dust are strongly indicative of a low risk of nuisance dust impact.

- Maximum deposited dust: J-A and Atacama:

  1.6 g/m^2/month including background (objective 4 g/m^2/month), with the mining contribution 0.1 g/m^2/month only (objective 2 g/m^2/month).

The results for PM_{10} are strongly indicative that dust mitigation measures, (including separation distances), are sufficient for there to be insignificant air quality impacts at the Camp due to the PM_{10} component of dust emissions from mining operations.

- Maximum 24-hour average PM_{10} concentration: J-A and Atacama:

  36 μg/m^3 including background (objective 50 μg/m^3).

- Maximum 24-hour average $PM_{2.5}$ concentration: J-A and Atacama:

  13 μg/m^3 including background (objective 25 μg/m^3).

The conclusion for 24-hr and annual $PM_{2.5}$ results is that dust mitigation measures, (including separation distances), are sufficient for there to be insignificant air quality impacts at the Camp due to the $PM_{2.5}$ component of dust emissions.

- Annual average $PM_{2.5}$ concentration:
  7.3 $\mu g/m^3$ including background (objective 8.0 $\mu g/m^3$).

The main conclusion of the modelling assessment of dust emissions from J-A and the proposed Atacama operation is there is a low risk of air quality impact due to nuisance dust and elevated airborne concentrations of PM_{10} and $PM_{2.5}$.

The results for the gaseous air pollutants, NO_2 and CO, were insignificant for the Camp, as determined by comparisons with their GLCs. Consideration was given to locations within the mine site at which a person would be likely to be present for an hour or more (corresponding to the averaging periods of the assessment criteria), with results indicating a low risk.

On the subject of flora and fauna impacts, the recommendations for dust mitigation for the protection of human health and amenity are generally considered to be adequate for the protection of flora and fauna surrounding the mine site boundaries.

Recommendations for dust mitigation measures centred around:

- substantial separation distances between the mining and minerals processing areas and the nearest sensitive receptor (Camp)
- use of water carts on unpaved roads to minimise wheel-generated dust by haul trucks
- rehabilitation of mined areas by earthworks
- stabilisation of stockpiles using suppressant (enhancing surface crusting), and
- revegetation of rehabilitated areas.

Air dispersion modelling results were provided for radionuclide emissions, based on the radioactive components of the source dusts. Interpretation of radionuclide modelling results is not included in Jacobs' scope.

Contents

Appendices

Tables

Figures

Acronyms and abbreviations

Abbreviation	Expansion / definition
AQ EPP	South Australian Environment Protection (Air Quality) Policy
BoM	Bureau of Meteorology
Bq/g	Becquerel per gram. A measure of the relative radioactivity of a material.
CO	Carbon monoxide (molecular formula)
ELA	Eco Logical Australia
EML	Extractive Minerals Lease
EPA	Environment Protection Authority; South Australia, unless otherwise stated
DEM	South Australian Department for Energy and Mining
g/m^2/month	Grams per m^2 per month – unit of deposited dust (AS 5380.10-1 2016)
GLC	Ground Level Concentration – maximum concentration specified in GSA (2019) for a pollutant based on evaluations at ground level using a prescribed testing, assessment, monitoring or modelling
GSA	Government of South Australia
ha	Hectare
HMC	Heavy Mineral Concentrate
Iluka	Iluka Resources Limited
J-A	Jacinth-Ambrosia
Jacobs	Jacobs Group (Australia) Pty Ltd
µm	micron – one millionth of a metre, or 10^{-6} m
$\mu g/m^3$	microgram per m^3 – unit of air pollutant concentration
ML	Mining Lease
MLP	Mining Lease Proposal
MPL	Miscellaneous Purposes Licence
MSP	Mineral Separation Plant
MUP	Semi-mobile Mining Unit Plant (MUP)
NORM	Naturally Occurring Radioactive Materials
NOx	Oxides of nitrogen (nitric oxide and nitrogen dioxide)
NO_2	Nitrogen dioxide (molecular formula)
PM_{10}	Particulate Matter 10 – airborne particles with an equivalent aerodynamic diameter of <= 10 µm
$PM_{2.5}$	Particulate Matter 2.5 – airborne particles with an equivalent aerodynamic diameter of <= 2.5 µm
RCA	Radiation Consulting Australia
RH	Relative humidity
Th	Thorium
TSP	Total Suspended Particulates (total suspended particulate matter)
U	Uranium

1. Introduction

1.1 Overview

Iluka Resources Limited's (Iluka) Jacinth-Ambrosia (J-A) mineral sands deposit was discovered in 2004, with production commencing in 2009. The mining operation is the world's largest zircon mine (Iluka, 2022), located within the Yellabinna Regional Reserve. The site location is shown in Figure 1-1. The J-A operation comprises two contiguous deposits, Jacinth and Ambrosia, and is South Australia's first mining development in a mixed-use regional reserve (the Yellabinna Regional Reserve) (Iluka 2022).

The J-A operation consists of mining and wet processing activities for the generation of heavy mineral concentrate (HMC). The concentrate is transported by road train to the Port of Thevenard then shipped to Iluka's Narngulu mineral separation plant (MSP) in Western Australia for final processing, where the final products of zircon, rutile and ilmenite are produced (Iluka, 2022).

The Atacama Project (the Project) is a satellite mineral sands deposit located approximately 5 km to the north-east of Iluka's existing operation at J-A. It contains both zircon and ilmenite. In late 2018, pre-feasibility study (PFS) 1 commenced to assess options for developing the Project from the zircon only resource. PFS 1 was completed in 2020, after which the Project was put on hold. In 2021, PFS 2 was commenced which aims to assess options for developing both the zircon and ilmenite resources. The preferred option is to transport material as a slurry from Atacama to J-A for processing and for tailings storage, utilising existing infrastructure at the J-A mine site.

J-A and Atacama are located 140 km from Nullarbor (bearing 244°), 195 km from Ceduna (bearing 134°), and 100 km from the closest point on the coastline; see Figure 1-1 (also Appendix D). The locations of the Atacama Project area and the J-A Mining Lease (ML) 6513 are detailed in Figure 1-2.

Figure 1-1. Jacinth-Ambrosia mine and BoM meteorological monitoring station locations

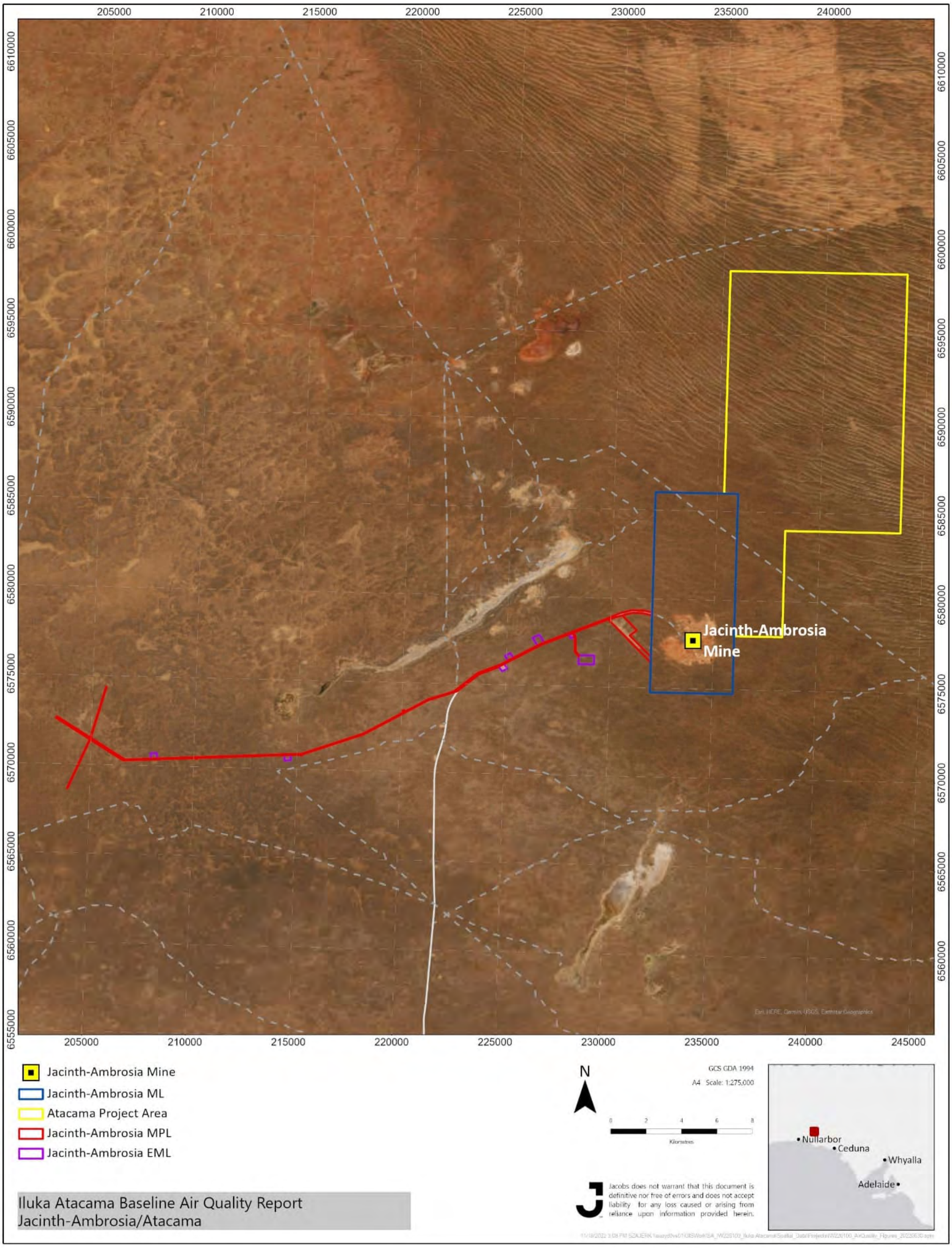

Figure 1-2. Location of Project

1.2 Scope of Assessment

The scope of the Air Quality Impact Assessment (AQIA) was based on meteorological modelling and air dispersion modelling of particulate and gaseous air pollutant emissions for development of the Atacama Project. The current assessment included a review of the previous modelling assessment conducted by Katestone (2008) for the J-A site as it was proposed then, and meteorological and dust and other monitoring data collected by Iluka during J-A's operation to date. The AQIA describes the potential air quality impacts due to the proposed mining activities related to the Atacama Project, cumulatively with the existing J-A mining and minerals processing activities and including estimates for background air pollutant levels.

This report complies with Terms of Reference 006 (TOR006) *Mineral mine lease/ licence applications* requirements (GSA, 2021) detailing potential impacts to air quality resulting from the proposed mining of the Atacama deposit, and a plan for managing these impacts. The report describes the findings of the study including descriptions of:

- Objectives of the study.
- Relevant criteria such as legislation, standards and guidelines.
- Study method.
- Existing environmental and social setting within which the project exists.
- Potential impacts with reference to source, pathways and receptors and potential significance of impact.
- Recommended avoidance, mitigation and management measures.
- Residual impacts.

The AQIA was undertaken with reference to the following guidelines and Policy:

- Ambient air quality assessment, which provides guidelines for the assessment of ambient air quality in South Australia (EPA SA, 2016), with reference to the design Ground Level Concentrations (GLCs) set out in SA's Environment Protection (Air Quality) Policy 2016 (GSA, 2022b).
- *Approved methods for the modelling and assessment of air pollutants in New South Wales*, which provides guidance on assessment of air quality impacts in NSW (NSW EPA, 2016). The NSW approved methods were used to assist with interpretation and assessment of the J-A and Atacama results for deposited dust, and with the application of the Calpuff air dispersion model.
- *Generic guidance and optimum model settings for the CALPUFF modelling system*, (Barclay & Scirie, 2011), as part of NSW EPA (2016).

Also, the AQIA utilised the companion radiation impact assessment by Radiation Consulting Australia (RCA, 2022) to inform air dispersion modelling for radiological impacts. The scope was limited to providing dispersion modelling outputs, with no interpretation of results, i.e.,

- Setting out a radiological (air) emissions inventory for modelling using input from RCA (2022), and from discussion with RCA (dispersion of radon emissions was excluded due to low risk).
- CALPUFF radionuclide emissions modelling.
- Providing outputs of modelling of radionuclide emissions as contour plots and predicted impacts at the nearest sensitive receptor (the Camp).

2. Project Description

2.1 Atacama Project Overview

The Atacama Project will mine the Atacama deposit to produce zircon and ilmenite heavy mineral concentrate (HMC). The deposit is located adjacent to the existing Iluka J-A mine and will be developed as a satellite mine to J-A making use of existing facilities and disturbance footprint at J-A for processing and deposition of tailings.

The Project will include the mining of ore through the development of open pits with ore slurry pumped to existing facilities at J-A. The open pits will be progressively rehabilitated as mining progresses, infilled with overburden and soil material up to the elevation level of the existing swales, avoiding the unnecessary stockpiling of overburden and rehandling of materials where possible.

The Atacama deposit consists of three main areas, which will be dry mined via three open pits with the following dimensions:

- Pit 1 (Western Pit): approximately 5,000 m long, 350m wide and 60m deep;
- Pit 2 (Central Pit): approximately 3,700 m long, 290m wide and 45m deep; and
- Pit 3 (Eastern Pit): approximately 5,800 m long, 460m wide and 75m deep.

There is also a small satellite pit to the south which may be mined at the end of the mine life, which is less than 500m in length.

The development and operation of the Project will result in air emissions due to land clearing and stockpiling of topsoil, subsoil and overburden; mining operations, including power generation; rehabilitation works and vehicle movements at the Atacama ML; and processing and tailings deposition at the existing J-A ML. In addition, ongoing operations at J-A will also contribute to air emissions. As such, the assessment has been conducted to assess worst-case emissions from the Atacama Project, based on the proposal mining schedule, cumulatively with current emissions from the existing J-A operations.

2.2 Environmental Indicators

From a review of relevant National Pollutant Inventory (NPI) emissions estimate manuals, other relevant literature on open-cut mining, and known pollutants from mineral sands mining operations the primary pollutants are fugitive particulates. Key pollutants include the following particulate fractions:

- Total Suspended Particulates (TSP); in relation to the determination of deposited dust and as an input to the determination of radionuclide ground level concentrations.
- Particles with an aerodynamic diameter less than or equal to 10 micrometres (µm) (PM_{10}).
- Particles with an aerodynamic diameter less than or equal to 2.5 micrometres (µm) ($PM_{2.5}$).

The Atacama radiation assessment (RCA, 2022) was reviewed to determine radionuclide parameters for dispersion modelling, e.g., uranium and thorium isotope components of the particulate matter emissions, see Section 5.2.

Gaseous emissions from power generation, nitrogen dioxide (NO_2) and carbon monoxide (CO), were also included in the assessment.

No significant sources of odour were identified for assessment.

2.3 Sensitive Receptors

The EPA (2019a) guidance document for evaluation of separation distances for effective air quality and noise management defines sensitive land use under the *Environment Protection Act 1993* (GSA, 2017) as:

a) use for residential purposes; or

b) use for a pre-school within the meaning of the Development Regulations 1993; or

c) use for a primary school; or

d) use of a kind prescribed by regulation.

The EPA (2019a) separation distance guideline defines a sensitive receiver as:

- any fixed location (including a house, building, other premises or open area) where:

  - human health# may be affected by air emissions from existing or proposed development, and/or

  - property damage or loss of amenity may be caused by air emissions from the existing or proposed development, and/or

- noise-affected premises (whether existing or future, based on land use zoning) that are in separate occupation from the existing or proposed noise source and used for residential or business purposes or constitute a quiet ambient environment set aside for public recreation and enjoyment, and/or

- plants, animals or ecosystems that may be affected by air and/or noise emissions.

#Note: In the case of air quality impacts on human health, the type of sensitive receivers will vary depending on the pollutant(s) in question, as different pollutants have impacts at different concentrations and over different periods of time. An important consideration when identifying potential sensitive receivers is length of exposure. The averaging time of GLCs and odour level criteria in the Environment Protection (Air Quality) Policy 2016 (GSA, 2022b), can be used as a guide when determining whether a given location is a potential sensitive receiver. For example, the GLC for nitrogen dioxide (NO_2) has a 1-hour averaging period, and any location where people spend an hour or more would be considered a sensitive receiver. In the case of particles (PM_{10} and $PM_{2.5}$), sensitive receivers are those places where people are located for 24 hours, due to the GLCs having a 24-hour averaging time, typically a residence.

The only human sensitive receptor in proximity to the Project is the accommodation village (Camp) located adjacent to the airstrip, approximately 3 km north-west of the J-A mine (approximately 8 km south-west of Atacama). The next nearest sensitive receptor is Yalata township, approximately 70 km south-west. However, for NO_2 and CO emissions, which have assessment criteria with an hourly averaging period, consideration should be given to locations within the mine site at which a person would be likely to be present for an hour or more.

3. Relevant Legislation, Policy and Guidelines

This section outlines the legislations, policies, and guidelines relevant to the AQIA and the air quality objectives for the Project.

3.1 Environment Protection (Air Quality) Policy 2016

The Government of South Australia (GSA) air quality standards are set out in the *Environment Protection (Air Quality) Policy 2016 (EPP)* (GSA, 2022b). The air quality standards are referred to as GLCs as maximum concentrations. They are used in testing, (by modelling or monitoring), whether an activity causes, or has the potential to cause, an exceedance of a GLC.

3.2 Air Quality Objectives

A summary of the GSA (2022b) air quality objectives for the Project is provided in Table 3-1. Air quality objectives comprise the averaging time and maximum concentration for a pollutant and are set out for (airborne) particulate matter 10 (PM_{10}), particulate matter 2.5 ($PM_{2.5}$), and the gaseous air pollutants NO_2 and CO.

Table 3-1: Air quality objectives (SA Environment Protection (Air Quality) Policy 2016 GLCs)

Pollutant, Classification	Averaging Time	Maximum Concentration (μg/m^3)
Particles as PM_{10}, Toxicity	24 hours	50
Particles as $PM_{2.5}$, Toxicity	24 hours	25
	12 months	8
Nitrogen dioxide (NO_2), Toxicity	1 hour	164
	Annual	30
Carbon monoxide (CO), Toxicity	1 hour	31,240
	8 hours	11,250

3.3 Deposited Dust Objectives

There are no South Australian standards for deposited dust, however, the general environmental duty, defined in section 25 of the *Environment Protection Act 1993* (*EP Act)*, may be applied to avoid environmental nuisance through the use of 'best available technology economically achievable' (BATEA) and dust management plans (DMPs). The general environmental duty defined in the *EP Act*, prescribes that 'a person must not undertake an activity that pollutes, or might pollute, the environment unless the person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm'.

Dust deposition was included in the assessment for two main reasons, firstly, dust deposition monitoring, coupled with fauna and flora surveys, are the primary methods employed in the existing J-A operations to document potential environmental dust impacts. Secondly, dust deposition modelling was required for the assessment of radiological impacts by RCA.

Deposited dust has the potential to impact on amenity, for example, deposited dust is classed as a nuisance by the EPA Victoria (EPAV, 2022), and deposited dust levels are used as air quality impact assessment criteria by EPA NSW (2016).

Dust impacts on vegetation health are influenced by a range of factors including the size, shape and composition of the dust, the dust deposition load, meteorological conditions, and the morphology of the vegetation being impacted. As such, there are no accepted standards for assessing dust impacts on vegetation.

A summary of dust deposition indicators to assist with interpretation of modelled deposition data is provided in Table 3-2.

Table 3-2: Dust deposition indicators

Reason for indicator	Dust deposition indicator	Notes
Protection of amenity, maximum totals	Maximum annual average including background, 4 $g/m^2/month$	EPA NSW 2016
	Maximum annual average increase in dust deposition above baseline, 2 $g/m^2/month$	EPA NSW 2016

Note: dust is assessed as insoluble solids as defined by AS 3580.10.1

4. Existing Environment

A baseline air quality assessment was conducted and issued initially in May 2020 as part of the PFS 1 project, then updated in May 2022 (Jacobs, 2022) for PFS 2 with minor amendments. The assessment described the existing or 'baseline' concentrations of the airborne particulate parameters PM_{10} and $PM_{2.5}$, and baseline levels of deposited dust; i.e., unaffected by current or future mining operations. Consideration was also given in the baseline assessment to gaseous pollutants. The outcomes relevant to the impact assessment are summarised in the following sub-sections.

4.1 Overview

The baseline air quality assessment (Jacobs, 2022) addresses one of the requirements from the TOR006 (GSA, 2021) and Minerals Regulatory Guideline 2a (MG2a), (GSA, 2020b), under the South Australia *Mining Act 1971* and Mining Regulations 2020: Provide a description of the existing levels of dust and contributors to air quality including odour, both natural and anthropogenic.

No PM_{10} and $PM_{2.5}$ data were available for assessment, so proxy data were used to establish baseline particulate concentrations for J-A and the Project.

Iluka's extensive dataset of deposited dust measurements at J-A enabled baseline values for dust deposition to be estimated for the Project. Consideration was given to gaseous pollutant emissions.

At the time of preparation of the baseline report, there were no on-site meteorological data available therefore climatic analysis utilised BoM monitoring sites at Nullarbor, Ceduna, and Tarcoola. Since that time, Iluka have commissioned a meteorological station and provided data from August 2020 until the end of June 2022.

For a description of local climatology please refer to the baseline air quality report, however the recent, locally acquired, meteorological data is compared to modelled prognostic data in Section 7.

4.2 Existing Air Quality

4.2.1 TSP and Dust Deposition

Four background monitoring stations were selected to determine baseline deposited dust for the Project (Jacobs, 2022), with data from 2009 to 2019 used in the analysis. Given that dust deposition rates decrease rapidly as distance increased from the dust source, the background sites for J-A provide an acceptable approximation of background conditions for the Project site, even during periods when J-A was in production.

A peak in the measured background dust deposition was observed around summer, and a minimum during the winter months, so background values were determined for those two periods separately; the results are provided in Table 4-1. Winter is represented by data collected in June, July and August while all other months constitute the non-winter months.

Table 4-1: Statistical results for deposited dust - insoluble solids ($g/m^2/month$)

Statistic	All months	Non-winter months	Winter months
No. of samples (approximately months)	393	286	107
90th percentile	1.55	1.75	0.81
70th percentile	0.85	0.96	0.50
50th percentile (median)	0.57	0.68	0.50

Using two significant figures, the estimated background deposited dust for the Project are:

- Non-winter months 1.8 $g/m^2/month$; and
- Winter months 0.8 $g/m^2/month$.

4.2.2 PM_{10}

Given no PM_{10} data were available for the Project, nor in the surrounding wider region, a PM_{10} proxy was used. PM_{10} data from EPA Whyalla's Schulz Reserve monitoring station was used for this purpose and a 90th percentile, 24-hour average PM_{10} concentration was deemed to be suitable for estimating a conservative background level for the Project.

Three years of hourly PM_{10} data from the Whyalla Schulz Reserve (2016-2018) were considered adequate to estimate background PM_{10} levels for the Atacama Project.

Given the seasonal differences in the measured PM_{10} at Whyalla, adoption of winter and non-winter background values was considered beneficial, otherwise particulate impacts may be overstated in the winter months due to the elevated background. A statistical summary of the results is provided in Table 4-2; the 90th percentile statistics were selected as the estimate for background.

Table 4-2: Statistical summary of EPA Whyalla-Schulz Reserve 24-hour average PM_{10} ($\mu g/m^3$)

Statistic	Non-winter months 2016-2018	Winter months 2016-2018
Number of 24-hour averages	779	273
99th percentile	36.4	49.4
90th percentile	24.2	16.6
70th percentile	18.0	12.4
Average	15.9	12.3

Using two significant figures, the estimated background 24-hour average PM_{10} concentrations for the Project are:

- Non-winter months 24 $\mu g/m^3$; and
- Winter months 17 $\mu g/m^3$.

4.2.3 $PM_{2.5}$

There are no $PM_{2.5}$ data available for the Project, nor in the surrounding wider region, therefore a $PM_{2.5}$ proxy was used. Measurements of $PM_{2.5}$ are more limited than for PM_{10}. There are no $PM_{2.5}$ data available from EPA's Whyalla monitoring stations; the nearest and most representative site for $PM_{2.5}$, is Port Augusta.

EPA Port Augusta measurements of $PM_{2.5}$ from March 2017 to December 2019 were analysed to determine estimates for the expected background $PM_{2.5}$ levels for the Project. A statistical summary is provided in Table 4-3.

Table 4-3: Statistical summary of EPA Port Augusta 24-hour average $PM_{2.5}$ ($\mu g/m^3$)

Statistic	Non-winter months 2017-2019	Winter months 2017-2019
Number of 24-hour averages	670	263
99th percentile	22.0	16.0
90th percentile	10.4	7.4
70th percentile	7.8	6.2
Average	7.4	5.9

Using two significant figures, the estimated background 24-hour and annual average $PM_{2.5}$ concentrations for the Project are:

- Non-winter months 24-hour - 10 $\mu g/m^3$: annual average - 7.4 $\mu g/m^3$; and
- Winter months 24-hour - 7.4 $\mu g/m^3$: annual average - 5.9 $\mu g/m^3$.

4.2.4 Background Levels of Gaseous Pollutants

Oxides of nitrogen (NOx) and carbon monoxide (CO) were the only criteria gaseous pollutants identified for assessment. The only identified, significant sources of gaseous emissions were the power generators. Background levels of NO_2 and CO are expected to be negligible for the Project site.

4.3 Existing Emission Sources

The only existing sources of pollutant emissions that would contribute to air quality impacts in the study area are the existing J-A mine and 'natural' emissions, mainly dust emissions from exposed areas due to wind erosion.

4.4 Terrain and Land Use

The J-A and Atacama Project sites are located within the Yellabinna Regional Reserve. The Reserve is arid, sparsely vegetated, with parts of the Atacama boundaries characterised by sand dunes and swales aligned approximately northwest-to-southeast, and typically around 200 metres apart.

The South Australia National Parks map provided in Appendix D shows the setting of the Iluka operations within the Yellabinna Regional Reserve, and the surrounding broader region. The main western boundary of the YWPA is approximately 100 km east of J-A and Atacama, well beyond the range of any impacts due to air emissions from Iluka mining activity.

From the air quality perspective, the terrain is relatively flat, with land elevations ranging between approximately 110 metres above sea level near the accommodation camp, up to approximately 190 metres above sea level in some parts within the Atacama site boundaries.

5. Air Emissions Inventory

Mining activities, identified from the information supplied by Iluka, which have potential for emissions of air pollutants including the following:

- Scrapers on soil and topsoil/ subsoil
- Loading of haul trucks by excavator
- Removal of overburden or ore by haul truck
- Placement of overburden on stockpiles (end dumping)
- Deposit of ore at mining unit plant (MUP)
- Replacement of overburden and soils in pit area
- Haul trucks on unpaved roads
- Wind erosion of stockpiles and exposed open pit areas

Based on proposed mining schedule provided by Iluka, the mine commences production in 2024 and continues through to 2031 with peak material handling volumes occurring in 2029. The assessment was therefore based on the proposed material volumes and mining schedule for 2029 i.e. peak period. The cumulative assessment requires the inclusion of emissions from the existing J-A operation, and as a conservative approach, it was assumed that the existing J-A operation would be running concurrently with the Atacama Project. For J-A operations the NPI reporting data for actual production in 2019/20 and 2020/21 were reviewed with the 2019/20 material volumes being slightly higher than in 2020/21. The J-A emissions were therefore based on those reported in 2019/20. This approach is considered conservative.

Emission source locations for Atacama were based on the changes in end of year mining schedule from 2028 to 2029 (Appendix A). It was assumed that stockpiles that were unchanged from 2028 to 2029 were inactive and therefore stabilised or revegetated.

5.1 Combustion Engine Emissions

Gaseous air pollutant emissions will occur from on-site plant and other mobile machinery; e.g., mining trucks and loaders. However due to the relatively small number of vehicles associated with the Project, (for example in comparison with the road vehicle fleet of a city or a large town), air quality impacts due to combustion engine emissions will be negligible.

The J-A site contains 12 diesel engines with power generation capacity approximately 1 MegaWatt (MW) each. Air exhaust emissions from these relatively large, stationary engines, based on a continuous power generation 9.8MW, were included in the assessment. Emission parameters for modelling were determined from a review of Katestone (2008), with emissions estimates re-calculated using NPI emission factors for stationary diesel engines (AG, 2008). The complete set of NPI results for the J-A engines are listed in Table 5-1. Emission estimates are summarised in Table 5-2.

Table 5-1: Power-house air emissions parameters

Parameter	Units	1 MW Power Generator
Co-ordinate location: Effective single point source location	m	E - 233,230 N - 6,577,910
Stack height	m	10
Stack diameter	m	0.6
Exit velocity	m/s	29
Exhaust temperature	Deg C	450

Table 5-2: Power-house air emissions estimates

Air Pollutant	1MW emission rate (g/s)	9.8MW emission rate (g/s)
Carbon Monoxide (CO)	0.917	9.0
Nitrogen Dioxide (NO_2)	0.658	6.5
Particulate Matter PM_{10}	0.119	1.2
Particulate Matter $PM_{2.5}$	0.117	1.1

5.2 Radionuclide Emissions

Air dispersion modelling can be used to support a radiation assessment by predicting GLCs of radioactivity in units of Becquerel per cubic metre (Bq/m^3), over the air quality study area, due to: (1) radionuclide components of dust emissions; and (2) radon emanations to atmosphere due to mining activities that expose radon sources to atmosphere.

The purpose of the companion RCA Environmental Radiation Impact Assessment report, (RCA, 2022), was to assess radiation related impacts for the existing J-A operation, and potential impacts due to processing both Atacama and J-A material. Radiological impacts were considered for processing onsite and for transportation of products from the mine.

Review of RCA (2022), and a discussion with the RCA consultant, (*private communication*, 30/8/22), indicated the radon gas emissions expected from the relatively small sources associated with Atacama and the J-A operation, including the surrounding natural sources, were low risk and would not require dispersion modelling. Therefore, the focus was on modelling the dispersion of the radionuclide components in dust emissions from areas of the Project identified as having radionuclides present. Background radiation levels were excluded from these modelling results (standard practice). The sources of radionuclides included the Atacama ore body, HMC stockpiles, and the tailings facility. A summary of radiation data for modelling is provided in Table 5-3, based on a review of RCA (2022).

Table 5-3: Summary of modelled radionuclide emissions

Source	Material	Description	Location	Emission Rate		
				TSP emissions (g/s)	Activity (Bq/g)	Activity Rate (Bq/s)
Dozer, Ore to MUP	J-A ore	Dozer hours in 2019/20 26,203hrs - equivalent of 3 dozers full time.	J-A	14.17	0.15	2.13
Placement of HMC on stockpile	HMC	Assumed all HMC stockpiled - based on 2019/20 production 451,486 tonne	J-A	0.17	5.06	0.87
Wind erosion of tailings	J-A ore	Area of tailings dusting is approximately 42ha (420,000 m2)	J-A	4.67	0.15	0.70
Wind erosion of HMC stockpile	HMC	Area of HMC is approximately 7ha (70,000 m2)	J-A	0.78	5.06	3.94
Excavation of ore	Atacama ore	Volume of ore removed is 1,976,669 BCM, equivalent to 3,731,101 tpa	Atacama	1.48	0.65	0.96
Placement of ore at MUP 1	Atacama ore	Volume of ore X BCM, equivalent to 3,548,365 tpa	Atacama	1.35	0.65	0.88
Placement of ore at MUP 2	Atacama ore	Volume of ore X BCM, equivalent to 182,736 tpa	Atacama	0.07	0.65	0.05

5.3 Particulate Emissions Estimates

The modelled dust emissions for the Project were developed based on published emission factors from the National Pollutant Inventory (NPI) Emission Estimate Techniques Manual for Mining (AG, 2012). Some general notes and assumptions made in the estimates include:

- Vehicles on unpaved roads – It is assumed that all roads are unpaved and level 2 watering (>2 litres/m^2/hr) applied, however it is likely that some roads will be sealed, and that actual watering may be lower. (At J-A it is reported that 60% of haul truck vehicle kilometre travelled (VKT) are on sealed roads).
- At J-A the pit excavations are wide and it is assumed there is no retention of dust emissions in the pit.
- At Atacama the pit excavations are less wide and deeper. Partial pit retention of emissions has been assumed with mitigation applied to TSP and PM_{10} emission rates as per the NPI manual, however no pit retention was assumed for overburden placed back into the pit.
- Wind erosion of stockpiles and open areas are modelled only for wind speed above 5.4 m/s (NEPC, 2012). The emission estimates in Table 5-6 and Table 5-9 assume emissions are constant and occur at all wind speeds.

A summary of modelled dust emissions is presented below in Section 5.3.1 and Section 5.3.2 for J-A and Atacama respectively.

5.3.1 J-A Emission Estimates

Emissions estimates for J-A are based on actual production data and NPI reporting for 2019/2020. A summary of modelled dust emissions is presented below in Table 5-4, key emission parameters in Table 5-5 and NPI emission factors and mitigation measures in Table 5-6.

Table 5-4: Summary of modelled particulate emissions – Jacinth-Ambrosia

Source (J-A)	Description	TSP kg/year	PM_{10} kg/year	$PM_{2.5}$ kg/year
Dozer, Ore to MUP	Dozer hours in 2019/20 = 26,203hrs – equivalent of 3 dozer full time.	446,760	107,748	16,162
Removal of overburden to haul truck	Volume of overburden moved is 5,210,970tpa	130,274	61,229	9,184
Placement of overburden on stockpiles	Volume of overburden moved is 5,210,970tpa	62,532	22,407	3,361
Placement of HMC on stockpile	Assume all production stockpiled	5,418	1,941	291
Vehicles on unpaved roads - overburden	Vehicle kilometres travelled (VKT) = 92,597 (Assume Ave load = 90t, GVM = 160t), equals 1.6km / trip	168,458	49,722	7,458
grader	Vehicle kilometres travelled (VKT) = 23,514	4,468	1,999	300
Wind erosion of stockpiles	Area of stockpiles active at any one time is approximately 244ha (2,440,000 m^2)	854,976	427,488	64,123
Exposed pit surface	Area of pit active at any one time is approximately 251ha (2,510,000 m^2)	879,504	439,752	65,963
Total		**2,552,389**	**1,112,286**	**166,843**

Table 5-5: Key emission estimation parameters - J-A

Parameter	Value	Units	Source
Mining operational days	365	Days per year	Assumption
Mining operational hours	24	Hours per day	Assumption
Total tpa of ore to ROM	9,332,618	tonnes / year	Iluka
Total tpa of overburden removed	5,210,970	tonnes / year	Iluka
Total overburden loaded and end-dumped	5,210,970	tonne/year	Iluka
Average trip length of haul trucks	1.6	Km	Iluka
Total vehicle kilometres travelled to move total material	92,597	VKT	Iluka
Total area of active stockpiles	2,440,000	m^2	Iluka
Total exposed pit surface	2,510,000	m^2	Iluka

Table 5-6: Adopted NPI emission factors and mitigation measures – J-A

Emission source	Units	Emission factors			Mitigation measure
		TSP	PM_{10}	$PM_{2.5}$[1]	
Dozer (J-A)	kg/hr	17	4.1	0.615	none
Excavation of overburden to haul truck (J-A)	kg/t	0.025	0.01175	0.00176	none
Placement of overburden on stockpiles (end dumping)	kg/t	0.012	0.0043	0.000645	none
Placement of HMC on stockpiles	kg/t	0.012	0.0043	0.000645	none
Vehicles on unpaved roads	kg/VKT	7.28	2.15	0.32	75% (level 2 watering)
Wind erosion of stockpiles and exposed pit area	kg/ha/hr	0.4	0.2	0.03	none

5.3.2 Atacama Emission Estimates

Emissions from Atacama were based on peak material volumes in the mining schedule plan, with peak material handling planned for 2029. Emission source locations for Atacama were based on the changes in end of year mining schedule from 2028 to 2029 (Appendix A). It was assumed that stockpiles that were unchanged from 2028 to 2029 were inactive and therefore stabilised or revegetated.

A summary of modelled dust emissions is presented below in Table 5 7, key emission parameters in Table 5 8 and NPI emission factors and mitigation measures in Table 5 9.

[1] A $PM_{10}/PM_{2.5}$ ratio of 0.15 was adopted as per guidance from Cowherd et al. (2006)

Table 5-7: Summary of modelled particulate emissions – Atacama

Source (Atacama)	Description	TSP kg/year	PM_{10} kg/year	$PM_{2.5}$ kg/year
Overburden - Dozer, direct in pit	Volume of overburden removed is 7,891,746 BCM, equivalent to 13,492,315 tpa. 7 dozer operating 5,840 hrs/yr, equivalent of 4.5 dozer fulltime.	335,070	153,541	24,243
Removal of overburden to haul truck	Volume of overburden removed is 12,351,974 BCM, equivalent to 21,951,929 tpa.	274,399	245,038	38,690
Excavation of ore to Haul Truck	Volume of ore removed is 1,976,669 BCM, equivalent to 3,731,101 tpa	46,639	41,648	6,576
Placement of overburden on stockpiles - in pit	Volume of overburden removed is 8,005,506 BCM, equivalent to 14,227,385 tpa	170,729	61,178	9,177
Placement of overburden on stockpiles – external to pit	Volume of overburden removed is 4,346,468 BCM, equivalent to 7,724,543 tpa	92,695	33,216	4,982
Placement of ore at MUP1	Volume of ore X BCM, equivalent to 3,548,365 tpa	42,580	15,258	2,289
Placement of ore at MUP2	Volume of ore X BCM, equivalent to 182,736 tpa	2,193	786	118
Vehicles on unpaved roads - CAT789	Vehicle kilometres travelled (VKT) = average trip length (~2 km) by number of trips (assuming CAT 789, 180t capacity, by 11,007,013 tpa material moved), equals 122,300 VKT	303,938	89,711	13,457
Vehicles on unpaved roads - CAT777	Vehicle kilometres travelled (VKT) = average trip length (~2 km) by number of trips (assuming CAT 777, 90t capacity, by 14,676,000 tpa material moved), equals 326,134 VKT	593,322	175,126	26,269
Wind erosion of in pit stockpiles	Area of in-pit active and inactive non stabilised stockpiles is approximately 150ha (1,500,000 m^2)	525,600	262,800	39,420
Exposed pit surface	Area of pit active at any one time is approximately 75ha (750,000 m^2)	131,400	124,830	19,710
Wind erosion of ex-pit stockpiles	Area of stockpiles active at any one time is approximately 30ha (300,000 m^2)	105,120	52,560	7,884
Total		**2,518,564**	**1,203,131**	**184,931**

Table 5-8: Key emission estimation parameters – Atacama

Parameter	Value	Units	Source
Mining operational days	365	Days per year	Assumption
Mining operational hours	24	Hours per day	Assumption
Volume of ore removed	1,976,670	BCM/year	Iluka
Total tpa of ore to ROM	3,731,101	tonnes / year	Iluka
Volume of overburden removed	20,221,643	BCM/year	Iluka
Total tpa of overburden removed	35,444,244	tonnes / year	Iluka
Overburden direct in-pit handling by Dozer	13,492,315	tonnes / year	Iluka
Total overburden loaded and end-dumped	21,951,929	tonne/year	Iluka
Average trip length of haul trucks	2.0	Km	Assumption
Total vehicle kilometres travelled to move total material	448,434	VKT	Assumption
Total area of active stockpiles	1,800,000	m^2	Assumption
Total exposed pit surface	750,000	m^2	Assumption

Table 5-9: Adopted NPI emission factors and mitigation measures – Atacama

Emission source	Units	Emission factors			Mitigation measure
		TSP	PM_{10}	$PM_{2.5}$ [1]	
Dozer	kg/hr	17	4.1	0.615	TSP - 50% pit retention PM_{10} - 5% pit retention $PM_{2.5}$ - none
Excavation of overburden to haul truck	kg/t	0.025	0.01175	0.00176	TSP - 50% pit retention PM_{10} - 5% pit retention $PM_{2.5}$ - none
Excavation of ore to haul truck	kg/t	0.025	0.01175	0.00176	TSP - 50% pit retention PM_{10} - 5% pit retention $PM_{2.5}$ - none
Placement of overburden on stockpiles (end dumping)	kg/t	0.012	0.0043	0.000645	none
Placement of overburden and soils in pit area	kg/t	0.012	0.0043	0.000645	none
Placement of ore at MUP	kg/t	0.012	0.0043	0.000645	none
Vehicles on unpaved roads (CAT777)	kg/VKT	7.28	2.15	0.32	75% (level 2 watering)
Vehicles on unpaved roads (CAT789)	kg/VKT	9.94	2.93	0.44	75% (level 2 watering)
Wind erosion of stockpiles	kg/ha/hr	0.4	0.2	0.03	none
Wind erosion of exposed pit area	kg/ha/hr	0.4	0.2	0.03	TSP - 50% pit retention PM_{10} - 5% pit retention $PM_{2.5}$ - none

6. Modelling Methodology

6.1 Overview

The following sections detail the methodology adopted to complete the meteorology and dispersion modelling.

The meteorology modelling of the study area was completed using the prognostic meteorology model from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) , The Air Pollution Model (TAPM), and the meteorology model CALMET. The puff model CALPUFF was used for the dispersion modelling for the Project.

6.2 TAPM

TAPM predicts three-dimensional meteorology, including terrain-induced circulations. TAPM is a prognostic meteorological model that uses databases of terrain, vegetation and soil type, leaf area index, sea-surface temperature, and synoptic-scale meteorology analyses for various regions around the world. TAPM is used to predict meteorology parameters at both ground level and at heights of up to 8,000m above the surface; these data were used as input to the CALMET model for this assessment.

6.3 CALMET

CALMET is a meteorological model which includes a diagnostic wind field generator containing objective analysis and parameterized treatments of slow flows, kinematic terrain effects, terrain blocking effects, and a divergence minimization procedure, and a micrometeorology model for overland and overwater boundary layers.

6.4 CALPUFF

CALPUFF is a regulatory model and is recommended for a wide variety of applications including long range transport and on a case-by-case basis, for near-field applications such as in coastal applications, complex flows and non-steady state situations, such as coastal applications, calm wind dispersion, stagnation, fumigation, complex terrain, and chemical transformation. It is suitable for source receptor distances from fence–line applications (tens of metres) to several hundred kilometres.

CALPUFF is a three-dimensional non-steady state puff dispersion model which is particularly suited for near-field impact assessments in complex geographical locations where there are spatially varying flows.

Of significance for this Project, the dispersion model can characterise:

- Emission plume history, where the positions of the airborne emissions (puffs) are stored from one hour to the next.
- Enabling the simulation of curved, recirculating, or stagnating transport of the emissions.
- Emission plume transport during near calm winds events, including build-up and fumigation.
- Dispersion over a range of land surfaces or water bodies.

Cumulative impacts for many sources within a spatially varying flow field, and a range of emission source types including point, area, volume, and buoyant line plume sources with time-varying emission conditions.

6.5 Model Settings

Table 6-1 presents a summary of the key input model settings for the TAPM and CALMET meteorology models, and the CALPUFF dispersion model.

As per guidance from the SA EPA (*email 11 August 2022, P. Shah to G. Simes and M. Pickett*), the modelled assessment year of 2009 was selected as this year is deemed to be representative of long-term climatic trends.

Table 6-1: Summary of model input parameters

Parameter	Input
TAPM (v.4.0.4)	
Number of grids (spacing)	4 grids (30 km, 10 km, 3 km, 1 km)
Number of grid points (x, y, z)	25 x 25 horizontally and 17 vertically (10-2000 metres)
Simulation period	30 Dec 2008 to 31 Dec 2009
Terrain information	Australian longitude/latitude grid at 9-second grid spacing based on data from Geoscience Australia. TAPM default databases used for vegetation, soil and leaf area index (1km grid resolution)
Centre of analysis	235,370 m E; 6,585,592 m S (UTM, zone 53)
Local data assimilation	No data assimilation
CALMET (v6.42)	
Meteorological grid domain	16 x 23 km
Meteorological grid resolution	1000m
Reference grid coordinates (centre)	237,000 m E; 6,585,500 m S (UTM, zone 53)
Cell face heights in vertical grid	0, 20, 40, 80, 160, 320, 640, 1200 and 2000
Simulation length	365 days
Modelling mode (NOOBS)	2 - No OBS
Surface meteorology stations	None
Upper air meteorology stations	None
Terrain data	SRTM1 Version 3.0 (~30 m)
Land use data	GLCC (Australia Pacific ~ 1km)
TERRAD (terrain radius of influence)	10km
CALPUFF (v7.2.1)	
Computational grid	16 x 23 km
Number of sensitive receptors	1
Dispersion modelling period	1 Jan 2009 to 31 Dec 2009
Dry deposition modelled (MDRY)	1 - Yes
Wet deposition modelled (MWET)	0 - No
Chemical transformation method (MCHEM)	0 - Not modelled
Dispersion coefficients (MDISP)	2 - Dispersion coefficient, use turbulence computed from micrometeorology
Minimum turbulence velocities (SVMIN)	0.2 m/s

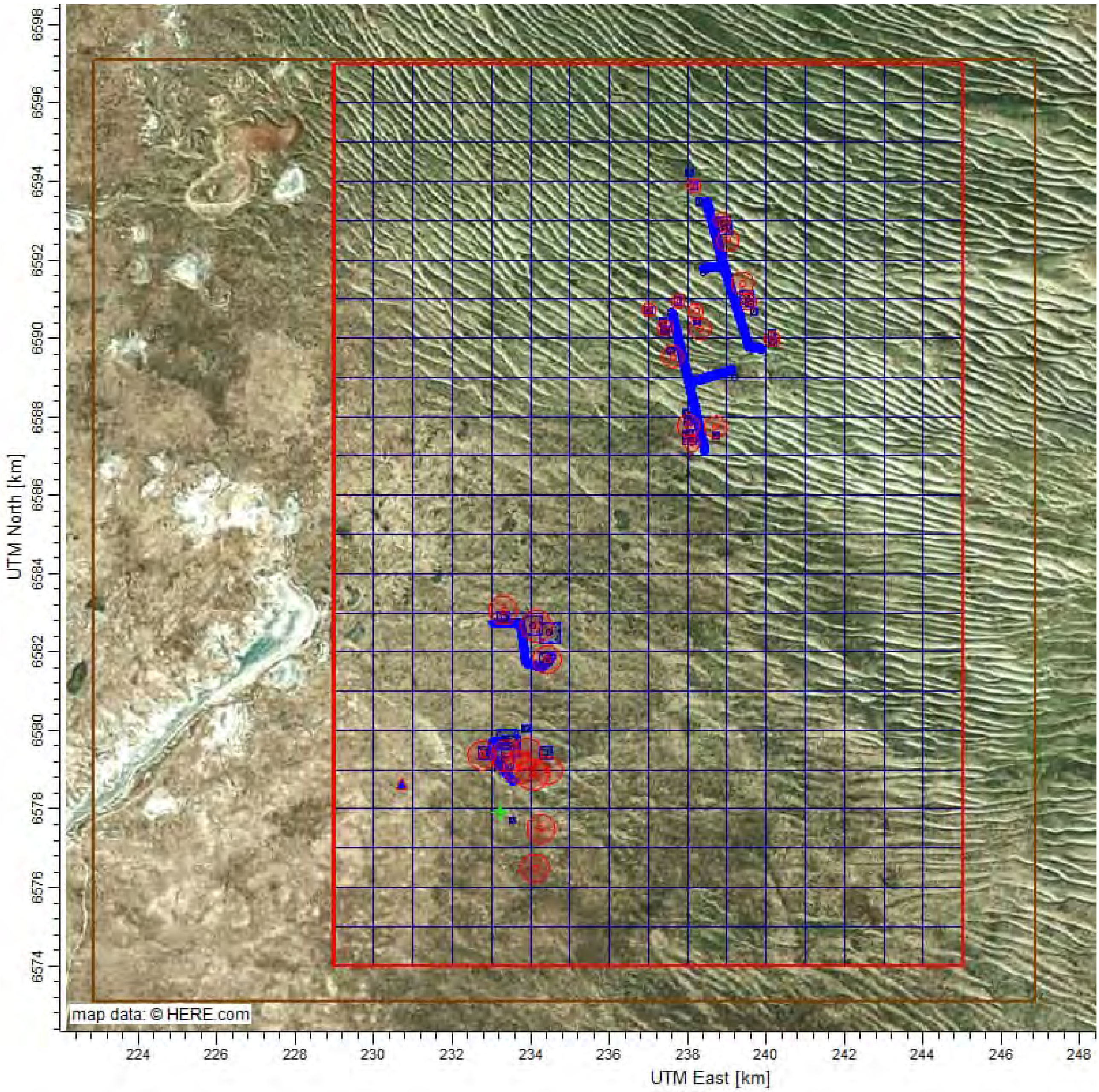

Figure 6-1. Model Domains

Figure notes:

1. Red circles represent dust emission area sources
2. Blue rectangles represent dust emission volume sources
3. Blue grid represents CALMET grid domain
4. Red rectangle represents CALPUFF computational grid
5. Brown rectangle represents TAPM grid domain input for CALMET
6. Thick blue line represent unsealed road sources

6.6 Modelled Scenarios

Two scenarios were modelled, one representing current emissions from J-A and a second consisting of current J-A operation and future Atacama emissions.

The J-A scenario was based on the NPI reporting data for actual production from 2019/2020.

Emissions from Atacama were based on peak material volumes in the mining schedule plan, with peak material handling planned for 2029. Emission source locations for Atacama were based on the changes in end of year mining schedule from 2028 to 2029 (Appendix A). It was assumed that stockpiles that were unchanged from 2028 to 2029 were inactive and therefore stabilised or revegetated.

The two scenarios can be summarised as:

- Existing operations scenario – based on J-A 2019/20 NPI reporting.
- Future worst-case scenario – based on J-A 2019/20 NPI reporting plus Atacama scheduled 2029 production.

6.7 Oxides of Nitrogen Conversion

With respect to oxides of nitrogen (NO_X), at the point of combustion approximately 90% of the NO_X will be nitric oxide (NO) and 10% nitrogen dioxide (NO_2). Air quality criteria relates to NO_2 and as such it is necessary to consider the conversion of NO_X to NO_2 which occurs over time as plumes disperse downwind.

The United States Environmental Protection Agency (USEPA) provides an industry standard for this conversion in Appendix W of the guidance document Guideline on Air quality Models, 40 CFR Part 51 which describes a three-tiered approach to calculating NO_2 concentrations based on dispersion model predictions of NO_X:

- Tier 1 – Full conversion of NO to NO_2 so that NO_x is 100% NO_2.
- Tier 2 – Ambient ratio method, where the predicted NO_x concentrations are multiplied by the ambient ratio of NO_2 to NO_x, derived from ambient monitoring data.
- Tier 3 – More detailed method accounting for plume dispersion and chemistry including the Ozone limiting method (OLM) and plume volume molar ratio method (PVMRM).

For this assessment, the Tier 1 approach has been applied to provide a conservative assessment of impacts.

7. Modelled Meteorology

The following sections provides a summary of the modelled meteorology and a comparison to measured data where applicable.

The meteorology modelling of the study area was completed using the prognostic meteorological model 'The Air Pollution Model' (TAPM) developed by CSIRO, and the meteorological model CALMET. The puff model CALPUFF was used for the dispersion modelling for the Project.

Meteorological data including wind speed & direction and temperature was obtained from on-site measurements adjacent to the Iluka J-A mine between June 2020 to July 2022. The on-site measured meteorological data was compared to the TAPM model output in this section, plus additional analysis of the CALMET modelled upper air data.

7.1 Winds

Figure 7-1 shows a histogram of measured (hourly average) wind speed at Iluka's J-A mine in 2021. Figure 7-2 shows the same plot using TAPM modelled data for 2009 (with the same averaging period and histogram bins). The wind speed distribution of the two figures is similar, indicating the TAPM model compares reasonably well to the measured wind speed data.

Figure 7-3 and Figure 7-4 show wind roses of the measured and TAPM modelled wind speed & direction data respectively. As in the above wind speed results, the measured data is from 2021 while the TAPM model is from 2009. The measured and modelled data agree reasonably well, with only minor differences.

Modelled winds speeds in 2009 were slightly lower than measured in 2021, with an annual average modelled wind speed of 3.5m/s vs measured average wind speed of 3.7. Whilst this may be due to variation year to year, it is known that TAPM tends to underestimate wind speeds. However, the use of lower wind speeds in dispersion modelling tends to be conservative since lower wind speeds result in poorer dispersion of pollutants (increasing their GLCs).

Overall, the modelled winds generally represent on-site measured meteorology well.

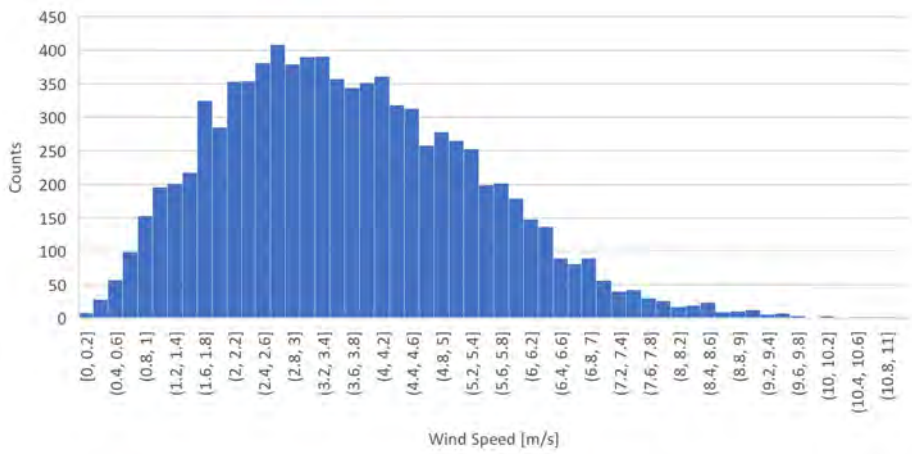

Figure 7-1. Wind speed measured at Iluka's J-A deposit over 2021

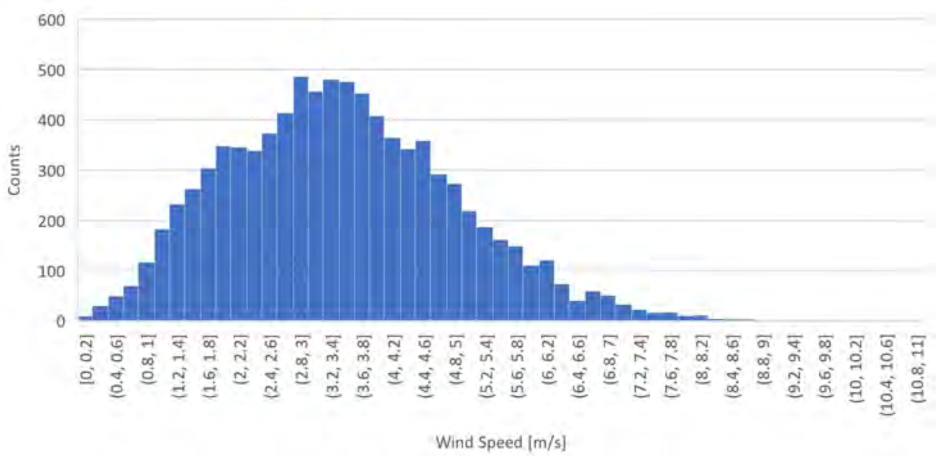

Figure 7-2. Wind speed modelled using TAPM over 1 year (2009)

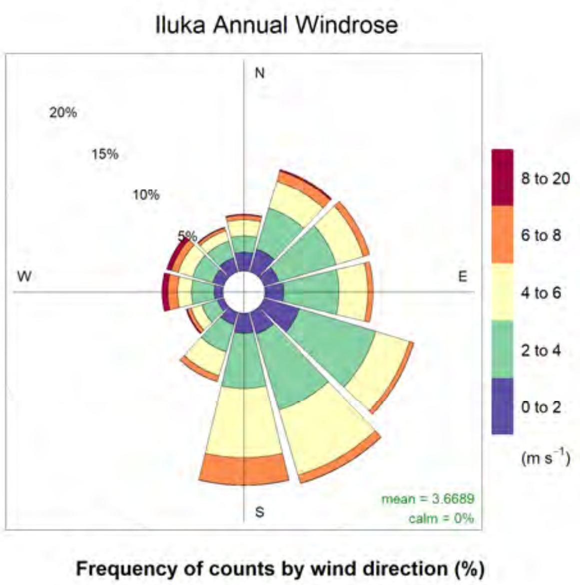

Figure 7-3. Annual wind rose – on-site measured data from J-A (2021)

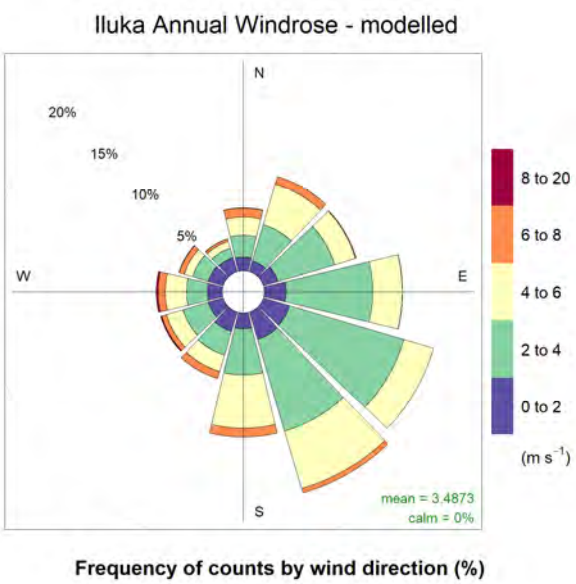

Figure 7-4. Annual wind rose – TAPM model output (2009)

7.2 Temperature

Figure 7-5 and Figure 7-6 show the measured and TAPM modelled air temperature. While these results also agree reasonably well, it is noted that the TAPM model does not include temperature recordings below 6° C. This discrepancy is not anticipated to impact on air dispersion modelling results as air temperature, whilst important in its influence on winds, does not have a large direct influence on air dispersion.

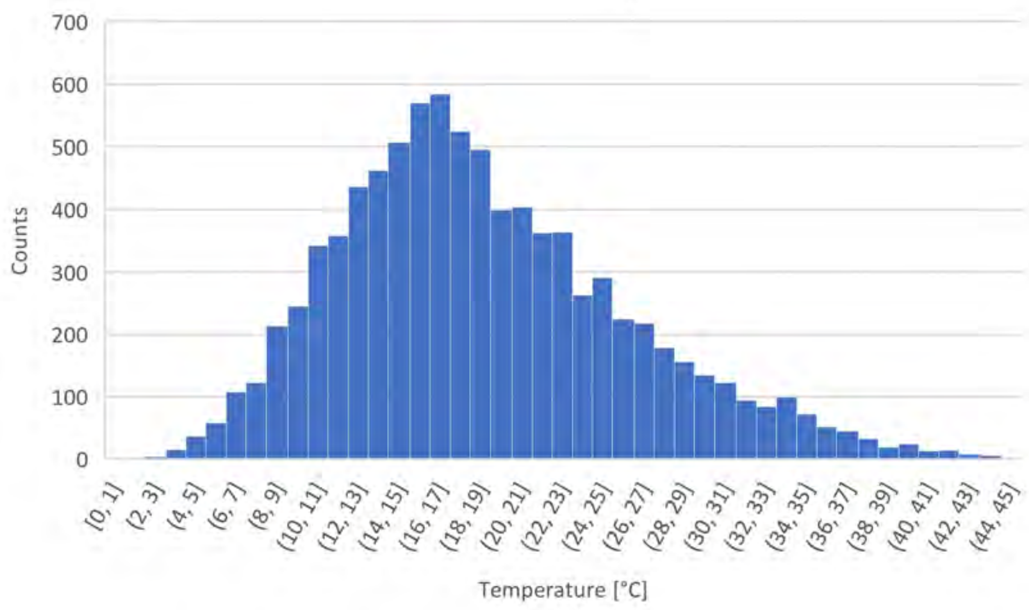

Figure 7-5. Temperature measured at Iluka J-A over 2021

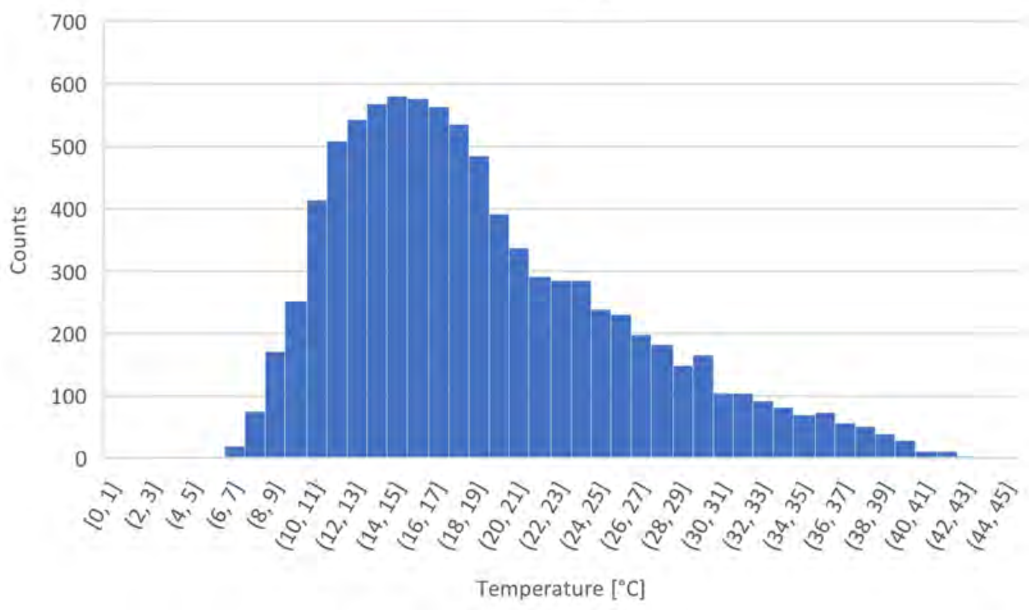

Figure 7-6. Temperature modelled using TAPM over 1 year (2009)

7.3 Mixing Layer Height

Mixing height or mixed layer height is an important meteorological parameter for air quality as it determines the height of vertical diffusion of atmospheric pollutants in the boundary layer (Aron, 1983; Stull, 1988; Tang, et al., 2016). Mixing height is estimated within CALMET for stable and convective conditions, with a minimum mixing height of 50m and maximum height of 2000m. Figure 7-7 shows the mixing height statistics by hour of the day at the J-A met station site from the CALMET predictions. The box and whisker plots show the minimum, first quartile, median, third quartile and maximum predicted mixing height for each hour of the day during the summer half-year and winter half-year.

The model predictions are consistent with general atmospheric processes that show increased vertical mixing with the progression of the day, as well as lower mixing heights during the night-time. The mixing height predictions show a typical pattern of daily mixing height gradual growth from morning continuing through the day, and subsequent steep decline moving into evening.

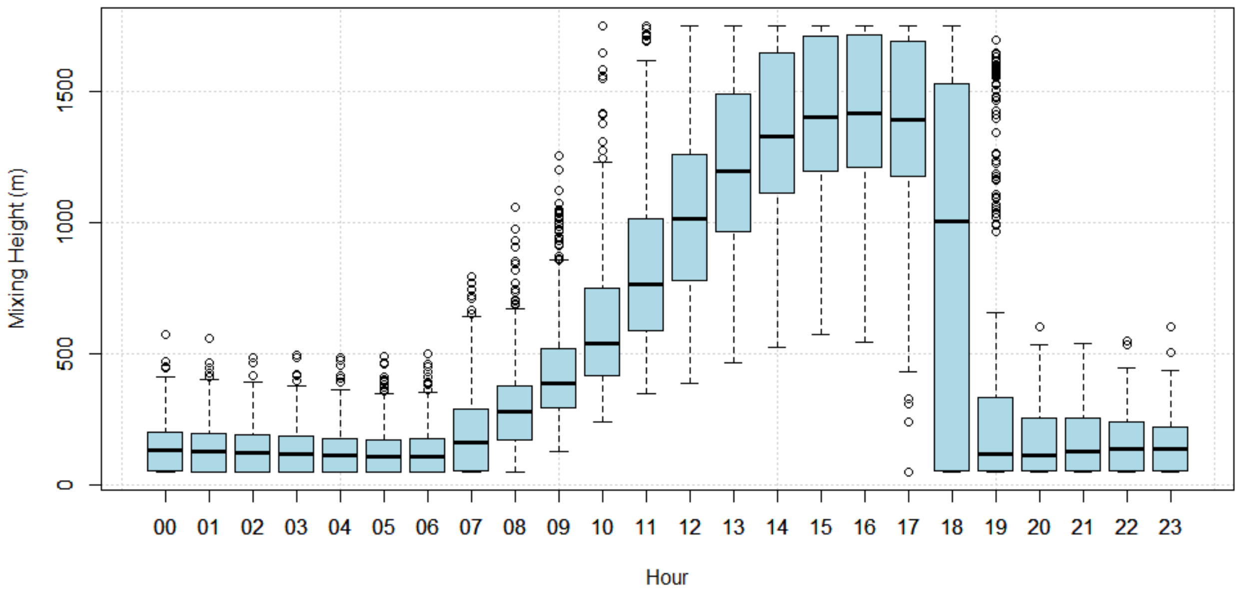

Figure 7-7. CALMET predicted mixing height plot

7.4 Atmospheric Stability

Stability class is used as an indicator of atmospheric turbulence in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner (PG) scheme, which uses six categories (A to F) to describe atmospheric stability based mainly on static stability (vertical temperature profile/structure), convective turbulence (caused by radiative heating of the ground) and mechanical turbulence (caused by surface roughness). In general, stable conditions result in less atmospheric mixing and poorer dispersion, and unstable conditions are more turbulent and result in greater mixing in the boundary layer. The PG stability classes are as follows:

- A: Very unstable
- B: Moderately unstable
- C: Slightly unstable
- D: Neutral
- E: Slightly stable, and
- F: Stable.

The stability class frequency distribution from the CALMET model is presented below in Figure 7-8 for the Project site and stability class by hour of day are presented in Figure 7-9.

The frequency distributions indicate a high proportion of stable conditions, with fewer highly and moderately unstable conditions. Stable conditions occur only during night-time hours and very unstable conditions are limited to the daylight hours in the middle of the day. The predominant stability classes are consistent with typical distributions for inland areas around Australia.

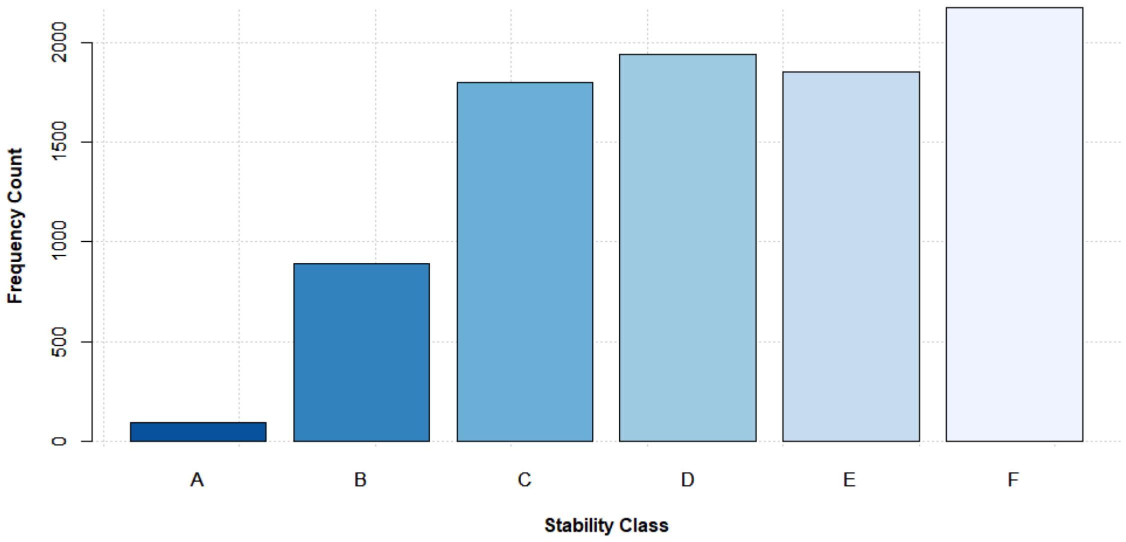

Figure 7-8. CALMET predicted stability class total frequency count

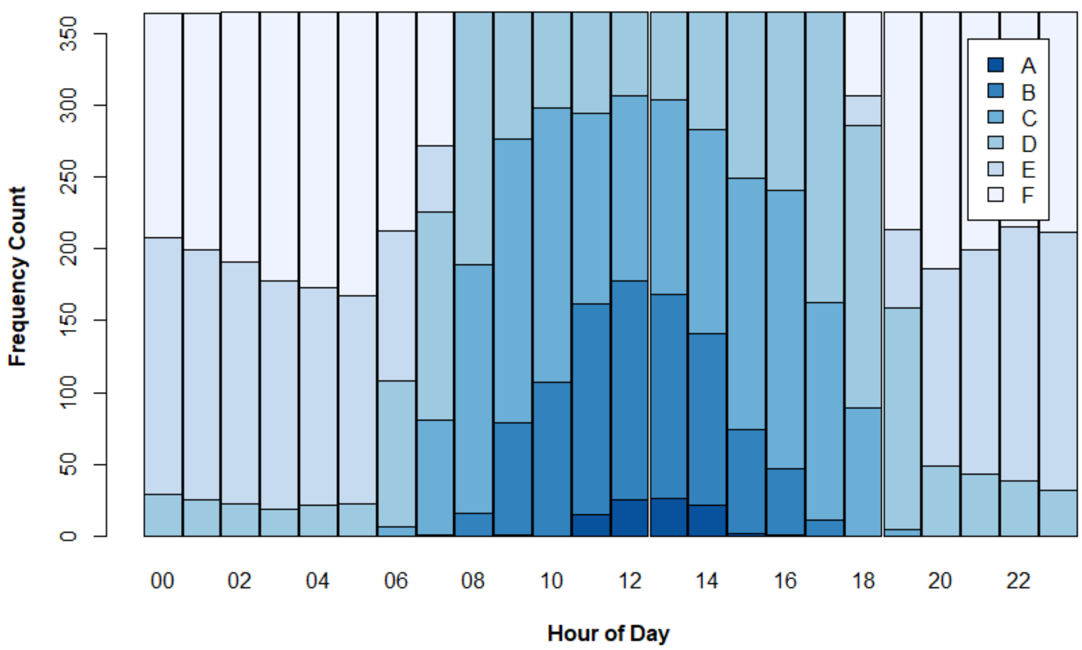

Figure 7-9. CALMET predicted stability class by hour of day

8. Results

This section provides the modelled results for air dispersion modelling, and impacts for the sensitive receptor (the accommodation village and camp located approx. 3km north-west of the J-A deposit, see Section 2.3). Two scenarios were modelled, the J-A mine at current production (based on 2019/2020 NPI reporting data) and the current J-A production plus Atacama production (Atacama production based on maximum material handling, scheduled in 2029) to determine cumulative impacts. The results pertaining to each of these scenarios are detailed below.

Modelling for gaseous pollutants NO_2 and CO, and radiological contaminants were only undertaken for the combined J-A and Atacama scenario.

8.1 Model Results – Jacinth-Ambrosia

A summary of model results of the existing J-A mine is presented below in Table 8-1. Results of modelled pollutants are compared against air quality objectives and includes background i.e. cumulative results for J-A operations and existing background. Results are expressed as a maximum for either sensitive receptor location or grid result depending on the averaging statistic i.e. the mine camp for 24-hr and annual averages, and maximum grid results for 8-hr rolling average, or hourly average results, if applicable.

The results of the AQIA are summarised as follows:

- Annual average dust deposition at the nearest sensitive receptor is well below the air quality objective. A Contour plot is shown in Figure 8-1.
- Predicted particulate concentrations for maximum 24-hr average and annual average $PM_{2.5}$, and 24-hr average PM_{10} were below the air quality objective at the nearest sensitive receptor location, the mine camp. Contour plots are shown in Figure 8-2, Figure 8-3 and Figure 8-4 respectively.

Table 8-1: J-A mine modelling results: predicted cumulative concentration of pollutants and dust

Pollutant	Averaging statistic	Result location	Predicted cumulative concentration	Air quality objective	Units
Deposited dust	Annual average	Camp	1.6	4	$g/m^2/month$
	Increase above background		0.1	2	$g/m^2/month$
PM_{10}	24 hr maximum	Camp	36	50	$\mu g/m^3$
$PM_{2.5}$	24 hr maximum	Camp	13	25	$\mu g/m^3$
	Annual average	Camp	7.3	8	$\mu g/m^3$

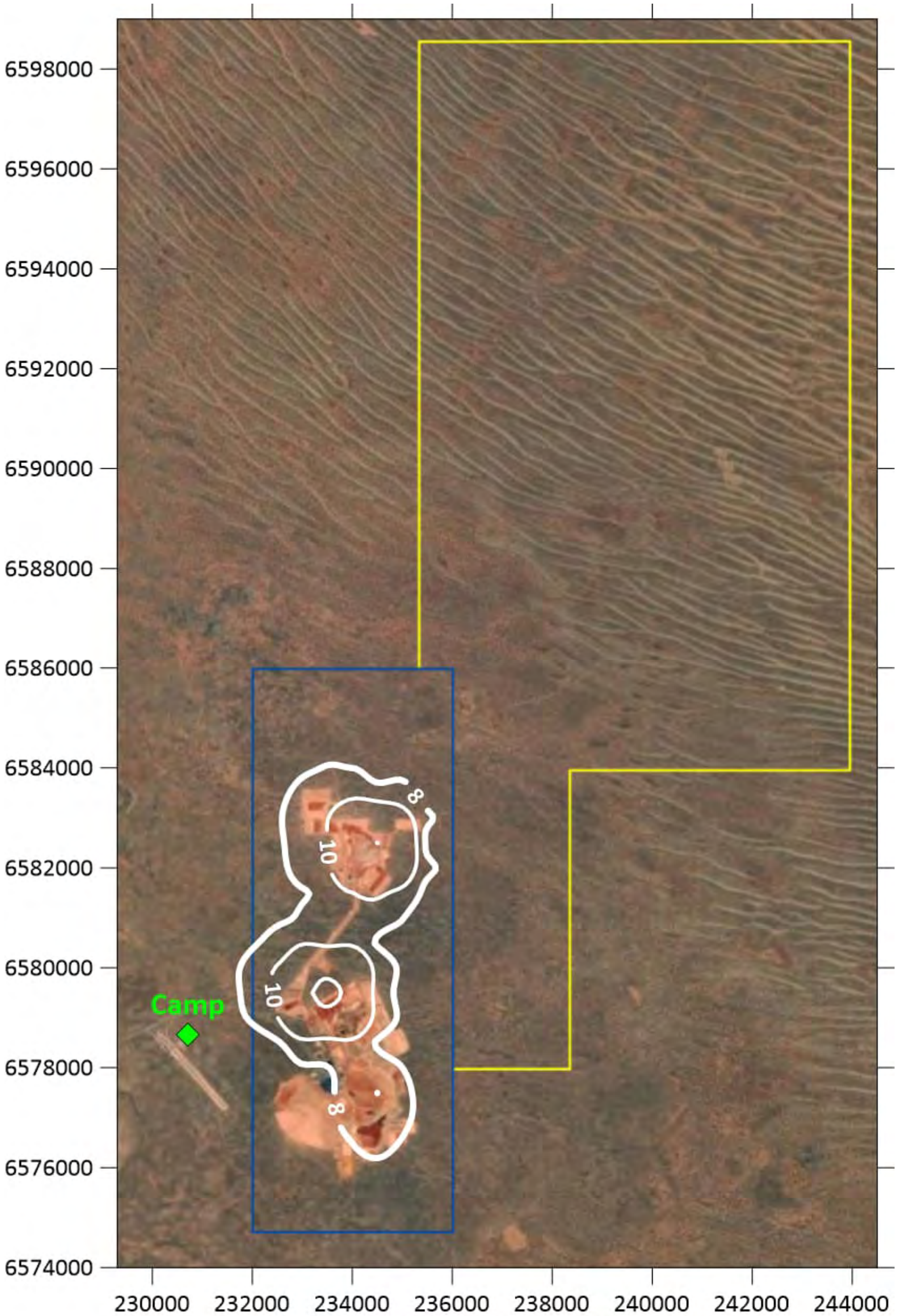

Figure 8-1. Maximum predicted cumulative dust deposition monthly rates (g/m^2/month) – J-A mine

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Monthly maximum dust deposition assessment criterion is 4 g/m^2/month
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

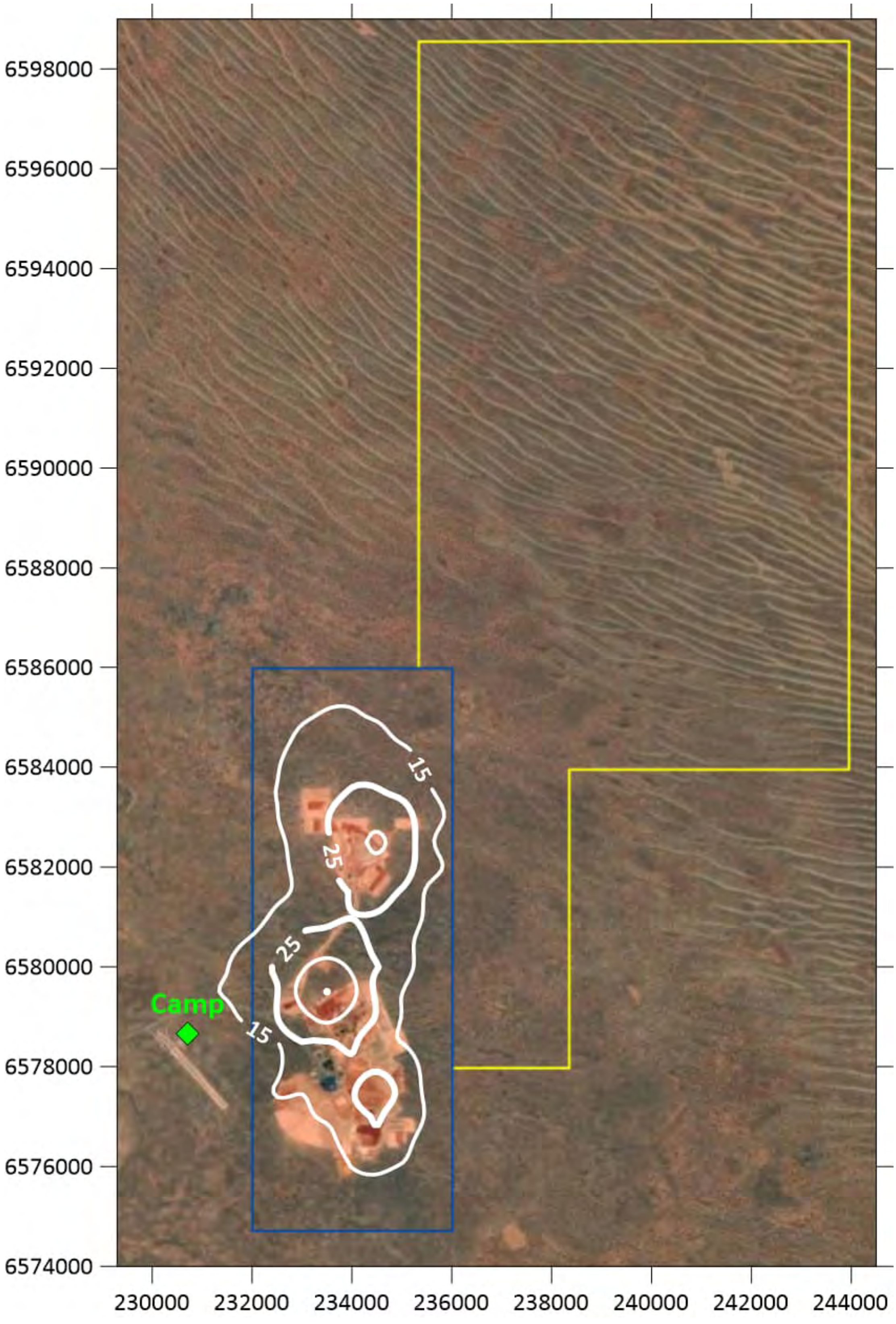

Figure 8-2. Maximum predicted cumulative $PM_{2.5}$ 24-hour concentrations (µg/m^3) – J-A mine

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. 24-hour maximum $PM_{2.5}$ assessment criterion is 25µg/m^3
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

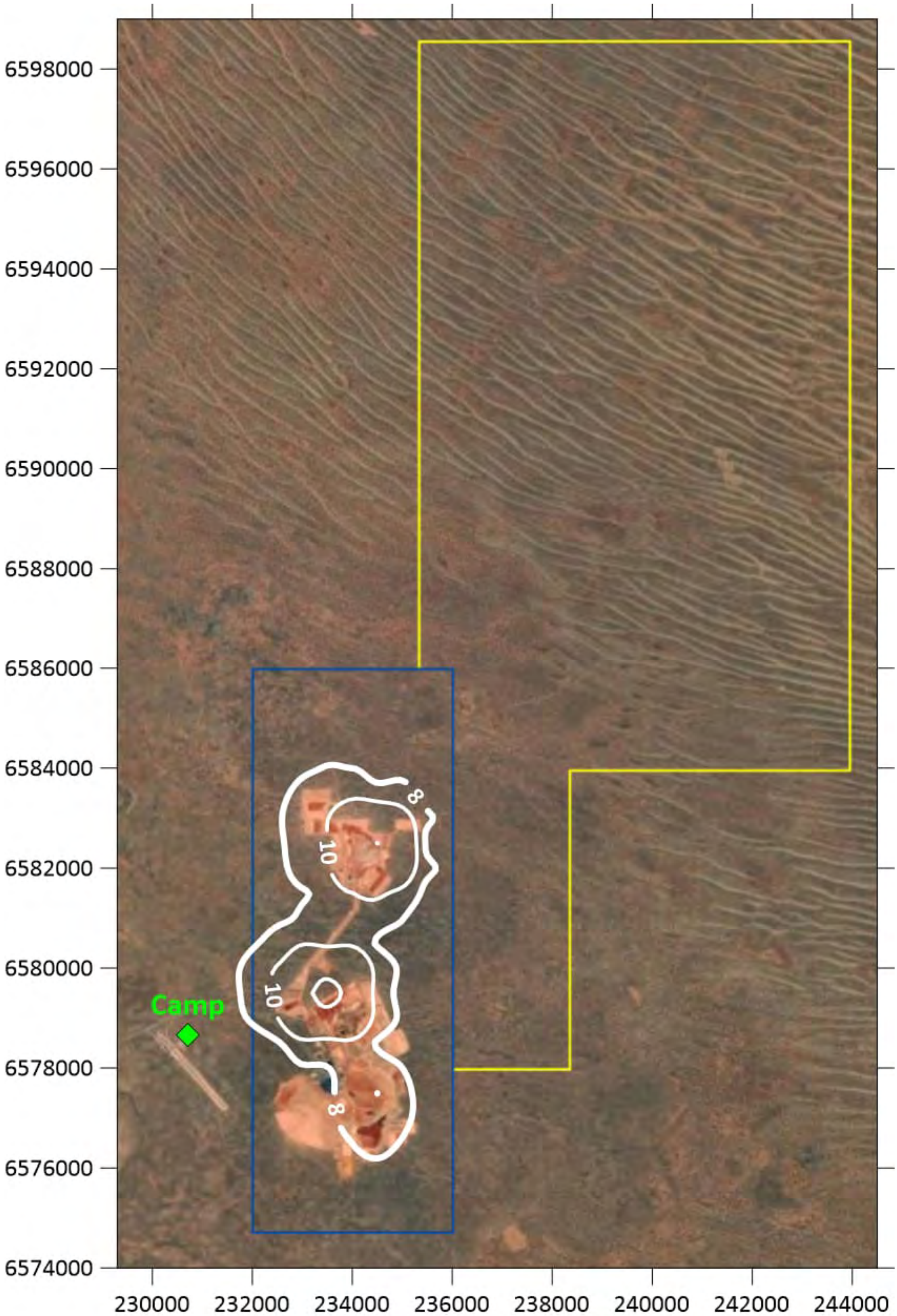

Figure 8-3. Maximum predicted cumulative $PM_{2.5}$ annual average concentrations (µg/m^3) – J-A mine

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Annual average $PM_{2.5}$ assessment criterion is 8µg/m^3
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

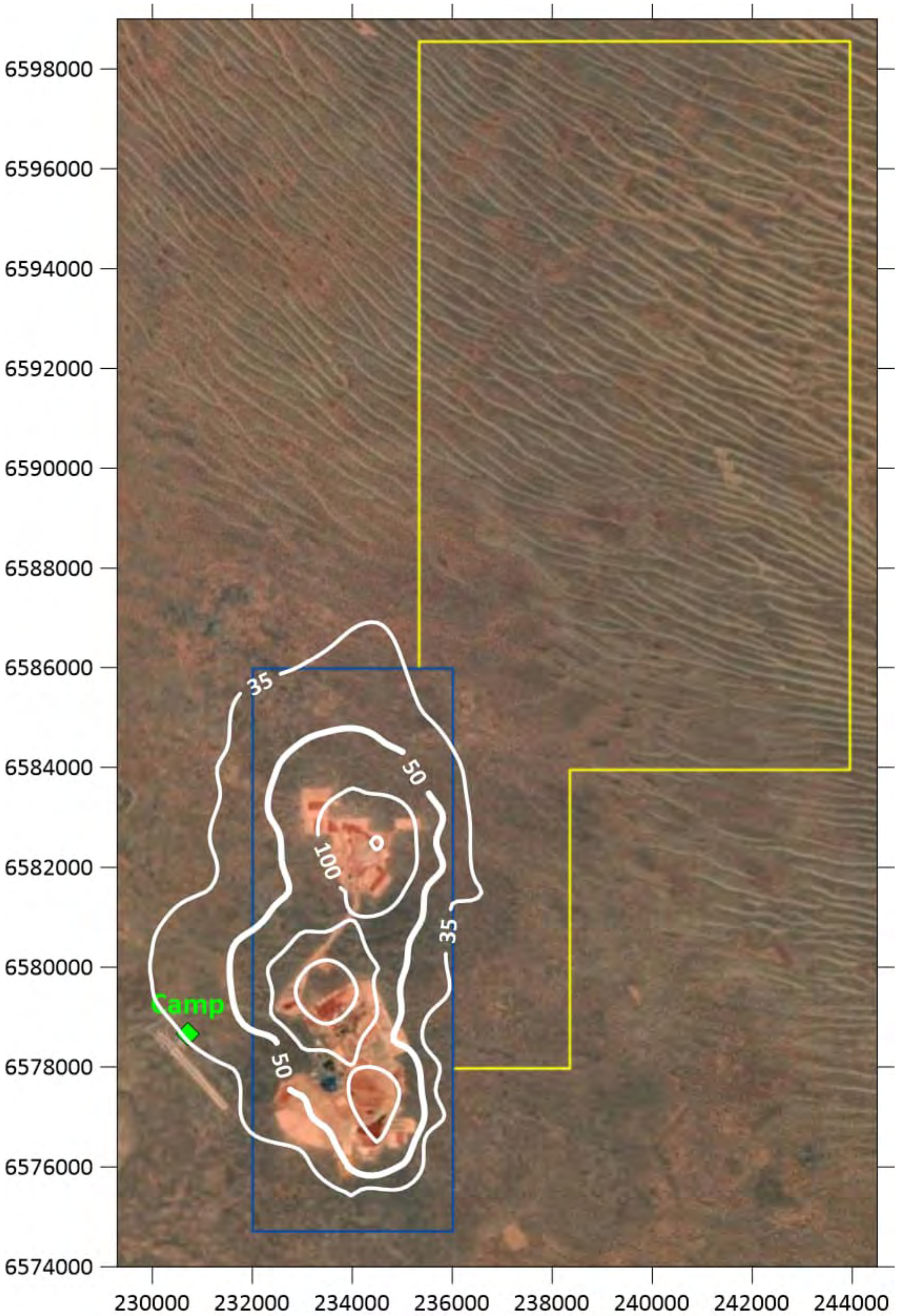

Figure 8-4. Maximum predicted cumulative PM_{10} 24-hour concentrations (µg/m³) – J-A mine

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. 24-hour maximum PM_{10} assessment criterion is 50µg/m³
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

8.2 Model Results – J-A and Atacama

A summary of dust and gaseous pollutant model results for the combined J-A and Atacama mines are presented below in Table 8-2. Results of modelled pollutants are compared against air quality objectives and include background i.e. cumulative results for J-A operations plus Atacama operations and existing background. Results are expressed as a maximum for either sensitive receptor location or maximum grid result depending on the averaging statistic i.e. the mine camp for 24-hr and annual averages, and maximum grid results for 8-hr rolling average, or hourly average results.

The annual average concentration of radionuclides in air, and the annual average radionuclides in deposited dust reported are reported in Table 8-3 and do not include background.

The results of the AQIA are summarised as follows:

- Annual average dust deposition at the nearest sensitive receptor is well below the air quality objective. A Contour plot is shown in Figure 8-5.
- Predicted particulate concentrations for maximum 24-hr average and annual average $PM_{2.5}$, and 24-hr average PM_{10} were below the air quality objective at the nearest sensitive receptor location, the mine camp. Contour plots are shown in Figure 8-6, Figure 8-7 and Figure 8-8 respectively.
- All predicted gaseous pollutant concentrations were well below respective air quality objectives. A contour plot for maximum hourly average NO_2 is shown in Figure 8-9 and contour plots for other pollutants and averaging statistics are included in Appendix C.
- An annual average radionuclide concentration in air of 0.13 Bq/m^3 was predicted for the Camp sensitive receptor. A contour plot is shown in Figure 8-10.
- The annual average radionuclides in deposited dust 0.35 Bq/m^2/year was predicted for the camp sensitive receptor. A contour plot is shown in Figure 8-11.

Interpretation of radiological model results is not included in Jacobs' scope.

Table 8-2: J-A mine and Atacama predicted cumulative model results

Pollutant	Averaging statistic	Result location	Predicted cumulative concentration	Air quality objective	Units
Deposited dust	Annual average	Camp	1.6	4	g/m^2/month
	Increase above background		0.1	2	g/m^2/month
PM_{10}	24 hr maximum	Camp	36	50	µg/m^3
$PM_{2.5}$	24 hr maximum	Camp	13	25	µg/m^3
	Annual average	Camp	7.3	8	µg/m^3
CO	1 hr maximum	Grid	50	31,240	µg/m^3
	8-hr maximum	Grid	8	11,250	µg/m^3
NO_2	1 hr maximum	Grid	36	164	µg/m^3
	Annual average	Camp	< 1	30	µg/m^3

Table 8-3: J-A mine and Atacama predicted radiological model results (no background)

Pollutant	Averaging statistic	Result location	Predicted concentration	Units
Radionuclides in deposited dust	Annual average	Camp	0.35	Bq/m^2/yr
Radionuclides in air	Annual average	Camp	0.13	Bq/m^3

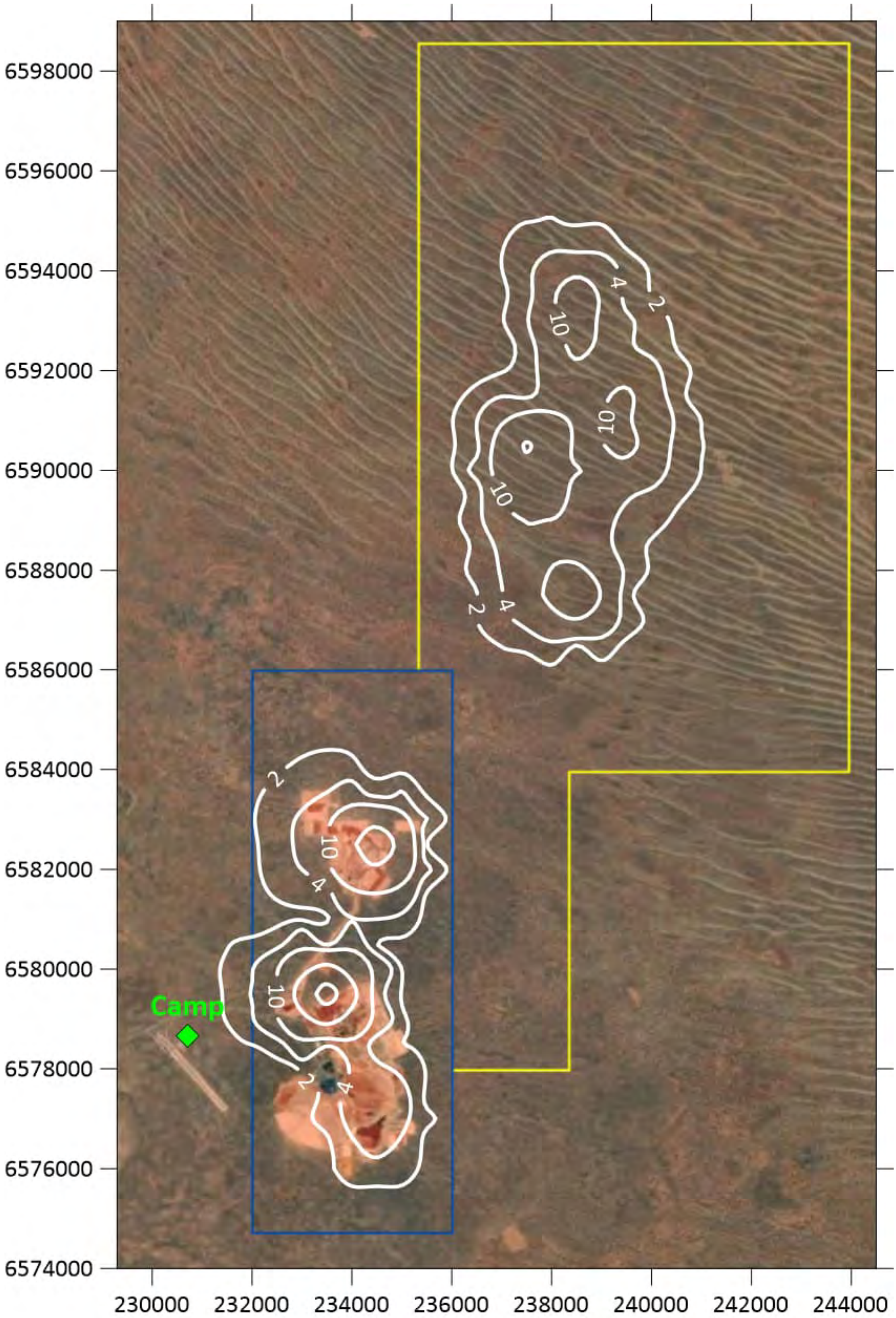

Figure 8-5. Maximum predicted cumulative dust deposition (g/m^2/month) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres

2. Monthly maximum dust deposition assessment criterion is 4 g/m²/month
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

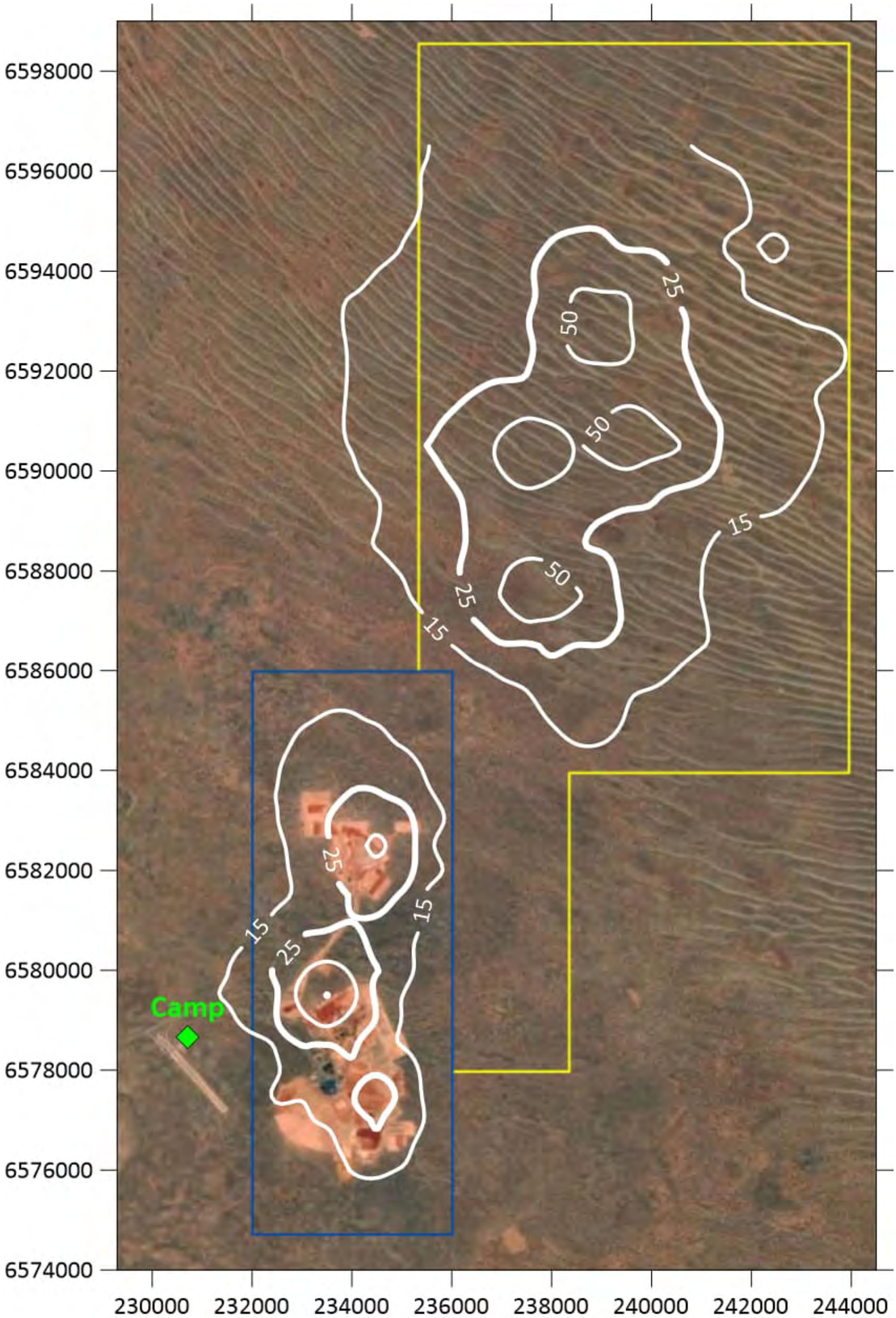

Figure 8-6. Maximum predicted cumulative $PM_{2.5}$ 24-hour concentrations (µg/m³) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. 24-hour maximum $PM_{2.5}$ assessment criterion is 25µg/m³
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

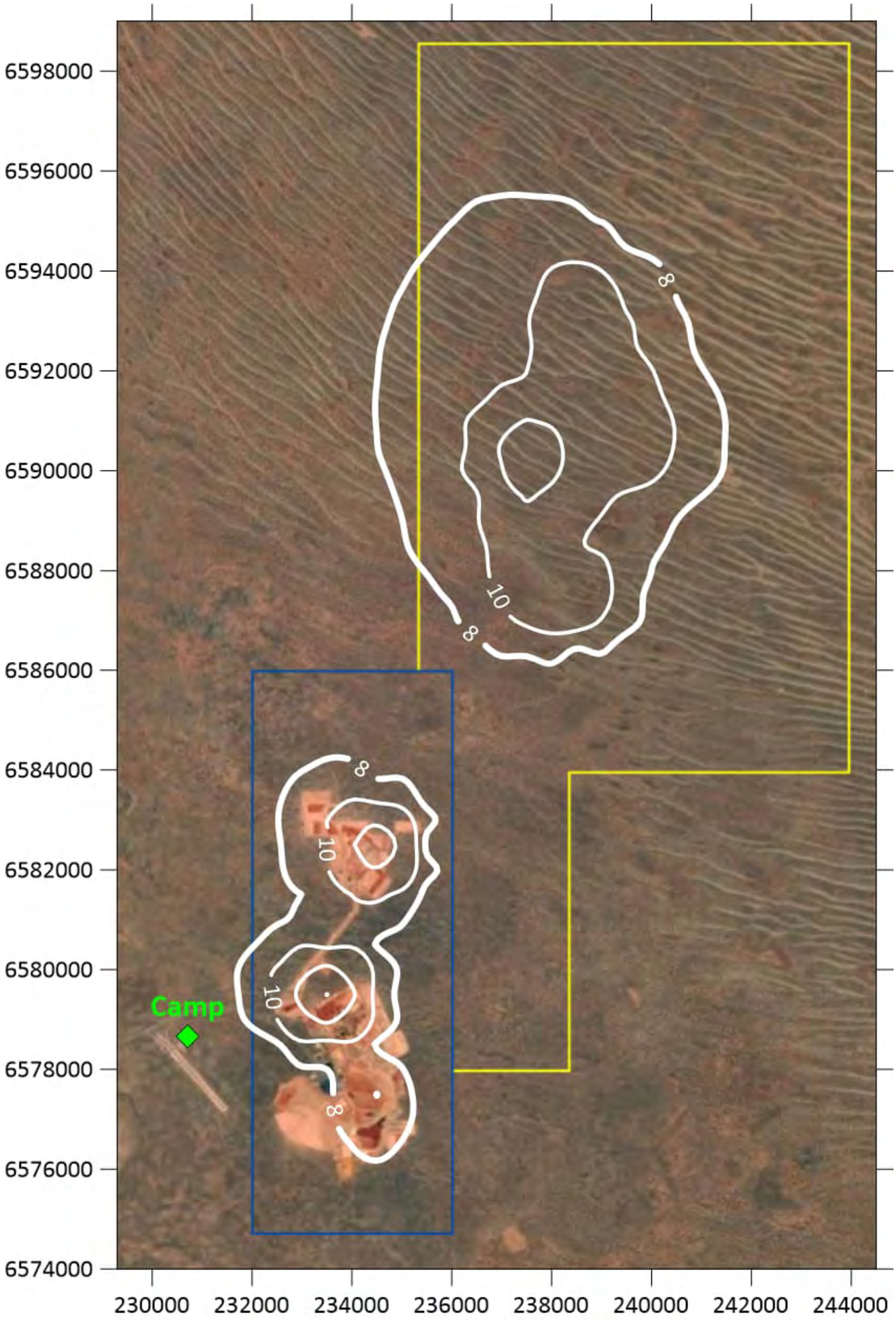

Figure 8-7. Maximum predicted cumulative $PM_{2.5}$ annual ave concentrations (µg/m^3) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Annual maximum $PM_{2.5}$ assessment criterion is 8µg/m^3
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

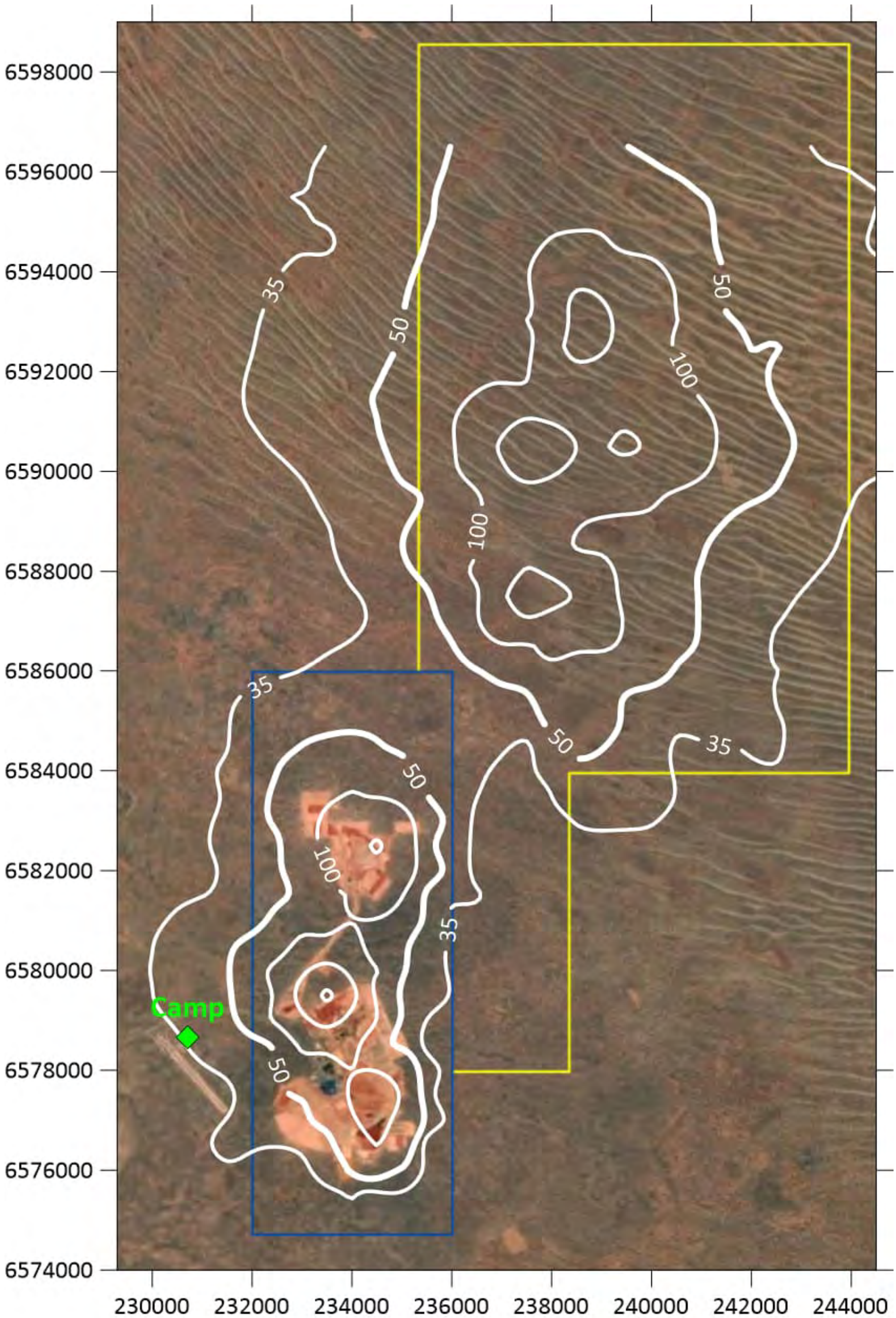

Figure 8-8. Maximum predicted cumulative PM_{10} 24-hour concentrations (µg/m^3) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. 24-hour maximum PM_{10} assessment criterion is 50µg/m^3
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

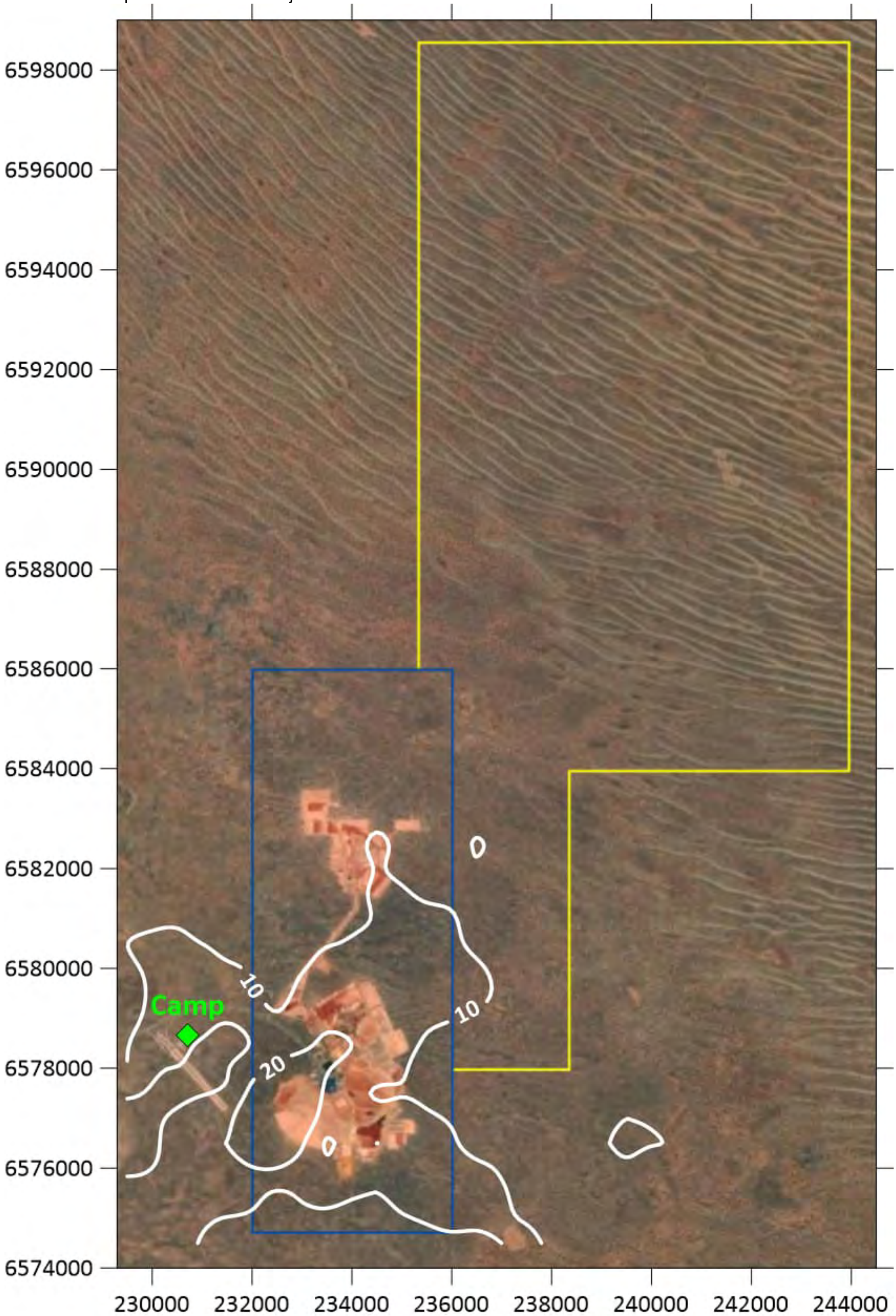

Figure 8-9. Maximum predicted NO_2 1-hour concentrations ($\mu g/m^3$) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. 1-hour maximum NO_2 assessment criterion is $164\mu g/m^3$
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

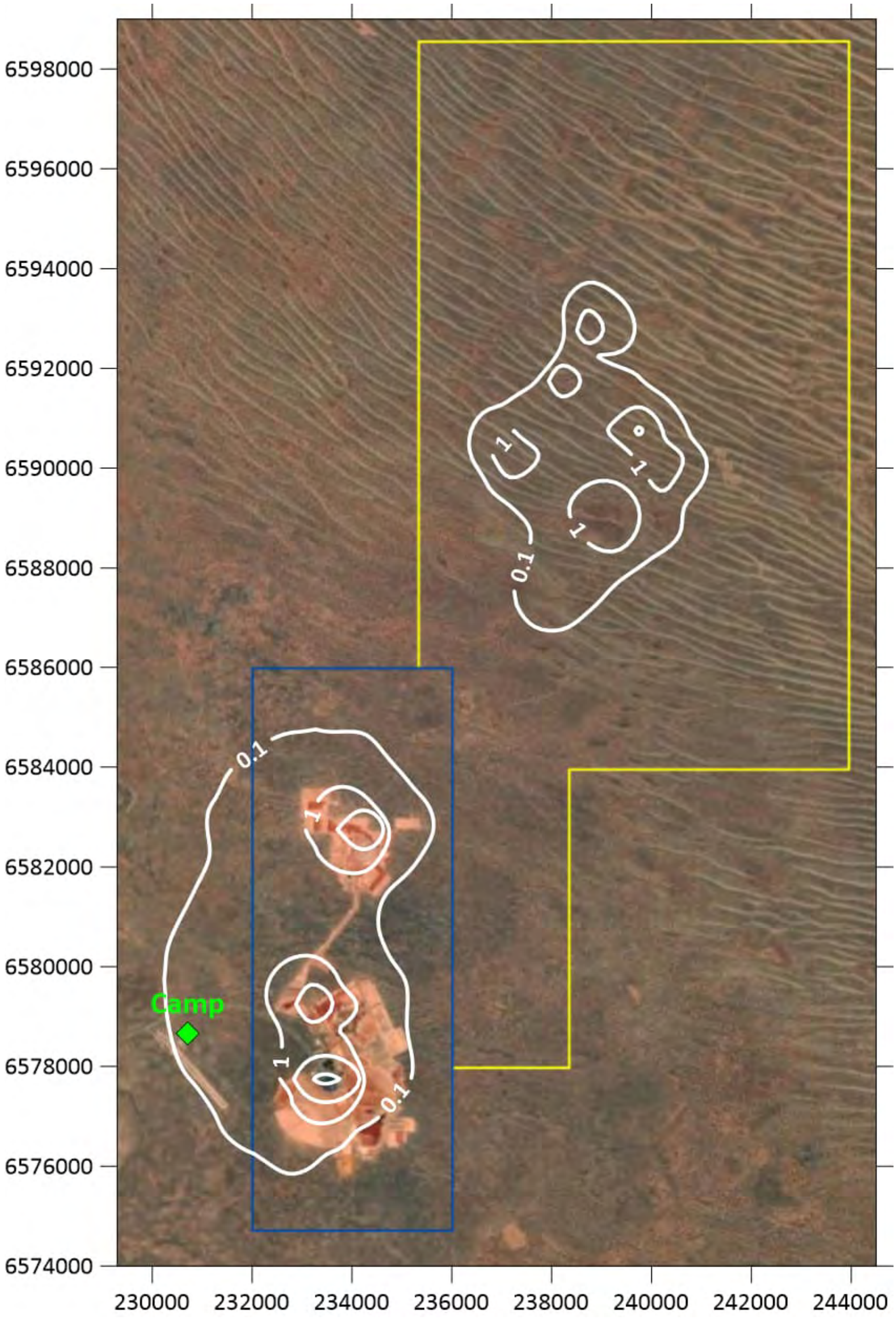

Figure 8-10. Annual average radionuclide concentration (Bq/m^3) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Blue line represents J-A ML
3. Yellow line represents Atacama Project Area
4. Background not included

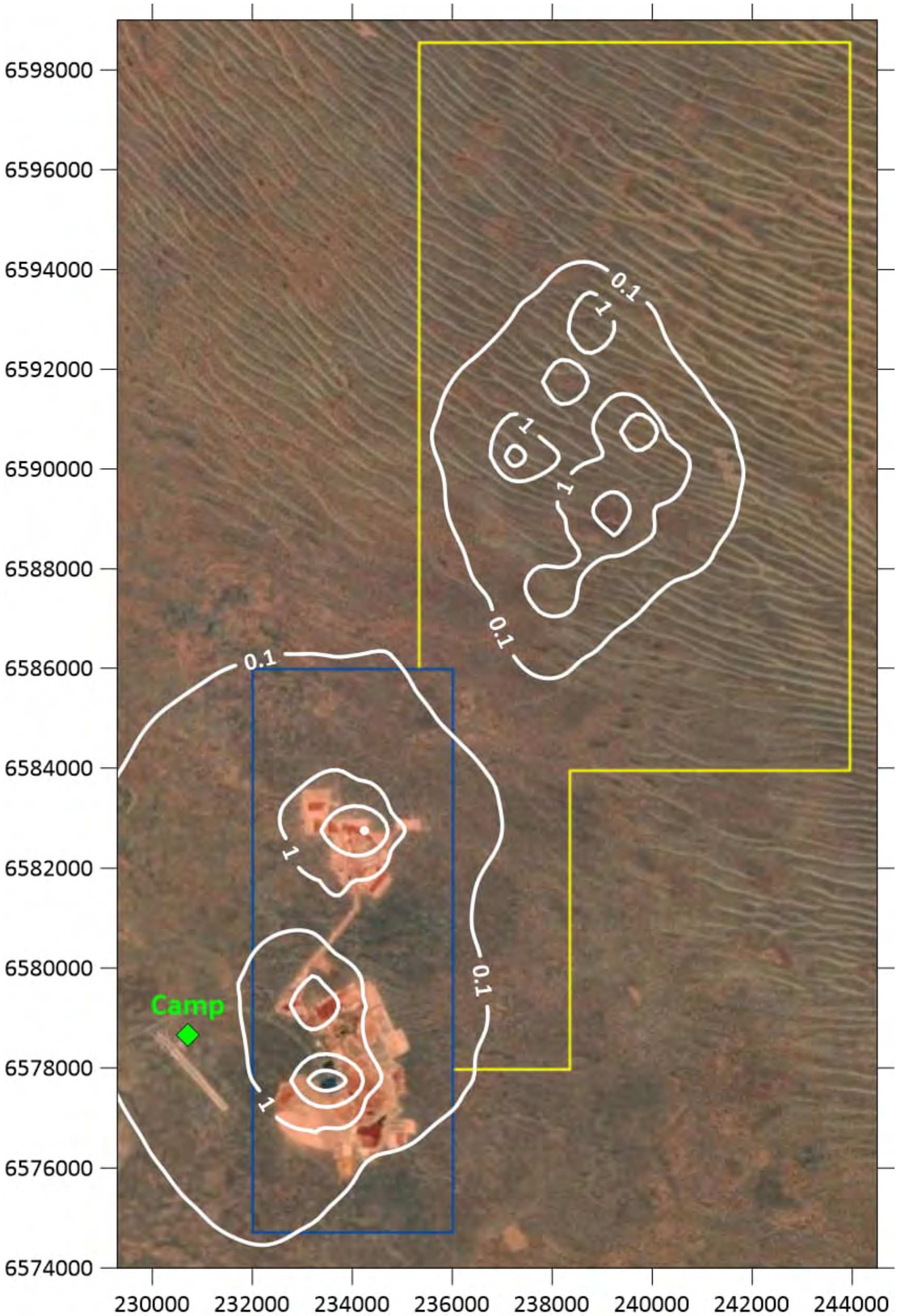

Figure 8-11. Annual average radionuclides in deposited dust (Bq/m^2/year) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Blue line represents J-A ML
3. Yellow line represents Atacama Project Area
4. Background not included

9. Recommended Mitigation Measures

The main sources of particulate emissions are from wind erosion of stockpiles and open areas, and from wheel generated dust. The significant separation distance between the mine sites (J-A and the Atacama Project) and the nearest sensitive receptor, the accommodation village and camp, has meant that the risk of air quality impacts is low, however the Project is required under the general environmental duty defined in the *EP Act* to take all reasonable and practicable measures to prevent or minimise any resulting environmental harm.

Large scale mining operations such as J-A and Atacama necessitate the clearing of vegetation and stockpiling of materials, however keeping the disturbed area to a minimum should be a primary focus for reducing the impacts to air quality and the environment from dust. Where stockpiles or exposed areas are likely to remain for longer periods of time and are susceptible to wind erosion, it is best practice to stabilise the stockpile. This may typically be achieved using dust suppressants or revegetation where possible.

Minimising the amount of stockpiled material is the first priority. The proposed mining schedule for Atacama proposes the progressive backfill and rehabilitation of the depleted pit areas as mining progresses through the deposit and this should be encouraged. Importantly, this reduces the need for double handling of materials and facilitates the more rapid rehabilitation of mined out areas.

Dust emissions from vehicle movements on unsealed roads can be minimised by either sealing heavily trafficked roads or using dust suppressants and / or watering. The modelling assumed level 2 watering of unsealed roads (>2 $l/m^2/hr$) and has assumed all roads were unsealed.

Whilst these mitigation measures for dust emissions from the Project may already be planned, the outcomes of the emissions inventory and modelling assessment reinforce and highlight the importance of these key dust emission sources, wind erosion and vehicle movements on unsealed roads, on air quality impacts from the Project.

10. Conclusion

The AQIA for the proposed Iluka Atacama mining operation, including the effects of the associated and adjacent J-A mining and minerals processing operation, was based on meteorological modelling and air dispersion modelling of particulate and gaseous air pollutant emissions. The assessment included a review of the previous Katestone (2008) air quality assessment for the proposed J-A site, as proposed in 2008. Meteorological, dust, and other monitoring data collected by Iluka during J-A's operation to date were used as input to the assessment.

Also, radionuclide dispersion modelling was completed as an input for (separate) radiation assessment.

The assessment was conducted to address GSA (2020b) Terms of Reference 006 (TOR006) requirements detailing potential impacts to air quality resulting from the proposed mining of the Atacama deposit, and a plan for managing these impacts. Recommended avoidance, mitigation and management measures were set out, focussing on the dust mitigation measures due to mining and minerals processing activities. Interpretation of the residual impacts; i.e., as shown by the modelling results, formed the major part of the assessment.

The AQIA was conducted in accordance with the EPA SA (2016) guideline, *Ambient air quality assessment*, which reflects the TOR006 requirements, and with reference to the design GLCs set out in SA's Environment Protection (Air Quality) Policy 2016 (GSA, 2022b). EPA SA (2016) sets out EPA's general risk assessment strategy and other details pertinent to air dispersion modelling.

The development and operation of the Project will result in air pollutant emissions due to land clearing and stockpiling of topsoil/ subsoil and overburden; mining operations; rehabilitation works and vehicle movements at the Atacama ML; and processing and tailings deposition at the existing J-A ML. In addition, ongoing operations at J-A will contribute to air emissions; all emissions were assessed cumulatively.

The existing Iluka J-A mining activities and the adjacent, proposed Atacama mining operation are remote: the nearest (non-mining) sensitive receptor is Yalata township, approximately 70km to the south-west. The nearest (mining) sensitive receptor is the Iluka accommodation village (Camp) located adjacent to the airstrip, located approximately 3km north-west of the existing J-A mine and approximately 8 km south-west of Atacama.

A summary of the modelling assessment results for the worst-case (nearest) sensitive receptor to the existing and proposed operations (the Camp), is provided in the following points:

The results for deposited dust are strongly indicative of a low risk of nuisance dust impacts at the Camp.

- Maximum deposited dust: J-A and Atacama:
  - 1.6 g/m^2/month including background (objective 4 g/m^2/month), with the mining contribution 0.1 g/m^2/month only (objective 2 g/m^2/month).

The results for PM_{10} are strongly indicative that dust mitigation measures, (including separation distances), are sufficient for there to be insignificant air quality impacts at the Camp due to the PM_{10} component of dust emissions from mining operations.

- Maximum 24-hour average PM_{10} concentration: J-A and Atacama:
  - 36 $\mu g/m^3$ including background (objective 50 $\mu g/m^3$).

The conclusion for 24-hr and annual $PM_{2.5}$ results is that dust mitigation measures, (including separation distances), are sufficient for there to be insignificant air quality impacts at the Camp due to the $PM_{2.5}$ component of dust emissions.

- Maximum 24-hour average $PM_{2.5}$ concentration: J-A and Atacama:
  - 13 $\mu g/m^3$ including background (objective 25 $\mu g/m^3$).
- Annual average $PM_{2.5}$ concentration:
  - 7.3 $\mu g/m^3$ including background (objective 8.0 $\mu g/m^3$).

The main conclusion of the modelling assessment of dust emissions from J-A and the proposed Atacama operation is there is a low risk of air quality impact due to nuisance dust and elevated airborne concentrations of PM_{10} and $PM_{2.5}$.

The results for the gaseous air pollutants, NO_2 and CO, were insignificant for the Camp, as determined by comparisons with their GLCs. Consideration was given to locations within the mine site at which a person would be likely to be present for an hour or more (corresponding to the averaging periods of the assessment criteria), with results indicating a low risk.

On the subject of flora and fauna impacts, the recommendations for dust mitigation for the protection of human health and amenity are generally considered to be adequate for the protection of flora and fauna surrounding the mine site boundaries.

Recommendations for dust mitigation measures centred around:

- substantial separation distances between the mining and minerals processing areas and the nearest sensitive receptor (Camp)
- use of water carts on unpaved roads to minimise wheel-generated dust by haul trucks
- rehabilitation of mined areas by earthworks
- stabilisation of stockpiles using suppressant (enhancing surface crusting), and
- revegetation of rehabilitated areas.

Air dispersion modelling results were provided for radionuclide emissions, based on the radioactive components of the source dusts. Interpretation of radionuclide modelling results is not included in Jacobs' scope.

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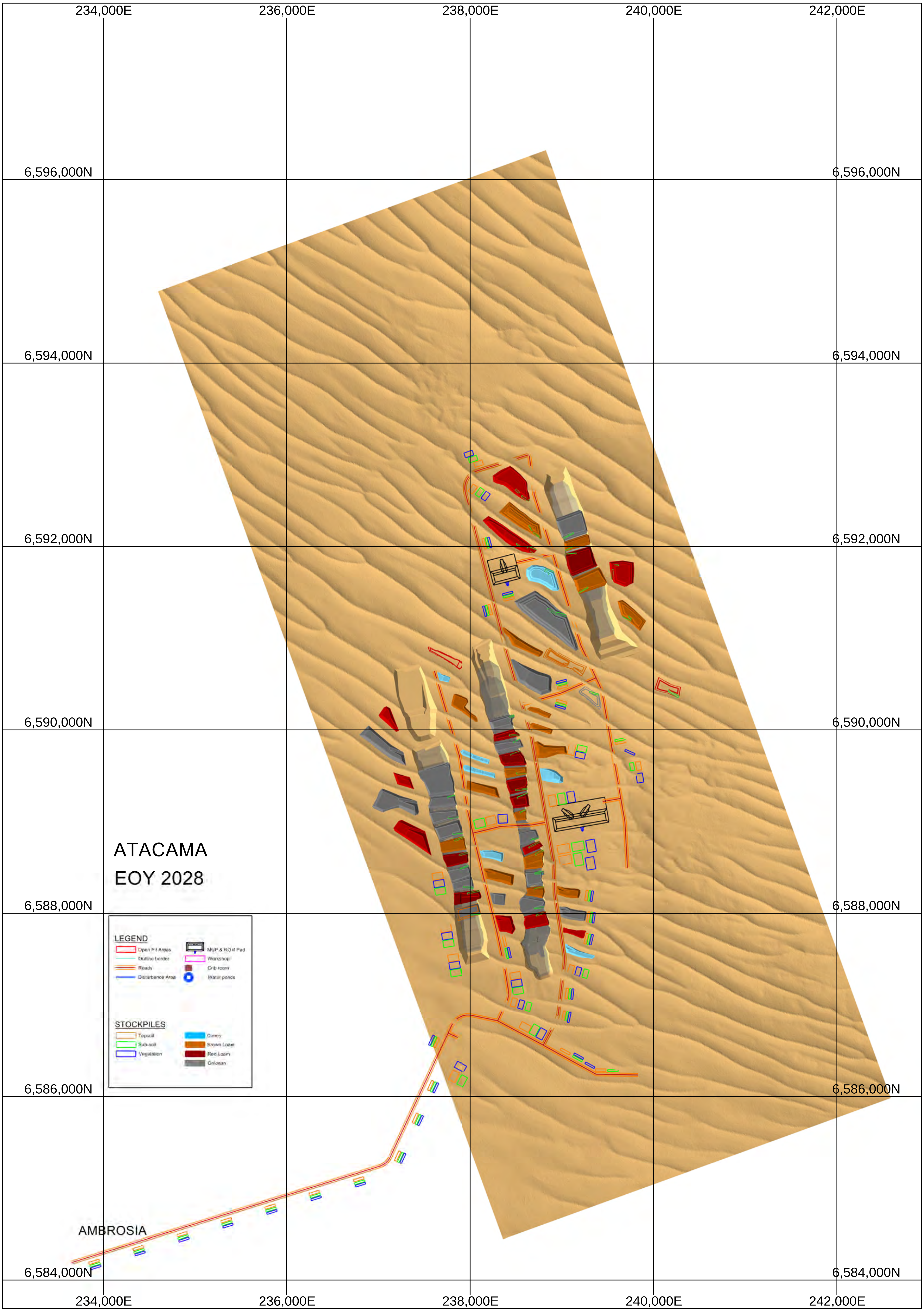
Appendix A. End of Year Mining Schedule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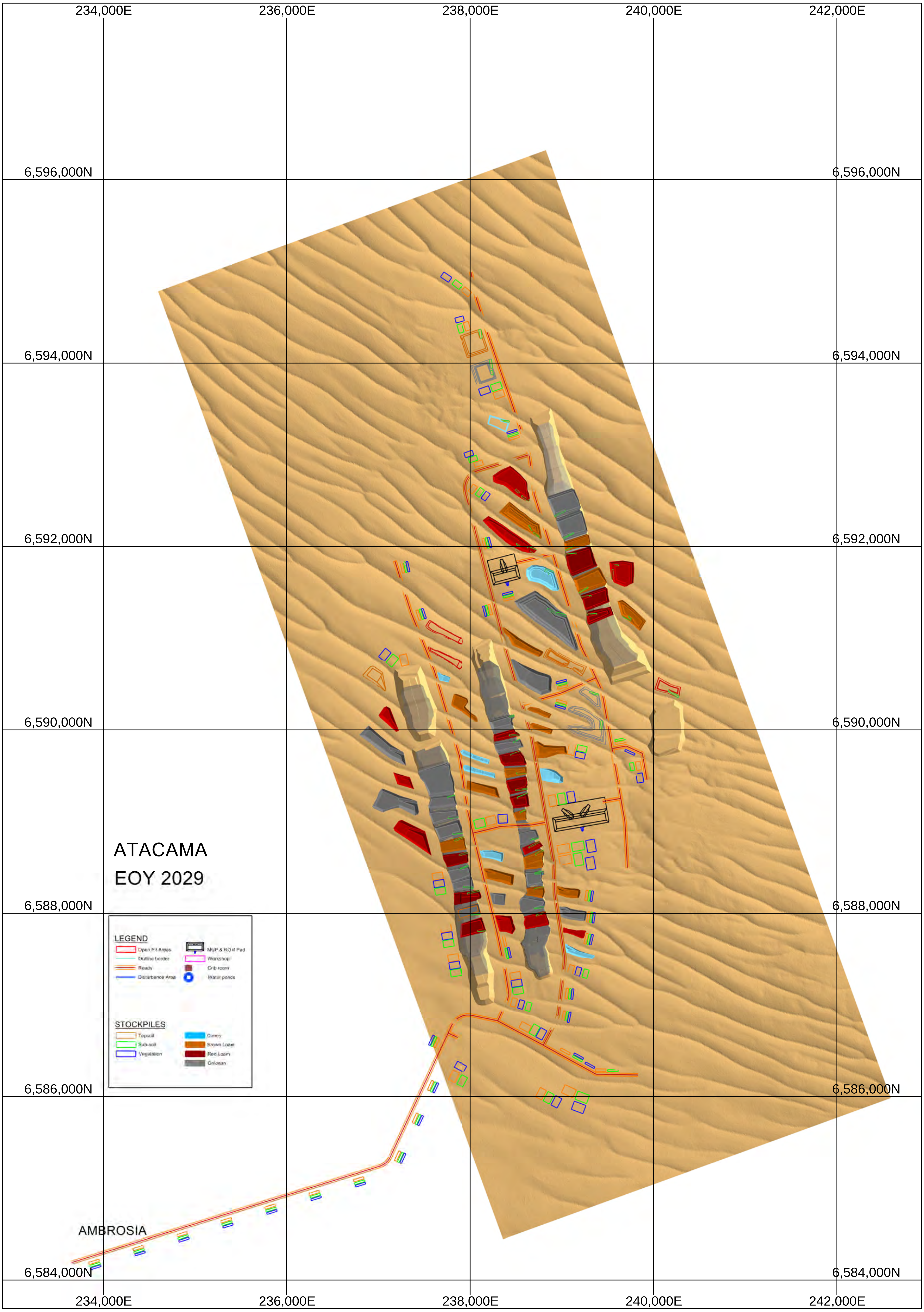
ATACAMA
EOY 2028
LEGEND
Open Pit Areas
Outline border
Roads
Disturbance Area
MUP & ROM Pad
Workshop
Crib room
Water ponds
STOCKPILES
Topsoil
Sub-soil
Vegetation
Dunes
Brown Loam
Red Loam
Oxide/Origin...
AMBROSIA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MUP & ROM Pad
Workshop
Crib room
Water ponds
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Topsoil
Sub-soil
Vegetation
Dunes
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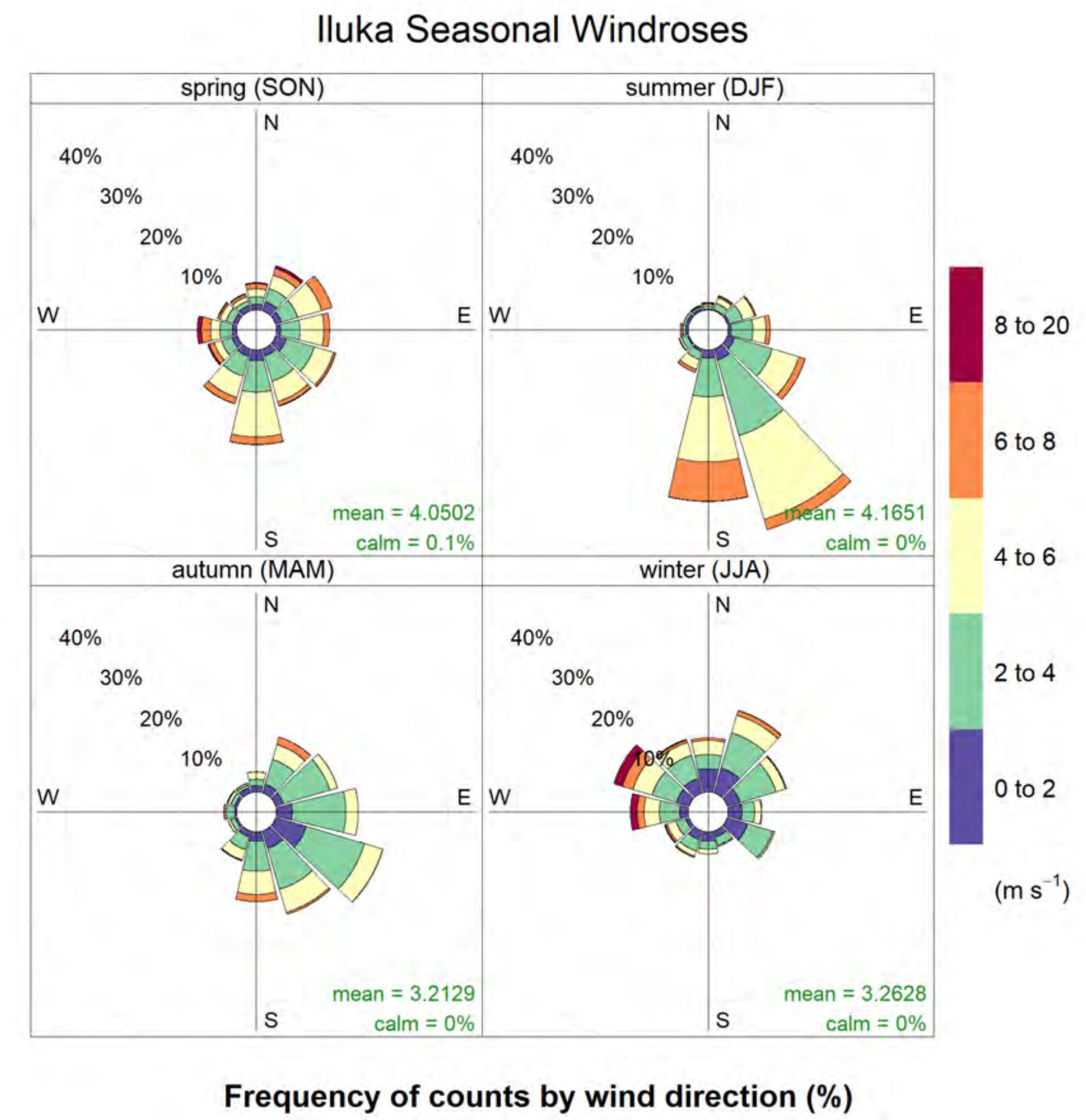
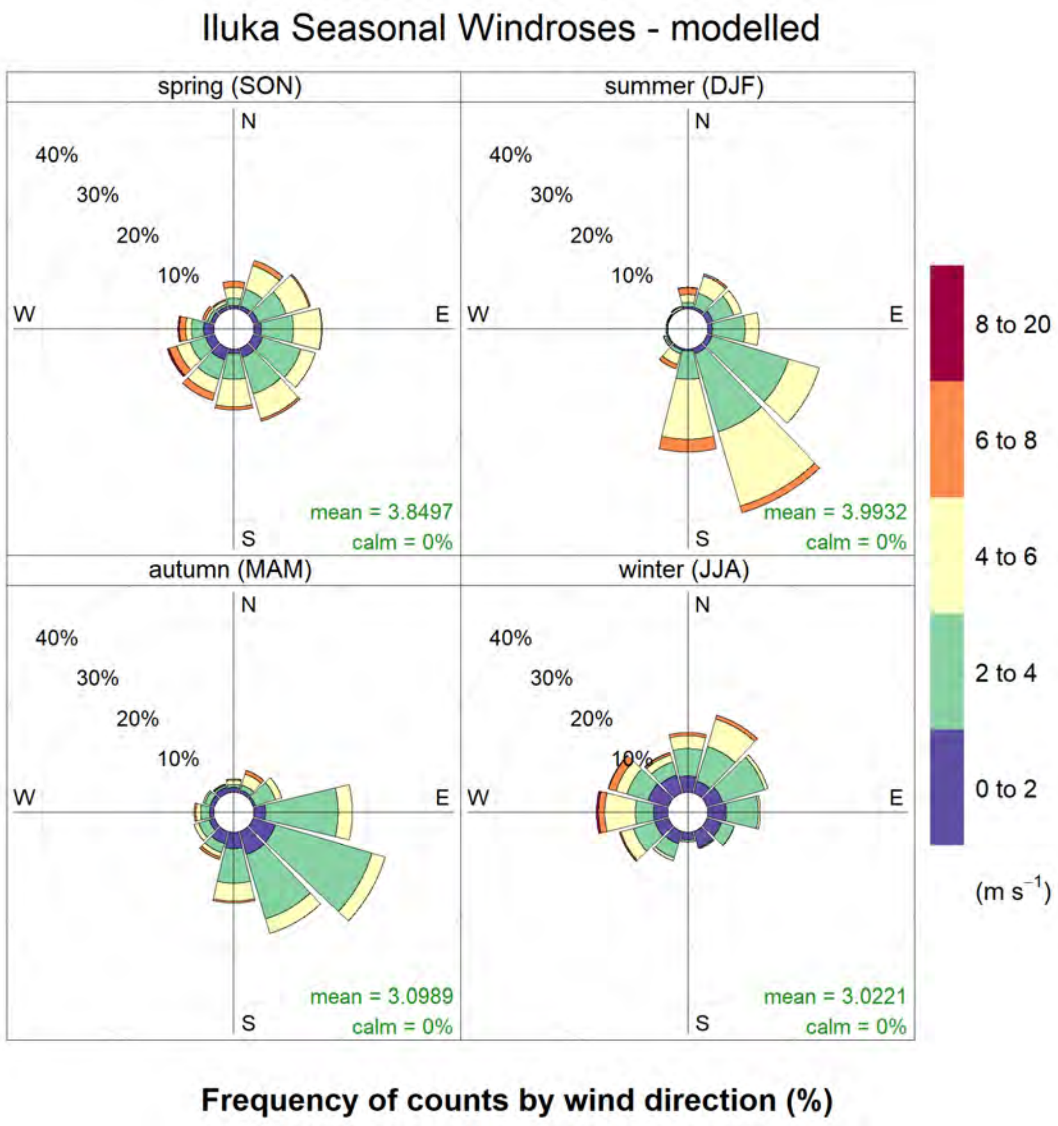
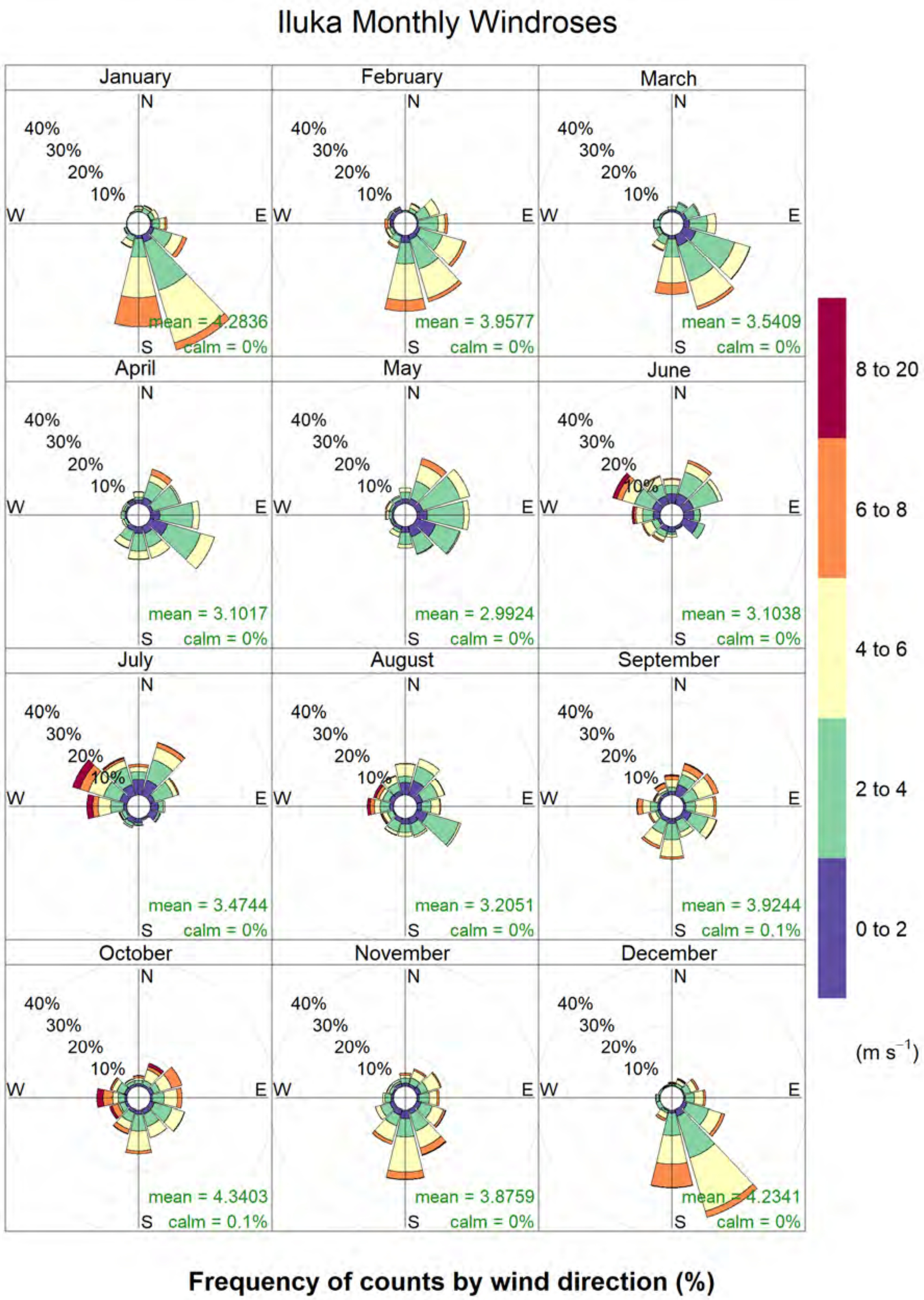
Appendix B. Modelled Meteorology - Wind Roses

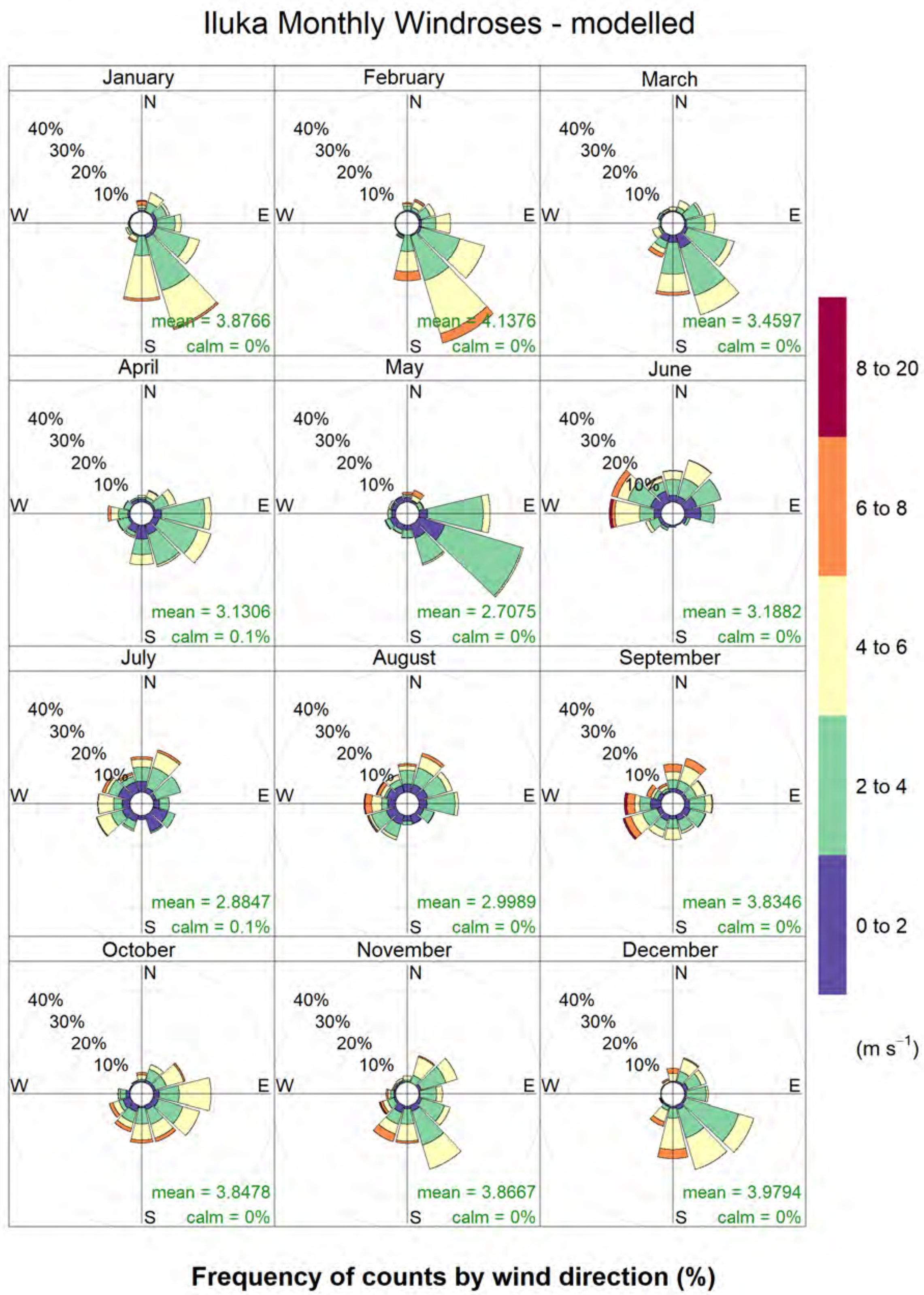
B.1 Seasonal Wind Roses – Iluka J-A measured data vs TAPM model




Iluka Seasonal Windroses - modelled
spring (SON)
summer (DJF)
autumn (MAM)
winter (JJA)
N
E
S
W
40%
30%
20%
10%
mean = 3.8497
calm = 0%
mean = 3.9932
calm = 0%
mean = 3.0989
calm = 0%
mean = 3.0221
calm = 0%
8 to 20
6 to 8
4 to 6
2 to 4
0 to 2
(m s-1)
Frequency of counts by wind direction (%)

B.2 Monthly Wind Roses – On-site Measurements vs TAPM model




Iluka Monthly Windroses - modelled
January
mean = 3.8766
calm = 0%
February
mean = 4.1376
calm = 0%
March
mean = 3.4597
calm = 0%
April
mean = 3.1306
calm = 0.1%
May
mean = 2.7075
calm = 0%
June
mean = 3.1882
calm = 0%
July
mean = 2.8847
calm = 0.1%
August
mean = 2.9989
calm = 0%
September
mean = 3.8346
calm = 0%
October
mean = 3.8478
calm = 0%
November
mean = 3.8667
calm = 0%
December
mean = 3.9794
calm = 0%
N
S
E
W
10%
20%
30%
40%
8 to 20
6 to 8
4 to 6
2 to 4
0 to 2
(m s-1)
Frequency of counts by wind direction (%)

Appendix C. Contour plots for CO and annual NO_2

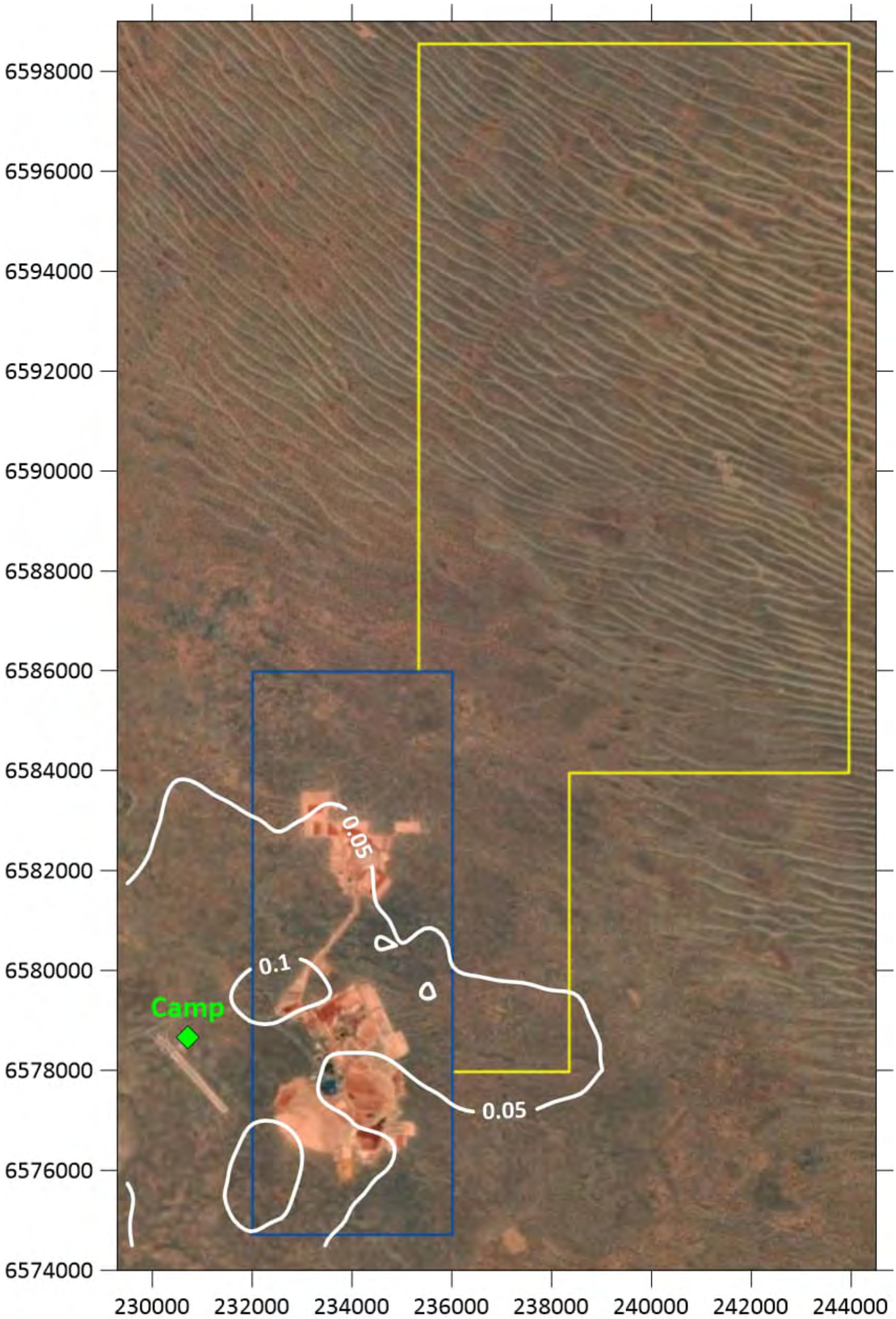


Figure C-1. Predicted annual average NO_2 concentration (µg/m^3) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Annual average NO_2 assessment criterion is 30 µg/m^3
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

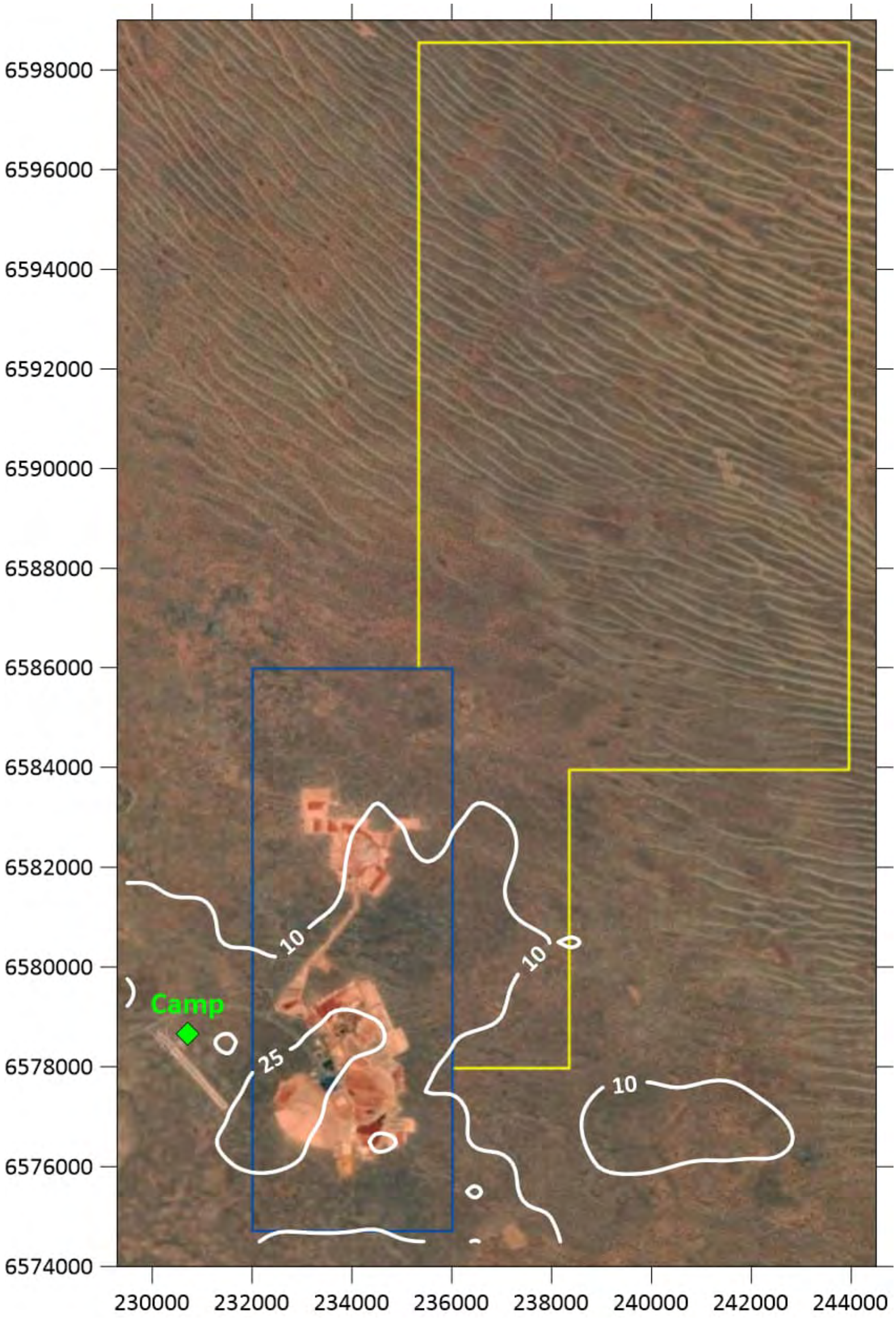


Figure C-2. Predicted Maximum 1-hr average CO concentration (µg/m³) – J-A and Atacama

Figure notes:

1. Coordinate reference system UTM Zone 53 in metres
2. Maximum 1-hr CO assessment criterion is 31,240 µg/m³
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

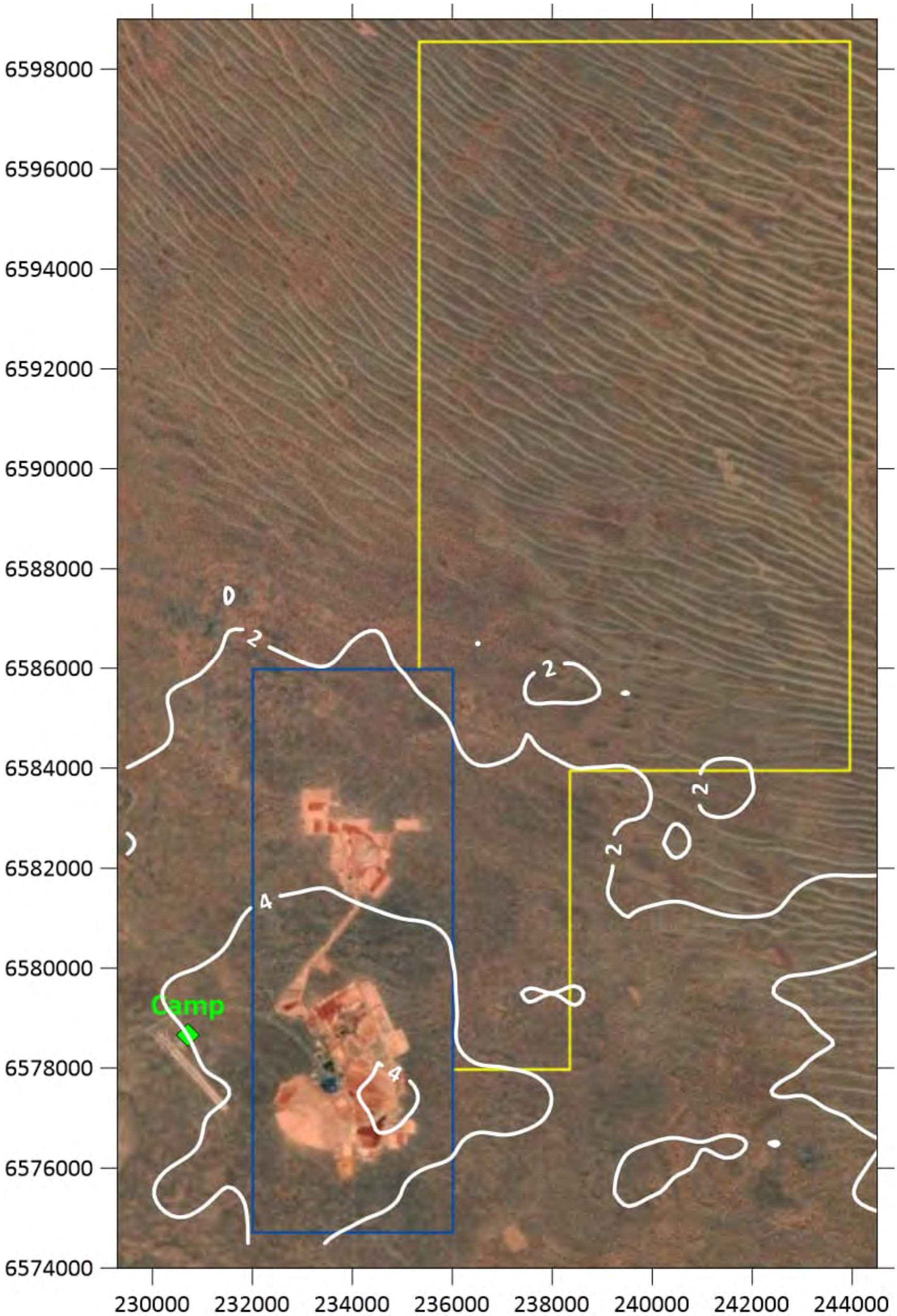


Figure C-3. Predicted Maximum 8-hr average CO concentration (µg/m^3) – J-A and Atacama

Figure notes:

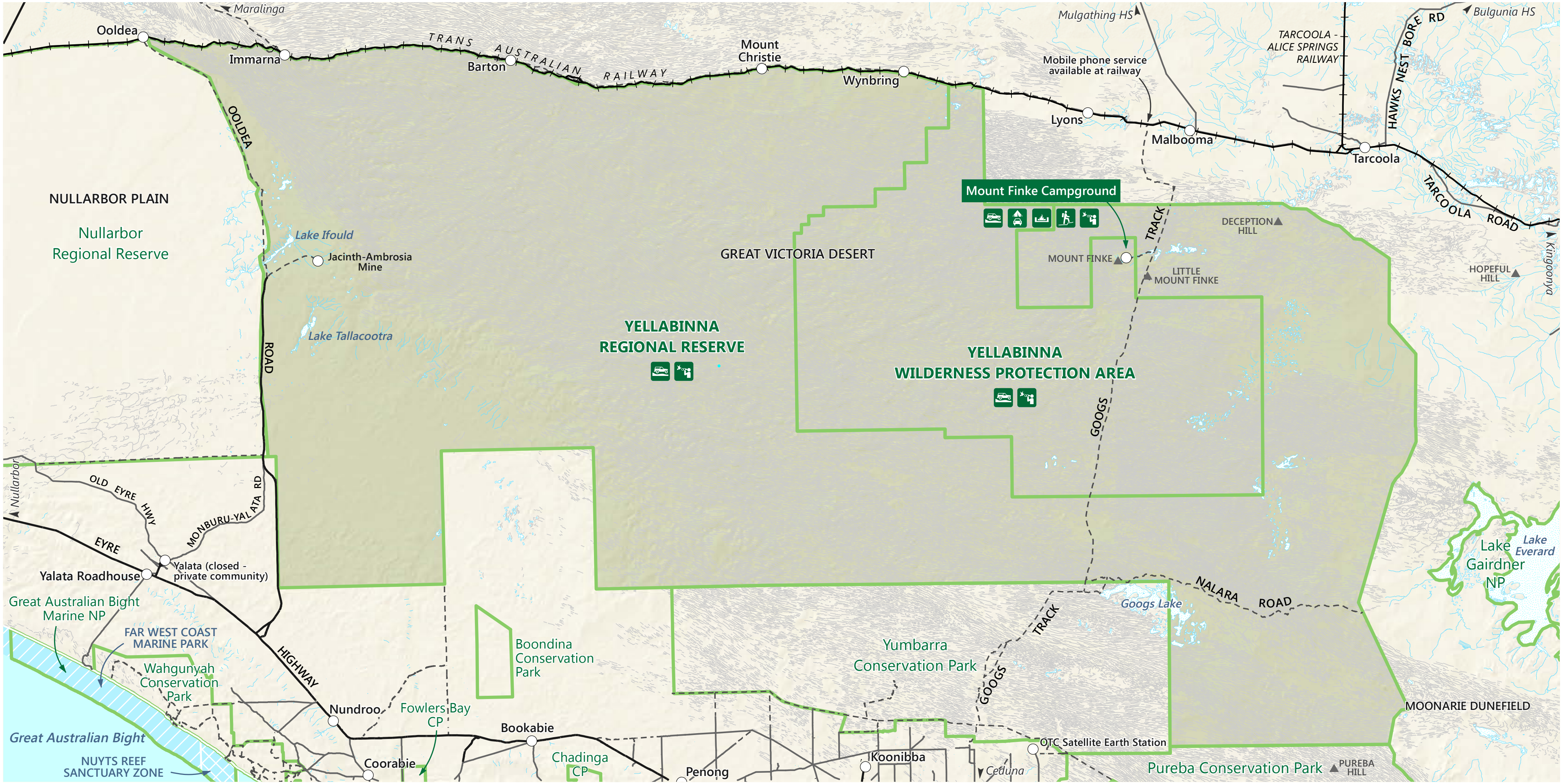
1. Coordinate reference system UTM Zone 53 in metres
2. Maximum 8-hr CO assessment criterion is 11,250 µg/m^3
3. Blue line represents J-A ML
4. Yellow line represents Atacama Project Area

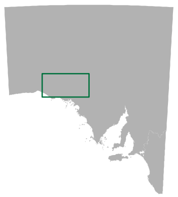
Appendix D. Regional Map including YeIlabinna Regional Reserve

Yellabinna Regional Reserve and Wilderness Protection Area

Government of South Australia

National Parks South Australia





0 10 20 kilometres

- Yellabinna Regional Reserve and Wilderness Protection Area
- Park boundary
- Marine Park
- Marine Park Sanctuary Zone
- Salt lake
- Sealed road
- Unsealed road
- Track
- Railway
- Sand ridge
- 4WD access only
- Campground
- Campfires permitted
- Moderately hard hike
- Birdwatching

parks.sa.gov.au

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Cartography by DEW, Mapland - 2018

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For more information, contact:
(08) 8625 3144

Thursday, December 15, 2022

Attn: Matthew Harding
Iluka Resources Ltd
GPO Box U1988
Perth WA 6845

Dear Matthew,

GHG ESTIMATES FOR ATACAMA PROJECT

Greenbase Pty Ltd (Greenbase) was engaged by Iluka Resources (Iluka) to prepare a greenhouse gas (GHG) estimate over the life of the Atacama Project located 5 km north of the existing Jacinth-Ambrosia (J-A) mineral sands mine.

The key inputs for estimating the GHG emissions from the project are diesel combustion from the mining, ancillary and rehabilitation fleets, and electricity sourced from diesel generators. Following the definition from the National Greenhouse and Energy Reporting Scheme (NGER), emissions from diesel combustion are defined as 'Scope 1' emissions.

Emission estimates were provided for the production period, which spans the period 2024 to 2031; and the rehabilitation period, which spans the period 2032 to 2051, inclusive. The project boundary includes the new mining pits and associated equipment. Additional processing at the existing J-A facility will be required, and the emissions associated with this activity were included in the assessment. Business as usual emissions for the J-A facility were not included in the assessment as data were not available.

Estimates

Data inputs for fuel used by the mining, ancillary and rehabilitation fleets were taken from ledgers prepared internally by Iluka. Inputs for electricity usage were taken from the power supply study provided by Hatch. Two different options were outlined in the power supply study. Emissions were calculated for both options, and summary results were calculated based on option F2A.

It was assumed that all electricity required for processing would be sourced from diesel generators, and these emissions estimates were therefore provided as Scope 1 emissions. If electricity is to be sourced from the grid, Scope 2 emissions will need to be calculated based on the South Australia grid factor. When calculating generator diesel usage, the generator efficiency was assumed to be 36%.

The estimates have been prepared using methods and emissions factors from the *NGER (Measurement) Determination 2008*. It was assumed that none of mining equipment will be road-registered and therefore non-transport emission factors were used, as displayed in Table 1 below.

Table 1 Emission and energy factors applied to Atacama

Fuel Type	Energy Content Factor	Emission Factor (kg CO_2-e/GJ)			
		CO_2	CH_4	N_2O	Total
Diesel (Non-transport)	38.6 GJ/kL	69.9	0.1	0.2	70.2
Electricity	0.0036 GJ/kWh				

The key inputs used for estimating GHG emissions over the estimate period can be seen in Table 2 below.

Table 2 Inputs for Atacama GHG emission projections

EXPECTED FUEL USAGE - PRODUCTION			
13 -	Mining Fleet		
13a	- Excavator	17,003,945	Litres
13b	- Haul Truck	63,990,000	Litres
13c	- Dozer	16,342,440	Litres
13d	**Total:**	**97,336,385**	**Litres**
14 -	Ancillary Fleet		
14a	- Grader	1,210,309	Litres
14b	- IT Loader	325,141	Litres
14c	- Haul Truck	948,703	Litres
14d	- Dozer	2,343,857	Litres
14e	- Excavator	1,850,988	Litres
14f	- Watercart	2,631,301	Litres
14g	- Loader	12,341,018	Litres
14h	**Total:**	**21,651,317**	**Litres**
15 -	Electricity Generation	*Sum not calculated - this is an either/or*	
15a	- Processing Option E1B	57,309,929	Litres
15b	- Processing Option F2A	57,822,593	Litres
25 -	Expected Fuel Usage - Rehabilitation		
25a	- Excavator 400t EX3600	-	Litres
25b	- Truck CAT789	-	Litres
25c	- Truck CAT777	-	Litres
25d	- Water Cart CAT777	2,530,080	Litres
25e	- Water Cart CAT740	590,352	Litres
25f	- Graders	2,108,400	Litres
25g	- Dozer D11	3,584,280	Litres
25h	- Excavator 120t EX1200	1,159,620	Litres
25i	- Scoops	1,644,552	Litres
25j	**Total:**	**11,617,284**	**Litres**

Results

Using the inputs from Table 2, the GHG emissions were estimated and can be seen in Table 3 and Figure 1 below.

Table 3 Summary results for Atacama GHG emissions and energy

EMISSIONS AND ENERGY SUMMARY			
1 -	Emissions Summary		
1a	Mining emissions	322,423	tCO2-e
1b	Processing emissions	156,683	tCO2-e
1c	Rehabilitation emissions	157,373	tCO2-e
1d	**Total Scope 1 Emissions:**	**636,479**	**tCO2-e**

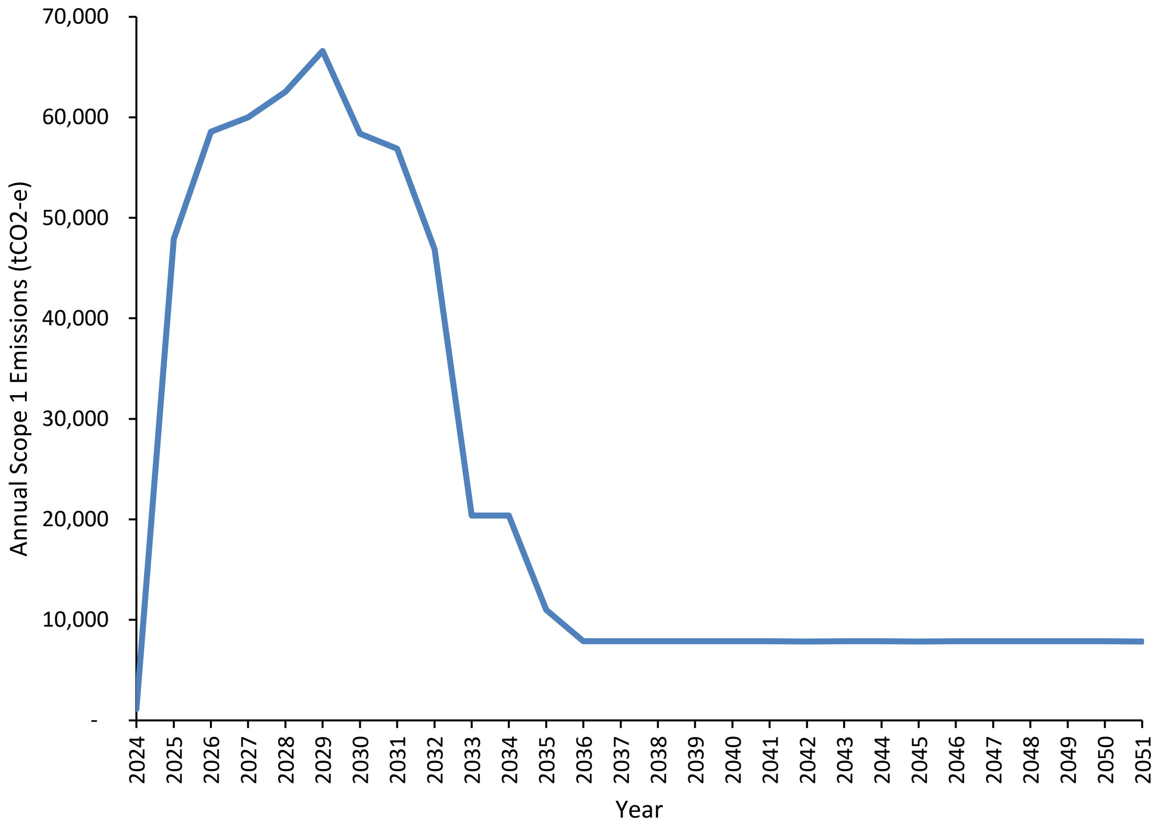

Figure 1 Annual Scope 1 emissions over LoM

The total GHG emissions over the life of mine, including rehabilitation, are projected as 636,479 tCO_2-e, with annual emissions peaking at 66,601 tCO_2-e in 2029. The details of these estimations can be viewed in the provided spreadsheet.

Please let me know if you have any questions.

Yours sincerely,

Alex Wheeler
Environmental Accountant

Greenbase Pty Ltd
awheeler@greenbase.com.au
(08) 6277 8805

Report

Atacama Traffic Impacts Study

H367947-0000-228-066-0001

Iluka Ref: MAT00004-J201-RPT-0014

			[signature]	[signature]	[signature]	
2022-12-19	1	Approved for Use	J. Pearse	C. Gault	C. Gault	M. Harding
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**
				Discipline Lead	**Functional Manager**	**Client**

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1. Introduction

Iluka is undertaking a pre-feasibility study (PFS) for the Atacama project, a high-grade zircon deposit located in remote South Australia. The Atacama deposit is located approximately 15 km northeast of Iluka's existing operations at Jacinth-Ambrosia (J-A), refer Figure 1-1 below.

Atacama will be developed as a satellite mine, making use of J-A's existing facilities and disturbance footprint for processing and deposition of tailings. Mining activity has occurred at J-A mine since 2009.

Hatch has been engaged to undertake a high-level Traffic Impacts Study which examines the anticipated traffic tasks associated with Atacama's construction and operational phases. The purpose of this report is to is to support the project's Mining Lease Proposal which will be lodged with the SA Department for Energy and Mining (DEM) later this year.

As highlighted in subsequent sections of this report, the haulage task associated with Atacama is essentially a continuation of J-A. Like J-A, Atacama will involve the haulage of Heavy Mineral Concentrate (HCM) in quad road trains to Port Thevenard near Ceduna. This report examines the additional transport tasks associated with the Atacama project including construction traffic and an addtional six years of mining operations.

Figure 1-1: Atacama Project Location (Image Sourced from Google Maps)

2. Terms of Reference for Mining Lease Proposals

This Traffic Impact Study has been prepared to support the project's Mining Lease Proposal, which is to be submitted to the South Australian Department for Energy and Mining (DEM). DEM has published Terms of Reference (TOR-006), which contain guidance for proponents on aspects that need to be covered in Mining Lease Proposal submissions. Aspects covered in this document relating to traffic impacts are detailed in Table 2-1.

Table 2-1: Relevant Terms of Reference (TOR006) Clauses

TOR-006 Reference	Requirement	Comments/section Included in the Report
1.1.3 – Proximity to Infrastructure and Housing	Provide information and a map (per 5.1.1.4)	Haulage route shown in Section 3. Sensitive receptor maps shown in Appendix A.3
	Identifying residences within and near the application area.	There are multiple residences and sensitive receptors within a 0 – 200m range of the proposed haulage route. The majority of residences are located in/near the townsites of Penong and Ceduna (refer sections 3.3 and 3.4).
	Identifying other human infrastructure such as (but not limited to) schools, hospitals, commercial or industrial sites, roads, sheds, bores, dams, ruins, pumps, cemeteries, scenic lookouts, roads, railway lines, fences, transmission lines, gas and water pipelines, and telephone lines (both underground and above ground).	Refer Section 3 which provides a road network overview including the Penong and Ceduna townsites, rest areas, school zones and railways level crossings.
	Identifying public roads to be utilised or affected as part of the proposed operations, including an estimate of the existing traffic movements.	Refer Section 3. Atacama's proposed haulage route remains the same as J-A.
2.7.1 – Access & Roads	Access route to the proposed operations and show in a map (as per 5.1.2.1 and 5.1.2.6)	Refer Section 3. Access to/from the proposed Atacama development remains the same as J-A.
	Indicate if any new roads are to be constructed, or if existing roads or intersections (public and private) are to be upgraded	No new roads are to be constructed/upgraded as part of the Atacama development.
	Transport system(s) used to and from the proposed operations and the estimated number of vehicle movements per day; and	Refer Section 3.6 for existing traffic volumes. Refer Section 4 and 5 for projected increase in traffic volumes.
	Airport/airstrips to be constructed	Existing J-A airstrip to be used.
4.1 – Assessment of Environmental Impacts	Impact Assessment	Refer to Appendix A.1 and A.2.

3. Road Network Overview

This section provides an overview of the road network between Atacama and Ceduna, which is relevant for both the construction and operational phases of the project. As shown in Figure 3-1, Atacama is located some 200km northwest of Ceduna, or approximately 265km by road.

Figure 3-1: Proposed Haulage Route between Ceduna and Atacama

3.1 Ooldea Road

In 2008, Iluka invested approximately $25million in developing an all-weather access road linking the J-A minesite to Eyre Highway. At approximately 90km in length, the project involved upgrading approximately 50km of the original (unsealed) Ooldea Road as well as constructing approximately 40km of new alignment. Ooldea Road now comprises of 3.3m-wide lanes, as well as sealed and unsealed shoulders. It is designed to support a maximum speed of 110km/h.

Ooldea Road meets the Eyre Highway at a large T-intersection which includes acceleration and deceleration lanes for vehicles turning to/from Ceduna. In addition to providing access to the J-A and Atacama deposits, Ooldea Road also connects the Eyre Highway to Maralinga and number of remote Indigenous communities including Oak Valley. Based on a desktop review and conversations with Iluka personnel, the standard of this road is generally good. According to RAVNet, the Ooldea Road is a state-maintained road. Traffic volumes and crash statistics for the Ooldea Road are not publicly available.

3.2 Eyre Highway

As shown in Figure 3-1, Atacama is connected to Ceduna via the Eyre Highway, which forms part of National Highway 1 linking South Australia to Western Australia. Eyre Highway is a state-maintained road. Based on Google Streetview observations, the condition of the Eyre Highway is generally good. According to Iluka's 2008 HMC Triple Road Route Assessment report, lane widths on Eyre Highway generally range between 3.0m and 3.4m.

In 2011, the Eyre Highway was assessed by the Australian Automobile Association as being among the lowest risk highways in the country, based on total number of casualty crashes per kilometre. A more detailed examination of the highway's recent crash history is provided Section 3.10 of this report.

3.3 Penong Townsite

Eyre Highway runs through the small townsite of Penong. Through Penong, Eyre Highway's posted speed limited reduces from 110km/h to 50km/h. There is also a 25km/h school zone with activated crossing lights (shown in Figure 3-2).

Figure 3-2: 25km/h School Zone on Eyre Highway Near Penong Primary School

3.4 Ceduna Townsite

Like J-A, the Atacama project will involve the haulage of HMC to Port Thevenard along a series of urban roads through Ceduna. The established route between Eyre Highway and Port Thevenard is via Kuhlmann Street, Murat Terrace, Railway Terrace, Thevenard Road, Davison Street and Bergmann Drive (refer Figure 3-3). The entirety of this route comprises of state-maintained roads. As highlighted in Appendix C, Kalari's quad train fleet has been granted approval by the National Heavy Vehicle Regulator (NHVR) to use this route.

It should be noted that in order to support the development of the Atacama project, Iluka invested in several upgrades to the Ceduna's road network, including:

- Eyre Highway / Kuhlmann Street intersection: Linemarking upgrades
- Thevenard Road / Davison Street intersection: Minor apron widening on southeast corner of intersection to facilitate left-turn movements into Davison Street
- Bergmann Drive / Davison Street intersection and level crossing: Intersection widening, pavement upgrades, new signage and linemarking

- Bergmann Drive widening: Minor widening to curve located west of Davison Street intersection.

Sightline assessments for key intersections within Ceduna are provided in Appendix D of this report.

Figure 3-3: Established Road Train Route Between Eyre Highway and Port Thevenard

3.5 Speed Limits

The posted speed limits along the proposed haulage route are outlined in Table 3-1.

Table 3-1: Speed Limits Along Proposed Route

Road	Posted speed limit
Ooldea Road	Unknown. Kalari road trains have a self-imposed speed limit of 80km/h (refer Appendix B).
Eyre Highway	110 km/h (100 km/h for heavy vehicles)
Kuhlmann Street	50 km/h*
Murat Terrace	60 km/h*
Railway Terrace	50 km/h*
Thevenard Road	60 km/h*
Davison Street	50 km/h*
Bergman Drive	50 km/h*

*Based on discussions with Kalari Transport, drivers are instructed to reduce their speeds by 10km/h in built up areas (including Penong and Ceduna townsites).

3.6 Traffic Volumes

Annual average daily traffic (AADT) volumes along the proposed haulage route have been sourced from the SA Department for Infrastructure and Transport (DIT). The data is relatively recent, having been collected between 2019 and 2021. As shown in Figure 3-4, traffic volumes along Eyre Highway range between 550 and 850 vehicles per day (vpd), with volumes increasing as one moves from west to east. Heavy vehicles constitute a high percentage of traffic on this section of Eyre Highway (between 37.5% and 58%).

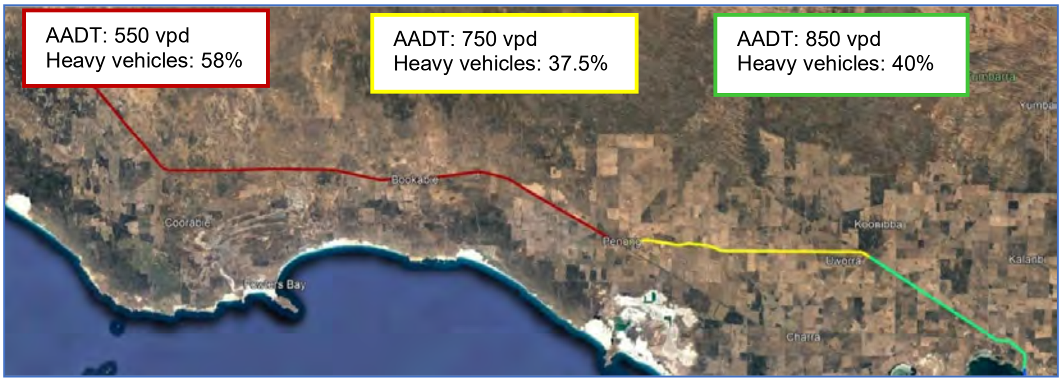


Figure 3-4: Daily Traffic Volumes (AADT) for Eyre Highway

Traffic volumes on key roads within the Ceduna townsite range between 1,000 and 2,200 vpd (refer Figure 3-5). A relatively high percentage of vehicles on the Port Thevenard route are heavy vehicles.

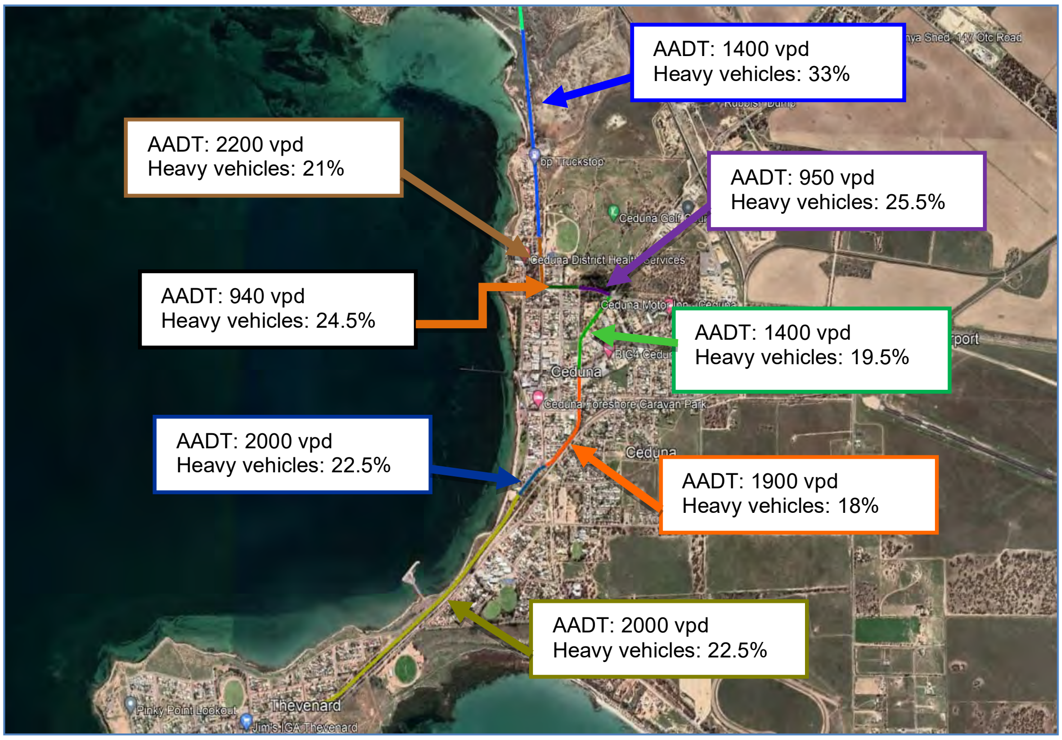


Figure 3-5: Daily traffic Volumes (AADT) for Ceduna Townsite

By urban standards, these volumes are relatively low. As discussed in Section 5 of this report, the haulage task associated with Atacama represents a continuation of existing J-A operations. Accordingly, the Atacama project is expected to have negligible additional impacts in terms of the town's network performance or intersection capacity. The geometry of key intersections within the Ceduna townsite is examined in further detail in Appendix D.

3.7 Rest Areas

A total of 13 rest areas have been identified on the Eyre Highway between Ooldea Road and Ceduna. As shown in Table 3-2, only certain rest areas have been formally assessed and approved by DIT for use by heavy vehicles.

Table 3-2: Eyre Highway Rest Areas

No.	Location	Type	Description	Surface	Approx. Size (m^2)	Condition	Approved by DIT for Heavy Vehicles?
1	Coorabie	2	Minor Rest Area	Unsealed	1781	Average	No
2	Coorabie	2	Minor Rest Area	Unsealed	3044	Average	No
3	Coorabie	4	Truck Informal Parking	Unsealed	5221	Good	Yes
4	Yalata	2	Minor Rest Area	Unsealed	2780	Average	No
5	Bookabie	2	Minor Rest Area	Unsealed	4207	Good	No
6	Bookabie	3	Truck Parking Bays	Spray Sealed	2970	Good	Yes
7	Penong	2	Minor Rest Area	Unsealed	7146	Good	No
8	Penong	2	Minor Rest Area	Unsealed	1701	Good	No
9	Uworra	3	Truck Parking Bays	Unsealed	2665	Good	Yes
10	Uworra	3	Truck Parking Bays	Unsealed	2673	Average	Yes

Kalari's Journey Management Plan (attached in Appendix B) specifies that road train drivers must take their legally required rest break at one of the rest areas shown in Figure 3-6 below. Based on discussions with Kalari, it is noted that operators typically stop at the pair of informal parking bays located near the Penong sports ground. It is recommended that Kalari seek formal approval from DIT regarding the continued use of these bays.

Figure 3-6: Approved Rest Areas for Kalari Road Trains (from JMP)

3.8 School Zones

There are two School Zones along the proposed route between Ceduna and Atacama:

- Penong Primary School – which includes a 25km/h children's crossing on Eyre Highway with activated crossing lights, and
- Ceduna Area School – located across the railway from Thevenard Road (a 25km/h speed restriction does not apply in this case).

3.9 Railway Level Crossings

As shown in Figure 3-7 below, there are three level crossings along the proposed haulage route, all within (or near) the Ceduna townsite. The crossing on Eyre Highway has active controls, whereas the two crossings near Port Thevenard have passive controls.

Figure 3-7: Level Crossings in (or Near) Ceduna Townsite

Table 3-3: Level Crossings in (or near) Ceduna Townsite

Level crossing	Image	Control
Eyre Highway		Active control (flashing lights)
Davison Street		Passive control (stop sign)
Bergmann Drive		Passive control (stop sign)

3.10 Crash history assessment

A summary of recorded road crashes between 2016 and 2020 is provided in Table 3-4 below.

Table 3-4: Crash History 2016-2020

Location	Length of Road	Total Crashes	No. of Fatalities	No. of Serious Injuries	No. of Casualties (Including Fatalities, Serious Injuries Minor Injuries)	Crashes Resulting in Property Damage (Value >$5,000)	Recorded Crash Types
Eyre Highway (Ooldea Road to Penong)	104km	32	2	5	23	19	• Rollover • Hit fixed object • Head on • Rear end • Side swipe.
Eyre Highway (Penong to Ceduna)	72km	18	0	1	8	12	• Rollover • Hit fixed object • Head on • Rear end • Hit pedestrian • Vehicle left road • Side Swipe.
Ceduna townsite	N/A	5	0	0	3	3	• Right angle crash • Roll over.

With two fatalities and five serious injuries in the past five years, the section of Eyre Highway between Ooldea Road and Penong appears to have a poorer safety record compared to the section linking Penong and Ceduna. While noteworthy, it is difficult to draw any definitive conclusions about the highway’s condition based solely on this information.

3.11 Predicted Development and Population Growth

As of 30 June 2021, the District Council of Ceduna had an estimated population of 3,651. Since 2006, the LGA’s population has remained very stable[1]. While there has been some urban expansion in recent years (most notably in the Ceduna Waters development located to the southeast of Port Thevenard), the scale of this growth has been relatively small. According to DIT, population growth in the Ceduna region is expected to be very low (if not negative) over the next 15 years[2].

[1] Estimated Resident Population (ERP) | RDA Eyre Peninsula Region | Community profile
[2] LGA Population Projections for South Australia 2016 to 2036.pdf

4. Construction Phase – Anticipated Transport Tasks

Development of the Atacama minesite is anticipated to commence in Q1 2024. Construction activities are expected to last for approximately 12 months, with production commencing in Q1 2025. Outlined below are the key transport tasks associated with Atacama's construction phase. They include:

- Transport of materials to site
- Transport of modules to site
- Transport of plant and equipment to site
- Transport of personnel to site.

4.1 Transport of Construction Materials to Site

During the construction phase, a large quantity of building materials will require transporting to site. It is anticipated the majority of these materials will be brought to site in heavy vehicles (B-doubles or road trains). Two processing options (Option E and Option F) are being investigated for Atacama. Depending on the option selected, the quantity of construction materials transported to site may vary slightly (refer Table 4-1).

Table 4-1: Indicative Trucking Movements for Construction Materials

	Estimated Freight Cost[1]	Percentage Attributed to Road Transport	Assumed Freight Rate ($ Per Net Tonne Km)[2]	Assumed Freight Distance (Km)[3]	Estimated Tonnes of Materials	Average Tonnes Per Truck	Approx. Number of Trucks
Option E	$2,800,000.00	50%	$0.09	1000	15,556	40	389
Option F	$3,200,000.00	50%	$0.09	1000	17,778	40	444
[1]Sourced from Atacama capex estimates (Hatch)							
[2]Sourced from Freight Australia							
[3]Approximate distance from Adelaide to Atacama							

Based on these estimates, it can be assumed there will be approximately 400-450 deliveries to site over the course of the construction phase. Based on a one year works program, this represents an average of 9 trucks per week.

4.2 Transport of Modules to Site

The development of Atacama will necessitate the construction of new/additional processing facilities at J-A. The design philosophy for Atacama's processing facilities involves maximising the level modularisation. In addition to reducing on-site labour costs and construction schedule, the proposed modularisation will enable certain parts of the processing plant to be repurposed/relocated following depletion of the Atacama deposit.

Figure 4-1: Example Module Transport (Image Sourced from Mammoet Australia)

Contractors charged with moving modules will be required to comply with oversize and/or overmass (OSOM) pilot and escort requirements from the SA Department for Infrastructure and Transport (DIT). All module movements will also need to consider any additional requirements/notices from the National Heavy Vehicle Regulator (NHVR). Figure 4-2 highlights the minimum pilot and escort requirements for OSOM loads in country South Australia.

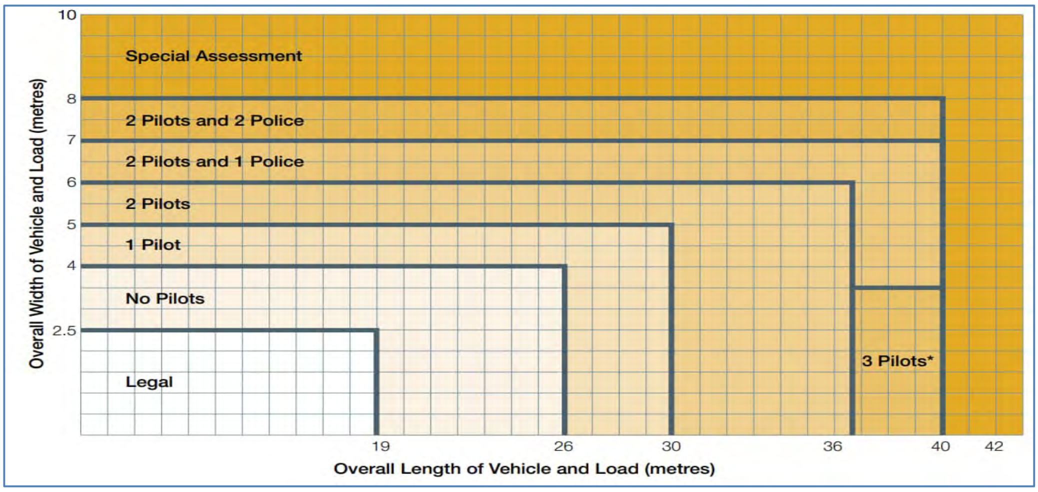


Figure 4-2: SA Country Area Minimum Pilot and Escort Requirements

4.3 Transport of Plant and Equipment to Site

A significant amount of surface mining equipment (SME) and construction plant will require transporting to site during the early phases of project. Based on discussions with Iluka personnel, an additional 45 pieces of SME will be required for the Atacama project consisting of haul packs, loaders, excavators, dozers. The transport of this equipment to site will likely employ the use of prime movers and low loaders. The piloting and escort requirements for this task will be akin to those for the transport of modules.

Figure 4-3: Example SME transport (Image Sourced from Mammoet Australia

4.4 Transport of People to Site

Based on discussions with Iluka, the average number of personnel required during construction is approximately 50, with a peak construction workforce of 90. While the majority of the construction workforce will be fly-in-fly-out, the construction phase of the project is expected to generate a small amount of additional traffic along Eyre Highway and the Ooldea Road. The quantum and composition of this traffic is difficult to estimate, but it is likely to have negligible impacts on the performance of the road network. A conservative estimate is 20-40 additional vehicle movements, mainly consisting of light vehicles and small trucks.

5. Operations Phase – Anticipated Transport Tasks

Production at Atacama is expected to commence in Q1 2025. Outlined below are the key transport tasks associated with Atacama's operational phase. These include:

- Transport of product to Port Thevenard
- Transport of reagents/consumables to site
- Transport of personnel site.

5.1 Transport of Product to Port Thevenard

The haulage task associated with the Atacama project represents continuation of existing J-A operations in terms of truck frequency, vehicle type and route choice. As a result of the Atacama project, approximately 4.1 million tonnes of additional product will be produced. Based on an assumed truck payload of 124 tonnes, this represents an additional ~33,580 loads to Port Thevenard.

Table 5-1: Comparison of Trucking Profiles with/without Atacama

J-A without Atacama					J-A with Atacama		
Year	Loads per day	Loads per year	Comments		Loads per day	Loads per year	Comments
2022	14	5110	Business as usual		14	5110	J-A only
2023	14	5110			14	5110	J-A only
2024	14	5110			14	5110	J-A only
2025	6	2190	Wind down period		14	5110	J-A and Atacama
2026	6	2190			14	5110	J-A and Atacama
2027	6	2190			14	5110	J-A and Atacama
2028	6	2190			14	5110	J-A and Atacama
2029	0	0			14	5110	J-A and Atacama
2030	0	0			14	5110	J-A and Atacama
2031	0	0			14	5110	J-A and Atacama
2032	0	0			6	2190	Atacama only
2033	0	0			6	2190	Atacama only
2034	0	0			6	2190	Atacama only
	Indicative remaining loads without Atacama	**24,090**			**Indicative remaining loads with Atacama**	**57,670**	
	Tonnes per truck	**124**			**Tonnes per truck**	**124**	
	Total tonnes	**2,987,160**			**Total tonnes**	**7,151,080**	

Proposed haulage route: The proposed haulage route between Atacama and Port Thevenard is approximately 275km in length, and is identical that currently used as part of J-A. It comprises mainly of Ooldea Road (93km) and Eyre Highway (176km). In Ceduna itself, road trains will follow the established road train route to/from Port Thevenard comprising of Kuhlmann Street, Murat Terrace, Railway Terrace, Thevenard Road, Davison Street and Bergmann Drive**.**

Proposed vehicle configuration:

- Quad road trains (prime mover with four trailers)
- Tri-axle dollies – 24 axles total
- GVM: 180 tonnes
- Width: 2.45m

- Height: 3.45m
- Length: 49.73m.

Figure 5-1: Kalari Quad Road Train

Fleet details:

- A total of 7 units
- Typically 6 units in operation (1 truck sometimes undergoing servicing/repairs).

As shown in Table 5-1, production at Atacama will supplement production at J-A and form a continuation of these operations, with a constant haulage task of 14 loads per day (or two return trips per day per truck) until 2031. Following depletion of the Atacama deposit (indicatively in 2032), a further 3-4 years of stockpile haulage is likely to occur, with road train operations scaled back to 6 return trips per day.

As per the J-A project, Atacama's road train operations will take place 24 hours a day, 365 days a year. Trucks are expected to depart Kalari's Ceduna depot (located at 3 Schwarz Street) at regular intervals commencing at 12:30am each day. Access to the depot is achieved via Murat Terrace, Goode Road and Schwarz Street. Kalari's drivers are required to follow the requirements of their journey management plan (attached in Appendix B). Key requirements of JMP include:

- Adhering to an 80km/h speed limit between on Ooldea Road between Eyre Highway and J-A Camp
- Adhering to a 60km/h speed limit between J-A Camp and minesite
- Ensuring drivers take rest breaks as per legislative requirements.

5.2 Transport of Reagents/Consumables to Site

During operations, there will be regular deliveries of various consumables to site. An estimate of the likely trucking movements is provided in Table 5-2 below.

Table 5-2: Indicative Trucking Movements for Reagents/Consumables

	Current Consumption (Without Atacama)	Estimated Consumption (with Atacama)	Indicative Number of Trucking Movements (er year)	Comments
NAOH (tonnes/year)	114.9	574.5	11	Based on 50t per truck
Flocculant (tonnes/year)	630	505	10	Based on 50t per truck
Diesel (L/year)	17,699,140	35,398,280	644	Based on 55,000L per truck
Other deliveries (maintenance consumables, spares, camp supplies).	Assumed 10 trucks per week (an approximate 50% increase on J-A) or 520 trucks per year.			

Based on the above, it is estimated that Atacama will generate around 1000-1200 deliveries per year, or around 20 per week, representing a 50%-80% increase on J-A's deliveries.

5.3 Transport of People to Site

The number of personnel on site during mining operations is expected to be approximately double that of J-A (300-350 FTE including contractors). While the majority of the construction workforce will be fly-in-fly-out, a small percentage of personnel are likely to drive to site from Ceduna and other parts of South Australia. The quantum and composition of this traffic is difficult to estimate, but it is likely to have negligible impacts on the performance of the road network. A conservative estimate is an 20-40 additional vehicle movements per day along Eyre Highway and Ooldea Road, and will mainly consist of light vehicles.

5.4 Pavement Assessment

The expected traffic loading generated over the operational life of Atacama has been examined to assess the possible impacts on pavement asset. In the case of an Austroads highest vehicle Class 12 (Triple Road Train) loaded with legal Higher Mass Limits (total load 125t), the Equivalent Standard Axle (ESA) is 15. When comparing with the proposed quad road train vehicle, the ESAs (with some dimensions and load margin) is proportionally calculated as under:

- Loaded – 181t – 25 ESAs
- Unloaded – 51t – 7 ESAs.

Based on the planned vehicle movements, the total ESAs are calculated as follows:

J-A without Atacama	Tonnes per load	ESAs	No. of loads	Total ESAs
Loaded	181	25	24,090	602,250
Unloaded	51	7	24,090	168,630
			Total	**770,880**

J-A with Atacama	Tonnes per load	ESAs	No. of loads	Total ESAs
Loaded	181	25	57,670	1,441,750
Unloaded	51	7	57,670	403,690
			Total	**1,845,440**

Additional pavement loading as a result of Atacama project: **1,074,560 ESAs.**

For an assumed subgrade CBR of 5% and the derived 1.8 million ESAs, the approx. required thickness of the granular pavement is 400mm. The main freight route is Eyre Highway which is the national highway connecting Adelaide and Perth. Given that, the existing highway pavement is expected to have min. 400mm thick granular pavement.

Overall, the following is concluded:

- The multiple (24) axles and wheels will spread the vehicles load to a large footprint and thus will minimize impact on the road pavement
- The route/Eyre Highway is already being used widely for freight movements and it is being maintained by the State Road authority (DiT)
- Relatively, the traffic loading generated by this project is considered not significant. Provided the highway/route is routinely maintained by road authority for safe operation, the project traffic loading is not expected to affect the pavement performance overall.

6. Conclusions

The transport task associated with Atacama is essentially a continuation of the J-A Project. Like J-A, Atacama will involve the haulage of Heavy Mineral Concentrate (HMC) in quad road trains to Port Thevenard near Ceduna. The road network used in both construction and operational phases is an established heavy vehicle route and can cater for oversized/overmass movements if appropriate approvals are sort from DIT and NHVR.

The construction phase of the project will involve the transport of modules, plant and equipment to site, as well as the delivery of steel, concrete, piping, etc. The transport tasks associated with Atacama's construction phase are expected to be similar to that undertaken during the development of J-A project (approximately 15 years ago).

The haulage task associated with the Atacama project represents continuation of existing J-A operations in terms of truck frequency, vehicle type and route choice. The development of the Atacama deposit will generate an additional 4.1 million tonnes of product (or approximately 33,580 additional product loads over the life of mine). Constituting an additional six years of haulage, product will be transported Port Thevenard using Kalari's quad road train fleet. The haulage route comprises primarily of Ooldea Road (93km) and Eyre Highway (176km). In Ceduna itself, road trains will follow the established road train route to/from Port Thevenard comprising of Kuhlmann Street, Murat Terrace, Railway Terrace, Thevenard Road, Davison Street and Bergmann Drive.

The traffic generated by the Atacama project is expected to have negligible additional impacts in terms of the region's road network performance. Provided the highway/route is routinely maintained, the Atacama project's proposed traffic loading is not expected to affect the network's overall pavement performance.

As part of this report, a risk assessment has been undertaken in accordance with the Department of Energy and Mining's Terms of Reference (TOR-006) for Mining Lease Proposal submissions. It is expected that impacts associated with the Atacama's construction and operational traffic can be effectively managed using J-A's established management plans, control measures and monitoring systems. It is noted the population of Ceduna and surrounding areas is expected to remain relatively stable over the next 10-15 years, meaning that public safety risk exposure resulting from Atacama's proposed haulage operations is unlikely to vary significantly during the life of the mine.

Appendix A
Traffic Impact Assessment (TOR006)

A.1 Potential impacts associated with public safety and traffic

Environmental element	Phase	Impact ID	Potential impact event	Source	Pathway	Receptor	Uncertainties and assumptions	Sensitivity to change (in assumptions)	S-P-R linkage? (Yes, No or Uncertain)	Justification for the confirmation/ non-confirmation of an S-P-R linkage?	Description of the likely impact event
Public safety and traffic	Operation	1	Increased traffic incidents (including with people, property, vehicles, and livestock) involving mining traffic due to the increase in duration of haulage to Port Thevenard.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Other vehicles, property, members of the public, livestock	It is assumed the Traffic Management Procedure, and other Plans and Systems for J-A are fit for purpose (aside from minor updates) for Atacama.	Low	Yes	S-P-R exists for the current haulage operations and is considered as confirmed as it will continue to exist for the extended period of time that the haulage route will be used for.	Increased traffic incidents (including with people, property, vehicles, and livestock) involving mining traffic due to the increase in duration of haulage to Port Thevenard.
Public safety and traffic	Operation	2	Increased traffic incidents involving mining traffic due to an increase in population in the regional towns that the route runs through.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Other vehicles, members of the public	Potential increase in population.	Low	Uncertain	While a significant population increase along the haulage route has been assessed as unlikely, this is not a certainty.	Increased traffic incidents due to the increased use of roads by public/local residents.
Public safety and traffic	Operation	3	Increased potential for amenity issues or complaints if there is an increase in population in the regional towns that the route runs through.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Other vehicles, members of the public	Unlikely potential for a significant increase in population. In the unlikely event this occurs, this directly links to an increase in sensitive receptors, particularly in terms of air, noise and other amenity impacts.	Low	Uncertain	While a significant population increase along the haulage route has been assessed as unlikely, this is not a certainty.	Increased complaints and amenity issues from sensitive receptors in relation to heavy vehicle operations along proposed haulage route.
Public safety and traffic	Construction	4	Increased traffic incidents involving mining traffic (including with people, property, vehicles and livestock) due to an increase in vehicle movements and/or change in type/size of vehicles during the construction phase of the project.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Other vehicles, members of the public, livestock	All traffic related to the construction phase of the Project is assumed to comply with a Construction Environment Management Procedure/Plan for Traffic. It is assumed the Construction Environment Management Procedure/Plan for Traffic is fit for purpose.	Low	Yes	An S-P-R linkage exists for the current operation and is considered as confirmed - increased traffic volumes and number of vehicle types during the construction phase increases the probability and further confirms this linkage.	Increased traffic incidents involving mining traffic (including with people, property, vehicles and livestock) due to an increase in vehicle movements and/or change in type/size of vehicles during the construction phase of the project.
Public safety and traffic	Construction	5	Increased potential for amenity issues or complaints due to an increase in vehicle movements or change in type/ size of vehicles during the construction phase of the project.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Other vehicles Members of the public	All traffic related to the construction phase of the Project is assumed to comply with a Construction Environment Management Procedure/Plan for Traffic. It is assumed the Construction Environment Management Procedure/Plan for Traffic is fit for purpose.	Low	Yes	An S-P-R linkage exists for the current operation and is considered as confirmed - increased traffic volumes and number of vehicle types during the construction phase increases the probability and further confirms this linkage.	Increased complaints and amenity issues from sensitive receptors regarding traffic generated by the construction phase of the project.

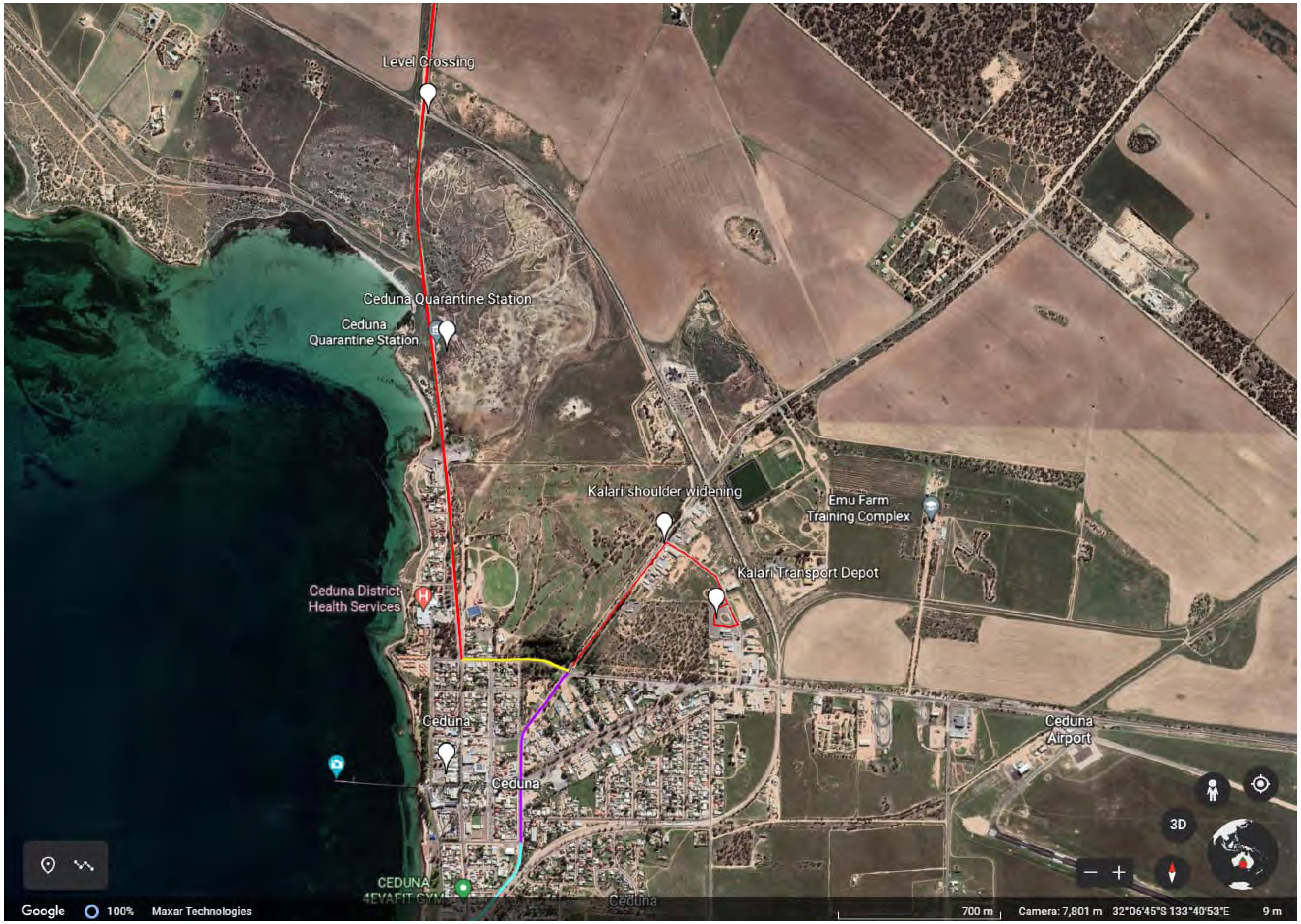
A.2 Impact Assessment – Traffic

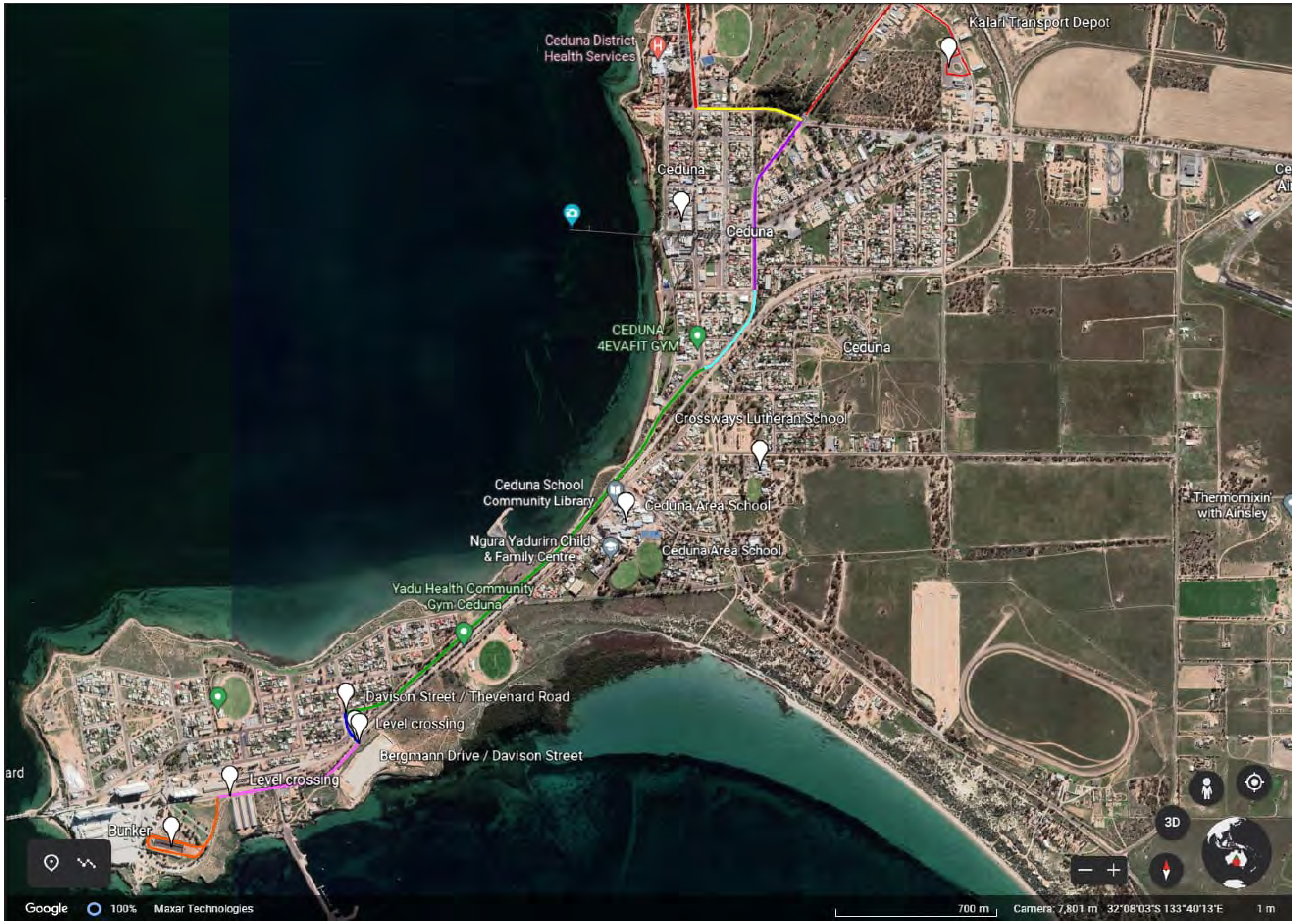
Section	Impact	Control/ Management Strategies	Uncertainties and assumptions	Proposed outcome	Leading indicator criteria	Outcome Measurement Criteria
Public safety and traffic	Increased traffic incidents (including with people, property, vehicles, and livestock) involving mining traffic due to the increase in duration of haulage operations to Port Thevenard.	• Cintellate incident management system • Emergency Response Plan and training • Road maintenance • Speed limit restrictions • Traffic management procedure • Designated pedestrian walkways on-site • Designated access roads for vehicles • Maintain on-site emergency response team, including assets and equipment.	Existing systems and procedures Traffic Management Procedures for the Operations exists, is fit for purpose for the extended duration of the route use and will be complied with.	No traffic incidents resulting in human or livestock injury or death caused by mine operations that could have been reasonably prevented by the Mine Operator.	N/A	Traffic incidents recorded (incident type, description, classification and action taken) in Iluka Incident Management System (Cintellate). Incident investigation (report stored in Iluka Incident Management System, Cintellate)
Public safety and traffic	Increased traffic accidents involving mining traffic if there is an increase in population in the regional towns that the route runs through.	• Cintellate incident management system • Emergency Response Plan and training • Road maintenance • Speed Limit Restrictions • Traffic Management Procedure • Designated pedestrian walkways on-site • Designated access roads for vehicles • Maintain on-site emergency response team, including assets and equipment.	Increase in population along haulage route (assessed as unlikely).	No traffic incidents resulting in human or livestock injury or death caused by mine operations that could have been reasonably prevented by the Mine Operator.	N/A	Traffic incidents recorded (incident type, description, classification and action taken) in Iluka Incident Management System (Cintellate). Incident investigation (report stored in Iluka Incident Management System, Cintellate)
Public safety and traffic	Increased potential for amenity issues or complaints if there is an increase in population in the regional towns that the route runs through.	• Regular review, update and implementation of existing Traffic Management Procedure • Consideration of speed restrictions and sensitive receptors along the route • Cintellate incident management system – including Complaints and Corrective Action Registers.	Population will increase (assessed us unlikely). An increase in population directly links to an increase in sensitive receptors that find the traffic to have an impact on their amenity.	Minimise unacceptable amenity impacts to sensitive receptors during mine operations.	N/A	All complaints and feedback from public are recorded in the Iluka Incident Management System (Cintellate). All recorded complaints relating to amenity impacts are investigated by the Mining Operator, and where required, corrective actions are implemented to prevent recurrence or to minimise the future potential impact as far as reasonably practicable. Complaint investigation (report stored in Iluka Incident Management System, Cintellate).
Public safety and traffic	Increased traffic incidents involving mining traffic (including with people, property, vehicles and livestock) due to an increase in vehicle movements and/or change in type and increase in size of vehicles during the construction phase of the project.	• Development and implementation of specific Traffic Management Plan/Procedures for the Construction Phase of the Project. • Cintellate incident management system • Emergency Response Plan and training • Road maintenance • Speed Limit Restrictions • Traffic Management Procedure • Designated pedestrian walkways on-site • Designated access roads for vehicles • Maintain on-site emergency response team, including assets and equipment.	All traffic related to the construction phase of the Project is assumed to comply with a Construction Environment Management Procedure/Plan for Traffic. It is assumed the Construction Environment Management Procedure/Plan for Traffic is fit for purpose.	No traffic incidents resulting in human or livestock injury or death caused by mine construction that could have been reasonably prevented by the Mine Operator.	N/A	Traffic incidents recorded (incident type, description, classification and action taken) in Iluka Incident Management System (Cintellate). Incident investigation (report stored in Iluka Incident Management System, Cintellate).
Public safety and traffic	Increased potential for amenity issues or complaints due to an increase in vehicle movements or change in type, increase in size of vehicles during the construction phase of the project.	• Development and implementation of specific Traffic Management Plan/Procedures for the Construction Phase of the Project. • Consideration of speed restrictions and sensitive receptors along the route • Cintellate incident management system – including Complaints and Corrective Action Registers.	All traffic related to the construction phase of the Project is assumed to comply with a Construction Environment Management Procedure/Plan for Traffic. It is assumed the Construction Environment Management Procedure/Plan for Traffic is fit for purpose.	Minimise unacceptable amenity impacts to sensitive receptors during the construction phase.	N/A	All complaints and feedback from public are recorded in the Iluka Incident Management System (Cintellate). All recorded complaints relating to amenity impacts are investigated by the Mining Operator, and where required, corrective actions are implemented to prevent recurrence or to minimise the future potential impact as far as reasonably practicable. Complaint investigation (report stored in Iluka Incident Management System, Cintellate)

A.3 Sensitive Receptor Maps


Penong
Google
100%
CNES / Airbus
100 m
Camera: 1,763 m 31°55'52"S 133°00'57"E
16 m
3D


Denial Bay
Lutheran Church
3D
Google
100%
CNES / Airbus
1,000 m
Camera: 14,054 m 32°01'20"S 133°33'16"E
38 m


Level Crossing
Ceduna Quarantine Station
Ceduna Quarantine Station
Kalari shoulder widening
Emu Farm Training Complex
Kalari Transport Depot
Ceduna District Health Services
Ceduna
Ceduna
Ceduna Airport
3D
Google
100%
Maxar Technologies
700 m
Camera: 7,801 m 32°06'45"S 133°40'53"E
9 m


Kalafi Transport Depot
Ceduna District Health Services
Ceduna
Ceduna
CEDUNA 4EVAFIT GYM
Ceduna
Crossways Lutheran School
Ceduna School Community Library
Ceduna Area School
Ngura Yadurirn Child & Family Centre
Ceduna Area School
Yadu Health Community Gym Ceduna
Thermomixin with Ainsley
Davison Street / Thevenard Road
Level crossing
Bergmann Drive / Davison Street
Level crossing
Bunker
Google
100%
Maxar Technologies
700 m
Camera: 7,801 m 32°08'03"S 133°40'13"E
1 m

Appendix B
Kalari Journey Management Plan

Kalari Pty Ltd Doc Ref: Iluka JMP - 05	Journey Management Plan for Transportation of Mineral Sand from ILUKA Jacinth Ambrosia Mine to the Ceduna / Thevenard Port - SA	Version 16 Date 23/06/2021

General Description: This procedure describes the specific requirements for the Journey Management Plan when travelling empty from the Kalari Ceduna Depot – Ceduna to the Iluka - Jacinth Ambrosia Mine and return loaded to the Thevenard Port - Ceduna in South Australia finishing back at the Kalari Ceduna depot.

Key Roles:

Drivers are responsible for: -

- Ensuring full compliance with Mass Management requirements.
- Ensuring full compliance with fatigue management & driving hours regulations
- Ensuring they are fit for duty
- **Reporting all non-conformance issues relating to safety of plant and equipment (including Clients Equipment), product spillage/estimated product loss, product contamination and mass management deficiencies. Reporting is via an Accident/Incident Report and is to be handed to your Supervisor**
- Ensuring full compliance with Fatigue Management & Driving Hours Regulations.

Supervisors are responsible for: -

- Determining a driver's fitness for duty
- Rostering drivers to take into account for proper rest breaks in accordance with the national regulation
- Scheduling trips to minimize any affects of fatigue
- Maintaining appropriate workplace conditions
- Managing incidents
- Ensuring drivers are trained in fatigue management

Journey Details:

Start At:	Kalari Ceduna Depot	Load At:	Jacinth Ambrosia Mine Site	Unload At:	Thevenard Port - Ceduna
Estimated Total Shift Working Time:	**11.00 hours**		**Estimated Total Distance:**	**565 km**	

Suggested Driving Plan:

Start Point	Travel to	Distance	Working Time	Rest Time
Kalari Ceduna Depot - SA	Jacinth Ambrosia Mine - SA	280 km	30 min – Pre Start Check 4.00 hours - Driving 45 min – Loading	1 x 30 min Rest Break or 2 x 15 min Rest Breaks (Under BFM 1 break of 15mins after 6 hours. 30 min break in first 8.5hrs and no greater than 11 hours)
Jacinth Ambrosia Mine - SA	Thevenard Port - SA	280 km	5.00 hours – Driving 30 min – Unloading	
Thevenard Port - SA	Kalari Ceduna Depot	5 km	15 min – Driving 30 min Fuel Up – Paperwork – Washdown and Prepare Vehicle for Next Trip	
Trip Time Totals:		**565 km**	**11.00 hours**	**>30minutes**

Note: Drivers must drive within signposted and heavy vehicle legal speed limits, and to the road conditions. Times between destinations are an estimate only.

Route:

The Company preferred route for this journey is:

From the Kalari Depot turn left into Schwarz Street – turn left into Goode Road – turn right at the roundabout into Kuhlmann Street – turn right into the Eyre Highway – over the railway line.

In the instance quad road trains need to be re-routed back to Ceduna drivers are to stop and communicate with management as soon as possible. Management will then advise drivers of the process to be undertaken to successfully re-route the quad road train.

Follow the Eyre Highway turning right onto the Jacinth Ambrosia Mine access road. If weather conditions are inclement and while in the right-hand lane on the Eyre Highway activate the beacon light to give greater safety caution to other road users and also on exit off the Haul Road back onto the Eyre Highway.

Return journey in reverse to Kuhlmann Street roundabout turn right into Murat Terrace continuing onto Thevenard Road – turn left into Davison Street – over the railway line – turn right into Bergmann Drive – over the railway line – turn left into the HMC Facility. Use caution at the rail crossing as they are very rough.

HMC facility turn right onto Bergmann Drive – over the railway line – turn left into Davison Street – over the railway line – turn right into Thevenard Road continuing onto Murat Terrace – straight through the second roundabout onto Goode Road – turn right into Schwarz Street. **Extra caution is required when turning right into Schwarz Street, under the current design of this intersection a TRTor QRT must remain entirely in the left-hand slip lane before entering the intersection. It is recommended that road trains wait for any vehicles entering the intersection to vacate thus allowing enough turning clearance.** Then turn right into the Kalari Ceduna Depot

Any deviation from the preferred route must first be authorised by the Driver's Supervisor in consultation with Iluka.

Drivers are required to complete a National Heavy Vehicle Drivers Work Diary entry & they must also record all rest and meal breaks on the Kalari Daily Worksheet to comply with regulation requirements.

Note: When traveling on Bergmann Drive the self-imposed speed limit to be 40km/h.

Note: Take extra care when approaching the railway crossing at Davison Street / Bergmann Drive and north of Ceduna.

Note: Kuhlmann Street / Murat Terrace Roundabout – Murat Terrace / McKenzie Street Roundabout – Murat Terrace / Poynton Street Junction driver awareness and land discipline required at these locations.

Note: The JA Mine haul road is a sealed road with speed restrictions of 80 km/h.

Engine Noise Reduction:

Drivers under no circumstance are to use engine brakes whilst traveling through any townships / built up areas along the planned driving route accept where emergency braking may be required.

Fatigue Management/Fatigue Breaks:

Drivers must ensure their personal safety and the safety of other road uses by recognizing signs of fatigue and implementing the appropriate fatigue management strategies.

If a driver experiences symptoms of fatigue there is an expectation that a driver must assess and implement the appropriate Revive Strategies and Actions as per the Kalari Fatigue Charter.

In the event a driver feels it to be necessary to pull over, some examples of revive strategies that can be implemented include; stop task and walk around, stretch, eat a meal or snack, strategically use caffeine or if necessary nap for no more than 15 minutes. Refer to the Fatigue Charter for a list of revive strategies.

There are a number of approved heavy vehicle parking bays which can be utilized. These are identified on the Journey Route below.

Proposed Heavy Vehicle Parking Areas

Drivers are encouraged to take their legally required rest break at any of (pending availability) the parking areas displayed on the driving route plan.

If a driver is unable to pull over at a designated/proposed parking area, the following considerations need to be made when identifying a suitable area to stop.

- Safe entry to the rest stop.
- Adequate merging allowance when exiting rest stop.
- Driver/vehicle security when using the rest stop.
- Weather Conditions.

- **Note: If unable to pull over 1 meter from the fog line, hazard markers are required.**

Driver schedules are to be arranged to allow as much night sleep as possible
Shifts should rotate from days to nights every four days & provide a 24 hour continuous break at every shift rotation

A reminder that REST is one of Kalari's Life Saving Rules-Fatigue affects your safety as well as the safety of other road users. Obey the rules and don't drive tired.

Note: Night sleep is from midnight to 6am.

Note: A fully equipped, air-conditioned site crib room is to be provided at the Jacinth mine site.

Journey Route Hazard Identification

<table>
<tr><th>Hazards Identified</th><th>Risk Reduction Measures</th></tr>
<tr><td>

1. Ceduna Traffic Management Route.

</td><td>

Driver to ensure the designated route through Ceduna as detailed on the attached plan is strictly adhered to at all times.

</td></tr>
<tr><td>

2. Crossing Rail Crossings.

</td><td>

Slow down and proceed with caution when crossing any rail track.

</td></tr>
<tr><td>

3. Stop at the Fruit Fly Inspection Point on the Return Journey.

</td><td>

</td></tr>
</table>

4. Slow down when traveling through any built-up areas.

5. Be aware of animals crossing the road especially at night-time.

6. Over width Loads.

Be aware of over width loads on the Eyre Highway. Ensure Channel 40 on the UHF is activated.

7. Jacinth Ambrosia mine turn-off onto Ooldea Road Bypass. 	The road to the mine is not marked, take care that you do not travel past the turn off point. Approximately 20km past Nundroo township. 
8. Mine Site Channel.	Switch the UHF Channel to 31at the camp site turn-off point. 
9. Speed Limit at turn-off roads. 	When passing turn off points to other roads ensure the speed limit of 60 km/h is adhered to. 

10. Mine Turn-Off.

Mine site approximately 4km past the mine camp. Adhere to the site speed limit of 25km/h when at the mine site.
Note: This is the site call up point when entering the Iluka JA Mine.

11. Site Safety Requirements.

Ensure all site safety requirements as displayed are adhered to.

12. Haul Road Speed Limit

The self-imposed speed limit when traveling on the Haul Road from the Eyre Highway to the Jacinth Ambrosia mine site is **80km/h** to the JA camp site turnoff point.

From the camp site to the mine site the speed limit is **60km/h**.

All other speed limits as sign posted on the road MUST be adhered to.

Note: Keep on the road at all times, do not attempt to drive on the old road.

Kalari Ceduna Site Location

Thevenard Port Layout Plan

Ceduna Township Driving Route Plan

Appendix C
Custom Road Train Exemption Permit

NHVR
National Heavy Vehicle Regulator

Permit number

283559V6

Custom Road Train Mass or Dimension Exemption Permit

Heavy Vehicle National Law
This Permit is issued under the provisions of *Section 122 of the Heavy Vehicle National Law* for the operation of a Class 3 vehicle *(as defined in this Permit)* subject to the conditions set out in this Permit and any attachments.

Permit details

This Permit is issued to

KALARI PROPRIETARY LIMITED

Address

850 Lorimer St
Port Melbourne, VIC 3207

Type

Custom Road Train

Vehicle configuration and description

Custom
A Quad (with tri-axle dollies)(24 axles)

Permit period

Start date	End date
31-Oct-2022	30-Oct-2025

continued on next page...

NHVR
National Heavy Vehicle Regulator

Permit number

283559V6

Vehicle details

Prime mover

Registration	State of Registration	VIN	GVM (t)	GTM (t)
XS60AL	SA	6F5000000JA463505	11t	n/a
XS61AL	SA	6F5000000JA463506	11t	n/a
XS62AL	SA	6F5000000JA463507	11t	n/a
XS63AL	SA	6F5000000JA463508	11t	n/a
XS64AL	SA	6F5000000JA463509	11t	n/a
XS20BD	SA	6F5000000KA465305	28.2t	n/a
SB00DN	SA	6F5000000AA442909	27.7t	n/a
XS02DJ	SA	6F5000000MA470394	27.9t	27.9t
XS80EE	SA	6F5000000MA473751	27.9t	27.9t

Tipper Semitrailer

Registration	State of Registration	VIN	GVM (t)	GTM (t)
SY43CD	SA	6T9T25WA1A0AAN099	43t	n/a
SY21BH	SA	6T9T25WA1A0AAN033	43t	n/a
SY24BH	SA	6T9T25WA1A0AAN038	43t	n/a
SY01CD	SA	6T9T25WA1A0AAN067	43t	n/a
SY14BH	SA	6T9T25WA1A0AAN024	43t	n/a
SY45BH	SA	6T9T25WA1A0AAN019	43t	n/a
SY23BH	SA	6T9T25WA1A0AAN035	43t	n/a
SY49DS	SA	6T9T25WA1COAAN046	43t	n/a

Converter dolly

Registration	State of Registration	VIN	GVM (t)	GTM (t)
YV87IB	VIC	6T9T25WA1C0AAN036	43t	n/a
SY28BH	SA	6T9T25WA1A0AAN040	43t	n/a
SY01BH	SA	6T9T25WA1A0AAN041	43t	n/a
1TOS489	WA	6T9T25WA1C0AAN033	43t	n/a
SY03BH	SA	6T9T25WA1A0AAN039	43t	n/a
SY22BH	SA	6T9T25WA1A0AAN037	43t	n/a
SY26CD	SA	6T9T25WA1A0AAN053	43t	n/a
SY48BH	SA	6T9T25WA1A0AAN020	43t	n/a

Tipper Semitrailer

Registration	State of Registration	VIN	GVM (t)	GTM (t)
1TOS486	WA	6T9T25WA1COAAN037	43t	n/a
1TOS481	WA	6T9T25WA1C0AAN027	43t	n/a
1TOS489	WA	6T9T25WA1C0AAN033	43t	n/a
1TOS483	WA	6T9T25WA1C0AAN042	43t	n/a

SY04CD	SA	6T9T25WA1A0AAN069	43t	n/a
SY26BH	SA	6T9T25WA1A0AAN036	43t	n/a
SY06BH	SA	6T9T25WA1A0AAN046	43t	n/a
SY42CD	SA	6T9T25WA1A0AAN101	43t	n/a

Converter dolly

Registration	State of Registration	VIN	GVM (t)	GTM (t)
1TOS485	WA	6T9T25WA1COAAN038	43t	n/a
1TOS094	WA	6T9T25WA1COAAN048	43t	n/a
SY05CD	SA	6T9T25WA1AOAAN068	43t	n/a
1TOS482	VIC	6T9T25WA1COAAN043	43t	n/a
SY18BH	SA	6T9T25WA1AOAAN032	43t	n/a
SY00BH	SA	6T9T25WA1AOAAN042	43t	n/a
1TOS491	VIC	6T9T25WA1COAAN028	43t	n/a
SY23BH	SA	6T9T25WA1AOAAN035	43t	n/a

Tipper Semitrailer

Registration	State of Registration	VIN	GVM (t)	GTM (t)
SY46BH	SA	6T9T25WA1AOAAN021	43t	n/a
1TOS092	WA	6T9T25WA1COAAN047	43t	n/a
1TOS490	WA	6T9T25WA1COAAN032	43t	n/a
SB19BH	SA	6T9T25WA1AOAAN031	43t	n/a
SY25CD	SA	6T9T25WA1AOAAN054	43t	n/a
1TOS093	WA	6T9T25WA1COAAN049	43t	n/a
SY32CD	SA	6T9T25WA1AOAAN103	43t	n/a
1TOS484	WA	6T9T25WA1COAAN039	43t	n/a

Converter dolly

Registration	State of Registration	VIN	GVM (t)	GTM (t)
SY30CD	SA	6T9T25WA1AOAAN102	43t	n/a
SY49BH	SA	6T9T25WA1AOAAN022	43t	n/a
SY12BH	SA	6T9T25WA1AOAAN025	43t	n/a
SY03CD	SA	6T9T25WA1AOAAN070	43t	n/a
SY13BH	SA	6T9T25WA1AOAAN027	43t	n/a

Tipper Semitrailer

Registration	State of Registration	VIN	GVM (t)	GTM (t)
SY47BH	SA	6T9T25WA1AOAAN023	n/a	43t
SY15BH	SA	6T9T25WA1AOAAN028	n/a	43t
1TOS480	WA	6T9T25WA1COAAN044	n/a	43t
SY02CD	SA	6T9T25WA1AOAAN071	n/a	43t
SY44EW	SA	6T9T25WA1COAAN045	n/a	43t

GCM must not exceed manufacturer's specifications

Permit number

283559V6

Loaded axle mass and spacings

Axle group	Axle group mass	Axle #	No. Tyres	Minimum distance from previous axle	Tyre size	Steerable	Minimum ground contact width	Load sharing
Prime mover 1-2 axle								
Steer	6t	1	2	n/a	295mm	Yes	2.4m	No
Drive	17t	1	4	3.79m	279mm	No	2.4m	Yes
		2	4	1.52m	279mm	No	2.4m	Yes
Tipper semitrailer 3 axle								
Trailer	22.5t	1	4	3.31m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No
Converter dolly 3 axle								
Dolly	22.5t	1	4	2.77m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No
Tipper semitrailer 3 axle								
Trailer	22.5t	1	4	2.77m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No
Converter dolly 3 axle								
Dolly	22.5t	1	4	2.77m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No
Tipper semitrailer 3 axle								
Trailer	22.5t	1	4	2.77m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No
Converter dolly 3 axle								
Dolly	22.5t	1	4	2.77m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No
Tipper semitrailer 3 axle								
Trailer	22.5t	1	4	2.77m	279mm	No	2.4m	No
		2	4	1.6m	279mm	No	2.4m	No
		3	4	1.6m	279mm	No	2.4m	No

Unladen dimensions

Unladen width (metres)	Unladen length (metres)	Unladen height (metres)	Tare mass (tonnes)
2.45m	49.73m	3.45m	50.3t

NHVR
National Heavy Vehicle Regulator

Permit number

283559V6

Laden dimensions

Width (metres)	Length (metres)	Height (metres)	Total mass (tonnes)
2.45m	49.73m	3.45m	180.5t

Forward projection (metres)	Rear overhang (metres)
n/a	n/a

Load type	Description of load
Indivisible	Mineral Sand

continued on next page...

Authorised Routes

Turn by turn description

283559r1v2 - Single Route

Start: Kalari Depot, Lot 3 Schwarz St, Ceduna SA 5690
Goode Rd, Ceduna
Eyre Hwy, [Ceduna - Penong]
Gypsum Mine Rd, Penong
End: Gypsum Mine Access, Gypsum Mine Rd, Penong SA 5690

283559r2v2 - Single Route

Start: Iluka Mine Access Road, Ooldea Rd, Yellabinna SA 5690
Ooldea Road, [Yellabinna – Yalata]
Eyre Highway, [Yalata – Ceduna]
Murat Terrace, Ceduna
Railway Terrace, Ceduna
Thevenard Road, [Ceduna – Thevenard]
Davison Street, Thevenard
Bergmann Drive, Thevenard
Finish: GRA, Port of Ceduna, Bergmann Dr, Thevenard, SA 5690
Return via reversal of route

283559r3v2 - Single Route

Start: Intersection of Ooldea Rd and Eyre Hwy, Yalata SA 5690
Eyre Hwy, Yalata
End: Rest Area/Truck-Turnaround, Eyre Hwy, Yalata SA 5690 (approx. 1.75km from Yalata Community Rd)

283559r4v2 - Single Route

Start: Intersection of Eyre Hwy and East Terrace, Penong SA 5690
Gypsum Mine Rd, Penong
Silo Rd, Penong
Point Sinclair Rd, Penong
End: Intersection of Point Sinclair Rd and Eyre Hwy, Penong SA 5690

Road conditions

DISTRICT COUNCIL OF CEDUNA

(1) RI10 - Heavy vehicle movement - Report of damage - In the event that the permitted heavy vehicle damages assets or infrastructure, contact must be made with District Council of Ceduna of Operations via 0886253407 with receipt of the advised damage from the road manager. A written statement of the damage must be recorded and provided in writing to the road manager prior to repairs of the damaged infrastructure or asset.

(2) RS01 - Speed restriction -The heavy vehicle is restricted to a maximum speed limit of 50 kph on the approved route, except where a traffic sign indicates a lower speed limit.

Department of Infrastructure and Transport (DIT)

(1) GO03 - You may be required under another law to obtain consent or approval from a Third Party entity. These

approvals must be carried and produced on request by an authorised officer. In this section Third Party entity usually include the following -a) police especially with respect to the movement of vehicles which exceed dimension requirements due to the potential risks to other road users and possible need for police assistance to control trafficb) rail infrastructure managers the movement of oversize/overmass heavy vehicles across level crossings or restricted access vehicles near rail infrastructure may create risks that need to be managedc) utilities restricted access vehicles may have adverse effects on utilities infrastructure with over height vehicles and telecommunications/power lines being a common concernd) private road owners allowing public access toll roads, ports, airports, hospitals and private estates are potential examples where those road owners, who may not be road managers for the purpose of the HVNL, also need to grant consent to the use of restricted access vehiclese) forestry agencies roads owned by governmental agencies can possess different characteristics that may pose risks not found on typical roads and if the government agency is not a road manager for the purpose of the HVNL may require special consideration to manage risks arising from the use of restricted access vehicles on these roads.

(2) TP04 - One Rail Australia - It is a requirement to carry an up-to-date One Rail Australia rail clearance at all times and comply with the conditions stated in that clearance. All conditions imposed by One Rail Australia must be adhered to.

Regulator

(1) GO03 -

You may be required under another law to obtain consent or approval from a Third Party entity.

These approvals must be carried and produced on request by an authorised officer. In this section Third Party entity usually include the following -

(a) police especially with respect to the movement of vehicles which exceed dimension requirements due to the potential risks to other road users and possible need for police assistance to control traffic

(b) rail infrastructure managers the movement of oversize/overmass heavy vehicles across level crossings or restricted access vehicles near rail infrastructure may create risks that need to be managed

(c) utilities restricted access vehicles may have adverse effects on utilities infrastructure with over height vehicles and telecommunications/power lines being a common concern

(d) private road owners allowing public access toll roads, ports, airports, hospitals and private estates are potential examples where those road owners, who may not be road managers for the purpose of the HVNL, also need to grant consent to the use of restricted access vehicles

(e) forestry agencies roads owned by governmental agencies can possess different characteristics that may pose risks not found on typical roads and if the government agency is not a road manager for the purpose of the HVNL may require special consideration to manage risks arising from the use of restricted access vehicles on these roads.

(2) GO03 -

You may be required under another law to obtain consent or approval from a Third Party entity.

These approvals must be carried and produced on request by an authorised officer. In this section Third Party entity usually include the following -

(a) police especially with respect to the movement of vehicles which exceed dimension requirements due to the potential risks to other road users and possible need for police assistance to control traffic

(b) rail infrastructure managers the movement of oversize/overmass heavy vehicles across level crossings or restricted access vehicles near rail infrastructure may create risks that need to be managed

(c) utilities restricted access vehicles may have adverse effects on utilities infrastructure with over height vehicles and telecommunications/power lines being a common concern

(d) private road owners allowing public access toll roads, ports, airports, hospitals and private estates are potential examples where those road owners, who may not be road managers for the purpose of the HVNL, also need to grant consent to the use of restricted access vehicles

(e) forestry agencies roads owned by governmental agencies can possess different characteristics that may pose risks not found on typical roads and if the government agency is not a road manager for the purpose of the HVNL may require special consideration to manage risks arising from the use of restricted access vehicles on these roads.

Travel conditions

Department of Infrastructure and Transport (DIT)

(1) DPTIRC01 - The Department of Infrastructure and Transport (DIT) provides road and traffic information to all road users. On the Traffic SA website at www.traffic.sa.gov.au you will find information about planned roadworks, road closures and traffic alerts. The website also contains information about roads and traffic during incidents and emergencies that may impact road users. Prior to travelling, please check the Traffic SA website for the latest update information to ensure the vehicle combination listed in this permit can travel and is safe to do so. There may be road works that will inhibit travel. Note: If travelling on outback roads please also check www.dpti.sa.gov.au/OutbackRoads for additional traffic information.

(2) TMP02 - Vehicle must comply with the current Heavy Vehicle (Mass Dimension and Loading) National Regulation as specified by the spacing between a tri and tandem axle groups not being less than 8m (unless the axle group masses are reduce). Spacing's between axle groups are measured between the first axle of the first group and last axle of the second group.

(3) TMP02 - Vehicle must comply with the current Heavy Vehicle (Mass Dimension and Loading) National Regulation as specified by the spacing between two tri axle groups not being less than 9.2m (unless the axle group masses are reduce). Spacing's between axle groups are measured between the first axle of the first group and last axle of the second group..

Vehicle conditions

Regulator

(1) LEC3NCRT01 - Heavy Vehicle National Law - National Class 2 Road Train Authorisation Notice - Conditions of Access

A class 3 Road Train operating under this permit must comply with all conditions of access as per the National Class 2 Road Train Authorisation Notice including any amendments and associated schedules of operation for the eligible class 3 vehicle combination.

(2) LEC3S8 - Heavy Vehicle National Law - Class 3 Schedule 8 RequirementA class 3 heavy vehicle operating under this permit must comply with the conditions stated within Divisions 1, 2, 3 and 5 of Schedule 8 of the Heavy Vehicle National (Mass, Dimension and Loading) Regulation, unless otherwise expressly exempted by a stated condition in this permit.

(3) LEOL - Other Laws and Legislation - Nothing within this permit exempts the driver or operator of the permitted heavy vehicle from complying with legislation regulating the use of heavy vehicle. This includes but is not limited to conditions applied within the vehicles registration, compliance with sign posted restrictions, traffic law or compliance with lawful directions of authorised officer.

(4) LEOL - Other Laws and Legislation

Nothing within this permit exempts the driver or operator of the permitted heavy vehicle from complying with legislation regulating the use of heavy vehicle. This includes but is not limited to conditions applied within the vehicles registration, compliance with sign posted restrictions, traffic law or compliance with lawful directions of authorised officer.

(5) LEOL - Other Laws and Legislation

Nothing within this permit exempts the driver or operator of the permitted heavy vehicle from complying with legislation regulating the use of heavy vehicle. This includes but is not limited to conditions applied within the vehicles registration, compliance with sign posted restrictions, traffic law or compliance with lawful directions of authorised officer.

continued on next page...

The driver of the heavy vehicle who is driving a vehicle that is subject to a permit issued under the HVNL must keep a copy of the permit for the exemption in the driver's possession.

The driver or operator of a heavy vehicle being used on a road that is subject to a permit issued under the HVNL must not contravene a condition of the permit.

The driver or operator must comply with the provisions of the Heavy Vehicle (Mass, Dimension and Loading) National Regulation unless anything contrary is applied within this permit.

It is an offence to operate a vehicle at a mass limit greater than indicated by an official traffic sign.

Declaration

Signed:

NHVR Delegate

Dated: 07-Oct-2022

Associated documents

N/A

END OF DOCUMENT

Appendix D
SISD Assessments

Safe Intersection Sight Distance (SISD) is the minimum distance that should be provided on the major road at any intersection. SISD provides sufficient distance for the driver of a vehicle on the major road to observe a vehicle on a minor road approach moving into a collision situation (e.g. in the worst case, stalling across the traffic lanes) and to decelerate to a stop before reaching the collision point.

SISD is assessed based on the following parameters and Equation 2 in *Austroads Part 4A*:

$$SISD = \frac{D_T \times V}{3.6} + \frac{V^2}{254 \times (d + 0.01 \times a)}$$

- An observation time of 3 seconds as per Austroads Part 3
- A reaction time of 2.5 seconds
- Deceleration coefficients for the purpose of SISD calculations are 0.24 for light vehicles and 0.26 for heavy vehicles, and
- Driver eye height is 2.4m for trucks and 1.1m for cars.

Intersection of Thevenard Road and Davison Street

The intersection of Thevenard Road and Davison Street is an unsignalised intersection of two local roads. There are two lanes (two-way) on Thevenard Road and two lanes (two-way) on Davison Street. The width of each lane in Thevenard Road is approximately 6.8m and in Davison Street is 6.1m. There are no acceleration/deceleration lanes.

SISD Calculation: At this intersection, vehicles travelling towards Atacama mine need to perform a right turn from Davison Street into Thevenard Road. Here vehicles must cross both lanes, so SISD should be checked for both lanes in Thevenard Road from conflict points. As these roads are mostly flat, the longitudinal grade is assumed as zero. In Figure D-, the red line indicates the SISD and the orange dashed line indicates the distance of driver eye until end of SISD line.

Table D-1: SISD Calculation for Right Turn From Davison Street to Thevenard Road

Speed V (km/h)	Reaction Time R_T (sec)	Observation Time O_T (sec)	Coefficient of Deceleration d	Longitudinal Grade a (%)	Grade Correction (m)	SISD (m)
60	2.5	3.0	0.24	0	0.0	151

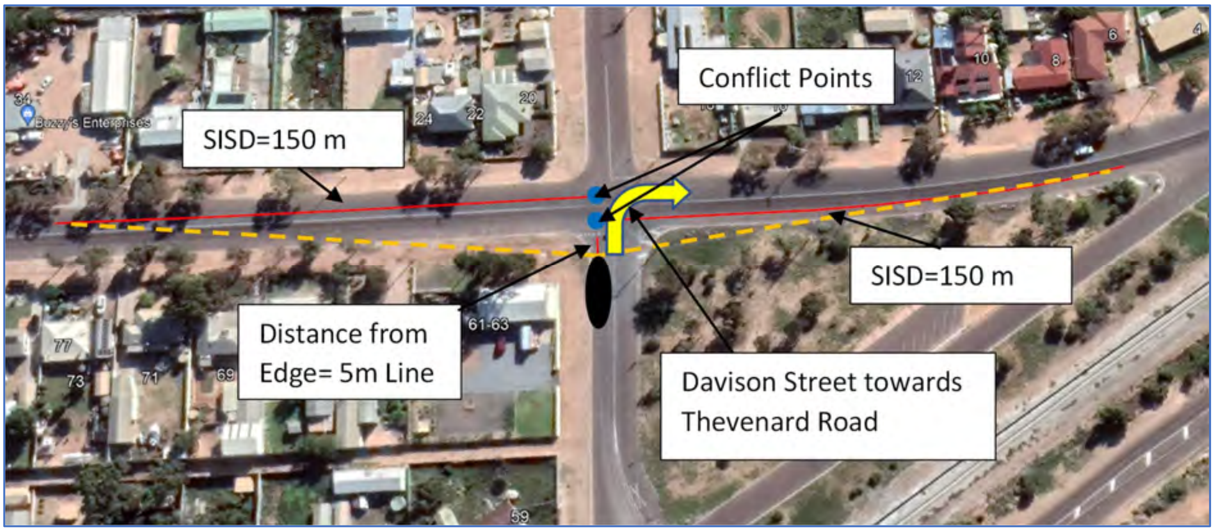


Figure D-1: SISD Check for Right Turn from Davison Street onto Thevenard Road

Conclusion: As there are no significant visual obstructions on the orange dashed line, drivers are expected to have adequate sightlines for right turns at this intersection.

D.1 Intersection of Eyre Highway and Kuhlmann Street

The intersection of Eyre Highway and Kuhlmann Street is an unsignalised intersection of two local roads. There are two lanes (two-way) on Kuhlmann Street and two lanes (two-way) on Eyre Highway. The width of each lane on Kuhlmann Street is approximately 6.8m and on Eyre Highway is 6.1m. There are no acceleration/deceleration lanes.

SISD Calculation: SISD need to be checked for both lanes on Eyre Highway. As these roads are mostly flat, the longitudinal grade is assumed as zero. In Figure D-2, the red line indicates the SISD and the orange dashed line indicates the distance of driver eye until the end of SISD line.

Table D-2: SISD Calculation for Right Turn From Kuhlmann Street onto Eyre Highway

Speed	Reaction Time	Observation Time	Coefficient of Deceleration	Longitudinal Grade	Grade Correction	SISD
V (km/h)	R_T (sec)	O_T (sec)	d	a (%)	(m)	(m)
60	2.5	3.0	0.24	0	0.0	151

Figure D-2: SISD Check for Right Turn from Kuhlmann Street onto Eyre Highway

Conclusion: While there are some trees on the orange dashed line, in Google Earth it can be seen these trees are not of sufficient size to block the sightlines of right-turning drivers at this intersection.

D.2 Intersection of Davison Street and Bergmann Drive

The intersection of Davison Street and Bergmann Drive is unsignalised flared T-intersection. There are two lanes (two-ways) on Bergmann Drive with additional deceleration lanes for turning into Davison Street. There are two stop lines before and after the railway level crossing.

SISD Calculation: Vehicles turning towards Port Thevenard must turn right from Davison Street into Bergmann Drive, necessitating a SISD check. As these roads are mostly flat, the longitudinal grade is assumed as zero. In Figure D-, the red line shows the SISD and orange dashed line shows the distance of driver eye until end of SISD line.

Table D-3: SISD Calculation for Right Turn from Davison Street to Bergmann Drive

	Reaction	Observation	Coefficient of	Longitudinal	Grade	SISD
Speed V (km/h)	**Time R_T (sec)**	**Time O_T (sec)**	**Deceleration d**	**Grade a (%)**	**Correction (m)**	**(m)**
50	2.5	3.0	0.24	0	0.0	**117.4**

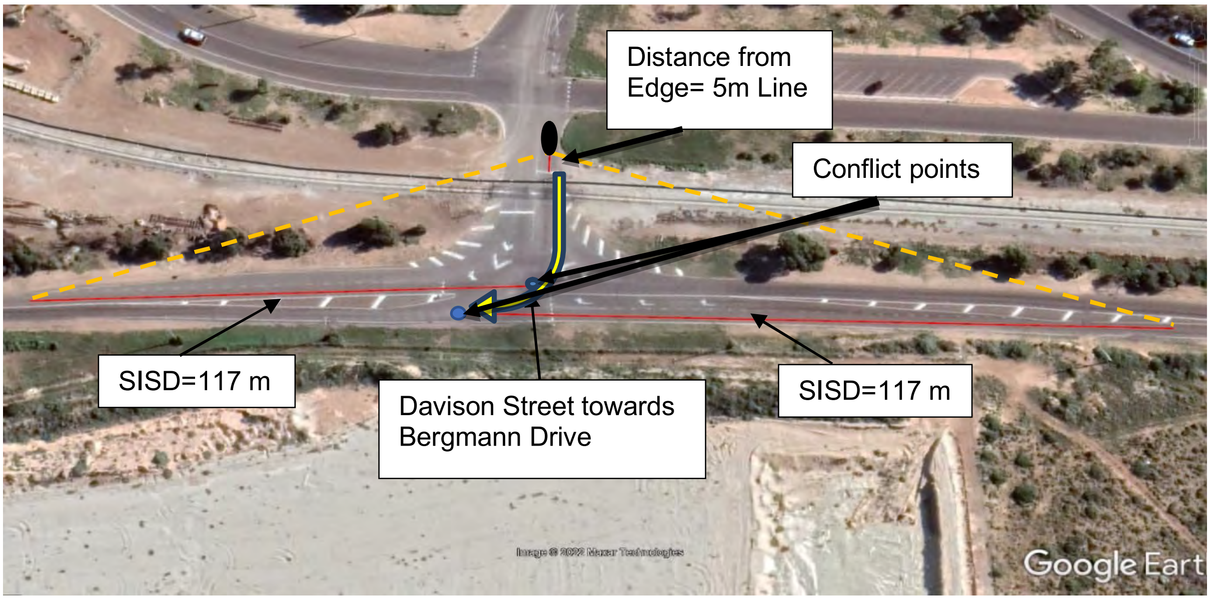


Figure D-3: SISD Check for Right Turn from Davison Street to Bergmann Drive

Conclusion: Based on the calculation above, and a review using Google Earth, sight distances at this intersection have been found to be safe.

D.3 Intersection of Eyre Highway and Ooldea Road

The Intersection of Eyre Highway and Ooldea Road is an unsignalised flared T-intersection. There are two lanes (two-ways) on Eyre Highway with additional deceleration lane for turning into Ooldea Road. The width of each lane on Eyre Highway is approximately 3 m on Ooldea Road is 3.3 m.

SISD Calculation:

Vehicles travelling towards Atacama must perform a right turn from Eyre Highway to Ooldea Road. This movement require vehicles to cross the eastbound lane on Eyre Highway, necessitating at SISD check. As these roads are mostly flat, the longitudinal grade is assumed as zero. InTable D-4, the red line shows the SISD, and the orange dashed line shows the distance between the driver's eye and the end of the SISD line.

Table D-4: SISD Calculation for Right Turn from Eyre Highway to Ooldea Road

	Reaction	Observation	Coefficient of	Longitudinal	Grade	SISD
Speed V (km/h)	**Time R_T (sec)**	**Time O_T (sec)**	**Deceleration d**	**Grade a (%)**	**Correction (m)**	**(m)**
100	2.5	3.0	0.24	0	0.0	316.8

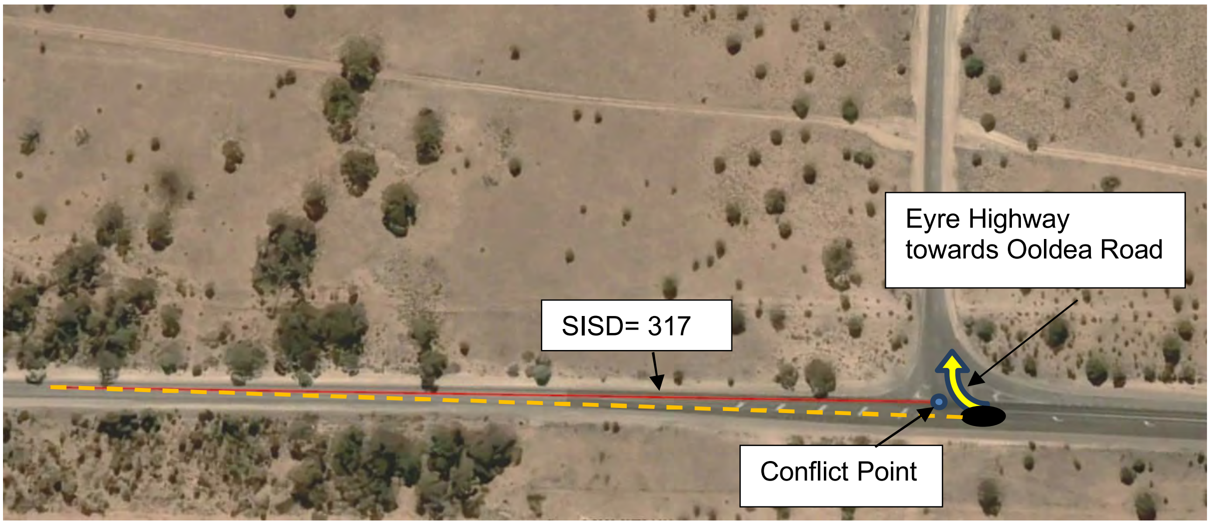


Figure D-4: SISD Check for Right Turn from Eyre Highway to Ooldea Road

Conclusion: As there is no object on the orange dashed line path and the road is almost flat, it is assumed the driver has good sight-lines for right turns at this intersection.

D.4 Roundabout of Kuhlmann Street and Murat Terrace

The roundabout at Kuhlmann Street and Murat Terrace in Ceduna has four legs. There are two lanes (two-way) on each leg. The approach width of each lane on Kuhlmann Street is approximately 5.3 m and on Murat Terrace is 4m. The entry width on Kuhlmann Street is 5m and on Murat Terrace is 7m. The exit width on Kuhlmann Street is 7m and on Murat Terrace is 6m. The circulating carriageway width is 9.5m. The posted speed on Kuhlmann Street is 50 km/ h and on the other legs is 60 km/h.

ASD Calculation: At this roundabout ASD needs to be checked for vehicles approaching the roundabout.

Table D-5: ASD Calculation for Approaching Cars to Roundabout

Location	Design/ Operating Speed V (km/h)	Reaction Time R_T (sec)	Coefficient of Deceleration d	Longitudinal Grade a (%)	Grade Correction (m)	ASD (m)
Kuhlmann Street	50	2.5	0.24	0	0	76
Murat Terrace	60	2.5	0.24	0	0	101

Figure D-5: ASD Check for Approaching Cars to Roundabout

Conclusion: As there are no objects on the orange dashed line, and the road is almost flat, drivers have good sightlines for this turning movement.

SISD calculation for vehicles turning towards Atacama mine: Based on Austroads Guide to Road Design (AGRD) Part 4A vehicles entering the roundabout from Murat Terrace into Kuhlmann Street need to have adequate sight distance for two potentially conflicting movements within the roundabout, namely:

- A vehicle entering from the approach immediately to the right, and
- A vehicle travelling on the circulating roadway.

As this is a local residential street roundabout, critical acceptance gap is 4 seconds. The approach speed for driver B and the speed for driver C inside of the roundabout is assumed the same as design speed of the respective approach roads. Based on Table 3.1 in AGRD part 4A and speeds the SISD is 67 m.

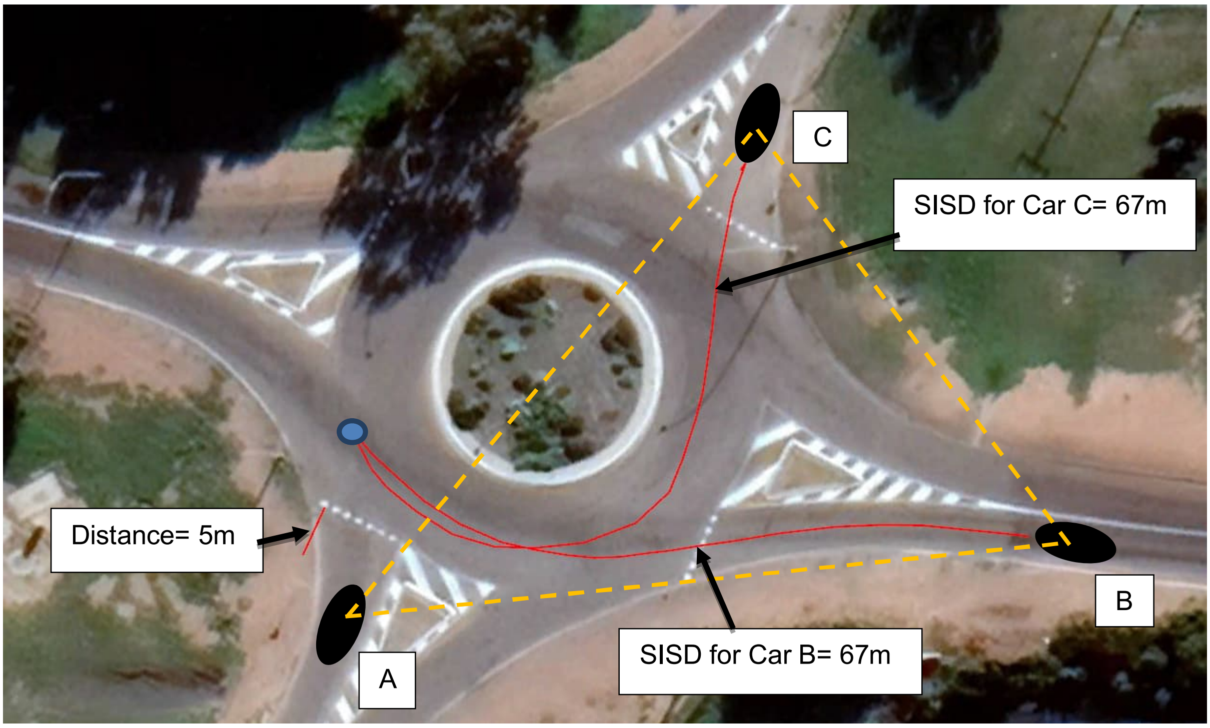


Figure D-6: SISD Check for Approaching Cars in the Murat Terrace for Left Turn to Kuhlmann Street

Conclusion: As there are no objects on the orange dashed line, and the road is almost flat, it is assumed there are good sightlines for vehicle entering from the approach immediately to the right and vehicles travelling on the circulating roadway.

SISD Calculation for vehicles turning towards Thevenard Port: A SISD calculation for vehicles turning right from Kuhlmann Street into Murat Terrace is same as above (67m).

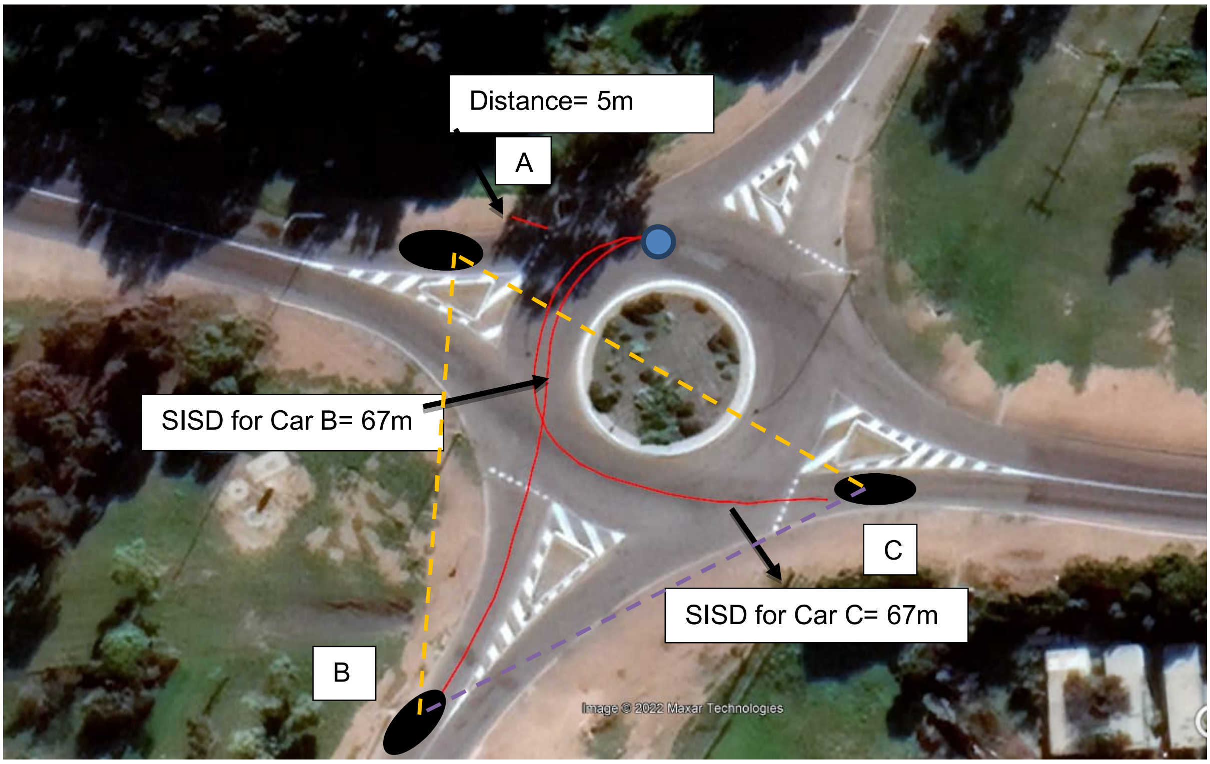


Figure D-7: SISD Check for Approaching Cars in the Kuhlmann Street for the Right Turn to Murat Terrace

Conclusion: As there are no objects on the orange dashed line, and the middle circle of the roundabout is raised approximately 20cm, drivers are assumed to have good sightlines for vehicles entering from the approach immediately to the right, as well as vehicles on the circulating roadway.

Iluka

Atacama Project

Environmental Radiation Impact Assessment

June, 2022

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Radiation Consulting Australia

CONTENTS

1. INTRODUCTION

1.1 Purpose of this report

The purpose of this technical report is to:

- Provide an assessment of the radiation related impacts specific to non-human biota and members of the public for the existing J-A operation.
- Assess the potential for impacts to non-human biota and members of the public arising from the cumulative radiological impacts due to processing both the Atacama and J-A material. Radiological impacts will be considered for processing onsite and for the transportation of products from the mine.

The assessment of potential radiological impacts will be undertaken using the Environmental Risks from Ionising Contaminants: Assessment and Management (ERICA) Tool.

This report consists of a number of scenarios (current and planned J-A operations, proposed Atacama operations and transport, and a combination of J-A operations and proposed Atacama operations and transport), each of which include the following:

- An outline of the relevant radiological characteristics of the scenario,
- A description of the methods for the assessment,
- Assessments of the radiological impacts to representative and user-specific flora and fauna (referred to as non-human biota (NHB)), and,
- Assessment of doses to members of the public (from the consumption of bush tucker).

1.2 Overview

Iluka's Jacinth-Ambrosia (J-A) mine is located approximately 280 km North West of Ceduna. The mine lease (ML) is located within the Yellabinna Regional Reserve and the Nullarbor Regional Reserve. Mining activities commenced in September 2009 with the pre-stripping of vegetation, topsoil and overburden and the commissioning of the Wet Concentrator Plant (WCP), Tailings Storage Facility (TSF), Heavy Mineral Concentrate (HMC) storage area and Mining Unit Plant (MUP). Processing of ore commenced in November 2009.

The J-A mine comprises two deposits, Jacinth in the south and Ambrosia in the north. There are other mineral sands deposits nearby including Typhoon and Sonoran (T-S) approximately 6 km and 10 km to the south-east respectively, and Atacama approximately 5 km to the north-east. A pre-feasibility study (PFS) is currently underway for the development of the Atacama deposit (referred to as the Atacama Project).

Low levels of uranium and thorium mineralisation are associated with the orebodies. The concentrations of radionuclides are highest in Atacama ore, up to 0.39 Bq/g and 0.26 Bq/g for Uranium-238 (U^{238}) and Thorium-232 (Th^{232}) respectively (based on ore sample assays). J-A ore has concentrations of approximately 0.10 Bq/g and 0.05 Bq/g for U^{238} and Th^{232} respectively. Concentrations in final product bulk samples for Atacama have been measured to be up to 2.78 Bq/g for U^{238} and 1.93 Bq/g for Th^{232}, similar to average J-A HMC concentrations measured over a 12 month period, with concentrations of 2.61 Bq/g for U^{238} and 2.42 Bq/g for Th^{232} (Iluka, 2018).

When mining and processing is carried out with materials containing uranium and thorium, there is the potential for radiological impacts to the environment to occur. It is therefore important to measure and characterise the potential dose pathways for members of the public and non-human species present in the environment, to determine whether there are any radiological impacts, and what dose pathways may require further control.

2. ENVIRONMENTAL RADIATION IMPACT ASSESSMENT

This document assumes a basic understanding of radiation protection. An overview of key concepts is provided here for contextualization of the environmental radiation impact assessment.

The protection of the natural environment from emissions from nearby human activities has historically been based on the protection of humans. This approach was outlined by the International Commission on Radiation Protection (ICRP), which stated that "if man is protected then it can be assumed that the environment is protected" (ICRP, 1991). More recently, however, it has been generally expected that there is a need to demonstrate, rather than assume, that non-human biota living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human activities (ARPANSA, 2014).

More recent publications (ICRP, 2014 and ARPANSA, 2015) have addressed this, and recommended that assessments be made on the impact of radiation on non-human biota. It is important to note that protection of non-human biota is demonstrated at the species level, rather than the individual level, as is the case for humans.

ARPANSA, 2015, suggests considering an as-simple-as-possible but as-complex-as-necessary approach to demonstrating protection, which assists in optimising the resources spent on the assessment and allows for a graded approach to protection. To facilitate this, a tiered approach may be used, which involves a first screening using simplified methodology and deliberately conservative (although not necessarily unrealistic) assumptions and parameter values, against a screening value of dose rate.

2.1 The ERICA Tool

The ERICA Tool was developed under the European Commission to provide a method of assessing the impact of radiological contaminants to the natural environment.

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has noted that the ERICA Tool is applicable for use in Australia (ARPANSA, 2010). The software uses changes in radionuclide concentrations and concentration ratios in species, derived from monitoring and studies, to provide an estimated dose and measure of radiological impact to a number of reference animals and plants (RAPs).

The database of the ERICA Tool has been built around a number of RAPs. Each RAP has a specified geometry, and default concentration ratio (CR) values. The geometry of an organism is represented as an ellipsoid – and by varying its axes – it can be used as a reasonable approximation for much of the existing wildlife on Earth (see Figure 2-1). Radiation damage arises due to ionisation along the path radiation takes as it passes through tissues, hence the dimensions of the organism have relevance to the degree of radiation damage that can occur. User specific organisms can be defined in ERICA, and the size and weight altered from that of RAPs.

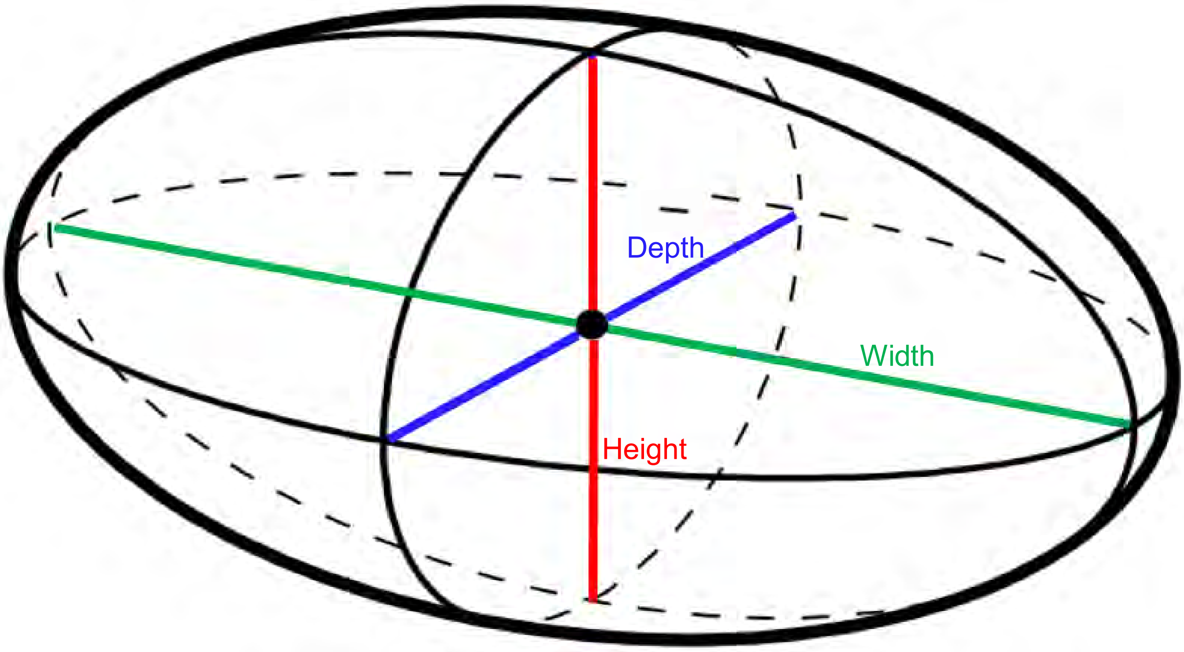

Figure 2-1: An example of an ellipsoid, which can be used to approximate the geometry of biota by varying the axes.

Some simplifications introduced when using RAPs include:

- An assumption of homogenous radionuclide distribution in the tissues of the organism (for internal dosimetry),
- Generic biological data in terms of habitat, occupancy, life cycle, and reproduction among other factors.

ERICA is a tiered assessment, and the level of assessment depends upon the level of impact (the higher the potential impact, the higher the level of scrutiny) (ARPANSA, 2015). The tiered approach aims to ensure that the level of assessment is commensurate with the level of risk. The tiers are:

- Tier 1, the first assessment level, requiring the least amount of input data. Tier 1 assessments are used to determine a risk quotient for the site, based on generic data. Where the potential impacts are higher and more data is available, a Tier 2 assessment can be conducted.

- Tier 2, which allows the user to examine and edit most of the parameters used in the calculation including concentration ratios, distribution coefficients, percentage dry weight soil or sediment, dose conversion coefficients, radiation weighting factors and occupancy factors, and results in a dose rate, rather than a risk quotient. Tier 2 assessments are primarily intended to involve a more intensive literature search to modify the assumptions of the benchmark criteria used in Tier 1 (e.g. to use site specific data or more appropriate data identified in literature).
- Tier 3, which are performed when the likely impacts need to be further defined (e.g. if doses are above screening values, or Derived Consideration Reference Levels (DCRLs)). Tier 3 offers the same flexibility as Tier 2 but allows the option to run the assessment probabilistically if the underling parameter probability distribution functions are defined.

Each assessment tier produces a dose rate which is comparable to a 'screening dose rate'. The default ERICA screening dose rate is 10 µGy/h (ARPANSA, 2015), which is the level below which no effects would be observed for even the most sensitive species (predicted no-effect dose rate).

The two important inputs for an ERICA assessment are:

- Operationally derived changes in media concentration (the additional radionuclide concentration in soils or water attributable to the operation), in units of Bq/kg or Bq/L.
- The radionuclide concentration ratios, which is the ratio of radionuclide concentrations in the media to concentrations in flora and fauna.

These inputs allow external and internal doses to be estimated for reference (or user defined) animals and plants. User defined species with specific CR value data (where available) and user specified geometry allow the user to estimate doses to specific species more accurately.

The latest version of the ERICA software was released in November 2021 (version 2.0) and was used in the assessment. A Tier 2 ERICA assessment was conducted because some additional concentration ratio data is available.

2.2 Initial (pre-mining) conditions

The Atacama study area was extensively surveyed in 2016 (SA Radiation, 2016) to determine pre-mining baseline radiological conditions in the immediate area surrounding proposed mining activities. Gamma dose rates were measured in a grid pattern over the entire study area, as well as along transects of interest over the ore body, and soil/sediment samples were taken from the same locations. The study area and measurement locations are shown in Figure 2-2.

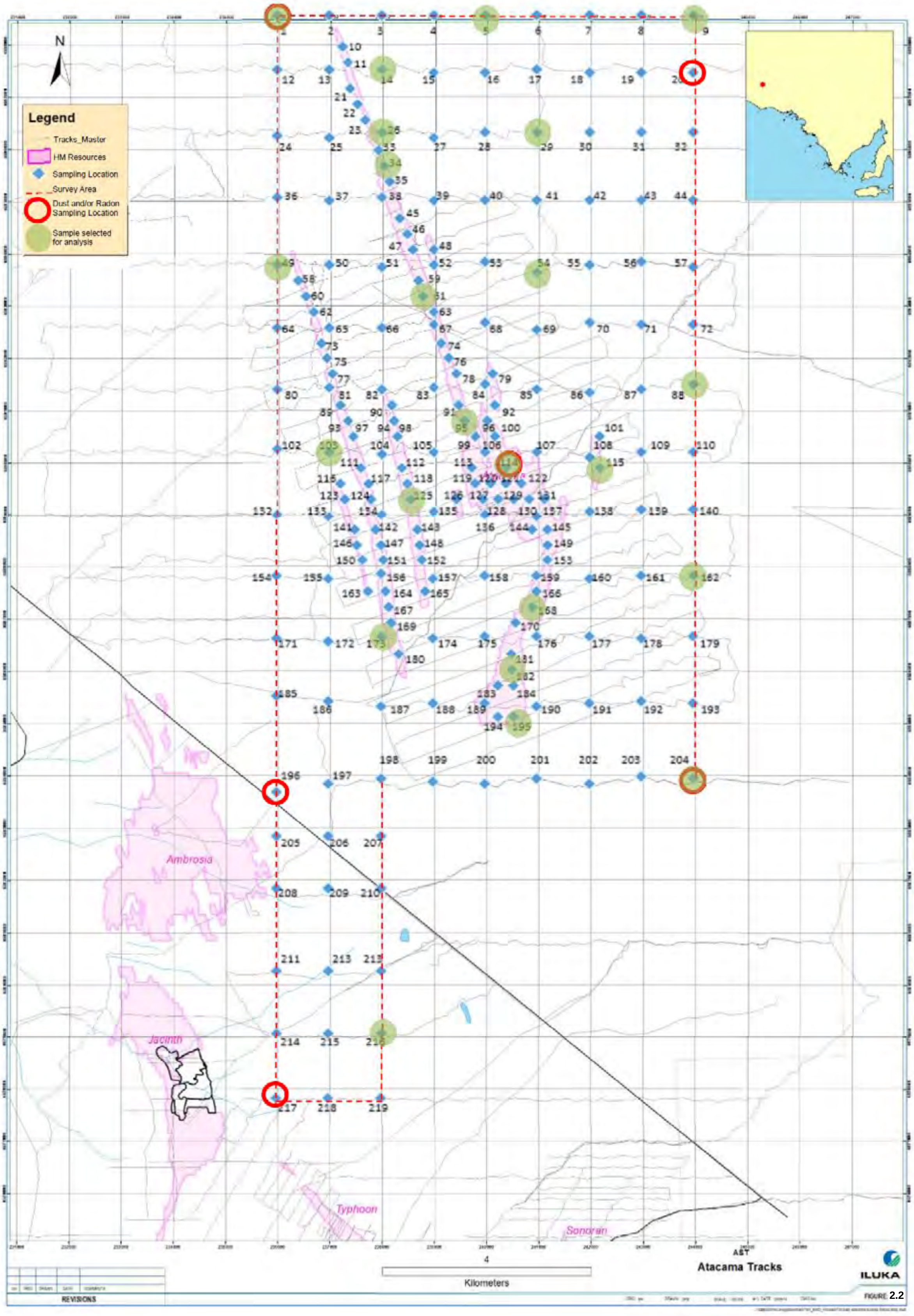

Figure 2-2: Atacama study area, along with sampling locations from the 2016 survey

The results reported in 2016 show that over the study area, uranium soil concentrations (in topsoil) are generally in the range of 0-4.5 ppm and thorium concentrations ranged from 0-9.5 ppm. The average concentrations of uranium and thorium were 0.75 ppm and 2.97 ppm respectively. These concentrations are low, but still typical of normal soils. For reference, the worldwide average uranium concentration is approximately 3 ppm, and the worldwide average thorium concentration is approximately 9 ppm (UNSCEAR, 2000).

Gamma surveys were conducted in 2016, and the average contact dose rate, as well as the dose rate at 1m was found to be 0.04 µGy/h over the study area. This dose rate is again low compared to typical environmental levels, with the average in Australia being 0.09 µGy/h (UNSCEAR, 2000).

Measurements conducted at the nearby J-A mine site are similar. The area surrounding the process plant and stockpile area at J-A has been surveyed previously, with topsoil concentrations measured to have activity concentrations of 0.014 Bq/g and 0.007 Bq/g for Th^{232} and U^{238} respectively (equivalent to 3.3 ppm Th and 0.55 ppm U) (Iluka, 2018). A survey of the Ambrosia deposit was conducted in 2018 (SA Radiation, 2018) to confirm baseline conditions, where contact dose rates averaged 0.04 µGy/h, and implied U and Th concentrations ranged from 0-2.2 ppm and 0-8.1 ppm respectively – comparable to the findings of the 2016 radiological survey of topsoils within the Atacama study area.

The data collected from all locations, surrounding each ore body, show that the radiological conditions are consistent across the wider area surrounding the current processing facility and mine site. Uranium and thorium concentrations in soil are low compared to Australian averages, which is reflected in measured terrestrial dose rates.

2.3 Assessment approach

Processing of material with similar radionuclide concentrations to the Atacama orebody has been undertaken at the process plant since mining of the Jacinth ore body commenced in 2009. Stockpiling of the product (HMC) occurs close by. This equates to 148 months or approximately 12 years of operation. This section provides an assessment of the radionuclide dose rates that have occurred as part of the approved J-A Project over the last 12 years of operation.

Dust deposition has been monitored since the commencement of mining, at a total of 15 sites surrounding the J-A plant, mine, camp and access roads (Figure 2-3). Dust mass varies at each site, typically with the highest dust masses occurring close to the stockpile and process plant. Dust mass per square meter per month has been calculated for each location, and ranged from 0.44 g/m^2/month at sites furthest from operational activities to 13 g/m^2/month at sites closest to operational activities (DU27), and close to transport routes (DU16 – in the prevailing wind direction). Monitoring location DU27 (situated immediately to the East of the HMC stockpiles) presents the highest potential impact for the site, and has therefore been chosen as a conservative reference location for doses arising from the J-A mine.

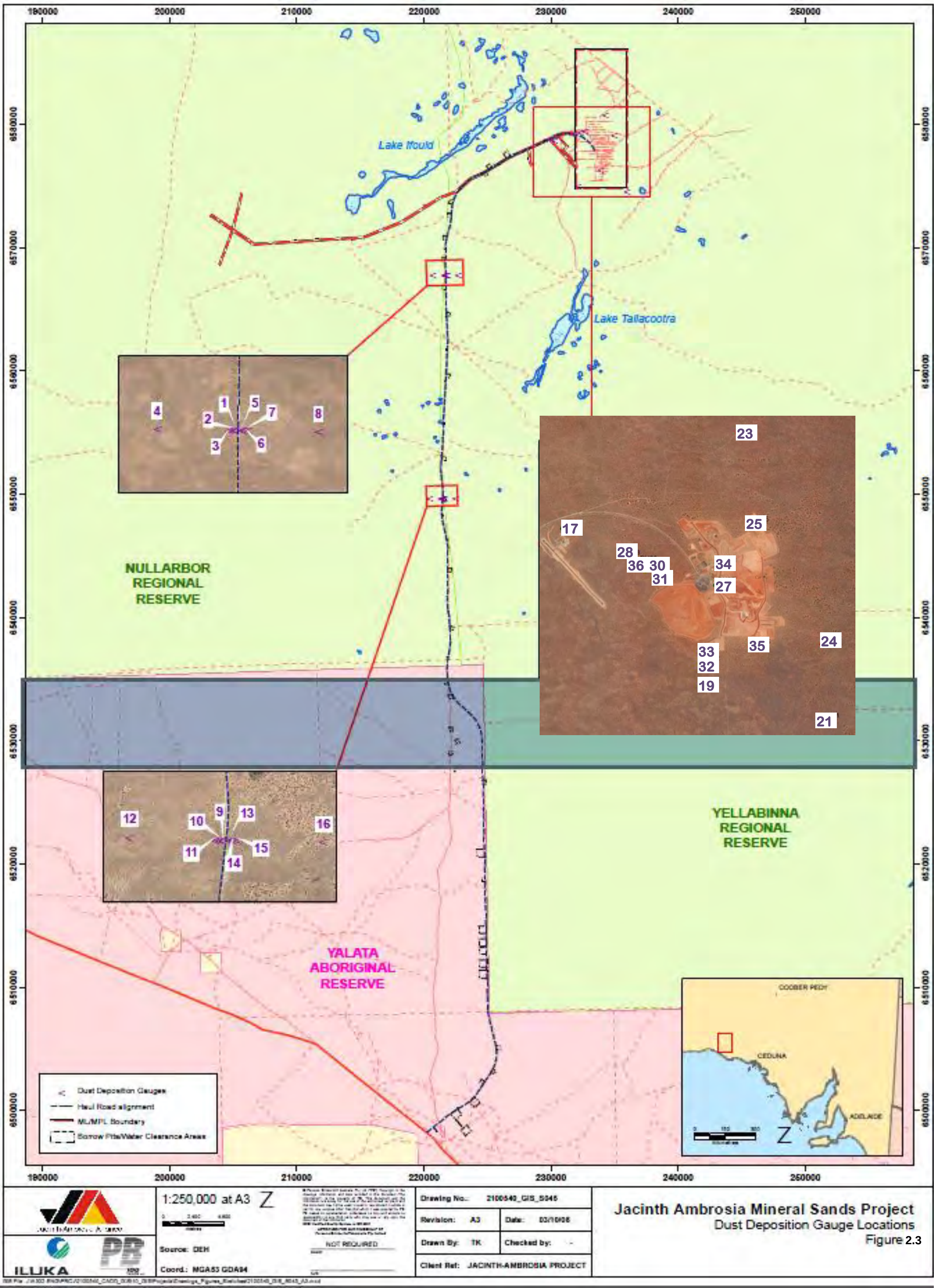

Figure 2-3: Dust deposition gauge locations Jacinth Ambrosia

Dust deposition monitoring was not undertaken prior to current J-A mining operations commencing, however the results from baseline monitoring at the T-S site (to the east) (SA Radiation, 2015) are considered to be reasonable approximations. The average dust deposition over each of the monitored sites at T-S is 1.25 g/m^2/month.

The difference between the approximate baseline dust and the dust measured at each location is likely attributable to operational activities (dust generated by processing, mining and stockpiling activities, along with dust generated from use and maintenance of roads). The additional dust is likely a combination of road materials, overburden, process material and HMC. Air quality estimates (Katestone Environmental, 2008) summarised in Table 2-1 estimate that the emission rates for total suspended particulates (TSP) derived from HMC and ore to be approximately 44% (where less than 10% of this, or 4% of the total TSP, is derived from HMC). Using this data, we can determine the upper limit for environmental contamination (assuming TSP is a reasonable indicator for deposited dust).

Table 2-1: Air quality estimates - TSP emissions for J-A

Activity	TSP (g/s)	Overall % of TSP
HMC Derived		
Product stockpiles (loader operations and wind erosion)	2.46	3.7%
TOTAL (HMC Derived)	**2.46**	**3.7%**
Ore Derived		
Ambrosia mining area (loader and scraper operations, wind erosion, and revegetation area)	12.28	18.7%
Jacinth mining area (loader and scraper operations, wind erosion, and revegetation area)	12.29	18.7%
Half of Jacinth and Ambrosia overburden and stockpiling activities (conservative estimate)	2.13	3.2%
TOTAL (Ore Derived)	**26.70**	**40.7%**
TOTAL (Topsoil Derived) All remaining activities (haul road emissions, a proportion of overburden and topsoil handling)	**36.54**	**55.6%**
ALL EMISSIONS	**65.70**	**100%**

Table data derived from Katestone, 2008

2.4 Radiological impact of current operations

If we consider that the additional dust at the most affected site close to operations involving HMC (DU27) is 11.79 g/m^2/month (once background has been removed), and conservatively use this as a representative location, then over a 148 month period (the time since operational activities commenced), a total of 1745 g of dust has been deposited. 768 g of this material is estimated to be derived from HMC or ore (based on 44% of emissions being derived from HMC and ore as mentioned in Section 2.3), with 70 g of the dust conservatively assumed to be HMC (4% of total TSP), and the remainder (977 g) assumed to be from other sources (roads, environment). Conservatively assuming that all of the material (i.e. that no material is redeposited elsewhere) mixes with the top 10 mm of soil over time (consistent with dust deposition data in Australian soil (Kaste, Heimsath and Bostick, 2007)), and assuming a soil density of 1500 kg/m^3, the total activity in the soil can be determined. The average radionuclide concentrations in J-A HMC over 12 months in 2018 have been used in calculations (based on assay results supplied by Iluka), 574ppm Th and 209 ppm U. This equates to activity concentrations of approximately 2.42 Bq/g Th^{232} and 2.64 Bq/g U^{238}. Ore concentrations are estimated to be 0.05 Bq/g Th^{232} and 0.10 Bq/g U^{238}. The remainder dust (road derived dust, subsoil and topsoil overburden) is assumed to be 0.014 Bq/g Th^{232} and 0.007 Bq/g U^{238} (Iluka, 2018), consistent with pre-mining baseline values. Based on these concentrations, once mixing is considered, calculated concentrations in soil due to deposited dust are 0.027 Bq/g Th^{232} and 0.024 Bq/g U^{238}, of which 0.013 Bq/g Th^{232} and 0.017 Bq/g U^{238} are above baseline values for concentrations in topsoil.

Assuming daughter products are in secular equilibrium, the soil concentrations (additional to baseline concentrations) applicable to ERICA are displayed in Table 2-2. It should be noted that radioactive daughter nuclides are included in the dose conversion coefficients of their parents if their half-lives are shorter than 10 days. The U^{235} decay chain is estimated based on the natural ratio of U^{238}:U^{235} of 0.9928:0.0072.

Table 2-2: Increased radionuclide concentrations in soil at reference location (worst case J-A operations) to March 2022

Radionuclide	Estimated activity concentrations in soil after 148 months of operations (Bq/g)	Increased activity concentration in soil (baseline subtracted) (Bq/g)
U^{238} Decay Chain		
U^{238}	0.024	0.017
Th^{234}	0.024	0.017
U^{234}	0.024	0.017
Th^{230}	0.024	0.017
Ra^{226}	0.024	0.017
Pb^{210}	0.024	0.017
Po^{210}	0.024	0.017
U^{235} Decay Chain		
U^{235}	0.001	0.0007
Pa^{231}	0.001	0.0007
Ac^{227}	0.001	0.0007
Th^{227}	0.001	0.0007
Ra^{223}	0.001	0.0007
Th^{232} Decay Chain		
Th^{232}	0.027	0.013
Ra^{228}	0.027	0.013
Th^{228}	0.027	0.013

For reference, the estimated activity concentrations of 0.024 Bq/g for U^{238} and 0.027 Bq/g for Th^{232} (equivalent to approximately 1.9 ppm and 6.5 ppm respectively) in soil is comparable to average concentrations of uranium and thorium in soils, with the worldwide average uranium concentration being approximately 3 ppm, and the worldwide average thorium concentration being approximately 9 ppm (UNSCEAR, 2000). Using the increased concentration in soils as inputs to ERICA, the output doses to RAPs can be determined (using generic CR values), and are shown in Table 2-3, with doses calculated to the 99^{th} percentile. All terrestrial RAPs available in ERICA were selected for assessment.

Table 2-3: Doses to reference animals and plants at reference location (worst case J-A operations) to March 2022

Organism	Total dose rate per organism (µGy/h)	No effect dose threshold (µGy/h)
Amphibian (reference)	0.578	10
Annelid (reference)	0.766	10
Arthropod – detritivorous (reference)	0.901	10
Bird (reference)	0.123	10
Flying insects (reference)	0.210	10
Grasses & Herbs (reference)	1.26	10
Lichen & Bryophytes (reference)	5.82	10
Mammal – large (reference)	0.283	10
Mammal – small-burrowing (reference)	0.301	10
Mollusc – gastropod (reference)	0.202	10
Reptile (reference)	0.580	10
Shrub (reference)	1.45	10
Tree (reference)	0.105	10

Some additional data was used to determine doses to some user defined plants and animals, based on estimated size, mass and occupancy data outlined in Table 2-4. Where possible Australian data was utilised (Table 2-5), and has been used to determine doses to Australian plants and animals. ERICA default values have been used where additional data is unavailable. Actinium values have been derived from Lanthium ERICA defaults due to the chemical similarity.

User defined animals and plants were selected based on the availability of Australian data, the species used to determine doses to humans from bush tucker ingestion (see Section 3) , and species of interest to the Atacama Project (threatened species identified under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999). It should be noted that the club spear-grass *(Stipa nullanulla)* is also considered relevant for the J-A mine, for which reference grasses and herbs doses have been used (due to an absence of published CR data, and mass and size data being similar).

Table 2-4: User specific geometry, mass and occupancy values

Species	Organism mass (kg)	Height (m)	Width (m)	Length (m)	Occupancy Factor
Red Kangaroo *(Macropus rufus)*	45.0	1.5	0.75	0.75	100% on soil
Emu *(Dromaius novaehollandiae)*	34.0	1.75	0.4	1.5	100% on soil
Mallefowl *(Leipoa ocellata)*	2.0	0.4	0.2	0.6	90% on soil, 10% in air
Grey Falcon *(Falco hypoleucos)*	0.5	0.4	0.1	0.4	90% in air, 10% on soil
Desert Greenhood (Pterostylis xerophilla)	1.0	0.75	0.75	0.75	100% in soil
Yellow Swainson-pea (Swainsona pyrophilla)	1.0	0.75	0.75	0.75	100% in soil
Ooldea Guinea-flower *(Hibbertia crispula)*	1.0	0.75	0.75	0.75	100% in soil
Princess Parrot *(Polytelis alexandrae)*	0.12	0.3	0.2	0.46	90% in air, 10% on soil
Sandhill Dunnart *(Sminthopsis psammophila)*	0.055	0.05	0.05	0.16	50% in soil, 50% on soil
Sand Goanna *(Varanus gouldii)*	6.0	0.3	0.3	1.4	50% on soil, 50% in soil

The home range and nesting habits of the Emu, Red Kangaroo, and Sand Goanna have also been considered to estimate doses. As an example, the Red Kangaroo has a considerable home range of approximately 5.6 km^2 (Viggers & Hearn, 2005), whereas within any 5.6 km^2 area only approximately 1km^2 can be within areas of maximum dust deposition based on dust deposition modelling (Katestone Environmental, 2008), while the remaining area (4.6 km^2) receives on average approximately half of the deposited dust (equivalent to 50% of the maximum dose). The total dose to the Kangaroo is therefore estimated to be approximately 59% of the maximum dose. The emu has a similar home range (5 – 10 km^2), is nomadic, and resides in areas where food and water is present (Patodjar et. al. 2009) so although it would be considered to have a greater reduction, it has been conservatively assumed that reduction is similar to that of the Red Kangaroo.

The sand goanna isn't as affected by home range (0.08 km^2), however the nesting habits do impact potential dose. The sand goanna digs burrows approximately 50-60 cm deep (where soil concentrations aren't altered to the same extent – a lead contamination study found that the topsoil concentrations were 6 times higher than subsoil concentrations (Kachenko and Singh, 2006)) where they spend the night, therefore only 50% of their time is spent on soil receiving a dose, the other 50% of their time in-soil receives a dose 6 times lower than what would be expected in unaltered ERICA doses). Further still, burrows are generally made in sand dunes, of which there are none located in the highest impacted sites. The closest sand dune-like structures to DU27 are topsoil stockpiles, where the maximum dust deposition is approximately 50% of the maximum estimated dust deposition. Total doses to sand goannas are therefore reduced by 75% compared to doses that would be anticipated at DU27 (50% reduction due to location, and a further 50% reduction due to occupancy on topsoil). This is conservatively applied to each scenario (eg. sand dunes are not present along most impacted sites along haul road), with the exception of doses calculated near the Atacama stockpile, where doses are not discounted by 50% (however the 6 times reduction to doses in-ground is still expected).

Table 2-5: User specific CR values derived from Australian data

Species	Elemental Concentration Ratio (Bq/kg fw whole organism / Bq/kg dw soil)							Source
	U	Th	Ra	Pb	Po	Pa	Ac	
Red Kangaroo[1] *(Macropus rufus)*	0.0076	0.000136*	0.289	0.0222	0.598	0.541*	0.0338*	ARPANSA, 2014
Emu *(Dromaius novaehollandiae)*	0.00126*	0.000389*	0.0362*	0.0608*	0.0102*	0.031*	0.570*	Default ERICA values for reference "Bird"
Mallefowl *(Leipoa ocellata)*	0.00126*	0.000389*	0.0362*	0.0608*	0.0102*	0.031*	0.570*	Default ERICA values for reference "Bird"
Grey Falcon (*Falco hypoleucos*)	0.00126*	0.000389*	0.0362*	0.0608*	0.0102*	0.031*	0.570*	Default ERICA values for reference "Bird"
Desert Greenhood (*Pterostylis xerophilla*)	0.00660*	0.00126*	0.11	0.0697*	0.0733*	0.0066*	0.00354*	Average Australian shrub, ARPANSA, 2014
Yellow Swainson-pea (*Swainsona pyrophilla*)	0.00660*	0.00126*	0.11	0.0697*	0.0733*	0.0066*	0.00354*	Average Australian shrub, ARPANSA, 2014
Ooldea Guinea-flower *(Hibbertia crispula)*	0.00660*	0.00126*	0.11	0.0697*	0.0733*	0.0066*	0.00354*	Average Australian shrub, ARPANSA, 2014
Princess Parrot *(Polytelis alexandrae)*	0.00126*	0.000389*	0.0362*	0.0608*	0.0102*	0.031*	0.570*	Default ERICA values for reference "Bird"
Sandhill Dunnart *(Sminthopsis psammophila)*	0.00065	0.000136*	0.0443*	0.0374*	0.00075	0.541*	0.038*	Arid Mouse, Read J and Pickering R, 1999
Sand Goanna *(Varanus gouldii)*	2.5	0.027	0.0044*	1.2	11	0.541*	0.570*	ARPANSA, 2014

*Default ERICA values for the most appropriate RAP were used where Australian data was unavailable. No default Actinium values were available, so default suggested values for lanthanum were used in their place due to having similar chemical properties.

Using user-specific data for these species in ERICA, doses to RAPs have been calculated to the 99th percentile, shown in Table 2-6 (using the radionuclide concentrations in soil from Table 2-2).

Table 2-6: Dose rate per organism at reference location (worst case J-A operations) to March 2022

Organism	Total dose rate per organism (µGy/h)*	No effect dose threshold (µGy/h)
Red Kangaroo *(Macropus rufus)*	0.625*	10
Emu *(Dromaius novaehollandiae)*	0.072*	10
Mallefowl *(Leipoa ocellata)*	0.123	10
Grey Falcon (*Falco hypoleucos*)	0.122	10
Desert Greenhood (*Pterostylis xerophilla*)	1.45	10
Yellow Swainson-pea (*Swainsona pyrophilla*)	1.45	10
Ooldea Guinea-flower *(Hibbertia crispula)*	1.45	10
Princess Parrot *(Polytelis alexandrae)*	0.112	10
Sandhill Dunnart *(Sminthopsis psammophila)*	0.271	10
Sand Goanna *(Varanus gouldii)*	1.90*	10

*Doses have been adjusted based on home range and/or nesting habits

All doses to RAPs and user-defined species in ERICA are below the screening threshold of 10 µGy/h. The screening threshold is the threshold at which even the most sensitive NHB are unlikely to suffer any population effects as a result of chronic exposure to that dose. All doses to all species are below the screening threshold (see logarithmic graph in Figure 2-4), and the appropriate DCRLs for each species. It can therefore be concluded that there are likely no impacts due to operationally derived radiation doses to NHB due to the current operations at J-A. Doses considered are maximum doses (at the time of closure), and doses are expected to reduce over time post-closure, where mixing of topsoil will continue to occur with no additional radionuclides added to the soil as a result of operations.

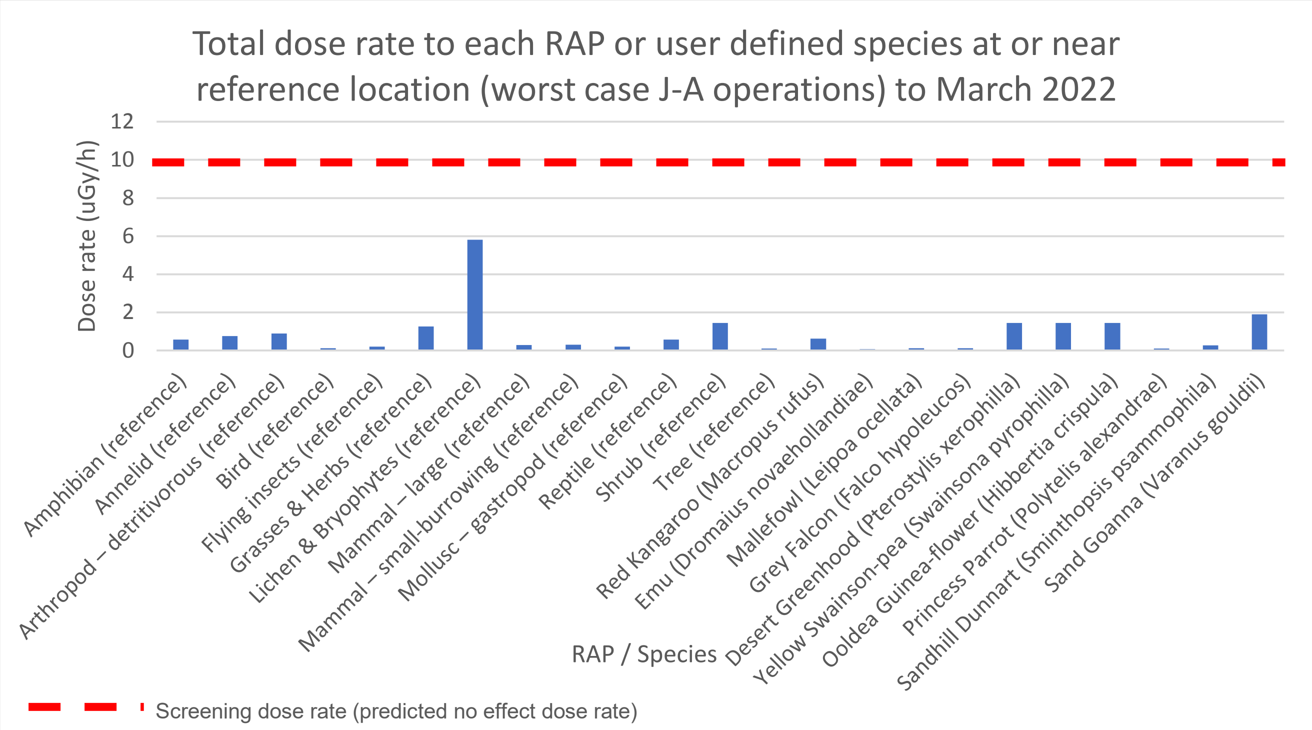

Figure 2-4: Total dose rate to each RAP or user defined species at or near reference location (worst case J-A operations) to March 2022

2.5 Cumulative radiological impacts of future operations (Atacama and J-A)

The ERICA assessment in Section 2.4 gives conservative doses to non-human biota as of March 2022 at the closest dust deposition monitoring location (worst case exposure scenario), however it does not consider the continued mining and processing of material from J-A for a further 10 year period and the addition of the Atacama Project which will include the mining of material for a 6.5 year period (i.e. 2025-2032) followed by the processing of stockpiled material for up to a further four years (i.e. 2032-2036). As such, in order to determine the potential impacts from future operations it has been assumed that these will occur over a 14 year period with similar activity concentrations in the HMC, similar throughput, and continued dust control. Atacama products are similar in terms of radionuclide concentration (however one bulk sample showed a slight increase in uranium concentration, up to 220 ppm, compared to the average concentration of 209 ppm over the previous 24 months for J-A HMC), and U and Th concentrations in ore are higher (up to 63 ppm and 31 ppm Th^{232} and U^{238} respectively based on assays). These increased concentrations (considered conservative – considering stockpiles will contain both J-A and Atacama HMC, and any windblown material will include both) have been considered for 10.5 out of the 14 years (with Atacama ore expected to be mined in 2025 concurrently with J-A to mine closure in 2032).

If we again conservatively assume that all of the material (no material is redeposited elsewhere) mixes with the top 10 mm of soil over time (consistent with dust deposition data around Mine Tailings, Stovern et. al. 2016), and assuming a soil density of 1500 kg/m^3, the total activity in the soil can be determined. The additional dust mass over the 26 years of production is expected to total 3726 g/m^2, with an average additional activity concentrations in soil of 0.064 Bq/g Th^{232} and 0.072 Bq/g U^{238} (calculated using the same methods as Section 2.4).

Assuming daughter products are in secular equilibrium, the soil concentrations (additional to baseline concentrations) applicable to ERICA are displayed in Table 2-7. It should be noted that radioactive daughter nuclides are included in the dose conversion coefficients of their parents if their half-lives are shorter than 10 days. The U^{235} decay chain is estimated based on the natural ratio of U^{238}:U^{235} of 0.9928:0.0072.

Table 2-7: Estimated increased radionuclide concentrations in soil after 26 years of operations (worst case)

Radionuclide	**Estimated activity concentrations in soil after 26 years of operations (Bq/g)**	**Increased activity concentration in soil (cumulative Atacama and J-A, baseline subtracted) (Bq/g)**	**Increased activity concentration in soil (Attributable to Atacama material, baseline subtracted) (Bq/g)**
U^{238} Decay Chain			
U^{238}	0.072	0.063	0.028
Th^{234}	0.072	0.063	0.028
U^{234}	0.072	0.063	0.028
Th^{230}	0.072	0.063	0.028
Ra^{226}	0.072	0.063	0.028
Pb^{210}	0.072	0.063	0.028
Po^{210}	0.072	0.063	0.028
U^{235} Decay Chain			
U^{235}	0.0034	0.0031	0.0013
Pa^{231}	0.0034	0.0031	0.0013
Ac^{227}	0.0034	0.0031	0.0013
Th^{227}	0.0034	0.0031	0.0013
Ra^{223}	0.0034	0.0031	0.0013
Th^{232} Decay Chain			
Th^{232}	0.064	0.050	0.015
Ra^{228}	0.064	0.050	0.015
Th^{228}	0.064	0.050	0.015

For reference, the estimated activity concentrations of 0.072 Bq/g for U^{238} and 0.064 Bq/g for Th^{232} (equivalent to approximately 5.8 ppm and 15 ppm respectively) in soil remains comparable to average soil concentrations of uranium and thorium in soils, with the worldwide average uranium concentration being approximately 3 ppm, and the worldwide average thorium concentration being approximately 9 ppm (UNSCEAR, 2000). Inputting the increased activity concentrations in soil into ERICA, yield doses to RAPs, and user defined organisms as detailed in Table 2-8. Doses are calculated to the 99th percentile.

Table 2-8: Doses to reference and user defined animals and plants after 26 years of operations (worst case)

Organism	Total dose rate per organism (J-A and Atacama derived) (µGy/h)	Total dose rate per organism (Atacama derived) (µGy/h)	No effect dose threshold (µGy/h)
Amphibian (reference)	2.73	0.75	10
Annelid (reference)	3.49	1.04	10
Arthropod – detritivorous (reference)	3.99	1.26	10
Bird (reference)	0.57	0.17	10
Flying insects (reference)	0.96	0.29	10
Grasses & Herbs (reference)	6.09	1.69	10
Lichen & Bryophytes (reference)	25.1	8.45	10
Mammal – large (reference)	1.31	0.38	10
Mammal – small-burrowing (reference)	1.40	0.40	10
Mollusc – gastropod (reference)	0.89	0.29	10
Reptile (reference)	2.74	0.75	10
Shrub (reference)	6.71	1.94	10
Tree (reference)	0.45	0.15	10
Red Kangaroo *(Macropus rufus)**	2.82	0.87	10
Emu *(Dromaius novaehollandiae)**	0.33	0.10	10
Mallefowl *(Leipoa ocellata)*	0.57	0.17	10
Grey Falcon (*Falco hypoleucos*)	0.56	0.16	10
Desert Greenhood (*Pterostylis xerophilla*)	6.68	1.93	10
Yellow Swainson-pea (*Swainsona pyrophilla*)	6.68	1.93	10
Ooldea Guinea-flower *(Hibbertia crispula)*	6.68	1.93	10
Princess Parrot *(Polytelis alexandrae)*	0.57	0.16	10
Sandhill Dunnart *(Sminthopsis psammophila)*	1.36	0.39	10
Sand Goanna *(Varanus gouldii)**	7.05	3.10	10

*Doses have been adjusted based on home range and/or nesting habits

All doses to RAPs and user-defined species in ERICA are below the screening threshold of 10 µGy/h, with the exception of Lichen and Bryophytes. The screening threshold is the threshold at which even the most sensitive NHB are unlikely to suffer any population effects as a result of chronic exposure to that dose. All doses to all species are below the screening threshold (see graph in Figure 2-5), and the appropriate and/or suggested DCRLs for each species (with the exception of lichen and bryophytes which are unlikely to be present in the area, and, acute exposure data (for mortality) suggests that they are among the least radiosensitive organisms (UNSCREAR 1996)), it can therefore be concluded that there are no population impacts due to operationally derived radiation doses to NHB due to proposed operations, including that of processing Atacama material. Dose derived from Atacama materials does not exceed the screening value of each RAP or user defined species. Doses considered are maximum doses (at the time of closure), and doses are expected to reduce over time post-closure, where mixing of topsoil will continue to occur with no additional radionuclides added to the soil as a result of operations.

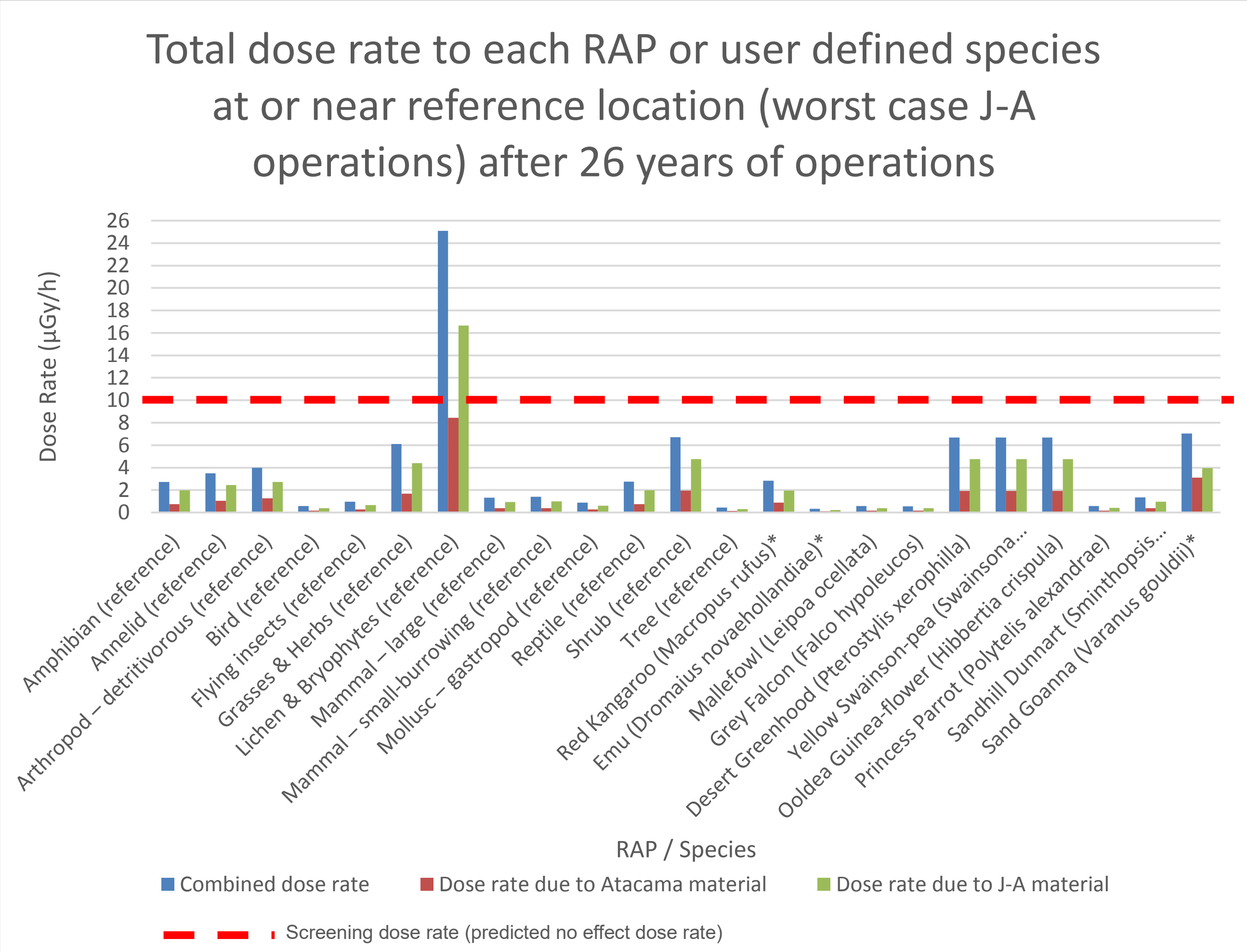

Figure 2-5: Total dose rate to each RAP or user defined species at or near reference location (worst case J-A operations) after 26 years of operations

2.6 Radiological impact at Atacama site

Deposition of radionuclides within the Atacama study area is expected to be considerably lower, even in the event that material is stockpiled prior to being trucked to the process plant (assuming similar controls to that of the J-A site are implemented regarding the stockpiling and trucking of material). The material contains considerably lower radionuclide concentrations than HMC (0.26 Bq/g Th^{232} and 0.39 Bq/g U^{238} in ore based on assays conducted by Iluka, compared to up to 1.93 Bq/g Th^{232} and up to 2.78 Bq/g U^{238} in HMC), so considerably larger quantities need to be released into the environment to give rise to doses greater than or equal to the doses that have been estimated at the J-A site. Even if we assume that dust deposition in the vicinity of stockpiling activities at Atacama is double what it is at the most affected site at J-A (23.58 g/m^2/month) for the anticipated mining life of 6.5 years, plus an additional 4 years of processing (for a total of 10.5 years), this will result in a total deposition of 2971 g/m^2. If we conservatively assume that 50% of all of the dust is attributable to Atacama ore (J-A dustablility studies suggest 44% from ore), which has approximate Uranium and Thorium concentrations of 31 ppm and 63 ppm respectively, the total deposited activity can be calculated to be 359 Bq and 239 Bq of U^{238} and Th^{232} respectively.

If we again conservatively assume that all of the material (no material is redeposited elsewhere) mixes with the top 10 mm of soil over time (consistent with dust deposition data in Australian soil (Kaste, Heimsath and Bostick, 2007)), and assuming a soil density of 1500 kg/m^3, the total activity in the soil can be determined. The activity concentrations can be determined to be 0.035 Bq/g Th^{232} and 0.046 Bq/g U^{238}, of which 0.021 Bq/g Th^{232} and 0.039 Bq/g U^{238} are above baseline values for concentrations in topsoil.

Assuming daughter products are in secular equilibrium, the soil concentrations (additional to baseline concentrations) applicable to ERICA are displayed in Table 2-9. It should be noted that radioactive daughter nuclides are included in the dose conversion coefficients of their parents if their half-lives are shorter than 10 days. The U^{235} decay chain is estimated based on the natural ratio of U^{238}:U^{235} of 0.9928:0.0072.

Table 2-9: Estimated increased radionuclide concentrations in soil within Atacama study area (after 10.5 years of operations)

Radionuclide	Estimated activity concentrations in soil after 10.5 years of operations (Bq/g)	Increased activity concentration in soil (baseline subtracted) (Bq/g)
U^{238} Decay Chain		
U^{238}	0.046	0.039
Th^{234}	0.046	0.039
U^{234}	0.046	0.039
Th^{230}	0.046	0.039
Ra^{226}	0.046	0.039
Pb^{210}	0.046	0.039
Po^{210}	0.046	0.039
U^{235} Decay Chain		
U^{235}	0.0021	0.0018
Pa^{231}	0.0021	0.0018
Ac^{227}	0.0021	0.0018
Th^{227}	0.0021	0.0018
Ra^{223}	0.0021	0.0018
Th^{232} Decay Chain		
Th^{232}	0.035	0.021
Ra^{228}	0.035	0.021
Th^{228}	0.035	0.021

For reference, the estimated activity concentrations of 0.046 Bq/g for U^{238} and 0.035 Bq/g for Th^{232} (equivalent to approximately 3.6 ppm and 8.5 ppm respectively) in soil remain comparable to the typical average soil concentrations of uranium and thorium in soils, with the worldwide average uranium concentration being approximately 3 ppm, and the worldwide average thorium concentration being approximately 9 ppm (UNSCEAR, 2000). Inputting the increased concentrations into ERICA, yield doses to the 99th percentile to RAPs, and user defined organisms as detailed in Table 2-10.

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Table 2-10: Doses to reference and user defined animals and plants within the Atacama study area (after 10.5 years of operations)

Organism	**Total dose rate per organism (µGy/h)**	**No effect dose threshold (µGy/h)**
Amphibian (reference)	1.05	10
Annelid (reference)	1.46	10
Arthropod – detritivorous (reference)	1.76	10
Bird (reference)	0.23	10
Flying insects (reference)	0.41	10
Grasses & Herbs (reference)	2.35	10
Lichen & Bryophytes (reference)	10.18	10
Mammal – large (reference)	0.53	10
Mammal – small-burrowing (reference)	0.56	10
Mollusc – gastropod (reference)	0.41	10
Reptile (reference)	1.05	10
Shrub (reference)	2.71	10
Tree (reference)	0.21	10
Red Kangaroo *(Macropus rufus)**	1.22	10
Emu *(Dromaius novaehollandiae)**	0.135	10
Mallefowl *(Leipoa ocellata)*	0.23	10
Grey Falcon (*Falco hypoleucos*)	0.23	10
Desert Greenhood (*Pterostylis xerophilla*)	2.70	10
Yellow Swainson-pea (*Swainsona pyrophilla*)	2.70	10
Ooldea Guinea-flower *(Hibbertia crispula)*	2.70	10
Princess Parrot *(Polytelis alexandrae)*	0.23	10
Sandhill Dunnart *(Sminthopsis psammophila)*	0.54	10
Sand Goanna *(Varanus gouldii)**	4.33	10

*Doses have been adjusted based on home range and/or nesting habits

All doses to RAPs and user-defined species in ERICA are below the screening threshold of 10 µGy/h, with the exception of Lichen and Bryophytes. The screening threshold is the threshold at which even the most sensitive NHB are unlikely to suffer any population effects as a result of chronic exposure to that dose. All doses to all species are below the screening threshold (see graph in Figure 2-6), and the appropriate and/or suggested DCRLs for each species (with the exception of lichen and bryophytes which are unlikely to be present in the area, and, acute exposure data (for mortality) suggests that they are among the least radiosensitive organisms (UNSCREAR 1996)), it can therefore be concluded that there are no population impacts due to operationally derived radiation doses to NHB due to proposed operations, assuming dust controls are similar to those in place at J-A if stockpiling is to occur at the location. Doses considered are maximum doses (at the time of closure), and doses are expected to reduce over time post-closure, where mixing of topsoil will continue to occur with no additional radionuclides added to the soil as a result of operations.

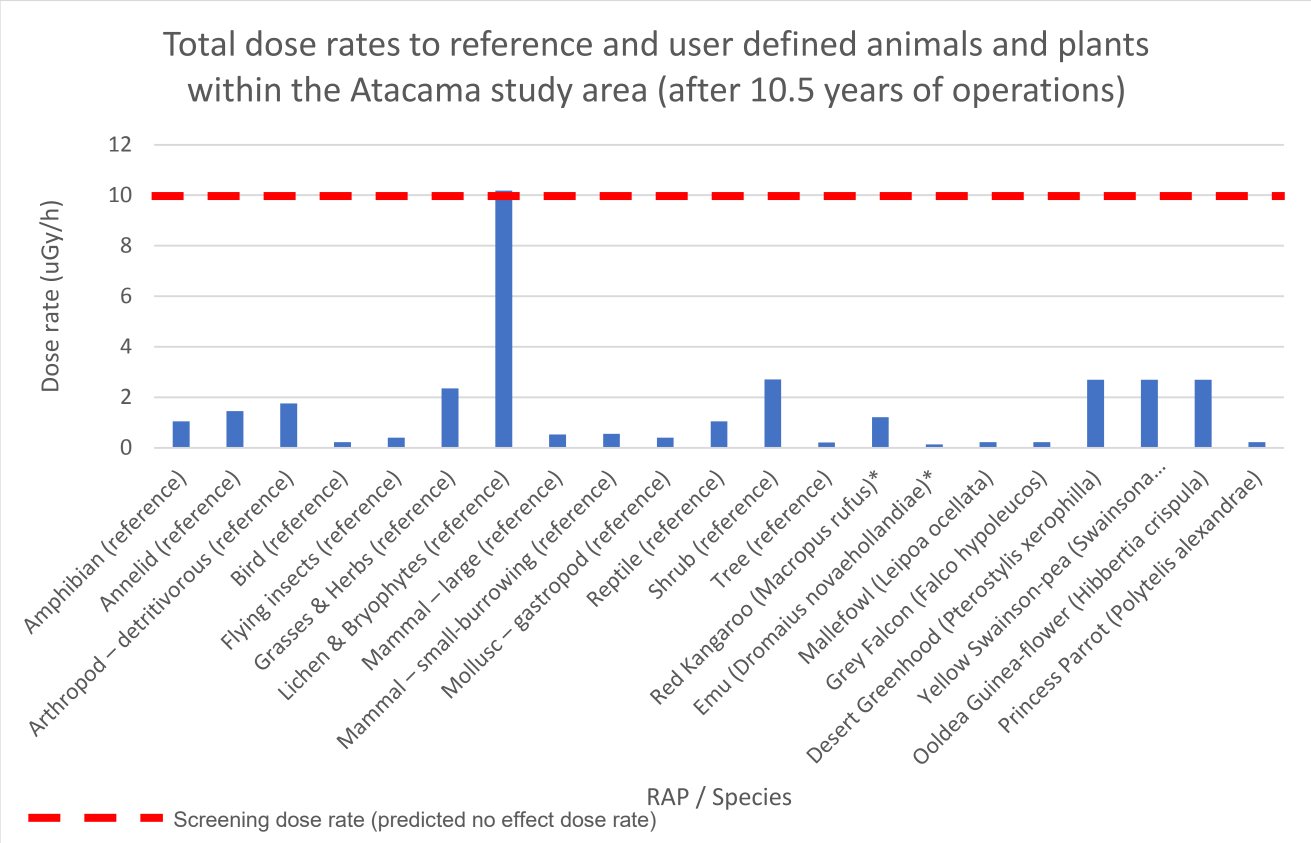

Figure 2-6: Doses to reference and user defined animals and plants within the Atacama study area (after 10.5 years of operations)

2.7 Radiological impact along HMC transport route

Deposition of radionuclides along the transport route to Port Thevenard is also likely to be much lower than sites closest to the process plant and stockpile. The highest dust deposition location along the access road (DU16) has an average dust deposition of 13.08 g/m2/month, however it has conservatively been used as a representative location.

Dust deposition monitoring was not undertaken prior to mining operations commencing, however background dust deposition was estimated to be 1.22 g/m^2/month for the area in an air quality assessment (Katestone Environmental, 2008).

The difference between this approximate baseline dust and the dust measured at the location is likely attributable to operational activities. In this case the additional dust is likely mainly derived from road dust (eg. not elevated from background due to site activities). Air quality estimates (Katestone Environmental, 2008) estimate that the emission rates for TSP derived from HMC for the site to be approximately 4%, due to management of the stockpile and loading activities. If we conservatively assume that the HMC contribution is the same along the haul road (likely to be much less than this, due to the absence of HMC handling activities and open stockpiles), we can determine the upper limit for environmental contamination (assuming TSP is a reasonable indicator for deposited dust).

If we again include the additional impact of future operations and again assume that operations will last a total of 26 years, with similar activity concentrations in HMC, similar throughput, and continued dust control, with Atacama HMC assumed to be hauled for 10.5 of the 26 years, we can determine the increased radionuclide concentrations in soil. The additional dust mass over the 26 years of production is expected to total 3748 g/m^2, with an average additional activity concentrations in soil of 0.038 Bq/g Th^{232} and 0.041 Bq/g U^{238}.

Assuming daughter products are in secular equilibrium, the soil concentrations (additional to baseline concentrations) applicable to ERICA are displayed in Table 2-11. It should be noted that radioactive daughter nuclides are included in the dose conversion coefficients of their parents if their half-lives are shorter than 10 days. The U^{235} decay chain is estimated based on the natural ratio of U^{238}:U^{235} of 0.9928:0.0072.

Table 2-11: Maximum increased radionuclide concentrations in soil along transport route

Radionuclide	Estimated activity concentrations in soil after 26 years of operations (Bq/g)	Increased activity concentration in soil (cumulative Atacama and J-A, baseline subtracted) (Bq/g)	Increased activity concentration in soil (Attributable to Atacama material, baseline subtracted) (Bq/g)
U^{238} Decay Chain			
U^{238}	0.048	0.041	0.013
Th^{234}	0.048	0.041	0.013
U^{234}	0.048	0.041	0.013
Th^{230}	0.048	0.041	0.013
Ra^{226}	0.048	0.041	0.013
Pb^{210}	0.048	0.041	0.013
Po^{210}	0.048	0.041	0.013
U^{235} Decay Chain			
U^{235}	0.0022	0.0019	0.0006
Pa^{231}	0.0022	0.0019	0.0006
Ac^{227}	0.0022	0.0019	0.0006
Th^{227}	0.0022	0.0019	0.0006
Ra^{223}	0.0022	0.0019	0.0006
Th^{232} Decay Chain			
Th^{232}	0.051	0.038	0.006
Ra^{228}	0.051	0.038	0.006
Th^{228}	0.051	0.038	0.006

Again, the estimated activity concentrations of 0.048 Bq/g for U^{238} and 0.051 Bq/g for Th^{232} (equivalent to approximately 3.6 ppm and 12 ppm respectively) in soil remain comparable to typical average soil concentrations of uranium and thorium in soils, with the worldwide average uranium concentration being approximately 3 ppm, and the worldwide average thorium concentration being approximately 9 ppm (UNSCEAR, 2000). Inputting the increased radionuclide concentrations into ERICA, yield doses to the 99th percentile to RAPs, and user defined organisms as detailed in Table 2-12.

Table 2-12: Maximum doses to reference and user defined animals and plants at reference location along transport route (after 26 years of operations)

Organism	**Total dose rate per organism (J-A and Atacama derived) (µGy/h)**	**Total dose rate per organism (Atacama derived) (µGy/h)**	**No effect dose threshold (µGy/h)**
Amphibian (reference)	1.83	0.51	10
Annelid (reference)	2.31	0.65	10
Arthropod – detritivorous (reference)	2.63	0.75	10
Bird (reference)	0.377	0.11	10
Flying insects (reference)	0.631	0.18	10
Grasses & Herbs (reference)	3.62	0.88	10
Lichen & Bryophytes (reference)	16.1	4.41	10
Mammal – large (reference)	0.87	0.25	10
Mammal – small-burrowing (reference)	0.93	0.26	10
Mollusc – gastropod (reference)	0.57	0.16	10
Reptile (reference)	1.83	0.51	10
Shrub (reference)	4.34	1.15	10
Tree (reference)	0.299	0.08	10
Red Kangaroo *(Macropus rufus)**	1.88	0.54	10
Emu *(Dromaius novaehollandiae)**	0.22	0.06	10
Mallefowl *(Leipoa ocellata)*	0.38	0.11	10
Grey Falcon (*Falco hypoleucos*)	0.37	0.11	10
Desert Greenhood (*Pterostylis xerophilla*)	4.31	1.14	10
Yellow Swainson-pea (*Swainsona pyrophilla*)	4.31	1.14	10
Ooldea Guinea-flower *(Hibbertia crispula)*	4.31	1.14	10
Princess Parrot *(Polytelis alexandrae)*	0.38	0.11	10
Sandhill Dunnart *(Sminthopsis psammophila)*	0.91	0.25	10
Sand Goanna *(Varanus gouldii)**	4.58	1.44	10

All doses to RAPs and user-defined species in ERICA are below the screening threshold of 10 µGy/h, with the exception of Lichen and Bryophytes. The screening threshold is the point at which even the most sensitive NHB are unlikely to suffer any population effects as a result of chronic exposure to that dose. All doses to all species are below the screening threshold (see graph in Figure 2-7 and the appropriate and/or suggested DCRLs for each species (with the exception of lichen and bryophytes which are unlikely to be present in the area, and, acute exposure data (for mortality) suggests that they are among the least radiosensitive organisms (UNSCREAR 1996)), it can therefore be concluded that there are no population impacts due to operationally derived radiation doses to NHB for current transport operations, and proposed transport operations including that of Atacama material, along the transport route. Doses considered are maximum doses (at the time of closure), and doses are expected to reduce over time post-closure, where mixing of topsoil will continue to occur with no additional radionuclides added to the soil as a result of operations.

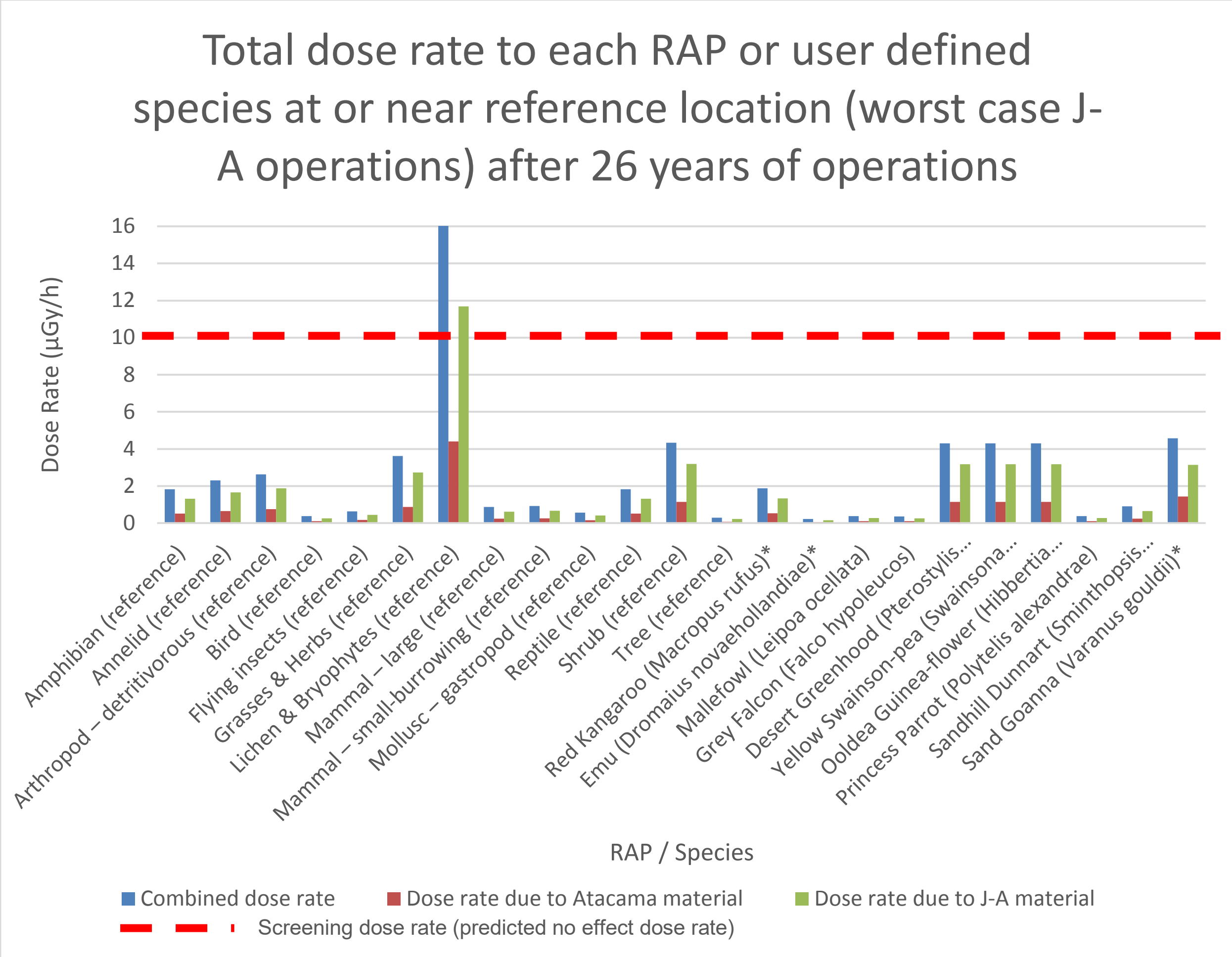

Figure 2-7: Maximum doses to reference and user defined animals and plants at reference location along transport route (after 26 years of operations)

3. HUMAN DOSES

Worker doses and member of public doses have been assessed using the RESRAD model, and are included in Appendix B. Detailed bush tucker dose assessments have also been calculated with site specific data.

3.1 Bush tucker dose assessment

An estimate of the potential dose from the ingestion of bush tucker has been made for members of the public living in the region and consuming bush tucker that has biologically accumulated radionuclides at the most impacted sites. Inhalation doses and external gamma doses to members of the public are considered negligible, as the closest community resides approximately 72km away and the only realistic exposure pathway is via ingestion of bush tucker containing radionuclides deposited from mining activities.

Ingestion doses for members of the public have been calculated based on the conservative assumption that all food consumed is sourced from the immediate area (near where the maximum radionuclide deposition has/will occur). In practice, the area is in a reserve, and it is highly unlikely that all bush tucker consumed will be from the site. If for whatever reason this were to occur, it would be unlikely that all food consumed by an individual is generated solely in the most impacted areas, so this provides a conservative estimate of ingestion doses.

The assessment method assumes that dust emissions from the proposed operation deposit in the surrounding environment and are taken up by plants and animals. Exposure to people occurs when the plants and animals are consumed. The assessment only considers the project originated radionuclides. There are three main factors to consider when making an ingestion dose assessment; food consumption rates, concentration factors into foods, and radionuclide concentrations released into the environment from the project.

Consumption rates assume a diet that consists of an intake of 155 kg/y of plant material and 125 kg/y of animal material based on the food consumption rates of traditional owners of the Maralinga lands (AAEC, 1986). These consumption estimates have been used and a factor has been applied for likely bush tucker consumption rates that will occur (based on predicted occupancy in the region). ERICA (v1.3) derived radionuclide concentrations (based on bioaccumulation in or close to the most impacted sites) given in Table 2-1 for the kangaroo and goanna have been used to estimate doses due to meat ingestion.

Table 3-1: ERICA outputs for activity concentrations in the kangaroo and the goanna (based on 26 years of operations at reference location)

Isotope	Activity concentration in organism (Bq/kg)	
	Kangaroo	Goanna
U^{238}	4.79E-04	1.57E-01
Th^{232}	6.80E-06	1.35E-03
Pb^{210}	1.39E-03	7.53E-02
Po^{210}	3.10E-02	5.70E-01
U^{234}	2.36E-05	7.75E-03
Th^{228}	6.52E-06	1.29E-03
Ra^{226}	1.82E-02	2.77E-04
Ra^{228}	1.44E-02	2.19E-04
Th^{230}	8.57E-06	1.70E-03
Th^{234}	3.82E-06	7.58E-04
Th^{227}	2.61E-06	5.19E-04
Ac^{227}	1.68E-03	2.05E-04
Ra^{223}	8.96E-04	1.36E-05
Pa^{231}	1.68E-03	2.05E-04

There is no readily available published data for Australian vegetation; however published factors are available in IAEA 2010 and the Compendium of Transfer Factors (DoE, 2003). For this assessment, the uptake factors used can be seen in Table 3-2.

Table 3-2: Elemental uptake values for vegetation

Element	Vegetation* Bq/kg (dry weight)/Bq/kg (dry soil weight)		
	Non Leafy (from IAEA 2010)	Leafy (from IAEA 2010)	Root (from DoE 2003)
Uranium	0.053	0.020	0.012
Thorium	0.0022	0.0012	0.00033
Radium	0.061	0.091	0.0020
Polonium	0.00019	0.0074	0.0070
Lead	0.015	0.080	0.0060
Protactinium	0.00036 (based on Am)	0.00047	0.00035
Actinium	0.00036 (based on Am)	0.00047	0.00035

*The concentration ratio figures are quoted as 'dry weight'. To apply the ratios to live plant matter, a factor needs to be applied which converts the dry weight to a wet weight. For this assessment it has been conservatively assumed that the wet weight is four times the dry weight. The wet weight ranges from 4 or 5 times higher for the vegetation described, so the number used is conservative.

The following assumptions have been made:

- It is assumed that locally sourced bush tucker (from the immediate area surrounding the mine) makes up 0.56% of a person's diet (therefore local vegetation is estimated to be 1.00 kg/y, and local meat ingestion is estimated to be 0.775 kg/y based on AAEC data). This estimate is based on the ratio of the combined J-A and Atacama MLs to the greater regional reserve footprint (11,540 Ha/2,012,225 Ha). For reference the closest Aboriginal community to J-A is approximately 72km away, and it is expected that bush tucker would be consumed closer to the community.
- The vegetation portion of the bush tucker consists of the same ratios of consumption rates given by Ridoutt, B et al.:
    - 21% root vegetables
    - 59% non-leafy vegetables
    - 20% leafy vegetables
- The composition of the meat portion of the bush tucker consists of:
    - 90% kangaroo
    - 10% goanna

The annual bush tucker consumption estimates for this assessment are therefore:

- 0.7 kg of kangaroo
- 0.075 kg of goanna
- 0.2 kg of root vegetables
- 0.6 kg of non-leafy vegetables
- 0.2 kg of leafy vegetables

The maximum change in radionuclide concentration in soil has been found to be 0.041 Bq/g and 0.054 Bq/g for Th^{232} and U^{238} respectively after 26 years of operation close to the J-A plant and stockpile (DU27). The intake of radionuclides is a function of the quantity of radionuclides in the soil, the quantity of radionuclides that transfer to the food, and the food intake. For example, to calculate the dose from consuming leafy vegetables containing U^{238} originating from operations, the calculations are as follows:

Assumed ingestion of leafy vegetables is 0.2 kg/y

The U^{238} concentration in soil is 0.063 Bq/g

The concentration ratio for uranium for leafy vegetables is 0.02 Bq/kg (dry weight) per Bq/kg (soil); converting to wet weight gives 0.005 Bq/kg (wet weight per Bq/kg (soil)).

Plant uranium concentration is 0.005 x 0.063, giving a U^{238} concentration of 0.003 Bq/g.

If ingestion of leafy vegetables is assumed to be 0.2 kg/y, this gives a total ingested activity of 0.06 Bq.

Ingestion of 0.06 Bq of U^{238} gives a dose of 0.456 nSv (using an ingestion dose coefficient of 7.6×10^{-9} Sv/Bq).

This calculation can be repeated for each radionuclide present for which CR data and intake-to-dose data is available (it is assumed that radionuclides are in secular equilibrium with daughter products), and doses calculated for each food type, as detailed in Table 3-3.

Table 3-3: Total maximum doses from ingestion of operationally derived radionuclides contained in bush tucker

Food	Dose (mSv/year)
Leafy Vegetables	0.0004
Non-Leafy Vegetables	0.0006
Root Vegetables	0.0001
Meat (Kangaroo)	0.018
Meat (Goanna)	0.0035
Total	**0.023**

Doses from ingestion of bush tucker across each location considered in this report are expected to be less than the doses estimated in the assessment of the most impacted site, due to the concentrations of radionuclides in plant and meat food sources being lower than that of the site with the highest radiological impact. It has conservatively been assumed that all plant and meat sources has accumulated radionuclides to the same concentration (in reality, while some kangaroos and goannas will spend time in the highest impacted sites and surrounding areas, there will be others that will spend time in the surrounding area containing much lower concentrations of operationally derived radionuclides). Doses to intake of vegetation and to lesser extent animals (including goannas and kangaroos) will be related to the increased radionuclide concentrations in soil; therefore the approximate doses at each site assessed in Section 2 can be estimated as detailed in Table 3-4.

Table 3-4: Estimates doses due to ingestion of bush tucker at each assessed site

Location/timeframe	**Estimated dose (mSv/year)**
Most radiologically impacted site (DU27) after 26 years of operations (including Atacama ore processing)	0.023
Most radiologically impacted site (DU27) due to current operations (148 months)	0.01
Estimated most radiologically impacted site at Atacama after 10.5 years of operations	0.01
Most radiologically impacted site (DU16) along transport route after 26 years of operations (including Atacama HMC transport)	0.023

When using the conservative assumption that bush tucker is consumed from the areas of highest operational impact at each site, and estimating that 0.56% of a person's diet comes from this area, total doses from ingestion are below the member of public dose limit. Realistically, doses are likely to be much lower if average radiological impact sites were to be used across the broader area (as it is unlikely that all food will be collected from the most impacted sites. Doses considered are maximum doses (at the time of closure), and doses are expected to reduce over time post-closure, where mixing of topsoil will continue to occur with no additional radionuclides added to the soil as a result of operations.

4. SUMMARY

No RAP or user defined animal or plant received a dose of above the screening dose rate of 10 µGy/h (with the exception of Lichen and Bryophytes, which are unlikely to be present, and have low radio-sensitivity), even if they were situated at the environmental monitoring location representing the greatest potential for radiological impact near J-A operation. This indicates that there are no impacts from a radiological perspective due to current approved operational activities. Likewise, estimated doses based on the combined radiological impact of future approved operational activities and the radiological impact of Atacama derived ore and product (yet to be approved) are below 10 µGy/h at the most impacted site near the J-A process plant, indicating that there are likely to be no impacts from a radiological perspective to NHB due to continued mining, processing, stockpiling and transport of HMC.

Lichen and byrophytes received the highest potential total dose rate of any RAP or user defined animal or plant, with a total dose rate (combined from internal and external sources) predicted to be 25.1 µGy/h at the conclusion of mining and processing activities, including doses that arise from Atacama material, and including up to 4 years processing following the cessation of mining (26 years in total). It is, however, unlikely that lichen and byrophyres will be present in the area. Lichen and byrophates have a CR value derived from contamination not only internal to the organism, but material deposited externally from the sample (leading to an overstated CR value, particularly for Po^{210} and Pb^{210}) (ERICA, 2021). If the CR value was taken to be accurate, lichen and byrophates are still unlikely to be effected by doses under 400 µGy/h, as they are among the least radiosensitive organisms (and therefore would likely be assigned to a DCRL band of 400-4000 µGy/h for population effects).

Dose estimates to members of the public due to bush tucker consumption dose estimates are below the member of public dose limit of 1 mSv/year (0.023 mSv/year), and comparable to the dose received from short haul domestic flights in Australia. Public doses are considered highly conservative, given that consumption of food from the local area is likely over estimated, and that it is unlikely that all food could be sourced from the areas that represent the areas of greatest radiological uptake.

The assessment has shown that the proposed operation at J-A, including that of processing and transporting Atacama ore, demonstrates population protection of NHB, and results in negligible impact to members of the public due to the collection of bush tucker.

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APPENDIX B – RESRAD ASSESSMENT

Iluka

Atacama Project

Environmental Radiation Impact Assessment
RESRAD Supplementary Report

June, 2022

Prepared by: Daniel Emes
Radiation Consulting Australia

CONTENTS

1. INTRODUCTION

1.1 Purpose of this report

The purpose of this supplementary report is to:

- Assess the potential for impacts to human health arising from the cumulative radiological impacts due to processing both the Atacama and J-A material (worst case scenario).

The approach is to use the RESidual RADioactivity (RESRAD) model for assessment of the dose or risk associated with residual radioactive material to human receptors during operations; rehabilitation; and potential final land use scenarios.

This report is a supplementary report, and should be read in conjunction to the Iluka Atacama Environmental Impact Assessment 06-06-22-v12 report (Radiation Consulting Australia, 2022).

1.2 Overview

Iluka's Jacinth-Ambrosia (J-A) mine is located approximately 280 km North West of Ceduna. The mining lease (ML) is located within the Yellabinna Regional Reserve and the Nullarbor Regional Reserve. Mining activities commenced in September 2009 with the pre-stripping of vegetation, topsoil and overburden and the commissioning of the Wet Concentrator Plant (WCP), Tailing Storage Facility (TSF), Heavy Mineral Concentrate (HMC) storage area and Mining Unit Plant (MUP). Processing of ore commenced in November 2009.

The J-A mine comprises two deposits, Jacinth in the south and Ambrosia in the north. There are other mineral sands deposits nearby including Typhoon and Sonoran (T-S) approximately 6 km and 10 km to the south-east respectively, and Atacama approximately 5 km to the north-east. A pre-feasibility study (PFS) is currently underway for the development of the Atacama deposit (referred to as the Atacama Project).

Low levels of uranium and thorium mineralisation are associated with the orebodies. The concentrations of radionuclides are highest in Atacama ore, up to 0.39 Bq/g to 0.26 Bq/g for Uranium-238 (U^{238}) and Thorium-232 (Th^{232}) respectively (based on ore sample assays). J-A ore has concentrations of approximately 0.10 Bq/g and 0.05 Bq/g for U^{238} and Th^{232} respectively. Concentrations in final product bulk samples for Atacama have been measured to be up to 2.78 Bq/g for U^{238} and 1.93 Bq/g for Th^{232}, similar to average J-A HMC concentrations measured over a 12 month period, with concentrations of 2.61 Bq/g for U^{238} and 2.42 Bq/g for Th^{232} (Iluka, 2018).

When mining and processing is carried out with materials containing uranium and thorium, there is the potential for radiological impacts to the environment to occur. It is therefore important to measure and characterise the potential dose pathways for members of the public to determine whether there are any radiological impacts, and what dose pathways may require further control.

2. RESRAD MODELLING AND ASSESSMENT

RESRAD is a family of software tools used to model and estimate radiation doses and risks from residual radioactive materials. The software was developed by the Environmental Science Division of Argonne National Laboratory under the joint sponsorship of the US Department of Energy and the US Nuclear Regulatory Commission. RESRAD is used extensively worldwide to evaluate radiologically contaminated sites, including sites in Australia.

The RESRAD code is an internationally accepted method of assessing potential radiation exposure and risk because of its adaptability to specific exposure scenarios. RESRAD has been benchmarked against other codes in the environmental assessment and site clean-up arena, and its models have been assessed for validity by the International Atomic Energy Agency (IAEA, 2004; Cheng & Yu, 1993).

The RESRAD model estimates direct exposure to external radiation from contaminated soil and internal dose from the inhalation of airborne radionuclides originating from contaminated soil including radon emissions. The model can also be used to calculate internal doses from the ingestion of contaminated vegetables and leafy greens; meat; fish; milk; drinking water; and soil. The RESRAD code has become popular because of its adaptability to specific exposure situations.

RESRAD Onsite evaluates the cancer risk to an individual present (eg. residing on, visiting, farming, working, etc.) within an area that is contaminated with radionuclides (Yu et al, 2001). The potential exposure pathways modelled within RESRAD Onsite are shown in Figure 1.

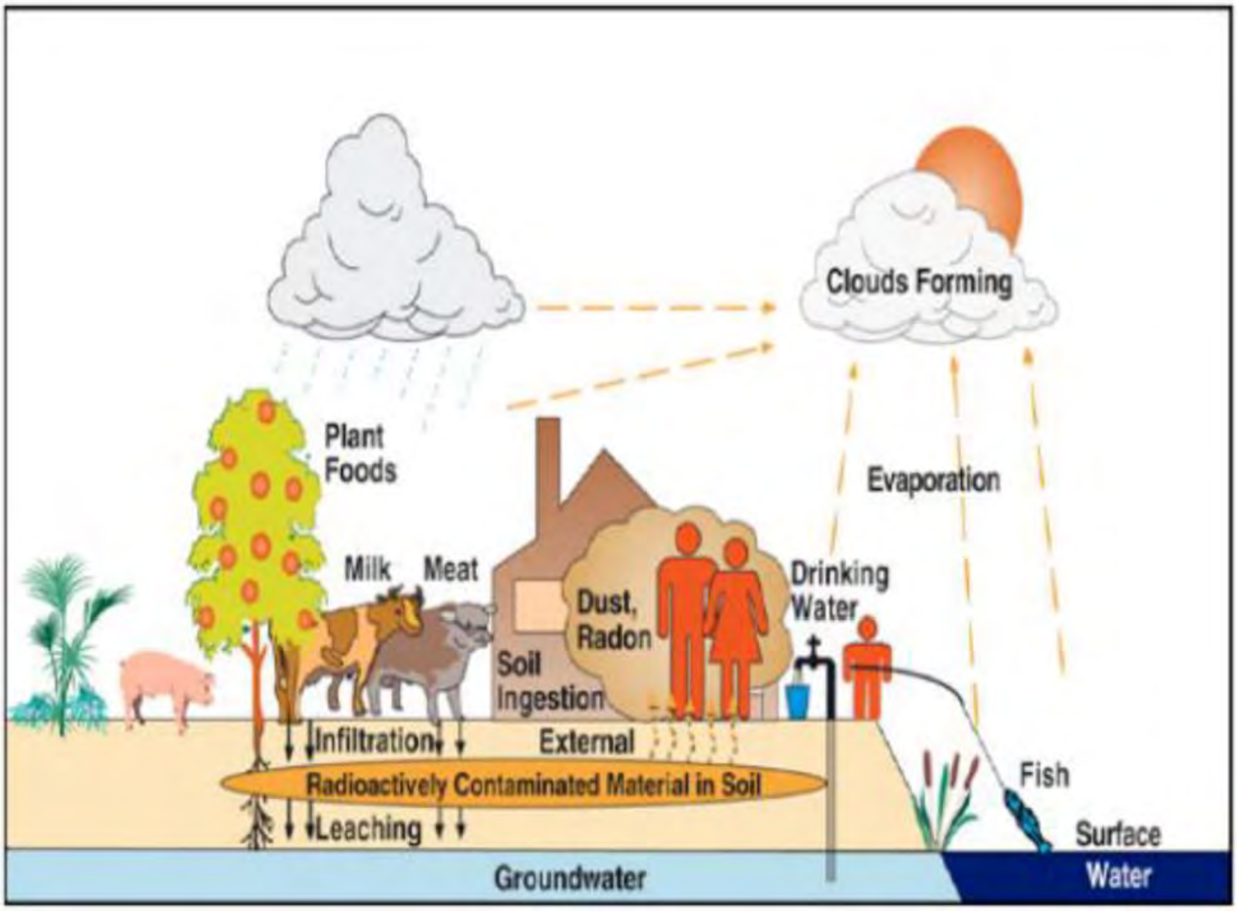

Figure 2.1: RESRAD Onsite potential exposure pathways

RESRAD onsite (version 7.2) has been used to determine worst case exposure scenarios to individuals accessing the land directly over the next 1000 years. A number of exposure scenarios have been calculated for the Atacama study area, specifically:

1. Operational phase (Atacama operations for 6.5 years, including deposition from J-A operations)
2. Rehabilitation phase (12 month worker presence for rehabilitation)
3. Post closure: residential farmer living on contaminated land

Occupancies for the different exposure scenarios vary, with the highest occupancy and greatest consumption of produce from the land at the highest potential risk (residential farmer). 95% occupancy is assigned to farmland with residence (ENhealth guidelines, 2021), which is considered highly conservative given the nature of sandy soils (poor nutrient retention, poor water retention) in the Atacama study area, which has extremely limited cropping or pasture potential.

For the operational phase of the Atacama area, it was assumed that workers spent 1000 hours external to vehicles directly on the study area (eg. half of their working hours). Likewise, during rehabilitation activities, it was conservatively assumed that workers would be spending all working hours directly on the soil in the study area.

Soil activity concentrations for each exposure scenarios were the same as concentrations calculated in order to perform ERICA assessments (Radiation Consulting Australia, 2022), outlined in Table 2.1. For the residential farmer, however, it was assumed that radionuclide mixing due to rehabilitation activities may extend to 2m (allowing for potential radon emanation to potential dwellings). Although mixing to 2m requires a 20x dilution of radionuclides in soil, in order to be conservative a 10x dilution has been modelled (to account for scenarios such as equipment that has been used to handle HMC is used to undertake rehabilitation activities without undergoing cleaning).

Table 2.1: Estimated increased radionuclide concentrations in soil after 26 years of operations (worst case)

Radionuclide	Estimated activity concentrations in soil after 26 years of operations (Bq/g)	Increased activity concentration in soil (cumulative Atacama and J-A, baseline subtracted) (Bq/g)	Increased activity concentration in soil (spread over top 2m of soil, baseline subtracted) (Bq/g)
U^{238} Decay Chain			
U^{238}	0.072	0.063	0.0063
Th^{234}	0.072	0.063	0.0063
U^{234}	0.072	0.063	0.0063
Th^{230}	0.072	0.063	0.0063
Ra^{226}	0.072	0.063	0.0063
Pb^{210}	0.072	0.063	0.0063
Po^{210}	0.072	0.063	0.0063
U^{235} Decay Chain			
U^{235}	0.0034	0.0031	0.0003
Pa^{231}	0.0034	0.0031	0.0003
Ac^{227}	0.0034	0.0031	0.0003
Th^{227}	0.0034	0.0031	0.0003
Ra^{223}	0.0034	0.0031	0.0003
Th^{232} Decay Chain			
Th^{232}	0.064	0.050	0.0050
Ra^{228}	0.064	0.050	0.0050
Th^{228}	0.064	0.050	0.0050

2.1 Pathway Selection and Occupancy

All potential exposure pathways considered in RESRAD are shown in Figure 2.2. Exposure pathways and occupancies have been selected for each occupancy scenario, and are presented in Table 2.2.

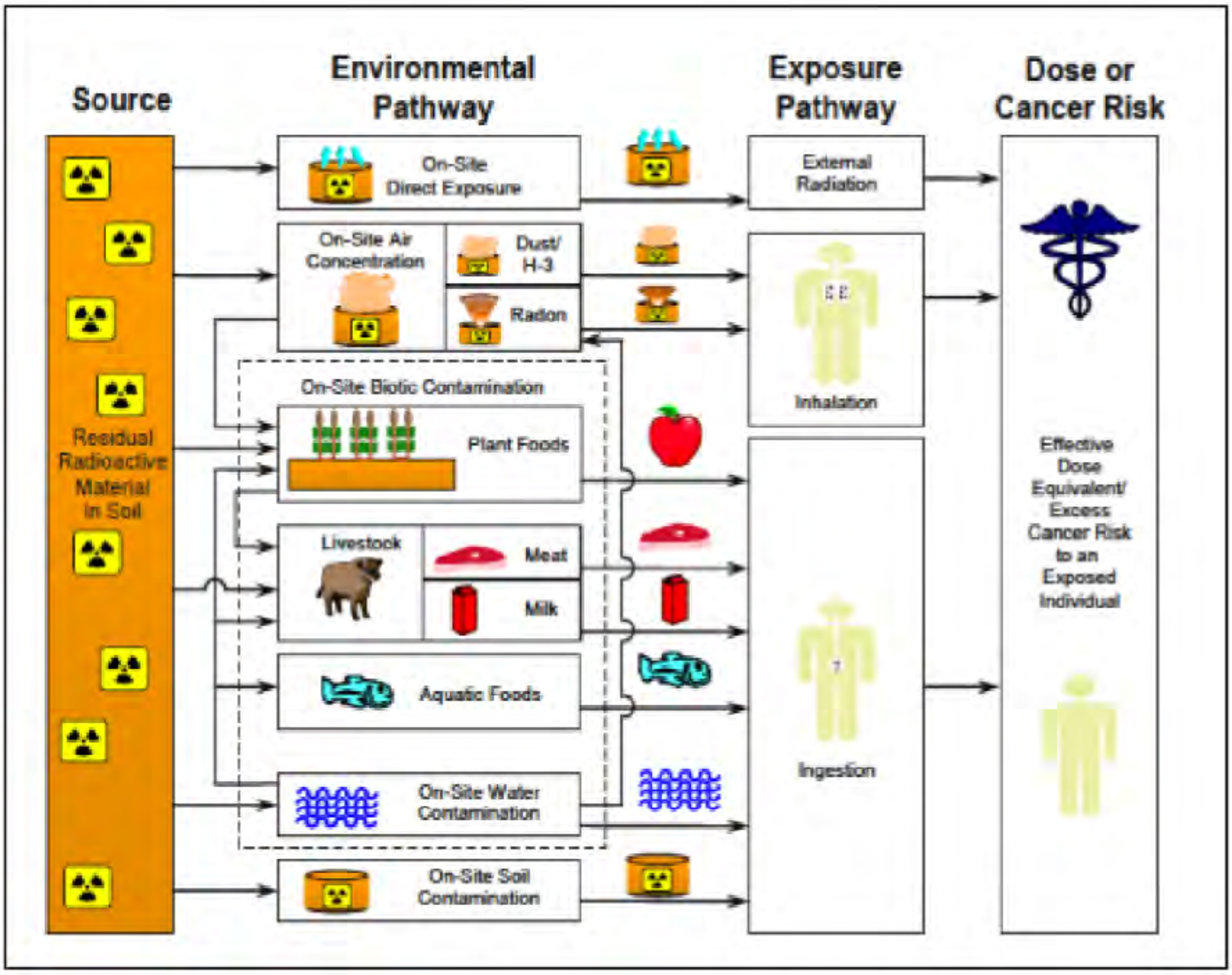

Figure 2.2: Potential exposure pathways to exposed individuals

Table 2.2: Pathways and occupancies selected for RESRAD modelling.

Pathway	Scenario 1	Scenario 2	Scenario 3
	Operations	Rehabilitation	Residential Farmer
External Gamma	✓	✓	✓
Dust Inhalation	✓	✓	✓
Plant Ingestion			✓
Meat Ingestion			✓
Milk Ingestion			✓
Aquatic Foods	Not considered relevant for Atacama (absence of surface water)		
Drinking Water	Not considered relevant for Atacama (salinity of groundwater/absence of surface water)		
Soil Ingestion	✓	✓	✓
Radon Inhalation	✓	✓	✓
Occupancy (fraction of time)	0.11 (50% of 2000 h/y) 26 years operational	0.22 (100% of 2000 h/y) 12 months of rehabilitation	0.95 (50% indoors; 45% outdoors)

2.2 RESRAD Input Data

For most input parameters, site specific data was sought. Where no site data is available, RESRAD default values have been adopted. The ERICA assessment this report supplements outlines the media concentrations used (maximum concentrations modelled for ERICA) and how they were calculated (Radiation Consulting Australia, 2022), and the overarching considerations within RESRAD are given below:

- A basic radiation dose limit of 0.3 mSv/y was adopted in line with international best practice
- Contamination zone of 0.1m for workers and rehabilitation
- Contamination zone was mixed to 2 m thick for farmers (due to mixing via rehabilitation activities, allowing deep enough to enter house under foundations)
- Average wind speed of 4 m/s (upper bound of Katestone 2008)
- Average rainfall of 174 mm/y (based on Tarcoola long-term mean)
- Zone size 21,520,000 m^2 (Atacama disturbance footprint of 2,152 ha)

2.3 Results

Results from the RESRAD model are shown in Table 2.3. Calculated doses are significantly below the relevant annual member of public dose limit, and radiation worker dose limit.

Table 2.3: RESRAD exposure results for each modelled scenario

Annual Dose Limit for Members of the Public: 1 mSv/y			
Annual Dose Limit for Workers (Occupational Limit): 20 mSv/y averaged over 5 consecutive years, with 50 mSv/y limit in any single year			
Pathway	**Scenario 1**	**Scenario 2**	**Scenario 3**
	Operations	**Rehabilitation**	**Residential Farmer**
Max Dose (mSv/y)	**0.07**	**0.06**	**0.17**
Year of max dose (y)	0	0	0
Gamma at max year (mSv/y)	0.058	0.057	0.029
Dust at max year (mSv/y)	0.0001	0.00005	0.0002
Radon at max year (mSv/y)	0.013	0	0.078
Soil at max year (mSv/y)	0.0018	0.0017	0.0011
Drinking Water at max year (mSv/y)	Not considered relevant for Atacama (absence of surface water)		
Plant Ingestion at max year (mSv/y)	N/A	N/A	0.053
Meat Ingestion at max year (mSv/y)	N/A	N/A	0.003
Milk Ingestion at max year (mSv/y)	N/A	N/A	0.003
Occupancy (fraction of time)	0.11 (50% of 2000 h/y) 26 years operational	0.22 (100% of 2000 h/y) 12 months of rehabilitation	0.95 (50% indoors; 45% outdoors)

2.4 Scenario 1 – Operational Phase

Assumptions

It was conservatively assumed that a worker would spend 50% of his/her time at work directly on the Atacama study area soil, and that the soil was at the maximum increased activity concentration that has been found at the site. No ingestion of plants or animals is assumed.

Results

Calculated doses are well below the annual radiation worker dose limits, and below the member of public dose limits.

Management

For the operational phase, doses to workers are significantly below the dose limits for radiation workers – no controls are necessary beyond good hygiene (washing hands and face before eating, drinking or smoking).

2.5 Scenario 2 – Rehabilitation Phase

Assumptions

It was conservatively assumed that a worker would spend 100% of his/her time at work directly on the Atacama study area soil, and that the soil was at the maximum increased activity concentration that has been found at the site. No ingestion of plants or animals is assumed.

Results

Calculated doses are well below the annual radiation worker dose limits, and below the member of public dose limits.

Management

For the rehabilitation phase, doses to workers are significantly below the dose limits for radiation workers – no controls are necessary beyond good hygiene (washing hands and face before eating, drinking or smoking).

2.6 Scenario 3 – Residential Farmer

Assumptions

It was assumed that a farmer would spend 95% of his/her time directly on the Atacama study area soil (50% of time in a dwelling, 45% of time on the land, and that the soil was contaminated to 2m below the soil surface due to mixing during rehabilitation phase. Ingestion of plants and animals from the study area is assumed to make up the farmer's diet. No water related pathways of exposure are assumed (minimal surface water presence, no groundwater contamination). Bush tucker assessments have been completed separately using ERICA derived plant and animal (Radiation Consulting Australia, 2022).

Results

Calculated doses are well below the member of public dose limits, and show reasonable agreement with bush tucker estimates given by ingestion of plants and animals with ERICA derived radionuclide concentrations (ingestion only). Using default input settings for the radon pathway, the total dose rate includes a significant portion from radon gas inhalation (almost 50%). It should be noted that as the RESRAD model was developed in the US, the radon dose pathway would be an over estimate for Australia in a residential scenario. Due to climatic conditions in America, houses are built to insulate against temperature fluctuations, thereby allowing radon build-up within dwellings. Further to this, a large proportion of houses in America have basements built into the underlying rock formation, thus further enhancing the build-up and containment of radon gas. Within the Australian landscape, houses are typically open and airy with good ventilation.

Management

During the institutional control period, memorial on title could be placed under the *Contaminated Sites Act 2003*, to prevent intrusion as administrative control, or alternative land uses e.g. solar farming could be considered. In the event that institutional control is lost (eg. records relating from the site are lost or destroyed), the doses are not significant, and are comparable to the dose received from short haul domestic flights in Australia. Doses are highest from year 0 in modelling (the year immediately after remediation has been completed), and decrease over time, so the longer access is restricted to potential land use, the lower the doses will be.

4. SUMMARY

Dose estimates to workers are well below the radiation dose limits to radiation workers (20 mSv/year, averaged over 5 years), and the dose limits to members of the public (1 mSv/year). Likewise, dose estimates to potential residential farmers are well below the dose limits to members of the public.

Dose estimates to members of the public due to the worst case post closure scenario are below the member of public dose limit of 1 mSv/year (0.17 mSv/year), and comparable to the dose received from a handful of short haul domestic flights in Australia. Public doses are considered highly conservative, given that consumption of food from the local area is likely over estimated, given that it is unlikely that all food could be sourced from the areas that represent the areas of greatest radiological uptake.

The assessment has shown that the current and proposed operations at J-A, including proposed plans to mine, process and transport Atacama ore, and undergo rehabilitation, will result in negligible impact to workers and to members of the public.

APPENDIX B - REFERENCES

Cheng, JJ,, Yu, C., 1993. Using the RESRAD Computer Code to Evaluate Human Health Risks from Radionuclides and Hazardous Chemicals

IAEA, 2004, Safety Assessment Methodologies for Near Surface Disposal Facilities, IAEA Vienna

Iluka, 2018, Radiation and Radioactive Waste Management Plan, Jacinth Ambrosia and Port Thevenard Operations

Iluka, 2018, Jacinth Ambrosia and Port Thevenard Storage Facility Annual Radiation Monitoring Report

Katestone Environmental, 2008, Air quality assessment of a proposed mineral sands mine and electricity generators – Jacinth Ambrosia Project

Radiation Consulting Australia, 2022, Iluka Atacama Environmental Radiation Impact Assessment

Yu et al., 2001, User's Manual for RESRAD Version 6

Environmental element	Project phase	Impact ID	Type of impact	Area	Potential impact event	Source	Pathway	Receptor	Uncertainties and assumptions	Sensitivity to change (in assumptions)	S-P-R linkage?	Justification for the confirmation/ non-confirmation of an SPR linkage	Control measures and management strategies	Uncertainties and assumptions2	Sensitivity to change (in assumptions)2	Proposed outcome	Draft outcome measurement criteria	Draft leading indicator
Heritage (Aboriginal, European, and geological)	C,O,CL	H1	New	Atacama ML	Unauthorised access to Aboriginal heritage sites, objects and/ or remains by mining personnel	Site Personnel	Unauthorised access, damage	Aboriginal heritage Item(s)	Minimal site-specific data is available at the time of writing. High reliance on exploration and desktop studies, for this S-P-R, that may not accurately reflect site conditions. Low level of confidence in the impact assessment (due to use of desktop and exploration-based data) and high uncertainty around impacts to Aboriginal Heritage Items Aboriginal Cultural Heritage heritage survey to be conducted with the FWCAC in early 2023. Unrecorded Aboriginal heritage items may be found during this survey.	High	Uncertain	S-P-R is not confirmed. No identified restricted areas have as yet been identified. Currently locations and potential impacts of Project related activities of Aboriginal Items within the Project Area are unknown (IHC,2020).	**Control** No – go areas clearly marked in consultation with Traditional Owners. **Design** A clearance survey is to be undertaken across the proposed ML with the FWCAC and a heritage consultant for Aboriginal heritage. **Management** Induction to include the requirements of the Aboriginal Heritage Act 1988 and the importance of maintaining no-go areas. Workforce cultural awareness training. A Cultural Heritage Management Plan will be developed and implemented and will include: •discovery protocol for potential heritage items •notification protocols •general information about the Aboriginal heritage exclusion areas (within confidentially requirements)	N/A	N/A	The tenement holder must during construction, operation and closure ensure there is no damage, disturbance, or interference to Aboriginal heritage items, objects and/or remains as a result of the Project activities, unless it is authorised under relevant legislation.	**Construction and operation** No unapproved disturbance to Aboriginal heritage sites, objects and/or remains. Mine records demonstrate that if an Aboriginal site, object or remain was discovered/ disturbed during operations, works ceased and the native title claimants and the Aboriginal Affairs and Reconciliation Division were notified. Works re-commenced only after notification and consultation over the appropriate actions. Compliance with agreed disturbance and heritage protection requirements, as defined in the Aboriginal Heritage Act 1988, and as agreed with the FWCAC. **Closure** All Aboriginal heritage sites are restored as agreed to with FWCAC	None proposed
Heritage (Aboriginal, European, and geological)	C,O,CL	H2	New	Atacama ML	Damage or disturbance to previously unrecorded Aboriginal heritage sites, object or remains.	Site Personnel Machinery	Excavations and earthworks- manual and machinery for the following activities: •vegetation clearance •removal of overburden •drill and blast operations •establishment of site infrastructure – buildings •road constructions •deposition of stockpiles	Aboriginal heritage Item(s)	Minimal site-specific data is available at the time of writing. High reliance on exploration and desktop studies, for this S-P-R, that may not accurately reflect site conditions. Low level of confidence in the impact assessment (due to use of desktop and exploration-based data) and high uncertainty around impacts to Aboriginal Heritage Items Aboriginal Cultural Heritage survey to be conducted with the FWCAC in early 2023. Unrecorded Aboriginal heritage items may be found during this survey.	High	Uncertain	S-P-R is not confirmed. Currently locations and potential impacts of activities associated with the Project on Aboriginal Items within the Project Area are unknown.	As above for H1	As above for H1	As above for H1	As above for H1	As above for H1	As above for H1
Heritage (Aboriginal, European, and geological)	C,O,CL	H3	New	Atacama ML	Access by mining personnel to unknown European heritage places and objects	Site Personnel	Unauthorised access, damage	European heritage Item(s)	No site-specific data available. Reliance on desktop studies and database searches. High uncertainty, with low confidence in impact uncertainty around impacts to European heritage Items. No known heritage items within the Project Area.	Medium	Uncertain	The closest known European Heritage site to the Project Area is located in Ooldea, approximately 28 km to the northwest of the Project. Historic heritage survey has not been undertaken and therefore there remains the possibility that European heritage may exist in the Project Area and unauthorised damage may occur. Any European heritage remaining in the region or Project Area is likely to be of significance, as defined by the Heritage Places Act 1993 and tied to themes of exploration and early movement across Australia (G. Cincunegui, personal communication, 1 February 2023). S-P-R is not confirmed. Possible receptors not identified in the Project Area at this stage, but remain possible. Impacts may range from minimal to major depending on access.	**Control** No – go areas clearly marked. **Design** A clearance survey is to be undertaken across the proposed ML with a heritage consultant (for European heritage). Based on observations during the Aboriginal heritage survey the need for a targeted European survey can be assessed near key areas (such as water courses) by a Heritage Consultant. Any remaining areas not surveyed can be managed seeing a site discovery processes to be included within the Cultural Heritage Management Plan. **Management** Induction to include the requirements of the Heritage Places Act 1993 and the importance of maintaining no-go areas. A Cultural Heritage Management Plan will be developed and implemented and will include: •Discovery protocol for potential heritage items •Notification protocols •General information about the European heritage exclusion zones (within confidentially requirements).	N/A	N/A	The tenement holder must during construction, operation and closure ensure there is no damage, disturbance, or interference to European heritage objects and/or places as a result of the Project activities, unless it is authorised under relevant legislation.	**Construction and operation** No unapproved disturbance to European objects and/or places. Mine records demonstrate that if a European object or places is discovered/ disturbed during operations, works ceased and a European Heritage Consultant was engaged to assess significance and advice of future actions and requirements to meet the Heritage Places Act 1993. Compliance with agreed disturbance and heritage protection requirements, as defined in the Heritage Places Act 1993. **Closure** If applicable all European heritage objects to be returned to their original position or relocated and managed in accordance with the relevant approval.	None proposed
Heritage (Aboriginal, European, and geological)	C,O,CL	H4	New	Atacama ML	Damage or disturbance to excavations to previously unrecorded European heritage places and objects	Site Personnel Machinery	Excavations and earthworks- manual and machinery for the following activities: •Vegetation clearance •Removal of overburden •Drill and blast operations •Establishment of site infrastructure – buildings •Road constructions Deposition of stockpiles	European heritage Item(s)	No site-specific data available. Reliance on desktop studies and database searches. High uncertainty, with low confidence in impact uncertainty around impacts to European heritage items No known heritage items within the Project Area.	Medium	Uncertain	As above for H3.	As above for H3	As above for H3	As above for H3	As above for H3	As above for H3	As above for H3
Heritage (Aboriginal, European, and geological)	C,O,CL	H5	New	Atacama ML	Heavy machinery use and blasting resulting in vibration impact to geological heritage.	Machinery and blasting	Vibrations	Geological heritage Item(s)	Assumes that vibrations will be minimal at the identified geological heritage Items, with the closest identified geological heritage Item approximately 190 km away. Blasting is not currently likely to occur within the scope of Project operations.	Low	No	The closest identified geological heritage item is approximately 190 km from the Project Area. Based on the nature of the operations blasting activities are not usually employed. In the event that blasting is required, it is likely to be occasional and with vibrations unlikely to reach the offsite heritage item. S-P-R not confirmed.						
Flora, fauna, and native vegetation	C,O,CL	FFNV1	New	Atacama ML	Habitat loss and direct loss of flora. Land clearance for construction of project infrastructure and/or rehabilitation causes a reduction of abundance and diversity of native flora.	Vegetation clearance	Land - Mechanical and earthmoving equipment / loss of habitat	Native vegetation	Plant growth response to edge effects / reconstructed topsoil profiles, Seed bank response to disturbance and stockpiling.	Low	Yes	To enable the construction of the Project approximately 2,057 ha of native vegetation is proposed to be cleared within the Project Area. The clearing of vegetation will result in a reduction in the availability of suitable habitat for flora species which are known or likely to occur within the Project area. The habitat within the Conceptual Footprint is in good condition and is used by a variety of species as detailed in the baseline (Section 3). All vegetation types (and hence habitat types) within the Project Area are found in abundance within the surrounding area, either within the Yellabinna Regional Reserve, or the Nullarbor Regional Reserve. A side effect of habitat loss is habitat fragmentation. The proposed mining operations consist of open-cut pits (largest being approximately 5,800 m long, 470 m wide) within the linear dune system. This size is likely to cause a local scale barrier effect with associated fragmentation. Flora and some fauna species which are found within arid and semi-arid ecosystems have evolved to traverse or disperse over large distances, and fragmented distribution is common. The scale of habitat fragmentation associated with the proposed mining operations is unlikely to result in a local extinction or decrease in population size of species with large home ranges. Habitat fragmentation can also result in an increase of ratio of the 'edge' of a habitat. The 'edge effect' associated with vegetation clearing and site disturbance can lead to increased opportunities for weeds and pest species to invade a native vegetation community, as well as changes to habitat such as increased light and wind which may affect the native flora assemblages. This may result in a decrease of abundance and/ or diversity of native non-threatened flora and threatened flora species. An S-P-R linkage is therefore confirmed.	**Design** All vegetation clearance restricted to approved footprint. Undertake a Landscape Function Analysis. **Control** Progressive rehabilitation of disturbed area, commencing as soon as practical Comparison of annual aerial photography to ensure vegetation clearance is within approved limits. Use of ground disturbance permit system. Restricting access to undisturbed areas not required during operations. **Management** Implementation of a Native Vegetation Management Plan. Implementation of a Rehabilitation Management Plan. Provision of a SEB.	Plant growth response to reconstructed soil profiles. Soil seed bank response to disturbance and stockpiling. Change in vegetation communities due to changed final landform. Ability to regenerate key species (e.g. Spinifex).	Low	The Tenement Holder must ensure that all clearance of native vegetation is authorised under appropriate legislation. The Tenement Holder must ensure that the post mining ecosystem and landscape function is resilient, self-sustaining and indicating that the pre-mining ecosystem and landscape function will ultimately be achieved.	**Construction and operation** Annual GIS comparison of approved clearance boundary and actual clearance boundary to show all vegetation is within authorised clearance boundaries (annual SEB reconciliation report). Annual vegetation health survey to be undertaken to measure: •plant mortality •new growth •evidence of flowering and fruiting •extent of smothering •evidence of saline stress. **Closure** Landscape Function Analysis (over a minimum of five years after the completion of rehabilitation) to show rehabilitated areas are trending towards pre-disturbance landscape function based on comparison with control site. The following will be collected: •Soil cover •basal cover of vegetation •litter cover •BSC •crust entirety •erosion type and severity •deposited materials •surface roughness •surface resistance to disturbance •slake testing •soil texture •vegetation diversity and abundance.	None proposed
Flora, fauna, and native vegetation	C,O	FFNV2	New	Atacama ML	Direct Loss – fauna Use of machinery and vehicles during construction of project infrastructure, transport of mineral extracts and personnel during mining activity, and during rehabilitation works causes direct impacts to native fauna. Fauna mortality through accidental capture in trenches or fencing required through construction and operation.	Mining operations Rehabilitation Moving vehicles / open trenches / fences	Land – mechanical and earthmoving equipment Accidental capture of, or vehicle strike of fauna.	Fauna	Sensitivity and aversion to disturbance of fauna species varies.	Low	Yes	Throughout the mine life there will be an increase of human activity and the use of vehicles and machinery. During the construction and vegetation clearance stage individual animals have the potential to be injured or killed through interactions with machinery. Fauna species which are at the greatest risk during this stage are species which burrow into the soil, nest amongst shrubs/ grasses, and are slow moving. The transportation of personnel between J-A site and Atacama also increases the potential for vehicle strike of fauna. During the night when visibility is at the lowest there is an increased risk of collision as many arid species forage during the cooler hours. There may be an increase in fauna interactions with infrastructure such as fence entanglements, and individuals falling into trenches. An S-P-R linkage is therefore confirmed.	**Control** Personnel forbidden from feeding or harassing wildlife. Fauna caution signage on haul road. Speed limits on roads used for Project activities. **Management** Implementation of a Fauna Management Plan. Maintenance of a fauna sightings and deaths register. Fauna handling and euthanasia procedures.	Sensitivity and aversion to disturbance of fauna species varies	Low	The Tenement Holder must ensure that there are no net adverse impacts from site operations on native fauna abundance or diversity within the lease are and adjacent areas.	**Construction and operation** Opportunistic visual observations and incident investigation (report stored in Iluka Incident Management System) demonstrates that the Mine Operator did not cause or could not have reasonably prevented fauna deaths or injuries from occurring. A review of mine records demonstrates that where an animal was found to be sick or injured as a result of mining operations Iluka complied with the Animal Welfare Act 1985.N	**Construction and operation** Quarterly review of the incident register for the management of sick or injured fauna, including the identification of any procedural changes required.
Flora, fauna, and native vegetation	C,O,CL	FFNV3	New	Atacama ML	Habitat Loss – fauna Land clearance for construction of project infrastructure and/ or rehabilitation causes a loss of habitat and reduction of abundance and diversity of native fauna.	Mine footprint areas requiring clearance	Land – mechanical and earthmoving equipment / loss of habitat.	Fauna	Species may move to and from disturbance area during fluctuations in environmental conditions.	Low	Yes	As per FFNV1	As per FFNV1	Fluctuation in population of mobile fauna species in response to temporal influences	Low	The Tenement Holder must ensure that there are no net adverse impacts from site operations on native fauna abundance or diversity within the lease are and adjacent areas.	**Construction and operation** As per FFNV1 Biennial Fauna survey of the diversity and abundance of native fauna species in project (impact) areas and control sites **Closure** As per FFNV1.	**Construction and operation** Quarterly review of the incident register for the occurrence of injured or deceased fauna, including the identification of any procedural changes required.
Flora, fauna, and native vegetation	C,O,CL	FFNV4	New	Atacama ML	Weeds The Project increases weed density, causing a reduction in the abundance and diversity of native flora and hence impacting native fauna indirectly.	Existing weeds within or external to Project	Introduced from offsite via contaminated soil or direct movement.	Native flora, fauna and vegetation	Surrounding area is largely a reserve assessed to be in high condition. Species, extent and density of weeds in surrounding areas is relatively unknown (due to limited surveys over the large area) and subject to change.	Low	Yes	The disturbance of land through throughout the LOM creates habitats that are favourable for weed species to become established and grow. Weeds can lead to a decrease in the habitat quality and out-compete native species. There are a variety of different distribution vectors for weeds, including: •wind •vehicles and earthmoving equipment •animals (native and introduced) •surface water flows. Weeds have the potential to degrade or replace native vegetation which results in loss of habitat for native fauna and flora species. Three introduced flora species have been observed within the Project Area: Rosy Dock, Wild turnip and Ward's weed. Each was present in low densities, including Wild Turnip which although found often, was recorded as sparse in each location. These species are not listed as Weeds of National Significance or Priority weeds under the Landscape SA Act for the Alinytjara Wilurara Landscape Management Region. Buffel Grass has been recorded in low density at J-A and is the subject of monitoring and treatment in conjunction with Landscape SA. The most likely mechanism for weeds to be transported is via vehicles and equipment moving into the Project Area. If not controlled, it is likely there will be an increase in diversity or abundance of weeds within the new ML. Appendix C3 shows the weeds which have been recorded at the J-A mine and/ or within the Reserve and therefore have a potential for spread and establishment within the Project Area. An S-P-R linkage is therefore confirmed.	**Design** Minimisation of disturbance areas. **Control** Ensure road building material is not brought in from an area where weeds may be present. Implementation of vehicle and equipment hygiene / wash down procedure. Inspect and if identified, treat weeds ahead of vegetation clearance to prevent transfer of pest plants to stockpiles. **Management** Regularly monitor disturbance areas for presence of weeds. Reporting of weed sightings via internal reporting system and reporting requirements highlighted in site induction program. Implement targeted weed management of observed significant increases in distribution or abundance or presence of new weed. Implementation of Pest Species Management Plan.	Intensity of weed management in the greater Yellabinna Reserve area (outside of the tenement boundaries). Weed introduction via uncontrolled public vehicles using haul road (public access area)	Moderate	The Tenement Holder must ensure there is no introduction of new weeds or plant pathogens nor an increase in abundance of existing weed or pest animal species in the lease area and adjacent areas caused by mining operations.	**Construction and operations** Annual weed survey to measure the diversity and abundance of weed species. Monthly field monitoring for the presence of weed species in disturbance areas (including soil stockpiles, road edges and mining infrastructure) to demonstrate no introduction of new weeds of plant pathogens nor an increase in abundance due to mining operations. Opportunistic visual observations of weed species demonstrates no introduction of new weeds or plant pathogens. **Closure** Following completion of active rehabilitation, and annually for a minimum of five years, a weed survey demonstrates that weed species diversity and abundance at closure is consistent with control sites.	**Construction and operation** Annual review of the weed survey and weed management register (comprising results of field monitoring and visual observations) considering trends that could indicate population increase or introduction of new weed species
Flora, fauna, and native vegetation	C,O,CL	FFNV5	New	Atacama ML	Pests - Fauna Direct impacts on fauna through predation by carnivorous pest species and indirect impact through changes in habitat.	Mining operations Rehabilitation	Pest animals attracted to waste materials and increased activity.	Native fauna	Monitoring has confirmed the presence of cats, foxes and rabbits. Species, extent and density of weeds in surrounding areas is relatively unknown (due to limited surveys over the large area) and subject to change.	Low	Yes	The introduction of fauna pest species can result in the decline of some species through predation or competition. Small mammals, reptiles and ground-nesting birds are particularly at risk from predator pests such as foxes and cats. Other vertebrate pests can impact both native fauna and flora (e.g., rabbits) through resource competition, weed spread, over-grazing of flora species and habitat degradation. Pest species have been recorded within the Project Area. The introduction of the European rabbit inflicts damage on a variety of ecological assets, native flora and fauna, vegetation communities, and landforms. Due to the rabbit's high reproductive rates and ability to survive in a variety of habitats they become established in areas rapidly (CoA, 2016). The Domestic cat is a threat to native fauna through predation and competition and disease transmission. Cats in Australia have contributed to the extinction of many small to medium-sized mammals and ground nesting birds in the arid zone previously (CoA, 2015). The European fox is another introduced predator which poses a major threat to many native Australia animals. They are listed on the Worlds Conservation Union's list of the 100 worst invasive species (DEWHA, 2008). Due to their rapid reproduction rate and high survival rate of cubs they colonise areas rapidly within a short period of time. The cat and fox have potential to decrease species populations significantly within the Project Area through increased predation. There is an increased risk of this occurring from the construction to operation phase due to human activity. Areas which have undergone vegetation clearance are known to attract predators as it exposes prey when they are traversing open areas. They have also been observed roaming along roads which provide them with easy access corridors. Activities that may result in the increase in pest fauna include unmanaged waste collection areas, increase in roadkill, increase in human activity and accidental transport with machinery, equipment or supplies. These pest species are known to be established in the area and no new species have been recorded as being introduced to the area since the inception of the J-A mine's fauna monitoring program. An S-P-R linkage is therefore confirmed.	**Design** Waste storage infrastructure is designed and maintained to prevent access by pest animal species Ensure all waste and food storage containers are adequately sealed **Control** Domestic animals prohibited on-site Prohibit feeding of wildlife Reporting of pest plant sightings via internal reporting system and reporting requirements highlighted in site induction program **Management** Implementation of Pest Species Management Plan Implement targeted pest species management for observed significant increases in distribution or abundance or presence of new pest species. Methods will be those used at J-A and align with regional practises.	Intensity of pest animal management in the greater Yellabinna Reserve area (outside of the tenement boundaries)	Low	The Tenement Holder must ensure there is no introduction of new weeds or plant pathogens nor an increase in abundance of existing weed or pest animal species in the lease area and adjacent areas caused by mining operations.	**Construction and operation** Biennial fauna survey demonstrates that there is no significant increase in abundance of pest animal species in the lease and adjacent areas. Monthly field monitoring of the presence of pest animal species including warrens and tracks in disturbance areas (including soil stockpiles, road edges and mining infrastructure) to demonstrate no increase in abundance and diversity due to mining operations. Opportunistic field observations for the presence of pest animal species demonstrates no increase in abundance in the lease area and adjacent **areas.** **Closure** Following completion of active rehabilitation, and annually for a minimum of five years, a fauna survey demonstrates pest animal abundance at closure to be consistent with control sites.	**Construction and operation** Annual review of register of pest animal sightings considering trends that could indicate population increase.
Flora, fauna, and native vegetation	C,O,CL	FFNV6	New	Atacama ML	Pests - Fauna Altered landscapes allow for migration of herbivore pest species which may consume native flora reducing the abundance and diversity of native flora species.	Mining operations Rehabilitation	Land – pest animals attracted to waste materials and increased activity.	Native flora and vegetation	Monitoring has confirmed the Presence of cats, foxes and rabbits. Species, extent and density of weeds in surrounding areas is relatively unknown (due to limited surveys over the large area) and subject to change.	Low	Yes	See above Project-related activities could result in an increase in abundance and/ or diversity of pest species in the area. These pest species would impact on a range of flora species (including listed species) due to increased grazing pressure. An S-P-R linkage is therefore confirmed.	As per FFNV5	As per FFNV5	Low	The Tenement Holder must ensure there is no introduction of new weeds or plant pathogens nor an increase in abundance of existing weed or pest animal species in the lease area and adjacent areas caused by mining operations.	As per FFNV5	As per FFNV5
Flora, fauna, and native vegetation	C,O,CL	FFNV7	New	Atacama ML	Pathogens Human activity and/or increased pest species introduce pathogens or diseases leading to a reduction in the abundance and diversity of native flora and/or native fauna.	Mine operations Workforce	Vehicles, people movements and machinery	Fauna	The prevalence of pathogens in the surrounding areas (i.e., outside of J-A and the Project Area) is unknown. No records of pathogens during Project surveys.	Low	Uncertain	Pathogens are biological agents which can cause disease or illness to the host, including reducing their ability to reproduce. Within South Australia three species (Mundulla Yellow, Austropuccinia psidii (Myrtle rust) and Phytophthora cinnamomi (Phythophora) are known to have the potential to impact native flora. However, there was no evidence of plant pathogens in the Project Area during field investigations at J-A or Atacama and the Project Area is not located in a high-risk Phytophthora cinnamomi (root-rot fungus), or Mundulla Yellows area due to the low average annual rainfall of 180 mm/ year (root-rot fungus occurs in areas where average annual rainfall is greater than 400 mm) and minimal human disturbance. Given the suboptimal conditions for pathogens, and the lack of records in the surrounding area, the source for this potential impact is uncertain, and hence the S-P-R linkage is uncertain.	**Management** Implementation of Pest and Weed Management Plan.	Presence of pathogens in the greater Yellabinna Reserve area is unknown.	Low	The Tenement Holder must ensure there is no introduction of new weeds or plant pathogens nor an increase in abundance of existing weed or pest animal species in the lease area and adjacent areas caused by mining operations.	As per FFNV4	As per FFNV4
Flora, fauna, and native vegetation	C,O,CL	FFNV8	New	Atacama ML	Toxins/poison The use of toxins as a method of pest control results in a reduction in the abundance and diversity of native flora and/or native fauna.	Hazardous Materials	Direct contact or indirect contact (bio-accumulation)	Flora and Fauna	Likely ingestion by and bioaccumulation in fauna species is unknown.	Low	Yes	Weed spraying has the potential to kill native flora species within the area. It may also secondarily poison native herbivores and lead to soil contamination. If soil contamination does occur, it can have localised impacts to the affected area. The impact of toxins / poisons on most native flora and fauna species is unknown.	**Control** Regular checks of baiting stations.	N/A	Low	The Tenement Holder must ensure that there are no net adverse impacts from site operations on native fauna abundance or diversity within the lease are and adjacent areas.	As per FFNV2	As per FFNV2

Environmental element	Project phase	Impact ID	Type of impact	Area	Potential impact event	Source	Pathway	Receptor	Uncertainties and assumptions	Sensitivity to change (in assumptions)	S-P-R linkage?	Justification for the confirmation/ non-confirmation of an SPR linkage	Control measures and management strategies	Uncertainties and assumptions2	Sensitivity to change (in assumptions)2	Proposed outcome	Draft outcome measurement criteria	Draft leading indicator
Flora, fauna, and native vegetation	C,O	FFNV9	New	Atacama ML	Project related ignition sources result in accidental fires and in a reduction in the abundance and diversity of native flora and/or native fauna. Project construction results in changed fire regime leading to a reduction in the abundance and diversity of native flora and/or native fauna.	Fire ignition sources Unplanned Events	Land - Vegetation Other flammable items on the mine site that could act as fuel	Native Vegetation Fauna Flora	Link between fire and persistence of some species is unknown or not well documented. Presence of fauna species known to be significantly affected by fire frequency (such as Malleefowl).	Low	Yes	Increased human activity into an area can cause change in the natural fire regime. It may decrease the frequency and intensity of fires via control measures and/ or increase accidental fires caused through the introduction of ignition points (i.e., vehicles and machinery). Species that are sensitive to fire may be impacted through Project-related activities if they lead to an increase in frequency. This process could lead to disturbance outside of the Project Conceptual Footprint involving repetitive loss of the dense shrub layer that forms critical habitat for species. If this were to occur, it has potential to: •reduce the area of occupancy the species can inhabit in the region •fragment populations as fire isolates remaining suitable habitat and •if a sufficiently large scale could: -disrupt the breeding cycle -impact habitat to the extent that the species is likely to decline and subsequently reduce the population size of the species. An S-P-R linkage is therefore confirmed.	**Design** Fire suppression systems installed. **Control** Hot works permitting system. Site based emergency response team and firefighting equipment. **Management** Implementation of a Native Vegetation Management Plan. Implementation of a Fire Risk Management Plan.	Bushfires in surrounding region impacting on Lease area.	Low	The Tenement Holder will ensure there are no uncontrolled fires that could have been reasonably prevented as a result of mining activities.	**Construction and operation** Fire incidents caused by mine operations recorded (incident type, description, classification and action taken) in Iluka incident management system reviewed annually to demonstrate outcome achievement (Does not apply to natural bushfires recorded for purposes of internal hazard reporting).	None proposed
Flora, fauna, and native vegetation	C	FFNV10	New	Atacama ML	Final landforms do not support rehabilitation of pre-mining flora and fauna habitat, causing a permanent and on-going change to abundance and diversity of native flora and fauna.	Construction of final landform	Land	Flora and fauna	Changes in vegetation communities as result of change in landform (loss of dune crests) is unknown.	High	Uncertain	Rehabilitation activities at Atacama are expected to be undertaken progressively, in conjunction with mining activities. The rehabilitation activities and final landforms are as discussed in Section 4. The net extraction of material and soil movements will result in changes to the topography, compared to pre-mining conditions and surrounding dunes. The pits cut across the existing regional dunes. The rehabilitated landforms will be shaped to blend with the surrounding landforms, but the dune crests are unlikely to be continuous in height. While care is expected to be taken to replicate soil profiles, the changes to landforms can be expected to result in impacts or changes to vegetation associations that regenerate within the rehabilitated footprint areas in comparison to those present in pre-mining conditions. This is a permanent but relatively small-scale impact. The dune crest habitats that will be removed are available over greater extent in the adjacent Yellabinna Regional Reserve. The ecology and detailed requirements for communities that use the small dune crest are unknown, hence the recreation of this habitat type to offset the permanent loss of the dune crests has some associated uncertainty. Given the uncertainty an S-P-R linkage has been confirmed.	**Management** Implementation of a Native Vegetation Management Plan Implementation of a Rehabilitation Management Plan	Rooting depth requirements for deep rooted plant species Viability of seeds for specific species within stockpiles Artificial germination success for specific species	Low	The Tenement Holder must ensure that the post mining ecosystem and landscape function is resilient, self-sustaining and indicating that the pre-mining ecosystem and landscape function will ultimately be achieved.	**Closure** Landscape Function Analysis to show rehabilitated areas are trending towards pre-disturbance landscape function based on comparison with control site. The following will be collected: •Soil cover •basal cover of vegetation •litter cover •BSC •crust entirety •erosion type and severity •deposited materials •surface roughness •surface resistance to disturbance •slake testing •soil texture •vegetation diversity and abundance.	**Closure** Assessment of early rehab success.
Flora, fauna, and native vegetation	C,O	FFNV11	New	Atacama ML	Light Anthropogenic sources of light at night due to 24 hr operation causing interruption to foraging and circadian rhythms of native fauna.	Artificial lighting	Phototrophic behaviours / attraction of insectivorous species	Native fauna	Unknown sensitivity of local species and populations to light sources	Moderate	Yes	During the operational phase at Atacama, operation will be 24 hours per day, seven days a week. Operation will require constant light sources. This may have impact on native fauna species through increased risk of predation, disruption of circadian rhythms, disorientation, attraction to light sources increasing injury and mortality risk and may have negative impacts on breeding and migration. There is also the potential for changes to vegetation growth and flowering patterns. There are no regulatory limits for lighting impacts to fauna. No noticeable impact as a result of light increase recorded at J-A. An S-P-R linkage has been confirmed.	Light only the object areas intended- keep lights as close to the ground as practicable to avoid light spill. Use the lowest intensity lighting appropriate for the task. **Control** Use adaptive light controls to manage light timing.	Sensitivity of specific fauna species to lighting is unknown.	Low	The Tenement Holder will ensure that there are no net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas.	As per FFNV3 (for construction and operation)	As per FFNV3 (for construction and operation)
Flora, fauna, and native vegetation	C,O	FFNV12	New	Atacama ML	Noise and Vibration Anthropogenic sources of noise due to 24 hr operation. Interruption of foraging and circadian rhythms of native fauna. Avoidance behaviour particularly by burrowing species.	Mine operation	Noise carried via wind	Fauna	Unknown sensitivity of local species and populations to noise and vibration	Low	Uncertain	Noise at Atacama is expected to increase from current ambient noise levels during the construction and operation phases of the mine. During these phases, increased noise is likely to occur in short, intense pulses from mobile plant equipment as well as in the form of more prolonged noises with consistent vibration, pitch and volume due to generators, excavators, pumps and vehicles. During operation mining activities will occur 24/7, which may cause avoidance of adjacent areas in the wider Reserve, interference with species' calls, increased risk of predation and interference with circadian rhythms which can ultimately result in decreased fecundity of individuals. The animal's initial reaction to a new noise source is fright and avoidance, but if other sensory systems are not stimulated, the animal learns quite quickly to ignore the noise source. Whilst some mobile species may choose to relocate to the adjacent habitat within the Yellabinna Regional Reserve, others may remain and acclimatize to the increased noise levels. The noise impacts to local fauna populations are likely to be below the level to produce detectable changes, and the impacts are expected to be low depending on the distance from the mine and the individual tolerances of the specific fauna species.	**Control** Equipment, machinery and vehicles should be regularly maintained (documented). All machinery and equipment to be used will comply with the relevant Australian standard for noise attenuation (e.g., have noise mufflers and be well maintained). Vehicles and machinery should not be left idling when not in use..	No noise studies have been completed as there are no anthropogenic noise receptors	Low	The Tenement Holder will ensure that there are no net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas.	As per FFNV3 (for construction and operation)	As per FFNV3 (for construction and operation)
Public health and safety	C,O	PHS1	New	Atacama ML	Unauthorized access to the active mining area (Atacama) by members of the public results in injury or death.	Mining and rehabilitation activities	Unintentional site access through bushland track, or site security failures	Public Local Community Visitors and staff of Yellabinna Regional Reserve Aboriginal people – members of FWCAC	There are no private landholders/ residents in 80 km radius or in Yellabinna Regional Reserve. The numbers of potential people on foot in near the Project Area during construction and operations is unknown, though based on experience at nearby J-A it is considered to be low.	Low	Yes	Unauthorised access to the Project Area during construction and operation is considered as unlikely to occur, though not impossible and cannot be discounted. To enter the Project Area, a person(s) would have to first enter the J-A area and security., or there is 4WD access through already establish tracks in the Reserve. Members of the FWCAC can access areas on the tenement for cultural purposes, including hunting and gathering and the use of Atacama both during Operation and Post Closure may include occasional passing through. Due to the remoteness of the Project Area (in its proximity to camping grounds, public roads and towns), it is unlikely that visitors, residents, local community members and Reserve staff will be walking in proximity to the Project Area, however the possibility of the members of the public, local community Reserve staff or FWCAC members unintentionally accessing site cannot be discounted. Therefore, a S-P-R linkage is confirmed.	**Design** Access to Atacama through single point access from the J-A mine site entrance. Signage erected and maintained to deter unauthorised access Mine plan designed to ensure the village is the first point of contact on the access road. **Control** Pre-mobilisation-site Access Request (SAR) process. Authorised public visits are managed through SAR process. Implementation of a traveller's drop-in procedure. **Management** Personnel educated to direct any unauthorised visitors to the village office at J-A. Maintain site-based Emergency Response Team and Ambulance Officers including assets and equipment. Implementation of an Emergency Crisis System and Iluka Group Standard. Incident reports concerning unauthorised site access, operational fires and traffic/ haulage events recorded in Iluka's Incident Management System.	Due to the remote location of the Project unauthorised access is unlikely but still possible.	Low	The Tenement Holder must during construction and operation ensure that unauthorised entry to the land does not result in public injuries or deaths that could have been reasonably prevented.	**Construction and operation** Unauthorised access incident recorded (incident type, description, classification and action taken) in Iluka's Incident Management System . Investigation completed in 14 days, or as agreed with the Director of Mines (or other authorised officer).	None proposed
Public health and safety	CL	PSH2	New	Atacama ML	Access to the rehabilitated landform (Atacama) post-closure by members of the public causes injury or death.	Rehabilitated landform	Intentional or nonintentional access to the area	Public Local Community Visitors and staff of Yellabinna Regional Reserve Aboriginal people – members of FWCAC	There are no private landholders/ residents in 80 km radius or in Yellabinna Regional Reserve. The numbers of potential people on foot in near the Project Area during construction and operations is unknown, though based on experience at nearby J-A it is considered to be low.	Low	Yes	All Project related infrastructure will be removed at the end of operations, unless otherwise agreed to with the Landholder. It is possible that if not adequately designed and successfully implemented the post-mining landform and vegetation could have an impact on public health and safety. The Project Area is in a Regional Reserve, managed by the Yumbarra Co-Management Board, a partnership between the FWCAC and the DEW. Members of the FWCAC can access areas on the tenement for cultural purposes, including hunting and gathering and the use of Atacama both during Operation and Post Closure may include occasional passing through. Although the area is remote from the existing Yellabinna Regional Reserve visitor facilities located at Mount Finke Campground, the Project Area is located within a regional reserve which is considered to have high natural and wilderness values. Access to the public will be allowed when rehabilitation is completed, and the lease is relinquished. The post mine land use will revert to Regional Reserve and therefore it is possible that people could be in the vicinity of the Project Area post-closure.	**Design** Final landform design reviewed against approved design **Management** Implementation of a Rehabilitation Management Plan. Implementation of a Mine Closure Plan.	Final landform design will be refined through mine life. It is currently unknown what if any infrastructure will be useful to the Landholder post-closure (DEW and FWCAC). It is assumed that all infrastructure will be removed.	Medium	The Tenement Holder must demonstrate that at closure the risks to the health and safety of the public so far as they may be affected by the final landforms are as low as reasonably practical.	**Closure** Topographic survey of rehabilitated site compared with approved design (comparison of RLs). Site audit of infrastructure type, disposal location and record of infrastructure having been removed offsite. Site audit of safety and compliance certificates (or similar records) for any retained infrastructure. Negotiation and sign off from Landowners (DEW and FWCAC) on relinquishment/ handover of any retained infrastructure.	None proposed
Public health and safety	C,O	PSH3	New	Atacama ML	Uncontrolled fires causing injury or death to members of the public.	Mining and rehabilitation activities	Hot works/ignition sources. use/storage of flammable materials. Accident/ rollover of mobile plant. Change in natural fire regimes for the localised Project Area due to mining operation and or closure final landform.	Public Flora and Fauna	It is assumed the perceived risk of fire due to Project-related ignition sources is low due to the predominant use of diesel on the Project area which has a higher threshold for ignition than other combustible materials.	Low	Yes	The Yellabinna Reserve is susceptible to fires during periods of high winds, high temperatures and dry conditions. The introduction of human activity into an area often leads to a change in the natural fire regime. Either it can decrease the frequency and intensity of fires due to control measures or increase through accidental fires caused through ignition points (i.e., vehicles, machinery, lightning strikes, arson, hot works/ on-site ignition sources or storage of flammable materials). The actual risk of fires due to Project-related ignition sources is expected to be low, if at all. The adjacent J-A mine has a positive track record in regard to mitigating the risk of ignition-based fires. However, the possibility of fires cannot be discounted.	**Control** Maintenance of fire breaks. Vehicles and equipment carry fire suppressant equipment. Emergency evacuation procedures established and communicated. **Management** Implementation of Fire Risk Management Plan, and the J-A Emergency Response Plan which will be extended to Atacama. Observation of fire ban rules. Fire truck, suppression equipment and trained emergency response team on call 24/7. Consultation with CFS, DEW, Ceduna Council and emergency service providers prior and during fire danger periods.	It is assumed the perceived risk of fire due to Project-related ignition sources is low due to the predominant use of diesel on the Project area which has a higher threshold for ignition than other combustible materials. It is uncertain what species within and surrounding the Project Area require fire regimes for succession (e.g. flora, colonising species of native fauna).	Low	The Tenement Holder must during construction and operation ensure that uncontrolled fires due to the mining operation does not result in public injuries or deaths that could have been reasonably prevented.	**Construction and operation** Fire incidents caused by mine operations recorded (incident type, description, classification and action taken) in Iluka Incident Management System Incident investigations completed within 14 days or other time period as agreed with the Director of Mines. Incident trends reviewed annually. (Does not apply to natural bushfires recorded for purposes of internal hazard reporting)	**Construction and operation** Quarterly review of incidents, audits and hazards relating to fire.
Waste	C,O,CL	W1	New	Atacama ML	Loss of amenity (odour, litter) results in increased abundance of pest species.	Open waste containers	Aeolian – windblown litter	Visual Amenity Native flora and fauna	Pest species are already known to occur in the region.	Low	Yes	Industrial and commercial wastes will be collected at the Atacama Project Area and transferred to J-A for main storage as per J-A's current management practices. Some interim lay down areas for inert wastes and materials may be established at Atacama. Treated sewage from office/ crib room ablutions may be disposed at Atacama in accordance with relevant regulatory requirements. Without mitigation measures it is possible that inappropriate waste storage and disposal could lead to an increased abundance of pest species (i.e., weeds and fauna), opportunistic access by native fauna and amenity issues with odour and litter. An S-P-R linkage is confirmed.	**Control** Waste Transfer Station for segregation of wastes. Waste facility fencing for exclusion of fauna/ containment of litter located at J-A. Receptacles for general wastes and recyclables installed throughout Project Area. Approved Wastewater Treatment Plants for treatment of greywater and sewage. Waste collection by EPA-licensed transporters and treatment/ disposal to EPA-approved facilities (where applicable). **Management** Preventive baiting programs for vermin (house mouse) Monitoring and housekeeping inspections. Site induction inclusive details onsite waste management procedures. Waste management awareness training. Implementation of a Waste Management Plan. Implementation of a Pest Species Management Plan.	N/A	Low	The Tenement Holder must ensure that no demolition, industrial or solid domestic waste (other than treated sewage) is disposed of on site.	**Construction and operation** Visual monitoring and recording in the site waste register demonstrates appropriate waste treatment, segregation and disposal demonstrates that appropriate waste treatment, segregation and disposal has occurred.. Audit of waste disposal records for all waste types (general waste, recyclables, hazardous and listed wastes) demonstrates that waste has been stored and managed in accordance with the Waste Management Plan. **Closure** Audit report demonstrates that no demolition, industrial or solid domestic wastes (except biosolids and residual infrastructure detailed in the Mine Closure Plan) have been left onsite.	**Construction and operation** Quarterly review of site waste register containing records of all waste movements from site.
Waste	C,O,CL	W2	New	Atacama ML	Soil contamination through inappropriate storage and handling hazardous materials and/ or through uncontrolled release of hazardous materials	Inappropriate storage Uncontrolled release	Spill or leak - direct application to soils	Soils	Lower volumes of stored diesel compared to J-A. No bulk flocculent storage, RO reagents, lab or warehouse hazmat storage compared to J-A. More SME movements compared to J-A so potential for small oil and field re-fuelling leaks etc. Location, volume and type of contamination Volume and frequency of spills is unknown, though based on experience at J-A they will be low.	High	Yes	Hazardous materials will be used for the Project as currently occurs at J-A. Inappropriate storage and handling of hazardous materials may include the co-storage of incompatible dangerous goods classes, storage without bunding or containment, poor management inventory and unsafe handling practices. Without preventative measures in place there is risk that contamination of soils could occur. An S-P-R linkage is confirmed. Multiple legislative instruments (acts, regulations, measures, policies, codes and guidelines) exist which govern the storage, handling, treatment and disposal of commercial and industrial wastes. A lack of adherence to these instruments and proper waste management processes could result in possible contamination of soils. The management of hydrocarbons Hydrocarbon spills and leaks expected to have to occur during the Project life. An S-P-R linkage is confirmed.	**Design** Bunding and containment of dangerous goods and hazardous substances per relevant legislation, guidelines and Australian/New Zealand standards. **Management** Implementation of a Hazardous Materials Management Plan. Implementation of a Waste Management Plan that covers management of hazardous wastes Hazardous Materials Approval procedure Inventory management, monitoring and inspection requirements. Spill response/ clean-up procedures. Emergency Response Team trained in fire and hazmat emergency response, including spill response trailer. Site induction inclusive details on-site hazardous materials management. Hazardous materials management training awareness program. Planned workplace inspections. Loss Control reporting system. Vehicle, plant and infrastructure preventative maintenance programs. Vehicle and equipment pre-start checks.	Location, volume and type of contamination Potential for legacy soil contamination in areas of storage and handling of Hazardous materials	Low	The Tenement Holder must ensure that fuel and liquid chemicals (hazardous materials) are managed in accordance with relevant EPA guidelines to prevent spillage and leakage to the environment.	**Construction and operation** Visual monitoring and recording of the appropriate clean up and disposal of contaminated material demonstrates that all spills were managed in accordance with Spill Response/ Clean Up Procedure and Iluka HSEC Group Standard – Hazard, Incident and Emergency Classification. Annual reporting to DEM (via the Annual Compliance Report) provides a summary of all Level 2 or higher hazardous material spill events, response clean up (as ranked according to the Iluka HSEC Group Standard – Hazard, Incident and Emergency Classification). Visual observations and incident investigation (report stored in Iluka Incident Management System demonstrates that all hazardous materials storage facilities comply with SA EPA Bunding Guidelines, or to a design agreed to with the SA EPA to prevent spillage and leakage to the environment. Visual monitoring and recording of the appropriate clean up and disposal of contaminated material demonstrates that all spills were managed in accordance with Spill Response/ Clean Up Procedure and Iluka HSEC Group Standard – Hazard, Incident and Emergency Classification. Annual reporting to DEM (via the Annual Compliance Report) provides a summary of all Level 2 or higher hazardous material spill events, response clean up (as ranked according to the Iluka HSEC Group Standard – Hazard, Incident and Emergency Classification). **Closure** Audit report demonstrates: •that soil sampling of target sites and management of any impacted soils has occurred in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM) and that classification for off-site disposal of material has occurred as per SA EPA information sheet (March 2010) Current criteria for the classification of waste – including industrial and Commercial Waste (Listed) and Waste Soil.	**Construction and operation** Quarterly review of incident register for spillages and leaks and the clean-up and disposal of contaminated material, including the identification of any procedural changes required. Quarterly review of incident register for spillages and leaks and the results of visual observations of hazardous materials storage facilities, including identification of any procedural changes required
Groundwater, including quality and quantity	C,O	GW1	New	Atacama ML	Reduction in groundwater levels within the fractured rock lithology.	Mine operations – pit trenching	Dewatering /evaporation of intercepted groundwater during mining	Reduced access to groundwater resources by third parties	Pit depth will not exceed 125 m AHD average depth, groundwater levels observed between 95 and 106 m AHD. Hydrogeology is inferred from J-A model, groundwater wells at Sonoran and Typhoon (Iluka exploration areas), and an Atacama specific drilling program that installed three wells.	Low	No	Groundwater levels at Atacama were measured at elevations between 95 and 106 m AHD (EMM, 2022a). Four pits will be constructed, to average depths of up to 125 m AHD. As such groundwater will not be intercepted and mine dewatering will not be required.						
Groundwater, including quality and quantity	C,O,CL	GW2	Incremental	Borefield	Reduction in groundwater levels in the paleochannel preventing beneficial use of the paleochannel groundwater by other parties.	Groundwater abstraction for mining operations (processing, rehabilitation, dust suppression).	Groundwater	Reduced access to groundwater resources by third parties	Refer to Change in Operations Application, attached as Appendix D.									
Groundwater, including quality and quantity	C,O	GW3	New	Atacama ML	Changes / reduction in groundwater availability impacting on groundwater dependent ecosystems.	Groundwater abstraction for mine operations (processing, rehabilitation, dust suppression).	Groundwater	Subterranean GDEs Terrestrial GDEs	Pit depth will not exceed 125 m AHD average depth, groundwater levels observed between 95 and 106 m AHD. Hydrogeology is inferred from J-A model, groundwater wells at Sonoran and Typhoon (Iluka exploration areas), and an Atacama specific drilling program that installed three wells. Groundwater will not be abstracted in the Project Area. Water will be supplied by J-A existing groundwater wells. Subterranean GDEs were not analysed in proximity to the Project Area. The conceptual hydrogeological model assumes that terrestrial GDEs source water from episodic rainfall events and soil moisture rather than regional groundwater resources. Salinity of the regional groundwater is too high for terrestrial GDEs to use >10,000 mg/L (Total Dissolved Solids (TDS)).	Low	No	It was considered by EMM (2022a) that there was a low likelihood of stygofauna presence in the Project Area due to the depth of the fractured rock aquifer and the highly saline nature of the groundwater environment. The closest stygofauna assessment near the Project Area was undertaken approximately 400 km away in Streaky Bay. Terrestrial GDEs exist in the Project Area. However, due to the depth of the groundwater and considering the shallowest groundwater encountered in the Project Area is 75 m BGL, it is considered that the terrestrial species are likely to rely on episodic rainfall and soil moisture rather than groundwater. Although subterranean GDEs were not analysed for the Project, there is no change in sensitivity. The ore at Atacama is located well above local groundwater elevation, groundwater will not be intercepted, and groundwater abstraction will not be required in the Lease area. There will be no changes in groundwater availability for stygofauna and terrestrial vegetation GDEs as a result of the Project. Impacts related to groundwater abstraction will be assessed as part of the J-A Change to Operations.						

Environmental element	Project phase	Impact ID	Type of impact	Area	Potential impact event	Source	Pathway	Receptor	Uncertainties and assumptions	Sensitivity to change (in assumptions)	S-P-R linkage?	Justification for the confirmation/ non-confirmation of an SPR linkage	Control measures and management strategies	Uncertainties and assumptions2	Sensitivity to change (in assumptions)2	Proposed outcome	Draft outcome measurement criteria	Draft leading indicator
Groundwater, including quality and quantity	C,O	GW4	New	Atacama ML	Hypersaline groundwater rise impacting soils and vegetation within and beyond the extent of the mine disturbance area.	Tailings disposal	Tailings seepage to groundwater and subsequent rise of saline water table (mounding)	Native vegetation Soils Lake Ifould	All tailings from the Project will be transported and stored at J-A, off site. Impacts related to this will be assessed as part of the J-A CiO. Future seepage rates, hydro stratigraphic mapping, vegetation sensitivity.	Low	No	The Project will make best use of the disturbance area and infrastructure already approved at nearby J-A by using the existing processing and storage facilities and expanding the existing in pit tailings facilities on already disturbed areas. Tailings will be split into two components at the concentrator stage, a benign coarse sand component and a fine slimes component <53micron in size. The coarse sand fraction of the tailings will be stored in a sand cap located at Jacinth North. The slime component will be deposited in the Ambrosia void as part of the remediation. Potential cumulative impacts to mounding outside of the Project Area resulting from the Project tailings seepage in the J-A lease will be assessed as part of the J-A CiO. Potential mounding within the Atacama Project Area as a result of the additional tailings seepage in the J-A lease will also be addressed as part of the J-A CiO, however it noted that impacts to vegetation and soils in the Atacama Project Area are unlikely. East of J-A, the groundwater elevation drops by approximately 15 m. This is interpreted as a fault potentially restricting groundwater flow and compartmentalising the groundwater system.						
Groundwater, including quality and quantity	C,O	GW5	New	Atacama ML	Groundwater contamination associated with accidental spills.	Exploration / infill drilling, Mine operations Fuel or chemical spills	Seepage of pollutants, chemicals, waste to groundwater from accidental spills and waste mismanagement.	Groundwater Ecological receptors at discharge points	The volumes of spills that may occur is unknown, however it is unlikely to be at large quantities	Low	No	Groundwater at Atacama has been found at elevations ranging between 95 and 106 m AHD (approximately 30 m below average pit base depth). And no significant receptors were identified in the area. The overburden within the Project Area is unsaturated and the region water table is located in the basement. Any spill at Atacama (either at natural surface or within the pits) is unlikely to be of a volume required to reach groundwater within the basement. Therefore, it is considered that there is no S-P-R linkage.						
Groundwater, including quality and quantity	O	GW6	New	Atacama ML	Contamination of groundwater with hypersaline process water	Mine operations – dust suppression Storage of process water on site	Process water seepage into groundwater	Groundwater Ecological receptors at discharge points	Distribution of soluble forms of aluminium minerals, neutralizing capacity of native groundwater	Low	Yes	Two 2.5 ML ponds will be established to the north of MUP 1. One pond will store process water and one pond will be RO water. The process water pond will have high salinity. Groundwater at Atacama has been found at elevations ranging between 95 and 106 m AHD (approximately 30 m below maximum pit depth). And no significant receptors were identified in the area. The overburden within the Project Area is unsaturated and the regional water table is located in the basement. Any seepage of process water at Atacama (either through dust suppression using hypersaline water or failure of any constructed pond lining), is unlikely to be of a volume required to reach groundwater within the basement. However, this is highly reliant on implementation of a control, being the design and ongoing maintenance of constructed ponds. Therefore, an S-P-R linkage is confirmed.	**Design** Water holding ponds are designed with appropriate lining including embankments and base. **Control** Regular inspection and maintenance of water holding ponds. No discharge of process water into the mine pits. **Management** Implementation of Groundwater Management and Monitoring Plan Monitoring of mine site groundwater chemistry Sampling and analysis of water holding ponds in the Project Area. Monitoring of vegetation health	Long term impact of hypersaline water seepage on groundwater chemistry and geochemistry	Low	The Tenement Holder must during construction, operations and closure ensure that there is no adverse change to groundwater quality and quantity as a result of the Project.	**Operation** Water quality samples collected and analysed at a NATA accredited laboratory for pH, EC, TDS, temperature, major cations (Ca, Mg, K, Na,), major anions (Cl, SO_4, Alkalinity, CO_3, HCO_3) dissolved organic carbon and dissolved metals (Fe, Mn Al, Cd, Cu and Ni) and SWL demonstrate no statistically significant deviation from baseline which can be attributed to mining operations.	None proposed
Surface Water, including quality and quantity	C,O	SW1	New	Atacama ML	Changed rates of subsurface infiltration due alteration of surface water regime within the dune system	Mining activities and landform changes	Changes in hydrology	Groundwater	Impacts on groundwater from flood modelling scenarios were not included in the model.	Low	No	Connecting previously discrete catchments is likely to result in larger catchments and concentrated volumes of surface water on the new low point in the combined catchment (potentially behind levees constructed to protect the mine), resulting in locally higher rates of subsurface infiltration. Groundwater recharge is inferred to be minimal (0.1 <1 mm/year (CDM Smith, 2022)) due to low rainfall in the area, high evapotranspiration rates and the large depth to groundwater (EMM, 2022a). It is unlikely that flooding in the dune swales will result in changes to the groundwater due to the localized impact of ponding. However, impacts on groundwater were not included in the model. There is no S-P-R linkage.						
Surface Water, including quality and quantity	C,O	SW2	Incremental	Both MLs	Changed drainage line flow regime and potential for increased sedimentation due construction and operation of the haul road	Haul road construction and operation	Change in hydrology	Unnamed ephemeral drainage lines crossed by the haul road	N/A	N/A	Yes	At the locations where the haul road crosses unnamed ephemeral drainage lines, flows are expected to be relatively minor, with depths of less than 0.2 m and peak velocities of around 0.6 m/s reported by the model at the 1% AEP scenario. At these locations there is an increased risk of erosion and sedimentation into the drainage line, particularly on the downstream side of the haul road due to locally changed flow patterns. For example, water flowing over road embankments may locally be shallower with higher velocity, while culverts concentrate flow and can create higher velocity jets at the outlet. During periods of rainfall this erosion and sedimentation may, through rainfall runoff, migrate down the drainage line, which has the potential to increase the turbidity and nutrients within the drainage lines. Whilst the impact is likely to be minimal given the low flow velocities within the drainage lines the impact is dependent upon implementation of design controls. As such, an S-P-R linkage is confirmed.	**Design** Surface water flow managed by culverts at waterway crossings Requirements for drainage design to minimise storm water runoff to unnamed drainage lines near the haul road **Management** Expand and enhance the existing J-A Surface Water Management Plan to Atacama	N/A	Low	The Tenement Holder must ensure no adverse impact on surface water quality as a result of mining operations.	**Construction and operation** Annual sediment sampling upstream and downstream of haul road drainage line crossings (measuring ECH, turbidity and pH) demonstrate that sediment quality (as a proxy for water quality) downstream is comparable with upstream results.	None proposed
Surface Water, including quality and quantity	CL	SW3	New	Atacama ML	Alteration of surface water flow regime resulting in impacts to vegetation	Mining activities and landform changes	Change in hydrology	Native flora and vegetation communities	Lack of understanding on how vegetation communities may be affected by changes in dune field hydrology and assumptions that vegetation will not be affected are based on hydrological engineering model.	Moderate	Uncertain	Investigations by Alluvium (2014) into the level of reliance on surface water by ecosystems in the Project Area concluded that 'vegetation species within the Atacama Project Area are not reliant on collection of surface water or periods of inundation to survive'. Alluvium (2014) considered that changes in hydrology within the Atacama Project Area will have limited impacts to the vegetation stratums in the short term (i.e.<10 years). Vegetation communities present within flood zones are not reliant on flows or flooding because these events occur at such infrequent intervals, they would not sustain ephemeral communities. All vegetation communities within the Project Area appear to be driven by soil depth primarily, with transitional communities present as responses to the last flood event. The period in which these areas stay inundated may also drive communities as a response to tolerance of extended wetting rather than reliance (Alluvium, 2014). Post mine completion the surface water model (EMM, 2022b) shows changes to the flood regime of the of the swale catchments, in that some areas which were dry will now be wet and vice versa (Figure 7 7). This change is discrete and limited to the extent of the Conceptual Footprint. All vegetation communities in proximity to the proposed development are well represented and this should ensure the ongoing viability of diverse ecosystems. However, vegetation communities have been assessed as a potential environmental receptor. There is a lack of understanding on how vegetation communities may be affected by changes in dune field hydrology in the long term, and ongoing monitoring should be implemented. The S-P-R linkage is uncertain and will require implementation of monitoring controls to understand this potential impact	Refer to Impact ID FFNV1	Refer to Impact ID FFNV1	Refer to Impact ID FFNV1	Refer to Impact ID FFNV1	Refer to Impact ID FFNV1	Refer to Impact ID FFNV1
Surface Water, including quality and quantity	C,O,CL	SW4	New	Atacama ML	Reduction or changes in local availability of surface water.	Mine operation, dust suppression, rehabilitation watering	Surface water collection, harvesting and use	Other users	Water will be supplied by J-A's existing groundwater wells with no collection or harvesting of surface water proposed in the Project Area.	0	No	The Atacama site is situated in the arid climate zone, with the monthly evaporation exceeding monthly rainfall rates in all months of the year (EMM, 2022b). There are no townships downstream of the mine site, and no water users are reliant on surface water from the dune swales or watercourses that would be affected by the Project. Water for the J-A mine site is currently sourced from an approved wellfield (MPL 110) which is located approximately 40 km from the J-A site. It is proposed that water for the Atacama project will be sourced from this existing wellfield. There is no S-P-R linkage.						
Surface Water, including quality and quantity	C,O	SW5	New	Atacama ML	Erosion and runoff from disturbed surfaces results in an increase in sedimentation in surface water within watercourses and Lake Ifould	Mining activities and landform changes	Sediment laden discharge / rainfall runoff	Water Courses Lake Ifould	N/A	Low	No	No discharges are proposed into watercourses from the proposed mining operations. No change in flow regime of creeks flowing to Lake Ifould is expected to occur. Surface water runoff from the disturbed areas, such as roads, MUP pads, contractor area, operation and maintenance areas, will be directed away from infrastructure towards sumps and roadside catchment drains. Diversion channels will redirect natural catchments and culverts will be used under roads to direct water towards the roadside catchment drains. The collected rainfall will be allowed to soak and /or evaporate off and will not contribute to the process water balance for the site. Sediment will be retained in the stormwater ponds and periodically cleaned out. Lake Ifould and the watercourses are not located within the Project Area and as such are a significant enough distance away that they will not be impacted by the mining activities, as such sediment laden runoff is not expected to reach these receptors. There is no S-P-R linkage.						
Surface Water, including quality and quantity	C,O	SW6	New	Atacama ML	Reduction in water quality resulting from mobilisation of fuel or oil spill contaminants.	Exploration / infill drilling, Mine operations Fuel or chemical spills	Rainfall runoff and mobilisation of contaminants	Dune swales within the area of disturbance Drainage lines along haul road	N/A	Low	Yes	During construction and operation, equipment will use diesel fuel and be lubricated with oils. There is a low likelihood risk of oil/ fuel spill from vehicles, for example in the case of mechanical failure. Due to the arid environment, the likelihood of fuel/ oil transport by surface water prior to clean up is very low. Heavy vehicles would primarily be used and parked within the dune system, where any transport of spilled material would be contained within the local dune swale and terminal pan. Any fuel stores located at the Atacama site would be constructed on bunded pads in accordance with appropriate guidelines, outside of areas identified to be at risk from flooding and away from watercourses. Spill clean-up procedures would be developed, and spill kits would be available. There is a S-P-R linkage due to the reliance on control and management methods to reduce this impact.	Refer to Impact ID W2	Refer to Impact ID W2	Refer to Impact ID W2	Refer to Impact ID W2	Refer to Impact ID W2	Refer to Impact ID W2
Surface Water, including quality and quantity	O	SW7	New	Atacama ML	Reduction in water quality resulting from contamination of hypersaline process water	Storage of process water on site	Unintentional contaminated discharge	Watercourses Lake Ifould	N/A	Low	No	Two 2.5 ML ponds will be established to the north of MUP 1. One pond will store process water and one pond will be RO water. The process water pond will have high salinity. These ponds will be lined with HDPE liner on the embankments and base above a compacted cushion layer. There is a low risk of failure of these pond dams if constructed to design and maintained. Whilst there is a reliance on The impact is unlikely however is dependent upon the implementation of design controls to prevent an uncontrolled water release, the location of the two ponds means that separation distances would prevent such a release resulting in an impact to watercourses and/ or Lake Ifould. As such, an S-P-R linkage is not confirmed.						
Noise and vibration	C,O	N1	New	Atacama ML	Increase in noise and vibration from surface mobile equipment (trucks, excavators, loaders etc.), MUP and vehicles and occasional blasting within the Project Area	Mining and rehabilitation activities	Atmosphere	Public and local community	Noise and vibration levels during these phases are unknown.	Low	No	The Project is isolated from towns and population centres with the closest community group being Yalata Aboriginal community, located 75 km south of the Project Area. Beyond this, the closest population center is Ceduna located over 200 km to the southeast. Access restrictions prevent tourists and members of the public from being nearing the Project Area. As such due to separation distances there is no S-P-R linkage.						
Noise and vibration	C	N2	Incremental	Transport corridor	Increase in noise and vibration along public roads – including Eyre Highway due to the increased traffic to and from the Project Area during construction	Vehicle movements	Transport of HMC along Eyre Highway and other publicly accessible roads	Members of the public	Refer to Change in Operations Application, attached as Appendix D.									
Noise and vibration	O	N3	Incremental	Transport corridor	Increase in noise and vibration along public roads – including Eyre Highway due to the increase in duration (not vehicle movement) of existing traffic route	Vehicle movements	Transport of HMC along Eyre Highway and other publicly accessible roads	Members of the public	Refer to Change in Operations Application, attached as Appendix D.									
Noise and vibration	C,O	N4	Incremental	J-A ML	Increase in noise and vibration at J-A due to the increase in duration of existing operations	Extended processing activities	Atmosphere	Flora and fauna	Refer to Change in Operations Application, attached as Appendix D.									
Air quality	C,O,CL	AQ1	New	Atacama ML	Mining activities cause a decrease in air quality due to nuisance dust emissions impacting health of the public.	Dust quantity - wheel generated from mine truck and plant operation Wind generated dust – stockpiles and disturbed open pit areas.	Aeolian/ wind	Public	AQIA dispersion modelling assumptions are correct Model assumed the following mitigation measures in place: Water carts on unpaved roads Inactive stockpiles are stabilised Mining operation progressively backfills and rehabilitates as mining progresses.	Low	No	There are no predicted air quality impacts to the general public due to remoteness of the Project Area with the nearest non mining receptor being Yalata, approximately 70 km to the southwest. No public roads, townships, residential receptors and facilities are in proximity to the Project. Dust modelling undertaken by Jacobs (2022c) for the peak production year indicates that the risk of air quality impacts to the camp (located 8 km from the Project disturbance area) will be low, further demonstrating that potential impacts to the public will not occur. There is no S-P-R linkage.						
Air quality	C,O,CL	AQ2	New	Atacama ML	Mining activities cause a decrease in air quality due to fuel combustion contaminant emissions impacting health of the public.	Mine construction and operations Vehicle and machinery operation and idling.	Aeolian	Public	AQIA dispersion modelling assumptions are correct.	Low	No	The Project will result in an increase in gaseous emissions, however the nearest non mining receptor, Yalata, is approximately 70 km to the southwest and the modelling assessment undertaken by Jacobs (2022c) showed that all predicted gaseous pollutant concentrations were insignificant for the worst-case mining receptor; the camp, at 8 km from the Project Area. Consideration was also given to locations within the mine site at which a person (employees) would be likely to be present for an hour or more with results indicating a low risk. There is expected to be only a relatively small number of vehicles associated with the Project and air quality impacts due to combustion engine emissions will be negligible. There is no S-P-R linkage.						

Environmental element	Project phase	Impact ID	Type of impact	Area	Potential impact event	Source	Pathway	Receptor	Uncertainties and assumptions	Sensitivity to change (in assumptions)	S-P-R linkage?	Justification for the confirmation/ non-confirmation of an SPR linkage	Control measures and management strategies	Uncertainties and assumptions2	Sensitivity to change (in assumptions)2	Proposed outcome	Draft outcome measurement criteria	Draft leading indicator
Air quality	C,O	AQ3	New	Atacama ML	Mining activities cause a decrease in air quality due to nuisance dust emissions impacting native flora.	Dust quantity - wheel generated from mine truck and plant operation Wind generated dust – stockpiles and disturbed open pit areas.	Aeolian	Native flora	AQIA dispersion modelling assumptions are correct	Low	Uncertain	The development and operation of the Project will result in air pollutant emissions due to land clearing and stockpiling of topsoil and overburden; mining operations in open pits; rehabilitation works and vehicle movements. Increases in dust within the atmosphere can result in adverse effects on vegetation through smothering the plant and inhibiting their ability to photosynthesize. Resulting in reduced plant growth or causing death to existing vegetation, consequently, decreasing the quality habitat. The extent of vegetation exposed to heavy dust is restricted to areas within close proximity to the Conceptual Footprint. Therefore, the impact to vegetation within the Yellabinna Regional Reserve would be minor as the disturbance footprint is relatively small (comparative to the size of the I Reserve). The modelling assessment undertaken by Jacobs (2022c) showed results that are strongly indicative of a low risk of nuisance dust impact. Jacobs further concluded that the recommended dust mitigations for the protection of human health and amenity are generally considered to be adequate for the protection of flora and fauna surrounding the mine site boundaries. The science behind this is uncertain, therefore it is considered still possible that dust emissions could impact on native flora due to stress and dieback. Research into dust deposition at J-A has not supported a definitive fatal effect on flora species, however some species such as the Pearl Bluebush has been affected by dust emissions from J-A. Visual observations have recorded smothering of plants and associated dieback, however, none of those plants have died, and many recover following rainfall and new leaf growth. These results have not been published.	**Design** Vegetation cleared in accordance with approval, with retention maximized Minimisation of open areas through staged clearing. **Control** Use of water carts on unpaved roads to minimise wheel-generated dust by haul trucks. Stabilisation of stockpiles using suppressant (enhancing surface crusting). Vehicle speed limits in accordance with TMP. Procedures for vegetation clearance and removal of soil profiles for stockpiling or direct return. Timing and management of clearance to minimise erosion. Revegetation of rehabilitated areas. **Management** Ongoing maintenance of haul roads. Dust and Air Quality Management Plan. Native Vegetation Management Plan. Mineral Stockpiles Management Plan. Rehabilitation Management Plan. Weather forecast and field suppression plans as part of the Dust and Air Quality Management Plan. Site induction inclusive of details on dust risks and management.	Research into dust deposition at J-A have provided credible, but so far unpublished results of non-fatal impacts on flora species including smothering of foliage with dust and associated dieback with recovery following rainfall.	N/A	The Tenement Holder must ensure that all clearance of native vegetation is authorised under appropriate legislation	**Construction and operation** Monitoring of vegetation health to be undertaken to measure: •plant mortality •new growth •evidence of flowering and fruiting •extent of smothering •evidence of saline stress.	None proposed
Air quality	C,O	AQ4	New	Atacama ML	Increase in emissions due to vehicle and machinery use cause a decrease in air quality impacting native flora and fauna.	Mine construction and operations Vehicle and machinery operation and idling.	Aeolian	Native flora and fauna	AQIA dispersion modelling assumptions are correct	N/A	No	The modelling assessment undertaken by Jacobs (2022c) showed that all predicted gaseous pollutant concentrations were well below respective air quality objectives. Vehicle emissions due to fuel combustion are not expected to occur at a level where there would be negative affects to flora or fauna, as guided by general descriptions in the Evaluation distance for effective air quality and noise management (EPA 2016). There is no S-P-R linkage.						
Air quality	C,O	AQ5	New	Atacama ML	Combustion of fossil fuels releases GHG to the atmosphere that contribute to GHG emissions impacting on the environment and the ability to achieve National and State greenhouse gas targets.	Vehicle and machinery operation and idling. Diesel generators – energy production	Aeolian	Australia State of South Australia	Emission estimates were provided for the production period, which spans the period 2024 to 2031; and the rehabilitation period, which spans the period 2032 to 2051, inclusive. Emission estimates include the additional processing required at the existing J-A facility Business as usual emissions for the J-A facility were not included in the assessment as data were not available. The estimate assumed that all electricity required for processing would be sourced from diesel generators. Scope 2 emissions have not been calculated. Cumulative impacts of other projects have not been considered in this assessment.	Low	Yes	Greenbase was engaged to prepare a GHG estimate over the life of the Atacama Project. The key inputs for estimating the GHG emissions from the Project are diesel combustion from the mining, ancillary and rehabilitation fleets, and electricity sourced from diesel generators. The total GHG emissions over the LOM, including rehabilitation, are projected as 636,479 tCO2-e, with annual emissions peaking at 66,601 tCO2-e in 2029 (Greenbase, 2022). This includes additional processing of Project ore at the existing J-A facility. This equates to average annual emissions of operations are anticipated to contribute emissions of around 23,000 t CO2-e per annum, resulting from diesel consumption, as a worst-case scenario. This would contribute 0.005% to Australian projected 'business as usual' greenhouse gas emissions of 656 million tonnes of carbon dioxide equivalent per annum (Mt CO2-e/annum) and 0.09% to South Australia's 'business as usual' 2020 greenhouse gas emissions of 25 Mt CO2-e/annum. These figures are based on a worst-case scenario and do not allow for the contribution of solar energy. Upon completion of construction, Atacama will be using solar power for some of the power demand supplied from the J-A power network. The existing solar farm located in the J-A lease will be upgraded, with an additional 1 MW generator, bringing the total potential capacity to 13 MW. Further, the existing 11 kV overhead line will be upgraded to a 33 kV overhead power line from the power station to the Ambrosia operation and extended 12 km, adjacent to the access road to MUP 1 and MUP 2. Whilst the amount of GHG emissions from the Project is minor compared to both the State and National total, the Project will still contribute. As such an S-P-R linkage is confirmed.	**Design** Reduce disturbance footprint that would otherwise be disturbed during land clearing. Incorporation of renewable energy electricity sources to replace diesel generated electricity. Use of emissions control equipment on fixed and mobile plant and equipment. **Management** Consideration of Iluka's emission offset strategy	N/A	N/A	The Tenement Holder will provide annual updates on GHG emissions	**Construction and operation** Annual reporting of operational emissions into the National Pollution Inventory (NPI) database and reporting under the National Greenhouse and Energy Reporting NGER (www.cleanenergyregulator.gov.au).	None proposed
Visual amenity	C,O	VA1	New	Atacama ML	The presence of mine infrastructure as well as mine construction and operation activities (including clearing, excavation of pits, stockpiling, dust generation and lighting) result in adverse impacts to visual amenity.	Mine operations and infrastructure	Line of sight	Visitors and staff of Yellabinna Regional Reserve Aboriginal people – members of FWCAC	Receptors are adequately consulted with thorough stakeholder engagement. There are no private landholders/ residents in 75 km radius or in Yellabinna Regional Reserve.	Low	Yes	The Project Area is remote and away from developed areas. The Project Area is isolated with the nearest town, the Yalata Aboriginal community, located approximately 75 km to the south. Ceduna, the closest large population centre is 290 km to the southeast of the Project Area (WSP, 2022). There are no residential or rural residential receptors in the vicinity, with the nearest residence at Yalata. The Project Area is not visible from public roads, and no new public roads are proposed to be constructed to facilitate the Atacama operation. No visual screening is proposed. There are no anticipated impacts to private landholders or public road users during construction and operation. Despite the above, the Project Area is within a Reserve and given the regional reserve status of the site, it is possible that in rare instances, there may be visitors to the broader area, including Aboriginal people and tourists/ visitors and staff of the Reserve. There may be impact to these users on rare occasion during construction and operation.	**Design** Design and siting of infrastructure to minimize impact. The MUP and roads will be aligned with pits and will disturb dune crests. All other infrastructure, stockpiles and disturbances will be limited to within the swales rather than the crests to the greatest extent practicable. The Project will maximise the use of services at J-A to minimize infrastructure required at the Project Area. Incorporation of progressive rehabilitation into the rehabilitation plan to the greatest extent practicable. **Control** Ongoing dust control during construction, operation and rehabilitation, implemented as discussed in Section 7.10. Staging of pit excavation and clearing of vegetation to minimise the disturbed area at any time during the operation phase. Progressive rehabilitation of the site will be undertaken during the life of the mine in accordance with rehabilitation plan. **Management** Implementation of Stockpile Management Plan. Implementation of Rehabilitation Management Plan.	Mine construction will be as per design. Rehabilitation activities are effective and in accordance with the rehabilitation plan.	Low	The tenement holder must ensure that the mining operations are conducted in accordance with the approved mine plan and that key stakeholders are engaged with throughout construction and operation.	**Construction and operation** Internal audit demonstrates that the mine infrastructure and layout are constructed in accordance with the approved mine plan.	None proposed
Visual amenity	CL	VA2	New	Atacama ML	The post mining landforms result in adverse impacts to visual amenity, within the context of the broader Reserve.	Rehabilitation and altered landforms	Line of sight	Visitors and staff of Yellabinna Regional Reserve Aboriginal people – members of FWCAC	Receptors are adequately consulted with thorough stakeholder engagement. There are no private landholders/ residents in 75 km radius or in Yellabinna Regional Reserve.	Low	Yes	It is possible that if not adequately designed and successfully implemented the post-mining landform and vegetation will have an impact on the visual amenity of the Project Area. The Project Area is in a Regional Reserve, managed by the Yumbarra Co-Management Board, a partnership between the FWCAC and the DEW. Members of the FWCAC can access areas on the tenement for cultural purposes, including hunting and gathering and the use of Atacama both during Operation and Post Closure may include occasional passing through. Although the area is remote from the existing Yellabinna Regional Reserve visitor facilities located at Mount Finke Campground, the Project Area is located within a regional reserve which is considered to have high natural and wilderness values. Access to the public will be allowed when rehabilitation is completed, and the lease is relinquished. The post closure landform may impact these users on rare occasion following completion of rehabilitation.	**Design** Design of final landform to be compatible with existing environment including all areas outside mine pits. Design of final landform to be developed in accordance with erosion and surface water assessment. Consultation with land managers and FWCAC on proposed post disturbance landform design. **Management** Implementation of rehabilitation plan during operations and post closure. Implementation of mine closure plan	Receptors are adequately consulted with through stakeholder engagement. There are no private landholders/ residents in 75 km radius or in Yellabinna Regional Reserve.	Low	The tenement holder must ensure that the reconstructed final landform is consistent with approved rehabilitation plan.	**Closure** Topographic survey of rehabilitated site compared with approved design (comparison of RLs).	N/A
Traffic	O	T1	Incremental	Transport corridor	Increased traffic accidents involving mining traffic due to an increase in duration (not vehicle movements) of the use of the existing traffic route for HMC transport.	Vehicle Movements	Transport of HMC along Eyre Highway and other publicly accessible roads	Other vehicles, members of the public, livestock	Refer to Change in Operations Application, attached as Appendix D.									
Traffic	O	T2	Incremental	Transport corridor	Increased traffic accidents involving mining traffic (persons) driving to the Project from the Far West Coast region.	Vehicle Movements	Transport (persons) along Eyre Highway and other publicly accessible roads.	Other vehicles, members of the public, livestock	Majority of the workforce will be FIFO; the DIDO workforce is expected to add around 20-40 vehicles on the road per day. The exact number of DIDO workers at this stage is unknown. The crash history on the current road route (J-A to Thevenard) is low.	Low	Yes	Mining for the Project is expected to last seven years, followed by three to four years of processing of stockpiled material (all processing to occur at J-A). The quantum and composition of this traffic is difficult to estimate, however it is reasonable to assume that (worst case) during this time 20-40 additional vehicles can reasonably be expected to be on public roads per day as a result of the Project (Hatch, 2022). The Traffic Impact Assessment by Hatch (2022) concluded that this additional transport is likely to have a negligible impact on the public road network. However unlikely the impact there remains an S-P-R linkage.	**Control** Policy to limit heavy vehicle travel after dark, speed controls around townships. **Management** Regular review, update and implementation of existing Traffic Management Plan for the operations to ensure that the Plan is current and fit for purpose throughout the proposed route use duration extension. The review must include, but not be limited to speed restrictions, access points, road inspections, sensitive receptors along the route. Implementation of an Emergency Response Plan and training. Maintain on-site emergency response team, including assets and equipment. Road maintenance. Training on traffic and incident management.	Existing systems and procedures Traffic Management Procedures for the J-A Operations exists and is fit for purpose for the extended duration of the route use and will be complied with.	Low	The Tenement Holder must demonstrate that during construction and operation, there are no traffic incidents resulting in public injury or death caused by the mining operations that could have been reasonably prevented.	**Operation** All traffic accidents/ near misses are recorded in the Iluka Incident Management System. All recorded traffic incidents are investigated within 14 days or other time period as agreed with the Director of Mines.	None proposed
Traffic	O	T3	Incremental	Transport corridor	Increased potential for amenity issues or complaints due to an increase in population size in the regional towns r elating to the transportation of HMC from the J-A ML.	Vehicle Movements	Transport of HMC along Eyre Highway and other publicly accessible roads	Other vehicles, members of the public, livestock	Refer to Change in Operations Application, attached as Appendix D.									
Traffic	O	T4	Incremental	Transport corridor	Increased potential for amenity issues or complaints due to an increase in duration of HMC transportation from the J-A ML.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Members of the public	Refer to Change in Operations Application, attached as Appendix D.									
Traffic	C	T5	Incremental	Transport corridor	Increased potential for amenity issues or complaints due to an increase in vehicle movements or change in type/ size of vehicles during the construction phase.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads.	Members of the public	Complaints received for the J-A operation relating to amenity issues for transport is low.	Low	Yes	During the construction phase (12 months) there will be an increase in vehicle movements along public roads to bring construction related items (SME, persons, modules and building supplies) to the Project Area. This will be approximately 400-450 trucks (average of nine trucks per week), 45 pieces of SME and 20-40 additional vehicle movements a day. During this time there is the potential for complaints to be raised by members of the public.	**Management** Development and implementation of a Traffic Management Plan for the Construction Phase of the Project Maintain Complaints and Corrective Action Register	All traffic related to the construction phase of the Project is assumed to comply with a Construction Environment Management Procedure/Plan for Traffic. It is assumed the Construction Environment Management Procedure/Plan for Traffic is fit for purpose.	Low	The Tenement Holder must demonstrate that during construction and operation all reasonable complaints raised by the public have been recorded and investigated.	**Construction** All complaints and feedback from public are recorded in the Iluka Incident Management System. All recorded complaints are investigated by the tenement holder, and where required, corrective actions are implemented to prevent recurrence or to minimise the future potential impact as far as reasonably practicable.	None proposed
Traffic	C	T6	Incremental	Transport corridor	Increased traffic accidents involving mining traffic due to an increase in vehicle movements and change in type and size of vehicle during the construction phase of the Project.	Vehicle Movements	Transport along Eyre Highway and other publicly accessible roads. Transport along haul road/s.	Other vehicles, members of the public	The crash history on the current road route (J-A to Thevenard) is low.	Low	Yes	See above. During this time there is the potential for accidents to occur as a result of construction traffic changes.	See T2	See T2	See T2	See T2	See T2 (for consstruction)	None proposed
Radiation	O, CL	R1	New	Atacama ML	Excavation and storage of ore generates naturally occurring radioactive material that impacts on the public.	Radioactive material in soils	Direct exposure – external gamma radiation Aeolian- dust, soil and radon inhalation Contaminated food consumption	Public	N/A	Low	No	The Project Area is within the Reserve and there are no sensitive public receivers in the vicinity. It is also highly unlikely that post closure land uses will include agricultural or production industries due to the nature of sandy soils (poor nutrient retention, poor water retention) in the Project Area, which has extremely limited cropping or pasture potential. The immediate surrounds are furthermore a conservation area. The ore material which will be temporarily stockpiled in the Project Area contains low levels of NORM which do not meet the definition of radioactive material as defined in the RPC Act. When radiation levels are below 1 Bq/g, material is considered to be non-radioactive. The ore will be moved to nearby J-A for further processing and refinement. Given the low levels of uranium and thorium within the ore, the temporary storage of material and the separation distances to members of the public, there is no S-P-R linkage.						
Radiation	O, CL	R2	New	Atacama ML	Excavation and storage of ore generates naturally occurring radioactive material, contaminating bushtucker that has biologically accumulated radionuclides, impacting on the health of Aboriginal people.	Residual radioactive material in soils	On site bush food consumption - ingestion	Aboriginal people	Model results based on assumptions: •All food consumed is sourced from the immediate area where the maximum radionuclide deposition has/will occur (conservative assumption). •All dust deposited by the storage of ore (and therefore radionuclides) are taken up by plants and animals. •Kangaroo and goanna used to estimate doses due to mean ingestion •Vegetation uptake values not available for Australian vegetation •Locally sourced bush tucker makes up 0.56% of a person's diet; based on ratio of combined J-A and Atacama mine lease to greater regional reserve footprint. •Assumed that all meat and vegetation sources have accumulated radionuclides to the same concentration. •Assumed that dust levels generated (and therefore radionuclide levels) are the same as the most impacted site at J-A	Low	No	Bush tucker assessments have been completed separately using the ERICA Tool and (RCA, 2022). Dose estimated to members of the public due to bush tucker consumption at 0.023 mSV/year, which is well below the public dose limit of 1 mSv/year, and comparable to the dose received from short haul domestic flights in Australia. Public doses are considered highly conservative, given that consumption of food from the local area is likely over estimated, and that it is unlikely that all food could be sourced from the areas that represent the greatest radiological impact. Members of the FWCAC are permitted to access areas on Iluka's tenements for cultural purposes, including hunting and gathering. The use of Atacama is likely to be limited to occasional passing through; as no significant cultural or hunting sites are close by and greater than a 24-hour residency by Aboriginal groups would be unusual (Joanne Lee, personal communication, 20 July 2022). No ore material will remain onsite upon completion of operation and as such the doses described above are the maximum that would occur during operations, with doses decreasing during rehabilitation and into closure. There is no S-P-R linkage.						
Radiation	O	R3	New	Atacama ML	Excavation and storage of ore generates naturally occurring radioactive materials in dust emissions that reduce vegetation health, impacting on the abundance and/ or diversity of native flora and fauna.	Emissions	Aeolian- dust deposition, soil and radon inhalation	Flora and Fauna	Limited published data regarding the effects of radiation on non-human biota. Model results based on conservative assumptions: •Doses considered in the model are maximum doses at end of operations. •Timeframe includes mining of material for a 6.5-year period followed by processing of stockpiled material for up to a further 4 years. •The ore material contains significantly lower radionuclide concentrations than HMC (which is stored at J-A), therefore significantly greater quantities would need to be released to equal the doses observed at J-A. •To be conservative the ERICA Tool has assumed that dust generated (and therefore radionuclide release) at Atacama is twice that of the most effected dust deposition site at J-A, which would be an approximate uranium and thorium concentration of 31 ppm and 63 ppm respectively. •User defined animals and plants were selected based on availability of Australian data; the species used to determine doses to humans from bush tucker ingestion; and species of interest to the Atacama Project (threatened species identified under the EPBC Act).	Low	No	The Atacama soil material contains considerably lower radionuclide concentrations than HMC (0.26 Bq/g Th232 and 0.39 Bq/g U238 in ore based on assays conducted by Iluka, compared to up to 1.93 Bq/g Th232 and up to 2.78 Bq/g U238 in HMC). So considerably larger quantities need to be released into the environment to give rise to doses greater than or equal to the doses that have been estimated at the J-A site (RCA, 2022). An ERICA Tool was performed based on doses to reference and user defined animals and plants within the Atacama Project Area after 10.5 years operation (6.5 years mining and 4 years further processing of stockpiled material). No RAP or user defined animal or plant received a dose of above the screening dose rate of 10 µGy/h apart from Lichen and Bryophytes (measured at 10.18 µGy/h). Lichens and Bryophytes are unlikely to be present in the Project Area and have low radio-sensitivity. Given that the results of the ERICA demonstrate that the threshold for an impact to occur (10 µGy/h) has not been met except for Lichen and Bryophytes and that these results are very conservative given they are allowing for radionuclide results based off concentrations double that observed at J-A , it is considered that there is no S-P-R linkage.						
Soil and land quality	C,O	SL1	New	Atacama ML	Land clearance results in loss of topsoil and subsoil, impacting on quantity available for rehabilitation.	Earthmoving equipment and plant	Excavation – stripping topsoil and vegetation clearing	Soils Final landform/ rehabilitation	It is assumed that staged clearing and excavation will occur. It is assumed that some topsoil will be lost during land clearance.	Low	Yes	To enable the construction of the Project approximately 2,057 ha of native vegetation is proposed to be cleared within the Project Area. The clearing of vegetation will result in the stripping of topsoil and subsoil and there is the potential for loss of topsoil during stripping in the absence of controls and management strategies, resulting in reduced topsoil and subsoil stockpiles. An S-P-R linkage is confirmed.	**Design** All vegetation clearance restricted to approved footprint. **Control** Prohibiting topsoil and subsoil (if other than brown loam) stripping when winds exceed 20 km/h. Vegetation clearance will be staged and progressive rehabilitation will be undertaken. Restricting access to stockpiles. **Management** Implementation of a Dust & Air Quality Management Plan. Implementation of a Minerals Stockpile Management Plan. Implementation of a Native Vegetation Management Plan. Implementation of a Rehabilitation Management Plan. Land clearance undertaken in accordance with Approvals.	N/A	Low	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use .	**Construction and operation** Annual soil balance completed from year 1 of vegetation clearance / stockpiling and a soils balance and inventory is subject to annual documented reconciliation and audit.	None proposed

Environmental element	Project phase	Impact ID	Type of impact	Area	Potential impact event	Source	Pathway	Receptor	Uncertainties and assumptions	Sensitivity to change (in assumptions)	S-P-R linkage?	Justification for the confirmation/ non-confirmation of an SPR linkage	Control measures and management strategies	Uncertainties and assumptions2	Sensitivity to change (in assumptions)2	Proposed outcome	Draft outcome measurement criteria	Draft leading indicator
Soil and land quality	C,O,CL	SL2	New	Atacama ML	Inappropriate management of excavated topsoil, subsoil and overburden results in unsuitable reconstructed soil profile that impacts rehabilitation vegetation growth and survival.	Excavation, stockpiling and reinstatement of topsoil, subsoil and overburden	Changes in soil chemistry and composition	Soils Final landform/ rehabilitation	Uncertainty around reactivity of soils and permeability of stockpiles.	Low	Yes	The excavation of soils will occur as part of the Project. These soils will be stored in separate stockpiles. Incorrect stockpile management practices may impact soil and land and consequently rehabilitation success. **Soil chemistry** CDM Smith (2022b) identify that the pH of the root zone of vegetation must be neutral or alkaline. The lower soil profiles may be acidic, and topsoils are neutral to alkaline. The placement of hard setting dispersive red loams at the surface may affect water infiltration in the root zone and negatively impact success of rehabilitation. Incorrect soil storage may impact the soil function. **Increased weeds in viable soil** Stockpiling and mixing of soils have the potential to affect viable native vegetation seed stocks through introduction of weed seeds, which typically grow faster and larger than native vegetation, reducing soil capacity. The removal, storage and replacement of soil layers will have to be managed appropriately to ensure that upon rehabilitation and successful plant growth is not adversely impacted. This linkage is heavily reliant on the implementation of mitigation measures and controls and as such an S-P-R linkage is confirmed.	**Design** Sequencing of overburden replacement to support selected landscape function and use. Topsoil types will be mapped and categorised for future use and mine closure planning. Topsoil and subsoil will be stockpiled separately to avoid working areas, areas of natural drainage and access tracks. If practical, topsoil will be directly returned to site rehabilitation works. **Control** Natural regeneration of vegetation cover on topsoil/subsoil stockpiles. Restricting access to stockpiles. **Management** Implementation of a Native Vegetation Management Plan. Implementation of a Dust & Air Quality Management Plan. Implementation of a Minerals Stockpile Management Plan. Implementation of a Rehabilitation Management Plan. Soil water and salt movement modelling undertaken in reconstructed soil profiles. Document the location and type of soils in each stockpile. Undertake survey scanning monitoring of topsoil and subsoil stockpiles for erosion, vegetation cover, weeds. Loams, soils and timber stockpiles to be included in annual soil balance and overburden inventories. Research program to clarify unknown characteristics of soils and vegetation.	N/A	Low	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use.	**Construction and operation** Annual soil balance completed from year 1 of vegetation clearance / stockpiling and a soils balance and inventory is subject to annual documented reconciliation and audit. **Closure** Landscape Function Analysis (over a minimum of five years after the completion of rehabilitation) to show that the BSC profile (minimum age class 2) and function has been restored. As described in Field guide for landscape function analysis for environmental monitoring and assessment, Minerals Regulatory Guideline 21 (MG 21) (DMITRE 2013).	None proposed
Soil and land quality	O, CL	SL3	New	Atacama ML	Erosion and loss of stockpiled topsoil, subsoil and overburden from fluvial and aeolian transport, results in loss of available material for rehabilitation and impacts water quality.	Soil stockpiling	Fluvial – rainfall runoff and mobilisation of soil Aeolian migration of small particles from stockpiles and deposition elsewhere	Soils Watercourses	N/A	Low	Yes	Soil stockpiled across the Project Area has the potential for water and wind erosion. Soil analysis undertaken by CDM Smith (2022b) shows the pedogenic clay and loams to be highly sodic and most samples analysed were dispersive. These materials will slake upon exposure to water and raindrop impact. Slaking is the process of soil collapse caused by the escape of entrapped air within the soil on immersion in water, which is similar to raindrop impact. Dispersion is the separation of soil aggregates and the movement of the clay fraction into suspension in water. Without the implementation of controls there is likely to be a significant loss of soil resources. As such an S-P-R linkage is confirmed.	**Design** Minimise potential erosion impacts through staged clearing and progressive rehabilitation where possible **Control** Restricting access to stockpiles Prohibiting topsoil and subsoil stripping when winds exceed defined threshold (note that the threshold will be defined in the relevant management plan) Surface water management infrastructure is designed to reduce loss of topsoil and subsoil through erosion and sedimentation for mine operational stockpiles and borrow pit stockpiles. Erosion and sediment control measures including vegetation cover or chemical application to minimise erosion Bunding around stockpiles to contain sediment migration from rain events Regular inspections and maintenance of sediment and erosion control devices during operations Natural regeneration of vegetation cover on topsoil/subsoil stockpiles **Management** Implementation of Erosion and Sediment Control Plan Implementation of Native Vegetation Management Plan Implementation of Rehabilitation Management Plan Implementation of the Dust and Air Quality Management Implementation of the Surface Water Management Plan Implementation of a stockpile monitoring program	N/A	Low	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use.	**Operation** Annual soil balance completed from year 1 of vegetation clearance / stockpiling and a soils balance and inventory is subject to annual documented reconciliation and audit. **Closure** Landscape Function Analysis (over a minimum of five years after the completion of rehabilitation) to show that the BSC profile (minimum age class 2) and function has been restored. As described in Field guide for landscape function analysis for environmental monitoring and assessment, Minerals Regulatory Guideline 21 (MG 21) (DMITRE 2013).	Regular erosion and sediment controls inspection records indicate that surface water management infrastructure has been implemented and maintained for topsoil, subsoil and overburden stockpiles. Inspection within 24 hours of >10mm/12hr rainfall events as recorded in onsite rainfall gauge, indicate no additional evidence of increased erosion or sedimentation
Soil and land quality	O	SL4	New	Atacama ML	Erosion of, and mismanagement of stockpiled acidic material, results in contamination of soils and reduction in soil quality.	Excavation, stockpiling and reinstatement of overburden	Changes in soil chemistry. Pyrite in soil oxidizes on exposure to Oxygen. Sulphuric acid generated	Soils Native flora and fauna	While there is evidence of AASS within two of the three boreholes tested in the Marine Sands, further testing including acid-base accounting (acid neutralisation capacity to maximum potential acidity ratio (ANC:MPA) which defines the net acid production potential (NAPP) found the Marine sands to be potentially non-acid forming. As such further test work is required to understand the potential for further acid generation of this material, and how widespread it is within the sands. The Acid base accounting result (ANC: MPA) for Marine sands is limited to one borehole sample. The current conceptualisation is that PAF material for high acid forming potential are located below the ore body and will not be mined. The AASS encountered within the Marine sands is not widespread and does not have high acid forming potential. This will be confirmed via further test work.	High	Uncertain	EMM (2022b) undertook a geochemical assessment of the lithologies in the Project Area based on the three boreholes drilled for groundwater baseline. They found that in all three boreholes the lignite and saprolite layers (i.e., those underneath the orebody) were either PASS or AASS, so a type of ASS. In ATMW02 and ATMW03 near the bottom of the Marine sands layer some samples were found to be AASS, meaning that some level of oxidisation has occurred on these samples, but that does not preclude their ability to generate further acidity. Acid-base accounting of the samples was also undertaken by EMM (2022b), which estimates the potential for the material to produce and also neutralise acid. The sands tested were from ATMW01 and found to be potentially non-acid forming. Whereas the lignite tested from ATMW01 and ATMW03 were found to be PAF. Noting that the PAF material is below the orebody and will not be mined. Whilst the above information seems to infer that the Marine sands are unlikely to generate acid, this result is limited to one borehole and therefore there is uncertainty around the S-P-R linkage	**Management** Amend the current J-A Soil Management Plan Undertake further geochemical analysis of Marine sands to quantify ASS risk.	AASS present in Marine sands in testing of two of three boreholes. Marine sands are potentially non-acid forming. PAF is evident in the Lignite layer which will not be mined.	High	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use.	**Operation** Annual mine records demonstrate all areas of acid sulphate encountered were appropriately managed.	None proposed
Soil and land quality	C,O,CL	SL5	New	Atacama ML	Long term stockpiling results in a loss of seedstock reducing ecological viability of top and subsoils impacting on rehabilitation	Soil stockpiling (Wet topsoil stockpiles and long topsoil stockpile time)	Changes in soil composition - Seeds rotting, aging	Final landform / rehabilitation	Time is a factor in the viability of the seedbank in the stockpiles; the length of time to seed degradation is an uncertainty. Moisture levels in the soil is a factor in the viability of the seedbank in the stockpiles. The impact of a changing climate on the seedbank, e.g., to a more wet or more arid environment, is an uncertainty.	Medium	Yes	When not directly returned, soil that is stripped as part of mining activities will be stockpiled during operations for later use in rehabilitation activities. The length of time between soil stockpiling and final reinstatement of the topsoil and subsoil profile will vary. Rehabilitation will take over 10 years to complete, and as such there is the potential that some of the soil stockpiles could remain in place in excess of 10 years. It is possible that the ecological viability of seed and microorganisms present within the topsoil and subsoil profiles may be diminished by the stockpiling process, or if stored for long periods of time, this could consequently impact on rehabilitation success (Golos and Dixon 2014). Current soil nutrient status is low and the ability of topsoil to store and retain nutrients is also low, with the organic matter held in the topsoil likely playing a key role in supporting the nutritional needs of the existing vegetation cover. Maintenance of this organic matter within the stockpiled topsoil's should be a priority for the rehabilitation program (CDM Smith, 2022b). Without the implementation of control and management strategies, it is possible there will be an impact on the ecological viability of soils that are stockpiled which could have a significant effect on ecosystem function of rehabilitated areas within the disturbance footprint. An S-P-R linkage is confirmed.	**Design** Progressive rehabilitation of disturbed area, commencing within first few years of operations, where possible Operate stockpile returns in a first out – first replaced system wherever possible **Control** Ensure, when establishing stockpiles that just enough moisture for erosion and sediment control processes-not excessive moisture added Collect seedstock from alternate locations over the life of the mine Topsoil and subsoil stockpiled to a maximum of 2 m and 4 m in height respectively, to preserve seed stock and micro-organism function Use of temporary sediment and erosion controls (e.g. mobile booms) if required Implement procedures for stockpiling and stockpile maintenance Direct return of topsoil and subsoil where possible Restricting access to stockpiles Direct seeding of rehabilitated areas Undertake survey scanning monitoring of topsoil and subsoil stockpiles for erosion, vegetation cover, weeds Undertake weed management on stockpiles **Management** Implementation of a rehabilitation management plan Implementation of the Stockpile Management Plan (currently used at J-A)	Stability of topsoil and subsoil stockpiles. Stability of rehabilitated soil surface. Seed longevity beyond previously examined 17 months. Microorganism availability in long-term (> 5 years) stockpiles"	Medium	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use.	**Construction and Operation** Annual soil balance completed from year 1 of vegetation clearance / stockpiling and a soils balance and inventory is subject to annual documented reconciliation and audit. **Closure** Landscape Function Analysis (over a minimum of five years after the completion of rehabilitation) to show that the BSC profile (minimum age class 2) and function has been restored. As described in Field guide for landscape function analysis for environmental monitoring and assessment, Minerals Regulatory Guideline 21 (MG 21) (DMITRE 2013).	None proposed
Soil and land quality	CL	SL6	New	Atacama ML	Hypersaline water use (dust suppression) results in contamination of soil materials	Mine operations – dust suppression	Hypersaline water seepage into soils	Soils Native vegetation	The response of dunal vegetation in the Project Area to increased salinity is uncertain	Medium	Yes	Surface soils have a low salinity (ECe < 2,000 µS/cm). Moderate salinities (2,000–4,000 µS/cm) are encountered within the carbonates and pedogenic clays. Salinities then decline with depth within the Pidinga loams and sands. This trend matches soil texture (CDM Smith, 2022b). Hypersaline water will be stored onsite for use in dust suppression management methods for the Project (as already occurs at J-A). It is possible that soils with the Project Area could become salinized through uncontrolled releases or inappropriate/ excessive application of hypersaline water. This could impact plant growth. An S-P-R linkage is confirmed.	**Management** Sample soil salt concentrations in areas required for dust suppression and remove salt contaminated soils prior to rehabilitation Implementation of Surface Water Management Plan which includes regular inspections of surface water drainage systems.	Depth of salinity in soils where hypersaline water used for dust suppression.	Medium	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use.	**Closure** Analysis of soil salinity (ECe) at soil test hole drilling within in-pit rehabilitated areas demonstrates no salinisation of rehabilitated soil profile compared to baseline. .	None proposed
Soil and land quality	CL	SL7	New	Atacama ML	Final rehabilitated landform(s) has high levels of erosion resulting in soil loss	Final landform	Fluvial and aeolian	Soils Native vegetation	It is expected that lessons learnt from over 10 years of operation at nearby J-A can assist with management methods.	Low	Yes	The characteristics of the soils indicate that they can be erosive when the surface crust is disturbed. After rehabilitation replaced topsoil will not have a strong surface crust initially without the implementation of control and management strategies this could result in a significant loss of soil resources while the crust is forming. In term this erosion could lead to unsuccessful rehabilitation outcomes for the final landform(s). An S-P-R linkage is therefore confirmed	**Design** Staging of pit excavation and clearing of vegetation to minimise the disturbed area at any time during the operation phase. Progressive rehabilitation of the site will be undertaken during the life of the mine in accordance with rehabilitation plan. **Control** Ongoing dust control during construction, operation and rehabilitation, implemented as discussed in Section 7.10. Rehabilitated areas ripped on the contour to increase surface roughness and slow wind speed at ground level. Replacement of vegetation debris to reduce wind and water erosion **Management** Implementation of a Native Vegetation Management Plan. Implementation of a Minerals Stockpile Management Plan. Implementation of a Rehabilitation Management Plan. Implementation of Erosion and Sediment Control Plan. Erosion modelling of final landform design.	Rehabilitation activities are effective and in accordance with the rehabilitation plan .	Low	The Tenement Holder must ensure that the soil function is capable of supporting the agreed land use.	**Closure** Landscape Function Analysis (over a minimum of five years after the completion of rehabilitation) to show that the BSC profile (minimum age class 2) and function has been restored. As described in Field guide for landscape function analysis for environmental monitoring and assessment, Minerals Regulatory Guideline 21 (MG 21) (DMITRE 2013).	**Closure** Prior to closure dust deposition monitoring for 12 months demonstrates that fugitive dust emissions from the rehabilitated landscape is consistent with control sites. [Prior to closure dust gauge sites will be established at agreed locations with DEM].