Verdant Minerals Ltd

Ammaroo Phosphate Project
Draft Environmental Impact Statement

October 2017

Executive summary

Introduction

Verdant Minerals Limited (VRM) proposes to develop the Ammaroo phosphate project (the project), which is the largest JORC compliant phosphate rock resource in Australia and one of the largest undeveloped phosphate rock resources in the world. Phosphate (P) is one of the three essential nutrients for plant growth, along with Nitrogen (N) and Potassium (K) and is a key input into the global fertiliser value chain that is critical in ensuring global food security.

The proposed project and the subject of this draft Environmental Impact Statement (draft EIS) is the initial development of the Ammaroo Phosphate project to produce up to 2 million tonnes per annum (Mtpa) of 32% P_2O_5 phosphate rock concentrate for export to Asian markets through the Port of Darwin. A bankable feasibility study is currently underway and is expected to be completed in the first quarter of 2018.

The project is located in the western Georgina Basin, approximately 220 kilometres (km) southeast of Tennant Creek, 125 km east of Barrow Creek and 270 km northeast of Alice Springs (Figure E-1) in the Northern Territory (NT) of Australia.

The project is in remote, arid and sparsely populated country, characterised by large pastoral leases including Ammaroo, Murray Downs, Elkedra and Neutral Junction Stations, and a number of small Aboriginal communities and homelands. The project area is located on the Ammaroo pastoral lease and a proposed rail corridor will transverse the Murray Downs pastoral lease and a portion of the Neutral Junction pastoral lease. The Kaytetye Alyawarr Awenyerraperte Ingkerr-wenh Aboriginal Corporation are the registered Native Title Party for the project area. Populations in the project area (Figure E-2) are serviced by regional centres including Tennant Creek, Ti Tree and Alice Springs.

The project will comprise:

- Open-cut mining of the shallow phosphate deposits
- Beneficiation and production of phosphate rock concentrate
- Transport of phosphate rock concentrate via rail to the Port of Darwin and on to international markets.

This draft EIS is submitted to the Northern Territory Environment Protection Authority for assessment under the Northern Territory *Environmental Assessment Act* and the Australian Government Department of Environment and Energy for assessment under the *Environment Protection Biodiversity Conservation Act*.

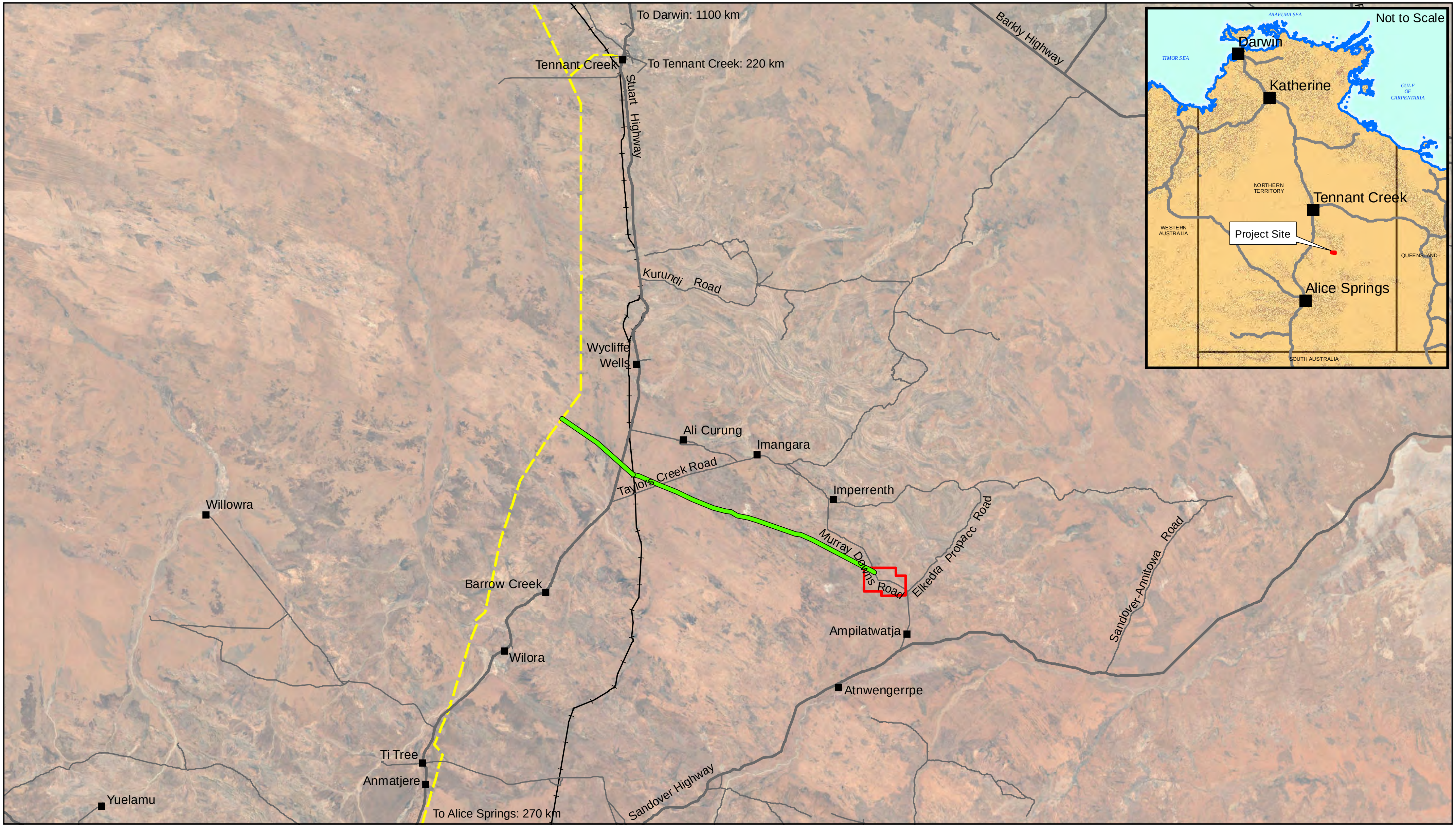
The Ammaroo resource

The main Ammaroo resource was discovered in 2010, and has expanded progressively through infill and extension drilling campaigns over the ensuing years. The most recent independent JORC estimate was announced in March 2017. The total resources including Measured, Indicated and Inferred is 1.141 billion tonnes P_2O_5 at an average grade of 14% P_2O_5 using a 10% cut-off; and the Indicated plus Measured resource, which is the subject of this study, is 301 Mt at 15.5% P_2O_5.

Environmental assessment process

The Notice of Intent (NOI) for the project was lodged on 29 April 2014 for consideration under the *Environmental Assessment Act (*EA Act). On 12 June 2014, the NT EPA decided that the project required assessment under the EA Act at the level of an Environmental Impact

Statement (EIS). VRM also submitted a referral (EPBC 2014/7260) to the Federal Minister for the Environment. In August 2014, the delegate of the Minister determined the project to be a controlled action and that assessment by preliminary documentation would be required at a Federal level under the *Environment Protection and Biodiversity Conservations Act 1999* (EPBC Act).



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0 20 40 60 80

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Major road
- Local road
- Rail
- Amadeus gas pipeline
- Access corridor
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
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Date	06 Oct 2017

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Location

Figure E-1

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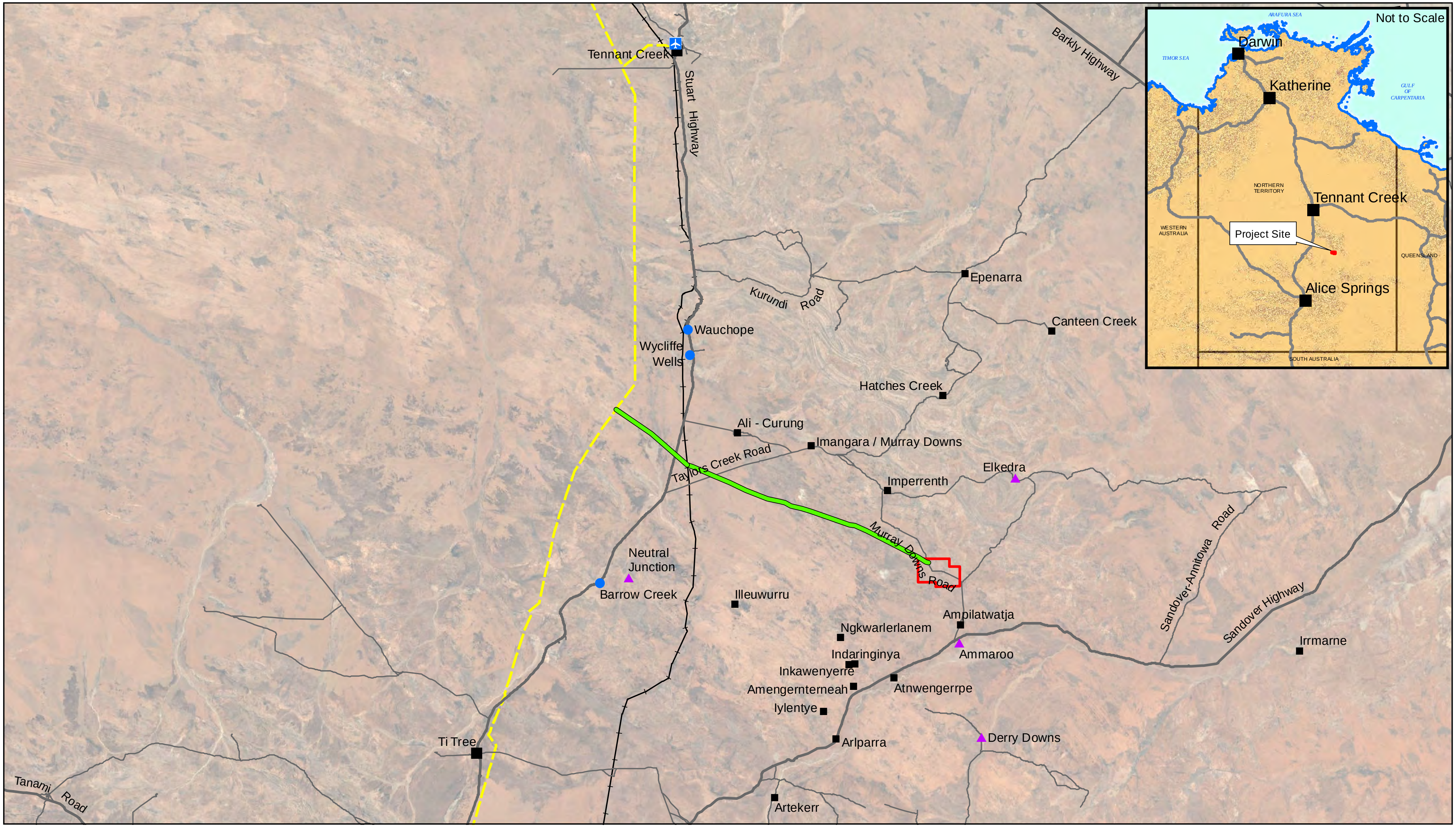
Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM



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0 20 40 60 80

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Airport
- Towns
- Communities
- Homesteads
- Roadhouses
- Major road
- Local road
- Rail
- Amadeus gas pipeline
- Access corridor
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

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Community context

Figure E-2

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

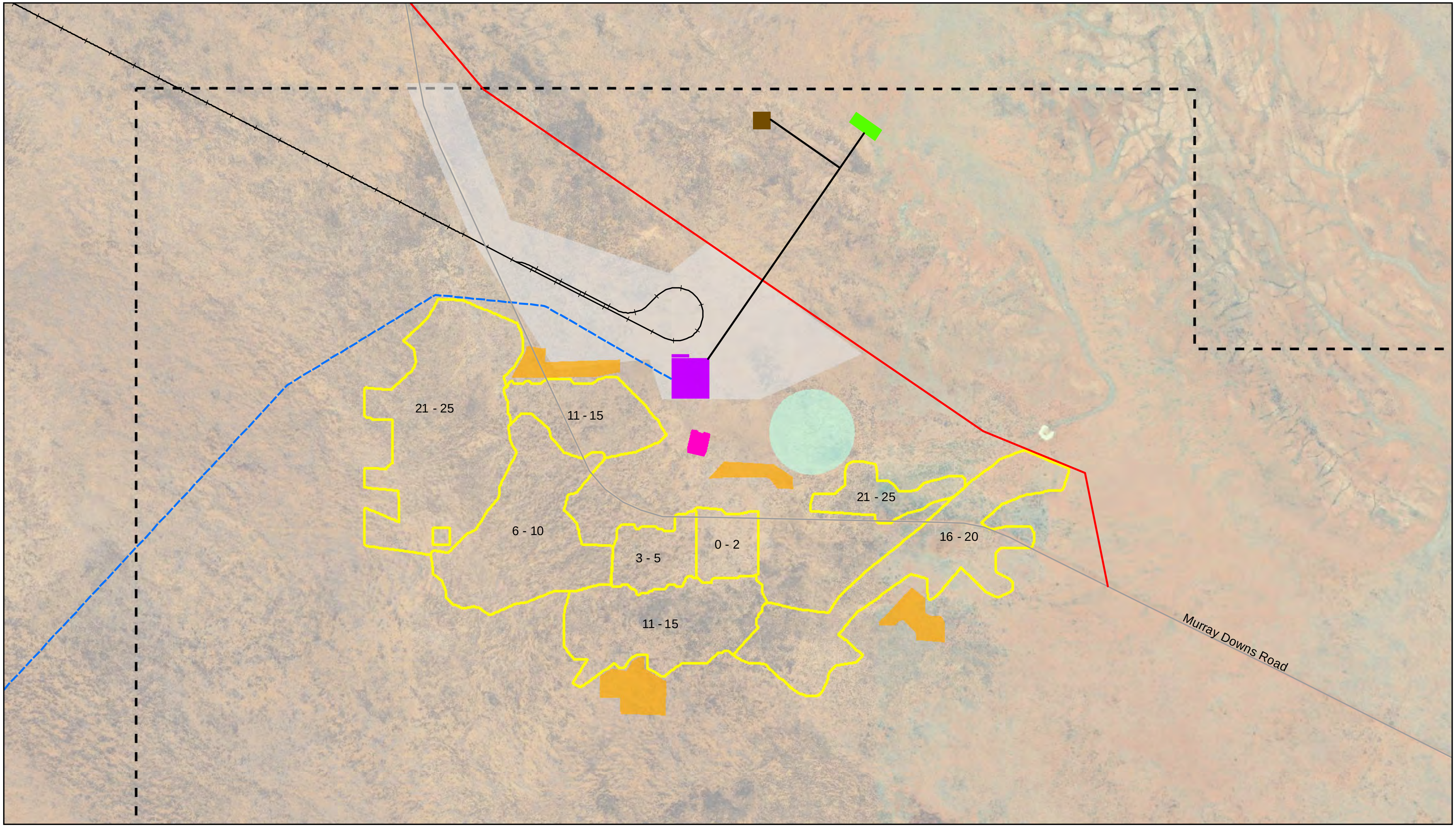
Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM

Project description

The project comprises the mine site and processing plant (Figure E-3), infrastructure corridor (Figure E-4) and supporting infrastructure such as roads, a power station and accommodation village. Key project components are summarised in Table E-1.

Table E-1 Project key components

Element	Characteristics
Project Life	
Construction period	2 years
Operational period	25 years, operating 24 hours every day
Production Estimates	
Ore	115 Mt over LOM
Overburden	322 Mt over LOM
Tailings	69 Mt over LOM
Plant feed	Average 2.5 Mtpa in years 1-5, 5 Mtpa in years 6-25
Production	1 Mtpa in years 1-5 , 2 Mtpa in years 6-25, 45 Mt over LOM
Mine site	
Mine staging	Designed to produce 1 Mtpa of phosphate concentrate ore through years 1 to 5, and 2 Mtpa of phosphate concentrate through years 6 to 25
Pit	Pits will be excavated to average depth of 23 metres, with a total surface area of approximately 1500 Ha over LOM
Materials handling	Open cut strip mining using truck and shovel operations to remove overburden and transport ROM ore to the beneficiation plant
Waste	Removal of overburden and temporary storage in waste dumps and subsequent placement in completed pits as part of a continuous rehabilitation process
Tailings Storage Facility	Surface tailings storage facility for an initial 3 year period and then in-pit tailings deposition once depleted pits are available for tailings disposal
Process plant	Crushing, conveying, screening, flotation, filtration systems required to beneficiate the ore from the pits into a concentrate rock for export
Finished product	Finished product storage and handling infrastructure to support loading of rail wagons
Infrastructure corridor	
Rail spur	105 km rail spur, connecting the process plant to the main Adelaide to Darwin railway line
Gas pipeline	137 km low pressure, carbon fibre, natural gas supply pipeline from the Amadeus Gas Pipeline to the site to provide gas
Borrow materials	An estimated 1.9 Mt of borrow materials (incl. ballast, substructure and base materials) will be sourced for construction of the infrastructure corridor
Other infrastructure and facilities	
Power	Installed capacity of approximately 24 MW, supplying an average load of 16 MW/hr for 2 Mtpa production from year 6 onwards. the power plant will comprise multiple high efficiency gas engines.
Borefield	The bore field will comprise three high flowing water bores equally spaced over 1.5-2.0 km run. The maximum raw water demand for 1 Mtpa phosphate rock concentrate production is approximately 220 m^3/hr and approximately 440 m^3/hr for 2 Mtpa
Workforce	
Construction	Peak of 300 direct jobs
Operations	165 direct jobs when the project is producing 2 Mtpa i.e. from year 6 onwards



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0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Existing roads
- Road realignment
- Access road
- Water supply pipeline
- Access corridor
- Accommodation camp
- Landfill
- ROM
- Mineral lease
- Pit extent (years)
- Construction area
- Beneficiation plant
- Surface tailings storage facility
- Temporary waste stockpiles

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Mine site general arrangement **Figure E-3**

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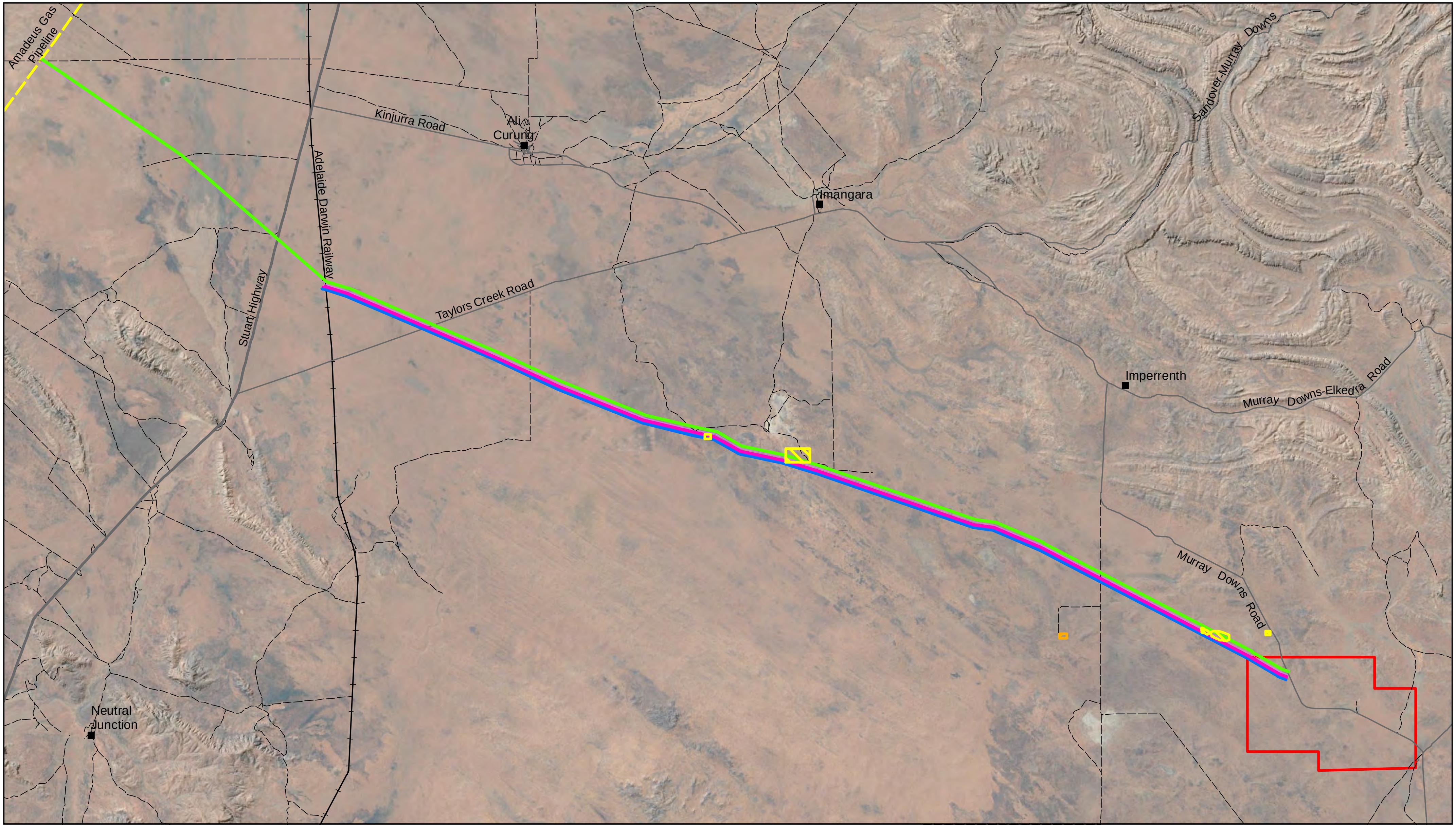
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 16/08/2017). VML - Proposed Corridor, Project Site, Pit Footprint (2017). Created by: CM



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0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and Communities
- 137 km natural gas supply pipeline
- Rail maintenance track
- 105 km rail spur
- Major Road
- Local Road
- Tracks
- Amadeus gas pipeline
- Rail
- Mineral lease
- Ballast Quarry
- Borrow Pit

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Ammaroo Phosphate Project

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Infrastructure corridor

Figure E-4

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 19/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM

Risk assessment framework

The EIS has been undertaken with a specific emphasis on identifying, analysing and mitigating the project's potential environmental risks. The risk assessment approach provides a framework for identifying components of the project with the potential for greater environmental risk and highlights project specific control measures to minimise or mitigate the likelihood and consequence of these identified risks.

A risk register was established to document the findings of the risk assessment process. The risk register contains details of impact pathways, consequences, planned controls, additional controls, and the residual risk rating. The environmental risk assessment identified 101 risk events. Nine of these events were identified to have positive socio-economic impacts.

Throughout this document, the term environment includes the natural, cultural, physical and social characteristics of the environment.

Surface water

The project is located within the Diamantina-Georgina Rivers Basin. Water courses in the project area and its surrounds are ephemeral. Intense rainfall events can result in short-term flooding across the region. The mine site contains no water courses, although a drainage floor is present within the north east of the mine site. This drainage floor has been dammed for pastoral purposes and is known as Woody's Dam.

It is expected that the flood protection berms will be implemented as required as the mine progresses.

The construction of a low set rail spur in the infrastructure corridor may affect upstream and downstream flood depths and extents. To prevent the railway embankment acting as a type of levee bank, appropriately sized culverts will be used. These will be located and installed to manage potential, temporary surface flows during major rain events. Scour protection will be installed where required to minimise any possible localised erosion and scouring in the immediate vicinity of the culverts.

Given the ephemeral nature of watercourses in the region, there are limited users of surface water resources. Local flora are either capable of surviving extended periods of drought or may be able to access perched water tables.

Groundwater

The project is located within the southern Georgina Basin, whose carbonate aquifer is the target water supply for the mine borefield. Aquifer testing at the borefield site indicates that the aquifer has the capacity to support well yields of over 75 L/s.

There are no wetlands or large Eucalypts that may indicate the presence of groundwater dependent ecosystems (GDEs) within the project site or in the surrounding area.

Groundwater from the Georgina Basin carbonate aquifer is used for community water supplies, station water supplies and for stock watering. The closest external bore is Hagen's Bore (used for stock), 15 km south east of the bore field, followed by the Ampilatwatja community bores, approximately 22 km south east.

A conservative estimate of the project's maximum use of ground water resources includes 876 ML total during construction, and 4.4 GL pa, or 110 GL total during operations. Water demand is expected to be considerably lower as a result of process water recycling, which is being studied through detailed engineering design, in the ongoing bankable feasibility study.

It is unlikely that significant drawdown (i.e. more than 3 m over the life of mine) will result at the closest bores due to groundwater extraction. The groundwater model further concludes that there is little measurable drawdown expected at any station homesteads or communities. Predicted drawdown at the Western Davenport Water Catchment District (WDWCD) boundary at the completion of mining is less than 1 m. The extraction therefore has no significant implications for existing users.

VRM has established an environmental management framework to ensure that groundwater values are protected; including annual model recalibration based on groundwater monitoring from seven monitoring bores.

Additionally, the mine pit remains above the water table and no impacts to groundwater from excavation are anticipated. Based on the geochemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is very low and the material can be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste. Overburden is suitable for management in unlined monofil waste rock dumps, with normal sediment and erosion control, and monitoring of key metals and metalloids noted as being elevated based on geochemical assessment.

Biodiversity

The region surrounding the project site includes only one potential sensitive vegetation type, riparian vegetation; however habitat survey concluded that no riparian vegetation or wetland habitat occurs within the project site. Flora survey recorded a total of 348 flora species, none of which are listed, threatened species under the EPBC Act and/or TPWC Act.

Thirteen introduced flora species were identified, one (*Calotropis procera*) of which is listed under the Weed Management Act as a Class B species.

A total of 133 fauna species were recorded within and surrounding the project site, comprising 29 reptiles, 86 birds and 18 mammals. Of these:

- None are threatened species under the EPBC Act and/or TPWC Act
- Two are migratory species under the EPBC Act
- None are endemic species

No threatened fauna species were recorded within the project site, but the Grey Falcon is considered likely to occur.

Five introduced fauna species were recorded, including cats (*Felis catus*), rabbits (*Oryctolagus cuniculus*), house mice (*Mus musculus*), foxes (*Vulpes vulpes*) and cattle (*Bos taurus*).

The potential direct and indirect impacts on flora, vegetation and fauna presented by the project and their residual risk level are outlined below.

Table E-2 Potential biodiversity impacts and residual risk level

Potential event	Residual risk level
Vegetation clearing	High
Edge effect	Low
Fragmentation of habitat	Medium
Weeds	Medium
Bushfire	Medium
Feral fauna - increase in resource competition and/or predation of native fauna	Low
Machinery and vehicles striking fauna	Medium
Soil erosion	Low
Hydrological changes to surface water	Low
Hydrological changes to groundwater	Low
Accidental tailings release	Low
Accidental chemical/hazardous material release	Low
Noise	Low
Dust	Low
Rehabilitation	Low
Fauna interaction with Tailings Storage Facility	Low
Discharge or seepage of poor quality water from mine infrastructure	Low

VRM has established an environmental management framework to ensure that biodiversity values are protected through the life of the project. The actions that will be implemented to avoid, control and/or minimise impacts on biodiversity values are contained in the following sub-plans:

- Biodiversity
- Hazardous materials
- Waste
- Weeds
- Bushfire
- Water
- Dust
- Mine Closure

Protected matters under the EPBC Act

Targeted EPBC-listed threatened species surveys were carried out, targeting those species likely to occur in the project area i.e. the Greater Bilby (Vulnerable) and the Great Desert Skink (Vulnerable).

Although Greater Bilby signs were not identified during the tracking surveys, it is possible that desert sandplains in the western half of the access corridor could be periodically utilised by the species. However, the lack of evidence supporting the presence of the species indicates a low likelihood that Greater Bilby occupy this area.

The mineral lease areas, water supply infrastructure and the section of access corridor east of the Stuart Highway are not considered suitable to support a population of Great Desert Skink. The likelihood of the species occurring is very low. A low likelihood of occurrence exists in small area of the western end of the access corridor, flanking the edges of the Taylor Creek floodplains.

The Rainbow Bee-eater and Glossy Ibis, which are migratory species listed under bilateral international conventions, do occur within the project area. The Rainbow Bee-eater is common and widespread, so habitats within the project area are unlikely to be considered ‘important habitat’, and the birds that occur there are unlikely to be an ‘ecologically significant population’ (in accordance with the EPBC Act).

The Glossy Ibis (*Plegadis falcinellus*) is a wetland species and generally found in wetlands and flooded grasslands. One sighting in 2011 survey was recorded in close proximity to Woody’s Dam. This sighting is assumed to be opportunistic use, as the dam supports neither a wetlands nor flooded grasslands habitat. The Glossy Ibis has not been recorded in subsequent surveys.

A significance assessment of the potential impacts to the individual species concluded that the project does not have the potential to impact on the threatened and migratory species as outlined in *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance.*

Health and safety

An assessment of the potential hazards to human health and safety associated with all stages and components of the project, including post-closure was undertaken. The high number of medium residual risks is a result of the major level of consequence for health and safety events, such as injury and mortality.

VRM will implement a health and safety management system that will be the basis for the management of all aspects of human health and safety for the Ammaroo project. The structure of the management system will use guidance provided by WorkSafe Australia and AS/NZS 4801:2001 Occupational Health and Safety Management Systems. As part of the management system, VRM’s risk management procedures will require the maintenance of a site-specific risk register to identify and assess and minimise risks to human health and safety over the life of the Ammaroo project.

Socio-economic assessment

The region is known for its strong cultural values. Ceremonial activities are still practised and there is a strong art movement. Home ownership is lower than that of the Territory overall. Public housing is generally overcrowded, which has flow on impacts on health, social cohesion, workforce participation and educational attendance and outcomes. As would be suggested, health outcomes in the social area surrounding the project are poor.

The most important (as measured by gross value added) industries are the construction, mining and agriculture, forestry and fishing industries. The region has generally lower median incomes than the Territory, with commiserate lower levels of labour force participation and higher levels of unemployment.

Communities are serviced by local Aboriginal corporations directly or through outreach services of the Alice Springs and Tennant Creek regional offices of the Australian and Northern Territory Governments, the Barkly Regional Council and non-government organisations.

The project’s potential impacts on social values were identified based on the following high level social characteristics detailed below. These impacts relate to the construction and operational phases of the project. There are high levels of uncertainty about these risks and there may be potential cumulative impacts as a result of other changes in the region, such as other large resources projects.

Table E-3 Potential social impacts

Social characteristics	Potential impacts
Population and communities	• Small increase in in-migration • Influx of families to smaller communities • Community tensions increased • Diversion of community members from volunteering positions • Reduced amenity for pastoral properties.
Economic	• Local business opportunities • Employment opportunities • Diversion of business capacity to the project • Inflationary pressures • Increase in the use of accommodation and transit resources.
Health and wellbeing	• Improved health outcomes • Reduced road safety • Mental health issues • Concerns over potential for pollution • Increased crime and anti-social behaviour.
Culture and heritage	• Damage or destruction of cultural heritage • Increased cultural maintenance resources
Natural resources and the environment	• Drawdown of groundwater resources
Human rights	• Inequitable access to jobs • Discrimination in the workplace

Transport

Transport and logistics is key to project development and operations. The Ammaroo site is reached by the sealed Stuart Highway then along unsealed roads. During project operations project freight, including product and consumables will be transported by rail. During the construction phase the site will be accessed by local roads, with a substantial short term increase in industrial traffic, mostly along the Murray Downs Road, which is a key local route.

A realignment of approximately 12 km of the Murray Downs Road to bypass the mine site will be required.

There is a risk that additional traffic on the public road network during the construction phase will reduce the operational performance of the road network, and in particular the Murray Downs Road. VRM is committed to managing and mitigating the project's impacts on the public road network through a road safety review and where necessary, a road inspection and maintenance agreement in consultation with the NT Government.

Aboriginal and historical cultural heritage

Investigations carried out for this EIS identified 110 Aboriginal archaeological sites consisting of a background scatter of utilitarian stone artefacts across the project area, including the mining lease and access corridor. In addition there are Central Land Council cultural exclusion zones within (or partially within) the project area. There are no historical heritage sites within the project area.

There is potential for direct impacts on 6 archaeological sites and 14 isolated artefacts that are located within the project footprint,

A Cultural Heritage Management Plan (CHMP) will be implemented including measures to enable the Proponent to meet its duty of care to protect the cultural and heritage values of places or items of significance including, where necessary, fencing-off of sites and/or approval to carry out work on heritage place or object and planning for an appropriate recording and salvage program if requested.

Air

Sensitive receptors assessed for compliance against air quality criteria comprise the accommodation camp (3.5 km) and nearby communities, including Ampilatwatja (12 km).

In terms of human health, the pollutant of major concern is particulate pollution related to dust generated by mining activity, specifically PM_{10}. Air quality impacts are predicted to be compliant with all relevant air quality criterion for the closest sensitive receptor, the accommodation camp, provided that dust controls are implemented. A range of mitigation and management measures will be implemented including water spraying, pit retention controls and progressive rehabilitation.

Noise

The existing noise environment within the vicinity of the project site is anticipated to be a typical rural noise environment setting, with potential local noise sources including fauna, wind, local neighbourhood activities and occasional local traffic. Sensitive receptors assessed for compliance against noise quality criteria include the accommodation camp (3.5 km) and communities along Murray Downs Road.

The noise and vibration assessment found that the project's activities during construction and operation should not exceed noise criteria. Therefore, no mitigation measures are required.

Rehabilitation

Rehabilitation will be continuous as overburden and tailings backfill open mine pits during operations. Rehabilitation objectives are:

- Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state, which does not preclude pastoral use or inhibit surrounding pastoral use.
- Achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values, and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.

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Appendices

Acronyms

Acronym	Meaning
4WD	Four wheel drive
µg	microgram
µg/m3	Micrograms per cubic metre
µm	Micrometre, or micron
µSv/h	Microsieverts per hour
µSv/y	Microsieverts per year
AADT	Annual average daily traffic
AAPA	Aboriginal Areas Protection Authority
ABA	Acid base accounting
ABS	Australian Bureau of Statistics
ACM	Acid consuming material
AEP	Annual exceedance probability
AFL	Australian Football League
AHD	Australian height datum
AL_2O_3	Aluminium oxide
AMD	acid, metalliferous and saline drainage
ANCOLD	Australian National Committee on Large Dams
ANZMEC	Australian and New Zealand Minerals and Energy Council
ANZECC	The Australian and New Zealand Environment Conservation Council
AQM	Air Quality Management
ARI	Average recurrence interval
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency (Australian Government)
ARRB	Australian Road Research Board
AS	Australian Standard
ASA	Asset Standards Authority
ASL	Above sea level
ASLP	Australian Standard Leaching Procedure
ATSIHP	Aboriginal and Torres Strait Islander Heritage Protection Act
AUD or $	Australian dollars
BAL	Basic auxiliary left (turn treatment)

BAR	Basic auxiliary right (turn treatment)
billion	Billion measured by $1x10^9$ (or 1,000 million) as per the US convention
BOM	Bureau of Meteorology
Bq	Becquerel (one disintegration per second)
Bq/g	Becquerels per gram
$CaCO_3$	Calcite
$CaMg[CO_3]_2$	Dolomite
CaO	Calcium oxide
$CaSO_4$	Gypsum
CadnaA	Computer Aided Noise Abatement
CE	Critically endangered
CHMP	Cultural Heritage Management Plan
Cl	Chloride
CLC	Central Land Council
CNG	Compressed natural gas
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth
dB	Decibel is the unit used for expressing the sound pressure level or power level in acoustics
dB(A)	Frequency weighting filter used to measure 'A-weighted' sound pressure levels
DEE	Department of the Environment and Energy
DENR	Department of Environment and Natural Resources
Dido	Drive-in/drive-out
DIPL	Department of Infrastructure, Planning and Logistics'
DITR	Department of Industry, Tourism and resources
DME	Department of Mines and Energy (Northern Territory Government)
DMP	Dust Management Plan
DOE	Department of the Environment (Australian Government)
DoEE	Department of the Environment and Energy (Australian Government)
DLRM	Department of Land Resource Management (Northern Territory Government)

DPIR	Department of Primary Industry and Resources
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EA Act	Environmental Assessment Act 1982 (Northern Territory Government)
EC	Electrical conductivity
EIS	Environmental Impact Statement
EL	Exploration lease
EMP	Environmental Management Plan
EN	Endangered
EPA	Environmental Protection Agency
EPAV	Environment Protection Authority Victoria
ENMM	Environmental Noise Management Manual
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Australian Government)
ESCP	Erosion and Sedimentation Control Plan
ESD	Ecologically Sustainable Development
ESIMP	Economic and Social Impact Management Plan
Fe_2O_3	Iron oxide
FD	Foul drain
Fe_2	Iron
FID	Financial Investment Decision
FIFO	Fly-in/fly-out
FOPS	Falling object protection systems
g/m2	Grams per square metre
g/m2/month	Grams per square metre per month
g/s	Grams per second
GDE	Groundwater dependent ecosystems
GJ/hour	Gigajoule per hour
GL	Gigalitre (billion litres)
GLC	Ground level concentration
GPS	Global positioning system
GWA	Genesee Wyoming Australia (rail operator between Tarcoola (SA) and Berrimah (NT)
H	horizontal

h	Hour
ha	Hectare
HCO_3	Bicarbonate
HG	High grade
IAEA	International Atomic Energy Agency
IAIA	International Association of Impact Assessment
IAP2	International Association for Public Participation
ICOMOS	International Council on Monuments and Sites
ICN	Industry Capability Network
ILUA	Indigenous Land Use Agreements
INAP	International Network for Acid Prevention
ISO	International Organisation for Standardisation
JORC	Joint Ore Reserves Committee
JSA	Job safety analysis
kg	Kilogram
kg/m	Kilogrmas per metre
kL	Kilolitre
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometres
km/h	Kilometres per hour
kWh/m^3	Kilowatts per hour per cubic metre
L	Litre
LA10(period)	The sound pressure level that is exceeded for 10% of the measurement period.
LA90(period)	The sound pressure level that is exceeded for 90% of the measurement period.
LAeq(period)	Equivalent sound pressure level
Land Rights Act	Aboriginal Land Rights (Northern Territory) Act
LNG	Liquid natural gas
LOM	Life of mine
LG	Low grade
$L/m^2/hr$	Litres per square metre per hour
L/s	Litres per second
m	Metre

ML/d	Mega litres per day
mm	Millimetre
m/s	Metres per second
m^3/hr	Cubic metres per hour
mAHD	Australian Height Datum in metres
MBACI	Multiple Before-After Control-Impact
MCM	Million cubic metres
MCP	Mine Closure Plan
MEP	Multiple extraction procedure
MIC	Maximum instantaneous charge
MIS	Maximum instantaneous charge
Mg	Magnesium
mg/kg	Milligrams per kilogram
mg/L	Mili grams per litre
mg/kg	Mili grams per kilogram
MgO	Magnesium Oxide
ML	mineral lease
ML/d	Mega litres per day
ML/y	Mega litres per year
MM	Mining Management
mm	millimetre
MMA	Mining Management Act
mm/s	Millimetres per second
MMP	Mining Management Plan
MNES	Matters of National Environmental Significance
MRCP	Mine Rehabilitation, Closure Plan
mSv/y	Millisieverts per year
Mt	Million tonnes
MT Act	Mineral Titles Act
Mtpa	Million tonnes per annum
MW	Megawatt (million watts)
MWh/hour	Megawatts per hour
Na	Sodium
NAF	Non-acid forming

NAG	Net acid generation
NAPP	Net acid producing potential
NOx	Nitrogen
NDRP	National Directory for Radiation Protection
NGERA	National Greenhouse and Energy Reporting Act
NMT	Nordic prediction method for Train Noise
NNTT	National Native Title Tribunal
NO_2	Nitrogen dioxide
NOI	Notice of Intent
NORM	Naturally occurring radioactive materials
NPI	National Pollution Inventory emission estimation guidelines
NRETA	Natural Resources, Environment and the Arts
NSW	New South Wales
NT	Northern Territory (of Australia)
NTA	Native Title Act
NTG	NT Government
NT EPA	NT Environment Protection Authority
NZS	New Zealand Standard
OTL	Overland Telegraph Line
P	Phosphate
P_2O_5	Phosphate
PAF	Potentially acid forming
PEHA	Public and Environmental Health Act
PEHR	Public and Environmental health regulations
PFS	Preliminary feasibility study
PJ	Peta joules
$PM_{2.5}$	Particulate Matter 2.5 micrometres or less in diameter
PM_{10}	Particulate Matter 10 micrometres or less in diameter
PMF	Possible maximum flood
POW	process oily water
PPE	Personal, protective equipment
PPV	Peak particle velocity
PW	Process water
Qld	Queensland

RCB	Reinforced concrete box culverts
RCP	Reinforced concrete pipe
RE	Rare Earth
RNDB	Rail Noise Database
RO	Reverse osmosis
ROM	Run of mine
RSF	Residues storage facility
Sacred Sites Act	Northern Territory Aboriginal Sacred Sites Act
SIA	Social impact assessment
SiO_2	Silcom dioxide
SMS	Safety Management System
SO_2	Sulphur dioxide
SOCS	Site of Conservation Significance
St	Street
Sv	Sievert
Sv/h	Sieverts per hour
Sv/y	Sieverts per year
SW	surface water
SWI	Safe work instructions
t	Tonne
t/hour	Tonnes per hour
t/m^3	Tonnes per cubic metre
TAPM	The Air Pollution Model
TBA	To be advised
TBC	To be confirmed
TDG	Transport of Dangerous Goods Act
TDG Act	Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act
TDS	Total dissolve solids
TMP	Traffic Management Plan
TOR	Terms of Reference (for the Preparation of an Environmental Impact Statement, Ammaroo Phosphate Project)
TPWC	Territory Parks and Wildlife Conservation
TREO	Total rare earth oxide
TSF	Tailings storage facility

TSP	Total suspended particulates
TSS	Total suspended solids
US	United States
UV	Ultra violet
V	vertical
VIC	Victoria
vpd	Vehicles per day
vph	Vehicles per hour
VRM	Verdant Minerals Limited
VSD	Variable speed drive
VU	Vulnerable
WA	Western Australia
WDWCD	Western Davenport Water Control District
WHO	World Health Organisation
WHS Act	Work Health and Safety (National Uniform Legislation) Act
WHS Regulations	Work Health and Safety (National Uniform Legislation) Regulations
WM Act	Weeds Management Act
WMPCA	Waste Management and Pollution Control Act
WRD	Waste rock dump
w/w	Percentage weight per weight

1. Introduction

1.1 Overview

Verdant Minerals Limited (VRM) proposes to develop the Ammaroo phosphate project (the project), located approximately 220 kilometres (km) southeast of Tennant Creek, 125 km east of Barrow Creek and 270 km northeast of Alice Springs, Northern Territory (NT) (Figure 1-1).

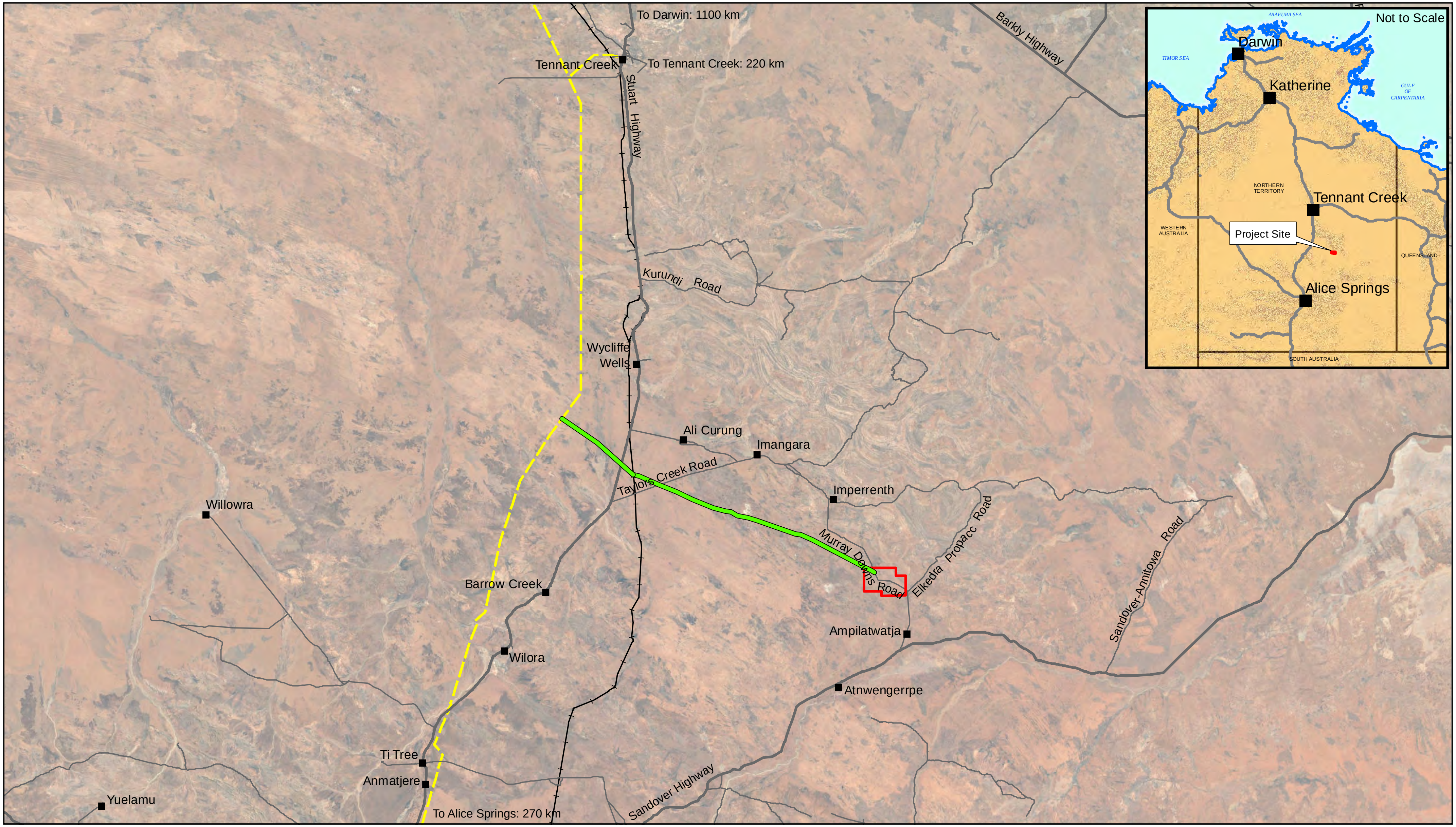
The project will comprise the following three components:

- Open-cut mining of shallow phosphate deposits.
- Beneficiation and production of phosphate rock concentrate.
- Transport of phosphate rock concentrate via rail to the Port of Darwin and on to international markets.

This draft Environmental Impact Statement (draft EIS) is submitted to the Northern Territory Environment Protection Authority for assessment under the Northern Territory *Environmental Assessment Act* and the Australian Government Department of Environment and Energy for assessment under the *Environment Protection Biodiversity Conservation Act*. It has been prepared in accordance with:

- Terms of Reference for the Preparation of an Environmental Impact Statement: Ammaroo Phosphate Project (TOR) (Appendix A).
- Request for additional Information (EPBC 2104/7260) (Appendix B).

A document comparing the TOR against this draft EIS has been provided in Appendix C.



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0 20 40 60 80

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Major road
- Local road
- Rail
- Amadeus gas pipeline
- Access corridor
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Location

Figure 1-1

G:\43\22544\GIS\Maps\4322544_100.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM

1.2 The proponent

VRM is a Darwin-based, ASX listed developer of Australian fertiliser mineral projects, including the Ammaroo phosphate project. VRM's portfolio of projects also includes the Karinga Lakes sulphate of potash project and the Dingo Hill silica project.

The company name was changed from Rum Jungle Resources Ltd to Verdant Minerals Ltd in December 2016.

Table 1-1 Proponent details

Characteristic	Detail
Company name	Verdant Minerals Ltd ABN 33122 131 622
Registered office	20 / 90 Frances Bay Drive, Stuart Park NT 0820
Postal address	GPO Box 775, Darwin NT 0801
Contact details	Chris Tziolis Managing Director T: +61 8 8942 0385 M: +61 437 021 415 E: ctziolis@verdantminerals.com.au
ASX code	VRM

VRM has engaged independent consultants to prepare specialist technical studies as well as the main draft EIS report. The names of, work done by and the qualifications and experience of key persons involved in the preparation of the draft EIS are provided in Appendix D.

1.3 Development context

Phosphate rock is a rock that contains high concentrations of phosphate minerals derived mainly from marine sedimentary deposits. It is essential to all forms of life, and is mined primarily to produce fertilisers for the agriculture sector. Currently, much of the world demand for fertiliser is met by geopolitically risky countries in North African and the Middle East. Australia is considered geopolitically stable and has one active phosphate mine in Queensland.

Phosphate rock was deposited in a wide range of ancient, marine depositional environments, and normally these are shallow, easy to access deposits. The largest demonstrated deposits of phosphate rock in Australia occur in the Georgina Basin.

Phosphate rock mined in other countries can have high levels of penalty elements including uranium and cadmium. Moroccan and Florida phosphate rock typically has high uranium. The European Union has recently voted to decrease the acceptable level of cadmium in fertiliser to 20 mg/kg over the next nine years (Farmers Guardian 2017). Australian Georgina Basin deposits are significantly lower in these penalty elements.

The Ammaroo deposit is the largest undeveloped JORC compliant rock phosphate resource in Australia. It is located in the south western Georgina Basin, which has the potential to become a major phosphate province. The resource is a mostly shallow, free digging, moderate grade phosphate ore that is easily beneficiated to a 32% market standard rock concentrate at a relatively low cost that is well suited to phosphoric acid production markets in India and Southeast Asia. Importantly, the Georgina Basin phosphate deposits, in combination with the Northern Territory's offshore and potentially onshore gas resources and the potassium-rich brine of the Central Australian salt lakes offer a medium term opportunity to develop a regional fertiliser production industry. The starting point for the development of this industry could be the export of phosphate rock concentrate from the Ammaroo project, which is the project being proposed in this draft EIS.

The Karinga Lakes sulphate of potash project and the Dingo Hole silica project offer opportunities to potentially develop small scale, low capital start-up operations to round out Verdant Minerals' portfolio of mineral projects.

1.3.1 Other proposals or actions associated with this project

There are no other proposals or actions associated with this project other than those presented in the draft EIS.

The presence of sub-surface phosphate in the Ammaroo area has been known since the late 1960s. Renewed exploration occurred after the sealing of the Stuart Highway and the building of the Adelaide-Darwin Railway; alongside a period of unsuccessful uranium exploration by the same companies. VRM (then Rum Jungle Uranium, later Rum Jungle Resources Ltd) began systematically exploring for phosphate in 2009, resulting in the discovery of what was then called Barrow Creek 1. The adjacent area, formerly called Arganara, was then acquired. Both areas were amalgamated into the main Ammaroo Resource.

Discoveries of satellite phosphate deposits at Ammaroo South and Rockhole suggest that the greater Ammaroo area is a phosphate province which may contain other, as yet undiscovered, phosphate resources and exploration is on-going.

1.4 Project location and regional context

1.4.1 Land use and tenure

The main Ammaroo project resource is located on Ammaroo Station and is covered by Mineral Lease applications that have been in place since 2012 and 2013. The infrastructure corridor intersects Ammaroo, Murray Downs and Neutral Junction stations. VRM also has contiguous exploration leases (ELs) on nearby Elkedra and Derry Downs Stations (Figure 1-2).

The area surrounding the project is sparsely populated and contains little development. Land use comprises cattle grazing, scattered Aboriginal communities and outstations, and pastoral station homesteads. The area supports an active beef cattle industry and stocking numbers vary seasonally.

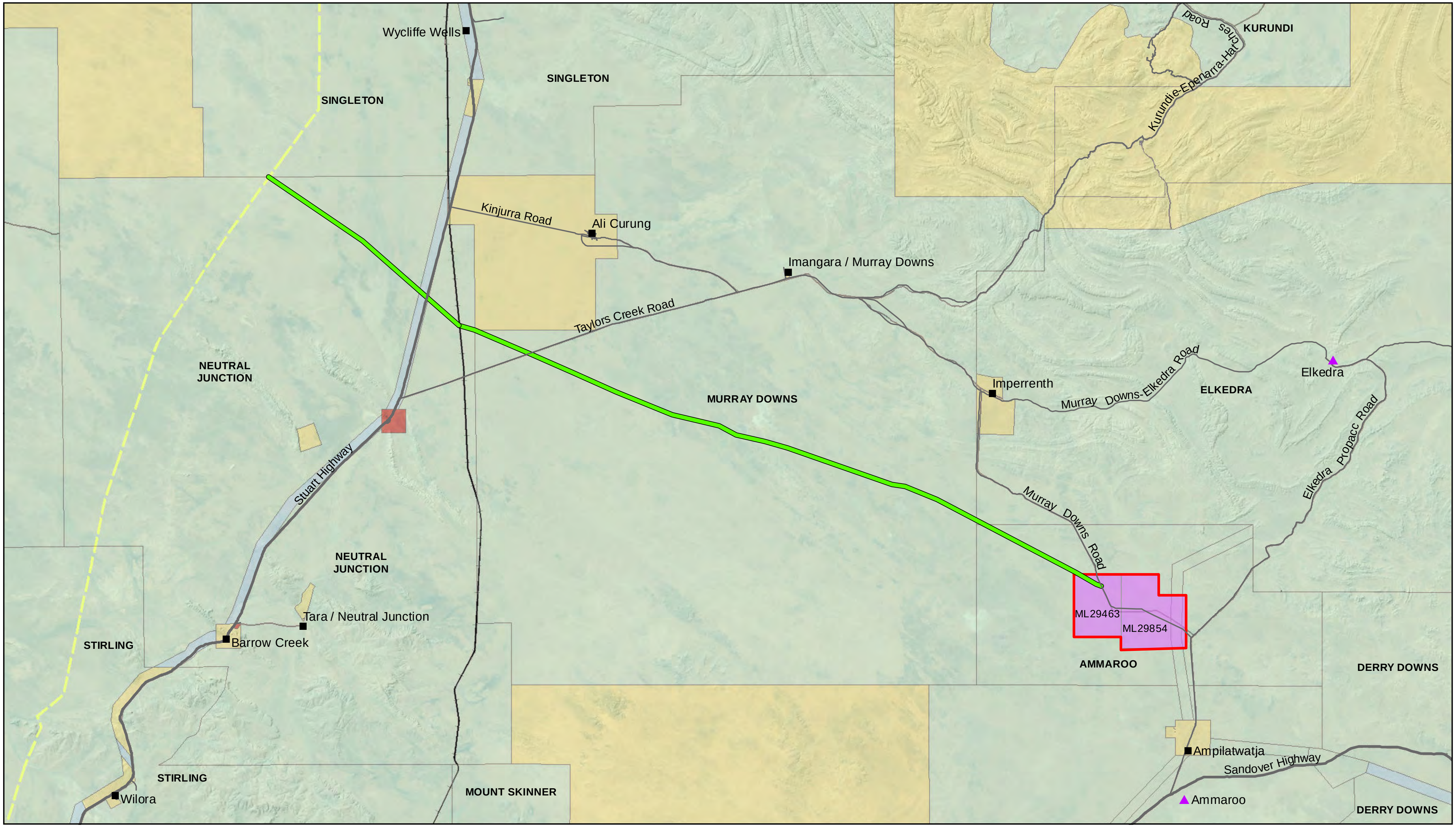
All pastoral stations are on Crown land under perpetual pastoral lease. There are smaller areas of Aboriginal land in the region, primarily associated with established communities. Much of the area to the north and west of the main Ammaroo resource is under petroleum exploration title, but there are no petroleum exploration applications, or granted tenure, over the Ammaroo resource itself.

1.4.2 Communities

The project is located in remote, arid and sparsely populated country characterised by small Aboriginal communities and homelands, and large pastoral stations. The local area includes the Alyawarre communities of Imangara (Murray Downs), Ampilatwatja and other Alyawarre outstations; and Arlparra, service centre for the Utopia Homelands to the south of the Sandover Highway. Ali Curung is on Kaytetye land north west of the project site. The broader Barkly region to the north and Sandover region to the south incorporate pastoral and other agricultural land uses on large pastoral properties including Ammaroo, Murray Downs, Elkedra and Neutral Junction Stations. More recently the Barkly has emerged as a potential horticultural province e.g. at Singleton station approximately 110 km to the northwest.

Populations within the project area are serviced by regional centres including Tennant Creek, Ti Tree and Alice Springs.

Communities and outstations are contained in Figure 1-3. A detailed discussion of the communities, and social context surrounding the project, is provided in Chapter 12: Socio-economic assessment.



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0 5 10 15 20 25

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Homesteads
- Major road
- Local road
- Access corridor
- Rail
- Amadeus gas pipeline
- Mineral lease
- Mineral titles
- Tenure
- Freehold
- Perpetual pastoral lease
- Reserve
- Vacant crown land

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
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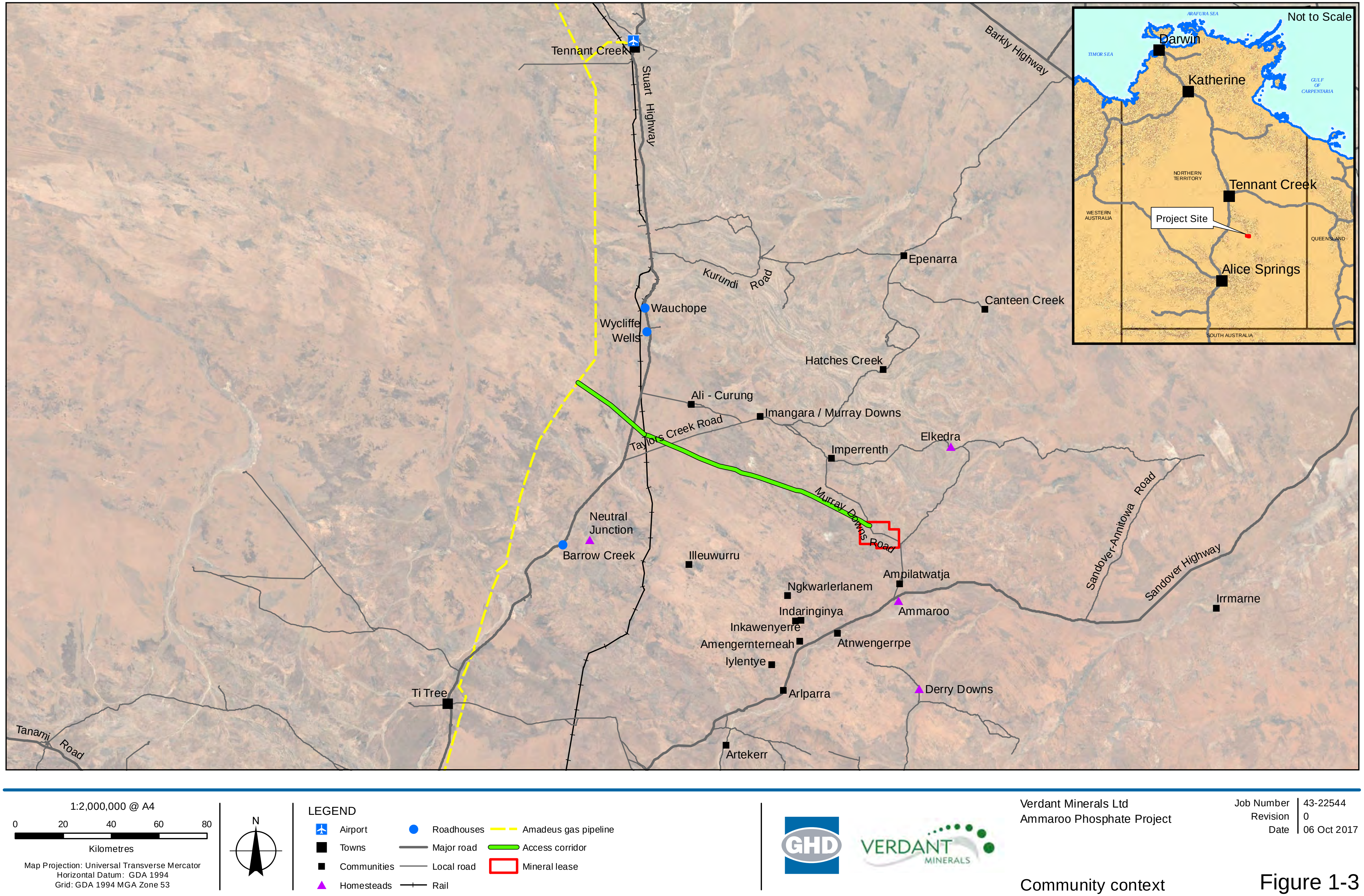
Land tenure

Figure 1-2

G:\43\22544\GIS\Maps\4322544_103.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 06/09/2017). VML - Proposed Corridor, Project Site (2017). DLRM - Tenure (2017). Created by: CM



Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Community context

Figure 1-3

G:\43\22544\GIS\Maps\4322544_108.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM

1.4.3 Transport network

Access to the project site is from the Stuart Highway, and then via the unsealed Sandover Highway from the south, or via the unsealed Murray Downs Road from the north. Cattle are trucked along the Murray Downs Road to the Port of Darwin for export. 4WD tourists using the Binns Track to access the Davenport Ranges National Park from the south, pass over the portion of Murray Downs Road that is in the project site.

Airports are located at Tennant Creek (220 km) and Alice Springs (270 km). A number of Aboriginal communities and outstations in the surrounding area have airstrips including Ti Tree, Arlparra, Ampilatwatja, and Ali Curung.

A detailed discussion of the transport network is provided in Chapter 13: Transport.

1.4.4 Land and water features

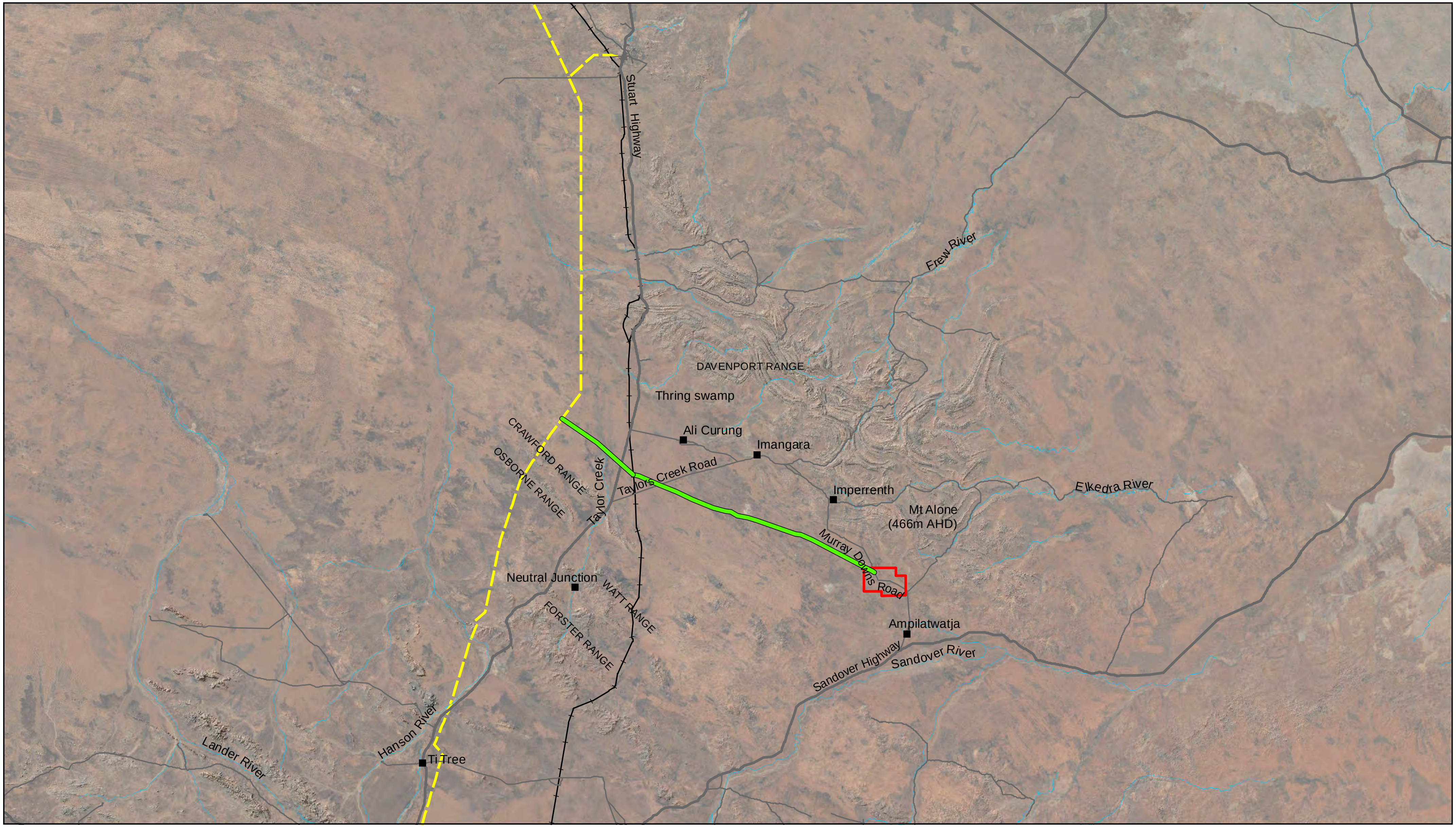
The project site is located in the Southern Georgina (geological) Basin on a dry, rocky plain. The entire project site falls within the Tanami bioregion, within the Sandover sub-region. The western section of the infrastructure corridor extends into the Wycliffe sub-region.

The site lies in the arid region of Australia with an annual rainfall of around 350 mm and a pan evaporation rate of about 4,000 mm. Most of the rain is associated with thunderstorms during monsoonal wet season cyclonic activity. Over some drought years there is minimal or no rainfall.

Ephemeral streams flow from the Davenport Ranges onto the plains after heavy rain events. The regional drainage system drains towards the east via the Elkedra and Sandover Rivers and their tributaries (Figure 1-4). The eastern portion of the mineral lease (ML) generally drains to the south-east towards the Sandover River, whilst the western side, including the access corridor generally drains to the west and north-west.

Creek beds tend to be mobile with deep sand deposition, with banks that show signs of active erosion. Some watercourses include low flow channels that appear to be actively migrating across the mobile sand bed. During infrequent, intense rain events out-of-bank flow occurs as sheet wash, leading to temporary and short-term flooding of adjacent lands.

A detailed discussion of surface water is provided in Chapter 7: Surface water.



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0 20 40 60 80

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Access corridor
- Major road
- Local road
- Drainage pathways
- Amadeus gas pipeline
- Rail
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Land and water features

Figure 1-4

G:\43\22544\GIS\Maps\4322544_105.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). DLRM - SOCS, Reserves (2017). Created by: CM

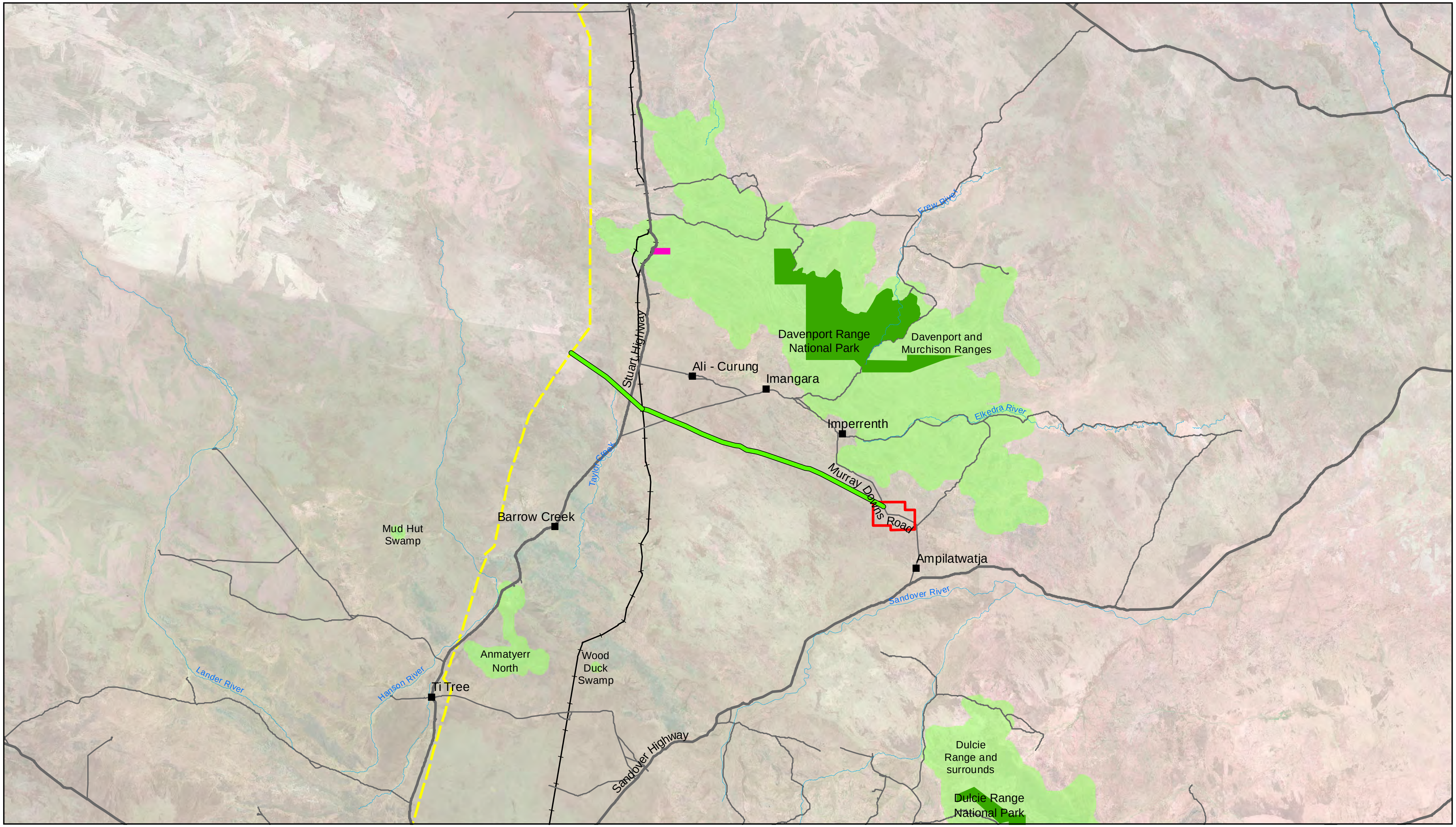
1.4.5 Regional sites of ecological, cultural or social significance

There are sites of ecological, cultural and social significance in the region reflecting the area's rich Aboriginal and European history. Sites in the region that have wider social and/or ecological value, are culturally important to Aboriginal people and/or are an established tourist attraction are listed in Table 1-2 and shown in Figure 1-5. Only two of these sites are close to the project area. The Davenport Ranges National Park is 50 km to the north, and the southwest section of the Davenport Ranges and Elkedra River Sites of Conservation Significance (SOCS) comes within 5 km of the mineral lease (Figure 1-5).

A detailed discussion of the ecological significance of the study area and surrounds is provided in Chapter 9: Biodiversity. Archaeological and Aboriginal cultural heritage sites are discussed further in Chapter 14: Aboriginal and historic cultural heritage.

Table 1-2 National parks and reserves and sites of conservation significance (DENR website)

Site	Description
National Parks / Reserves	
Davenport Range National Park	Also known as Iytwelepenty, the National Park has ecological significance and is an important sanctuary for fauna. It is approximately 50 km north of the mine site
Devils Marbles Conservation Reserve	The Devils Marbles are also known as Karlu, and hold great cultural importance, being a living cultural landscape and traditional country for the Warumungu, Kaytetye, Alyawarra and Warlpiri people. The Reserve is 125 km north west of the mine site
Dulcie Range National Park	The National Park contains a number of springs and wetlands of ecological values. It is 100 km south of the mine site.
Site of Conservation Significance	
Anmatyerr North SOCS	Stirling Swamp supports various wetland habitats and a population of the threatened dwarf desert spike-rush, which is only found in the NT. The low rocky ranges in the south of the site are the only known location for the threatened giant sweet potato. Threatened species found at the site are Australian Bustard and Bilby. Anmatyerr North SOCS is 135 km to the south west of the mine site
Davenport and Murchison Ranges SOCS	Seven threatened species have been found within the site including two bird and five mammal species including the Black-footed Rock-wallaby and Bilby. The ranges support diverse terrestrial and aquatic fauna species, including a diverse range of fish in long lasting waterholes. At least eleven plant species known only from the NT have been found to habitat the sheltered gorges. The boundary of the SOCS is 6 km to the north of the mine site.
Dulcie Range and surrounds SOCS	The Dulcie Range and surrounding hills contain springs, permanent rock holes, and riverine waterholes that provide habitat and drought refuge for populations of the Black-footed Rock-wallaby and aquatic biota such as fish. The site also has sheltered gorges that protect a number of plants that have restricted ranges. Five threatened species including two species of Land Snails known only from the site have been recorded. The SOCS is 70 km to the south of the mine site.
Wood Duck Swamp SOCS	An ephemeral swamp located 70 km north east of Ti-Tree that holds water for many months in an arid environment and is dominated by smooth-barked coolabah *Eucalyptus victrix* Wood Duck Swamp SOCS is 120 km to the south west of the mine site



Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
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Protected areas and sites of conservation significance

Figure 1-5

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Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). DLRM - SOCS, Reserves (2017). Created by: CM

1.4.6 Other major projects within the region

There are a number of potential mining, mineral processing operations, gas fields and gas pipelines that are within 400 -500 km of the project site, based on the current information detailed on the Industry Capability Network.

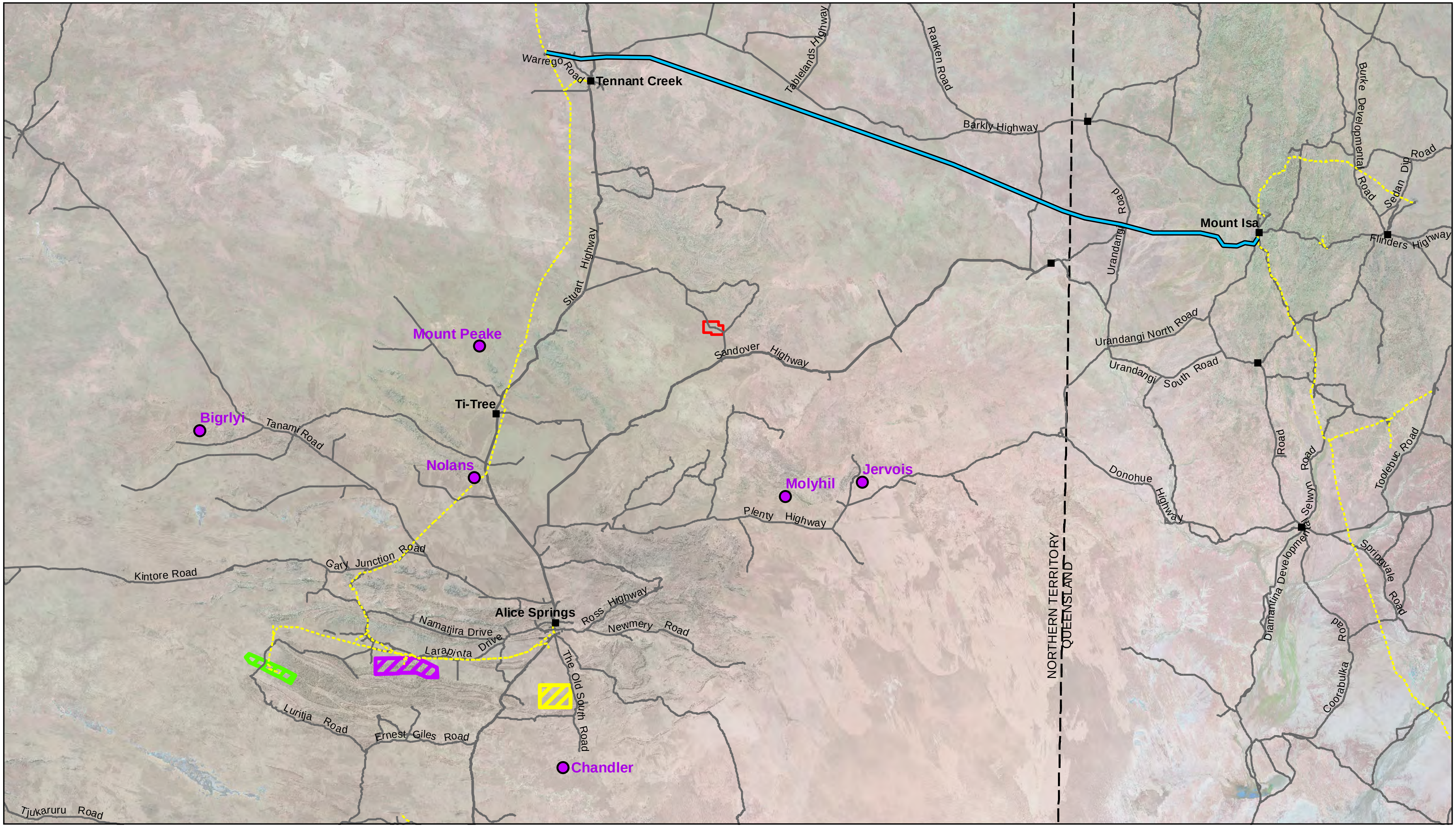
Central Petroleum Limited has acquired natural gas production assets in the Amadeus Basin, including the 100% ownership of the Palm Valley and Dingo gas fields; and 50% ownership of the Mereenie oil and gas field in a joint venture with Santos. Central Petroleum provides established customers with gas via the Amadeus Basin to Darwin natural gas pipeline. The Amadeus Basin to Darwin natural gas pipeline is operated by APA Pipelines Pty Ltd.

Jemena Northern Gas Pipeline Pty Ltd has begun construction of the 622 km high pressure underground gas pipeline that will link the Amadeus Basin to Darwin natural gas pipeline in Tennant Creek to gas infrastructure in Mount Isa in Qld in 2018.

Beyond these confirmed projects, there are a number of planned projects that were not formally committed to development at the time of publishing this draft EIS. These are listed in Table 1-3 and Figure 1-6.

Table 1-3 Potential projects (Source: ICN 2017)

Project	Proponent	Project type	Start	Distance to the project
Nolans	Arafura Resources	Rare earths	2018	224 km
Mount Peake	TNG Limited	Vanadium pentoxide / ferrovanadium / refinery	2018	185 km
Chandler Salt Mine	Tellus Holdings	Salt	2018	379 km
Jervois	KGL Resources	Copper, gold, silver, lead and zinc	2019	168 km
Beetaloo basin	Origin Energy	Unconventional hydrocarbons	TBA	500 km
Molyhil	Thor Mining Plc	Tungsten-molybdenum	TBA	144 km
Bigrlyi	Energy Metals	Uranium vanadium	TBA (on care and maintenance)	425 km



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0 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Other projects within 400 km of Nolans Project
- Roads
- Northern Pipeline Project
- Existing gas pipeline
- Palm Valley Gas Field
- Dingo Gas Field
- Mereenie Oil Gas Field
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

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Other projects in the region

Figure 1-6

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). DLRM - SOCS, Reserves (2017). Created by: CM

1.5 Structure of this draft EIS

This draft EIS consists of a main report (this report) and supporting technical appendices. The structure of the main report is outlined in Table 1-4.

Table 1-4 Draft environmental impact statement structure

No.	Section title	Description
1	Introduction	Introduces the proponent and proposed project, its context and location.
2	Project description	Provides a detailed description of the project, including its components and staging.
3	Regulatory context	Lists the regulations and legislation applicable to the construction, operation and decommissioning of the project.
4	Environmental context	Provides an overview of the environmental context of the project, including climate, geology, and soils.
5	Consultation	Describes the consultation programme undertaken for this draft EIS, including stakeholder groups and their concerns at a high level.
6	Risk assessment	Describes the risk assessment method undertaken for this draft EIS.
7	Surface water	Describes the surface water values within the project area, the potential project impacts and mitigation measures.
8	Groundwater	Describes the groundwater values within the project area, the potential project impacts and mitigation measures.
9	Biodiversity	Describes the biodiversity values within the project area, the potential project impacts and mitigation measures.
10	Protected matters under EPBC Act	Describes matters specific to the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act), and in particular, potential impacts on Matters of National Environmental Significance (MNES).
11	Health and safety	Describes the health and safety issues relating to the project, and the mitigation measures to control these.
12	Socio-economic assessment	Describes the social and community values within the project area, the potential project impacts and benefits, and mitigation measures.
13	Transport	Describes the traffic network, the potential project impacts and mitigation measures.
14	Aboriginal and historic cultural heritage	Describes the historic and Aboriginal heritage values within the project area, the project potential impacts and mitigation measures.
15	Air	Describes the air quality baseline within the project area, the project potential impacts and mitigation measures.
16	Noise	Describes the ambient noise environment within the project, the potential project noise impacts and mitigation measures.
17	Rehabilitation	Describes the conceptual framework, objectives and risks involved in rehabilitation, decommissioning and closure for the project.
18	References	Lists the external documents referenced in this draft EIS.

2. Project description

2.1 The Ammaroo deposit

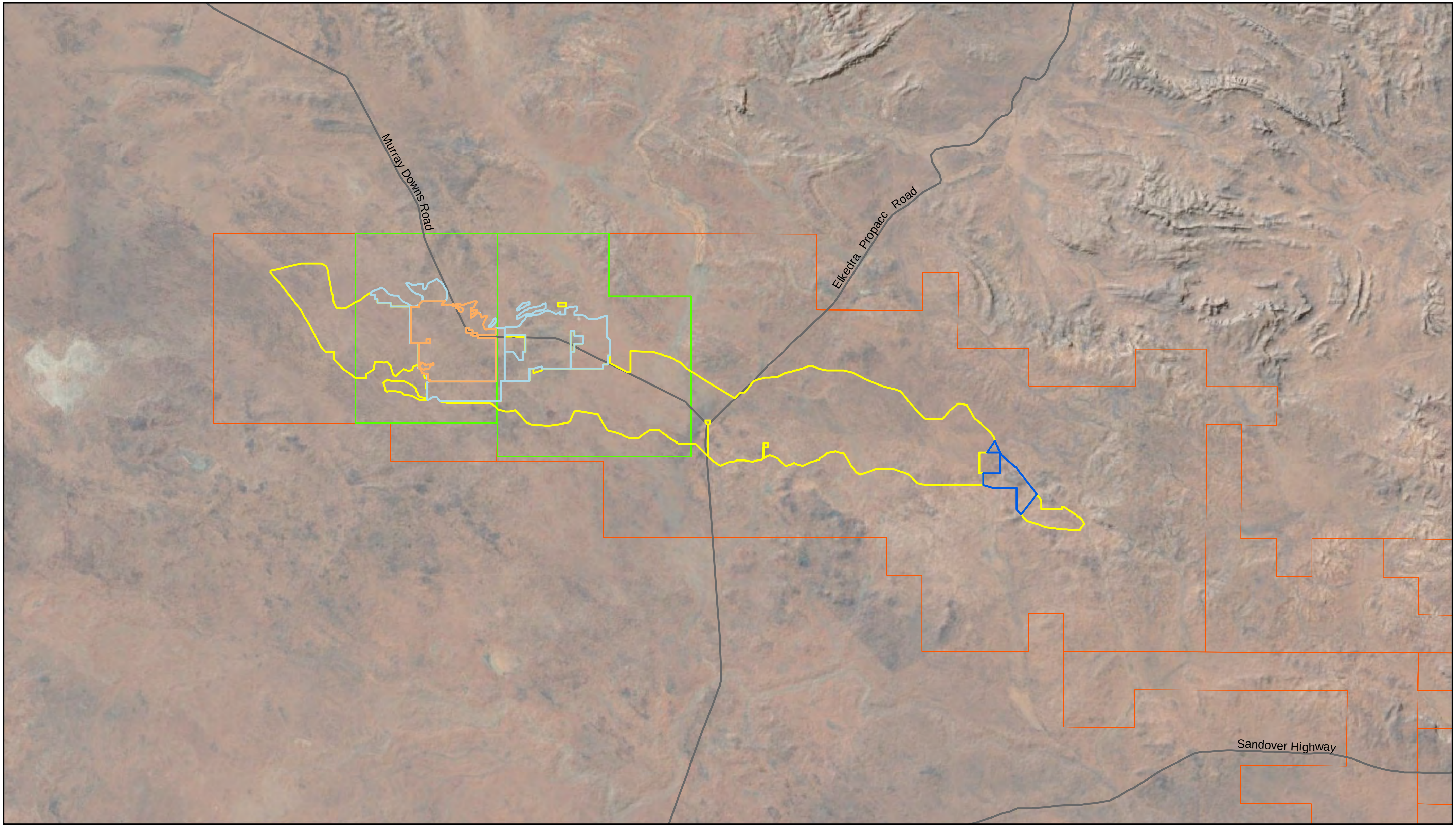
The Ammaroo Project is rock phosphate project. Exploration has been directed at locating phosphate where it is:

- Shallow, and above the water table (low strip ratios)
- Not entirely weathered (predictable rock properties amenable to mining)
- Highest grade and thickest and geochemically containing the lowest level of penalty elements

The mineralisation within the greater Ammaroo area (Figure 2-1) extends 40 km and trends approximately east-west with an average thickness of around 7.0 metres and an average north-south width of approximately 3.5 kilometres. The mineralisation is flat-lying to gently undulating with a slight general inclination towards the south. It is overlain by between 1 – 56 m of overburden with an average depth to mineralisation of around 23 m.

The JORC resource at a 10% P_2O_5 cut-off extends to around 60 m depth, with approximately 90% at depths of less than 40 m below surface. The overburden consists of a layer of red sandy silt fine and gravel, underlain by weathered siltstone and low grade (<10% P_2O_5) phosphatic siltstone.

The main Ammaroo resource was incrementally and systematically updated from 2010 to 2016, following infill and extension drilling campaigns. The most recent independent JORC estimate was announced in March 2017. The total resources, including Measured, Indicated and Inferred (Figure 2-1) is 1.141 billion tonnes P_2O_5 at an average grade of 14% P_2O_5 using a 10% cut-off. Only the better-defined Measured and Indicated categories are the subject of this draft EIS. At a 10% P_2O_5 cut-off, the Indicated plus Measured resource is 301 Mt at 15.5% P_2O_5. These categories have phosphate which is potentially the most easily processed and the lowest strip ratio (most economical to mine) and have been secured under Mineral Lease applications since 2012 and 2013.



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0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Exploration target
- Indicated
- Inferred
- Measured
- Road
- ML application area
- Exploration lease

GHD

VERDANT MINERALS

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Phosphate deposits

Figure 2-1

G:\43\22544\GIS\Maps\4322544_114.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 07/07/2017). VML - Ammaroo Deposit, MLs (2017). Created by: CM

2.2 Project key components

In 2014 VRM (then Rum Jungle Resources), completed a Notice of Intent for the Ammaroo project, including downstream, high grade development options. Those downstream options are not included in this proposed action.

VRM plans to selectively and progressively mine the Ammaroo Phosphate resource, targeting a ROM grade of 15% P_2O_5, and feed the run of mine (ROM) rock into a crushing and flotation beneficiation plant located on site to produce up to 2 million tonnes per annum (Mtpa) of a 32% P_2O_5 rock concentrate product. This product will be transported by rail via a new low set rail spur, from the Ammaroo site to the Port of Darwin for export. The project comprises the following key components:

- Mine site (Figure 2-2):
  - Mining and rehabilitation of a sequence of pits over a minimum 25 year mine life
  - Temporary storage and management of rom stockpiles and primary crushing for feed to the process plant
  - Removal of overburden and temporary storage in waste dumps and/or placement in completed pits
  - Clearance of access and haul roads for operation of the mine and location of fixed and temporary facilities
  - Building and operation of tailings facilities, both above ground for an initial period of operation and in-pit tailings once depleted pits are available for tailings disposal.
- Process plant
  - Crushing, conveying, screening, flotation, filtration systems required to beneficiate the ore from the pits into a concentrate rock for export
  - water systems to provide process water for the beneficiation plant including storage and recycling ponds, reagent tanks, water treatment facilities and tailings treatment and pumps
  - Finished product storage and handling infrastructure to support loading of rail wagons.
- Non process infrastructure
  - Onsite power station of approximately 24 MW installed capacity based primarily on a number of gas engine generators
  - An accommodation camp with an approximate capacity of 170 permanent rooms and 300 temporary rooms during construction with associated amenities to support a Fifo/Dido permanent and contract workforce during construction and long term operation of the mine
  - Water supply bore field and approximately 18 km water pipeline
  - Other facilities such as offices, workshops, stores, security
  - Utility type facilities including water treatment, utility air and water, power distribution, fuel storage.

Infrastructure corridor of 137 km length from project site to Amadeus gas pipeline (Figure 2-3) including

- 105 km rail spur, connecting the process plant to the main Adelaide to Darwin railway line
- 137 km low pressure, carbon fibre, natural gas supply pipeline from the Amadeus Gas Pipeline to the site to provide gas for power generation and potential product drying
- A rail maintenance access track alongside the rail embankment

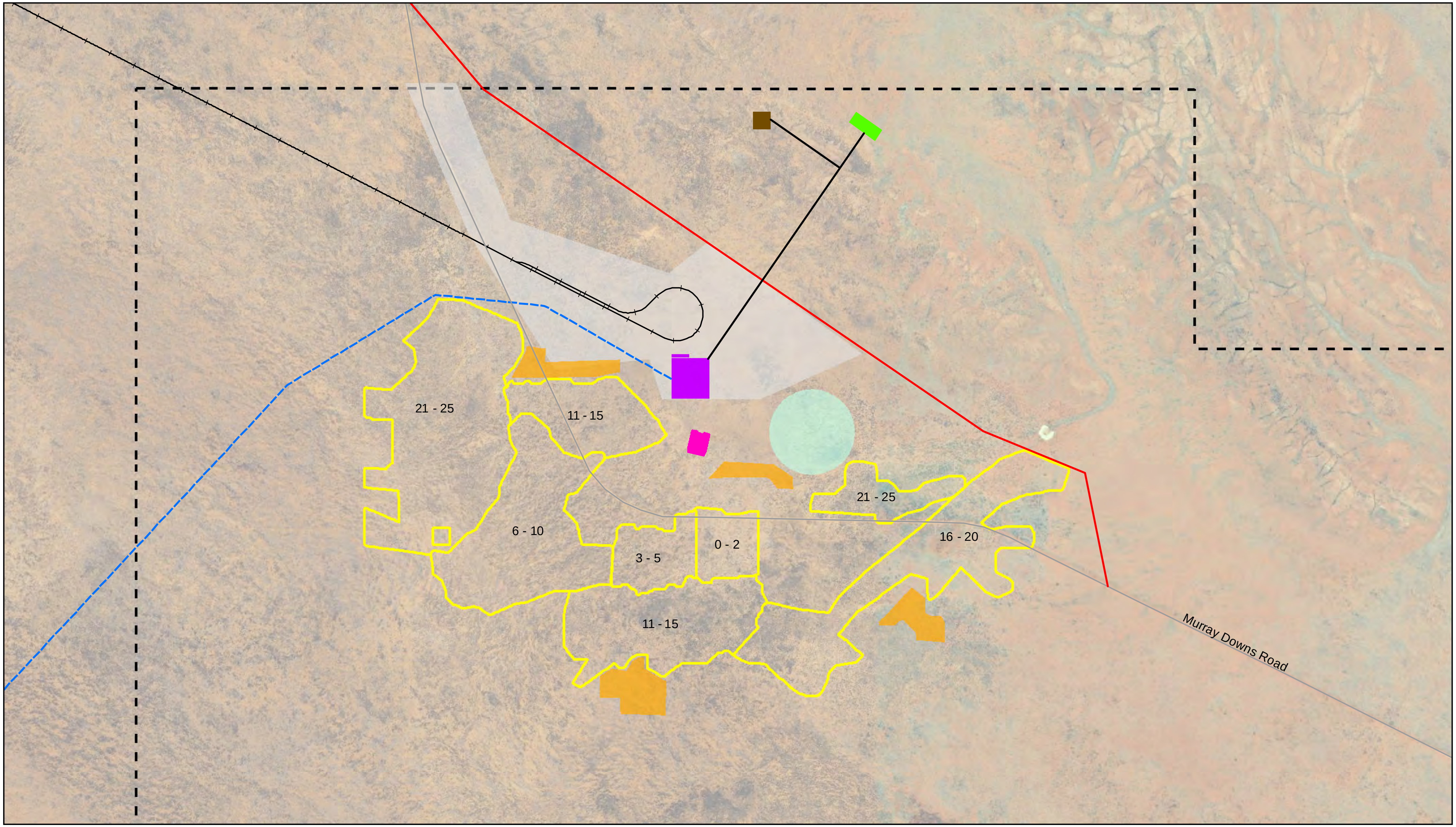
Access to a number of borrow pits located along the rail corridor (Figure 2-3) to supply gravel and ballast material for rail construction and the construction of other infrastructure on the mine site.

Road access to the project site via a realignment of the Murray Downs road (Figure 2-4). The realignment of a section of the public road is required to avoid the mine site and process plant area (Figure 2-2) i.e. as determined by the location of the ore body.

The maximum disturbance footprint for key mine components is listed in Table 2-1.

Table 2-1 Disturbance area calculations – project footprint

Disturbance area (closure domains)	Size / length	Area (ha)
Borrow pits	Comprises 5 pits and access tracks	550
Access corridor	Rail infrastructure length 105 km incl. rail loop at mine site	800
Gas pipeline	137 km total (approx. 35 km additional length beyond railway corridor)	115
Pit areas	25 year pit staging	1500
Processing site / mine admin / power plant area and incl. construction area, accommodation camp and rail loop area		650
Murray downs road realignment area	Approx. 12 km	50
Borefield pipeline	Up to 18 km, incl. maintenance track	20
Surface tailings storage facility	1060 m diameter	90
Total		**3775**



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0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Existing roads
- Road realignment
- Access road
- Water supply pipeline
- Access corridor
- Accommodation camp
- Landfill
- ROM
- Mineral lease
- Pit extent (years)
- Construction area
- Beneficiation plant
- Surface tailings storage facility
- Temporary waste stockpiles

Verdant Minerals Ltd
Ammaroo Phosphate Project

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Date	06 Oct 2017

Mine site general arrangement **Figure 2-2**

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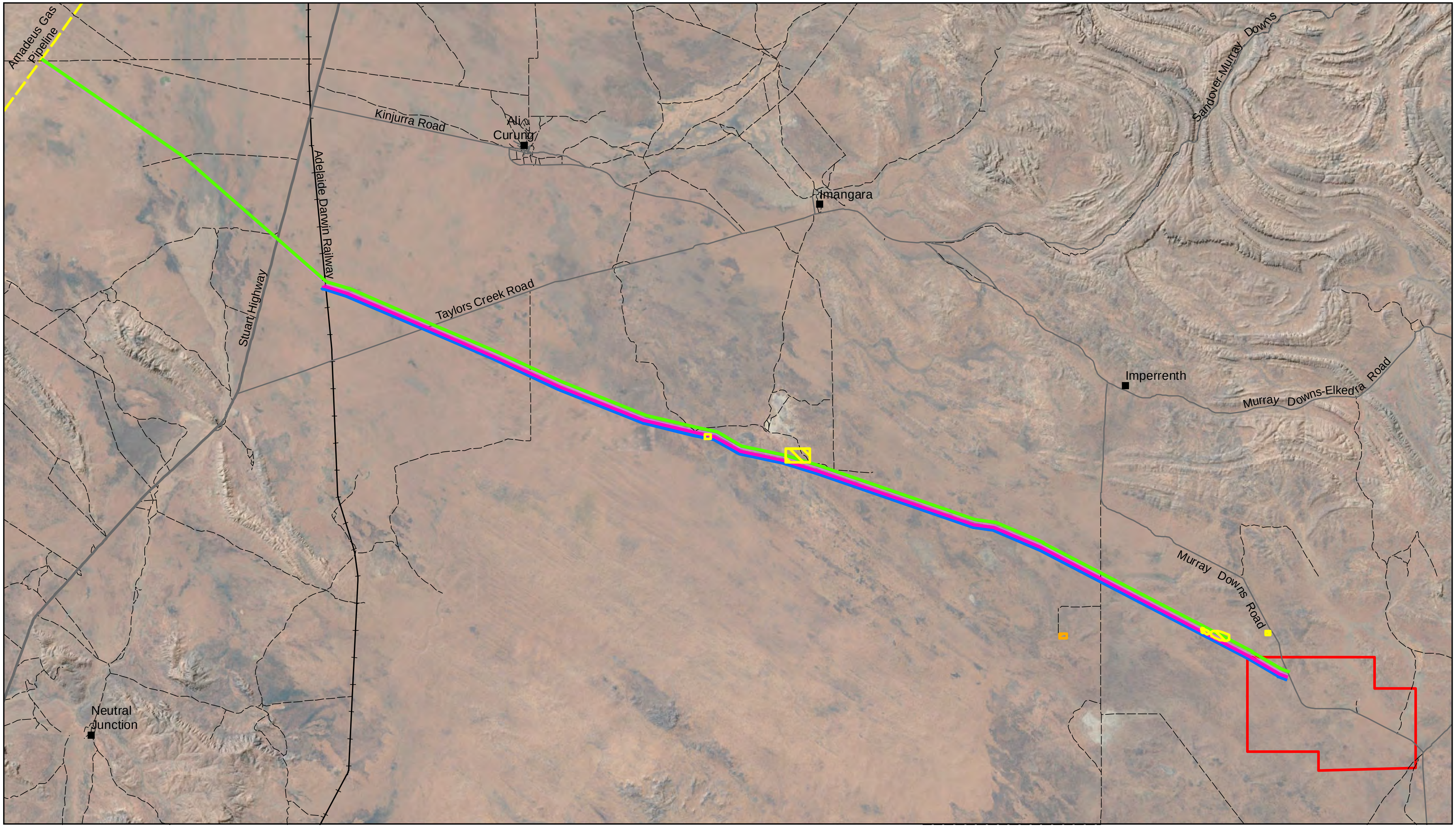
Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 16/08/2017). VML - Proposed Corridor, Project Site, Pit Footprint (2017). Created by: CM



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0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and Communities
- 137 km natural gas supply pipeline
- Rail maintenance track
- 105 km rail spur
- Major Road
- Local Road
- Tracks
- Amadeus gas pipeline
- Rail
- Mineral lease
- Ballast Quarry
- Borrow Pit

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Ammaroo Phosphate Project

Job Number 43-22544
Revision 0
Date 06 Oct 2017

Infrastructure corridor

Figure 2-3

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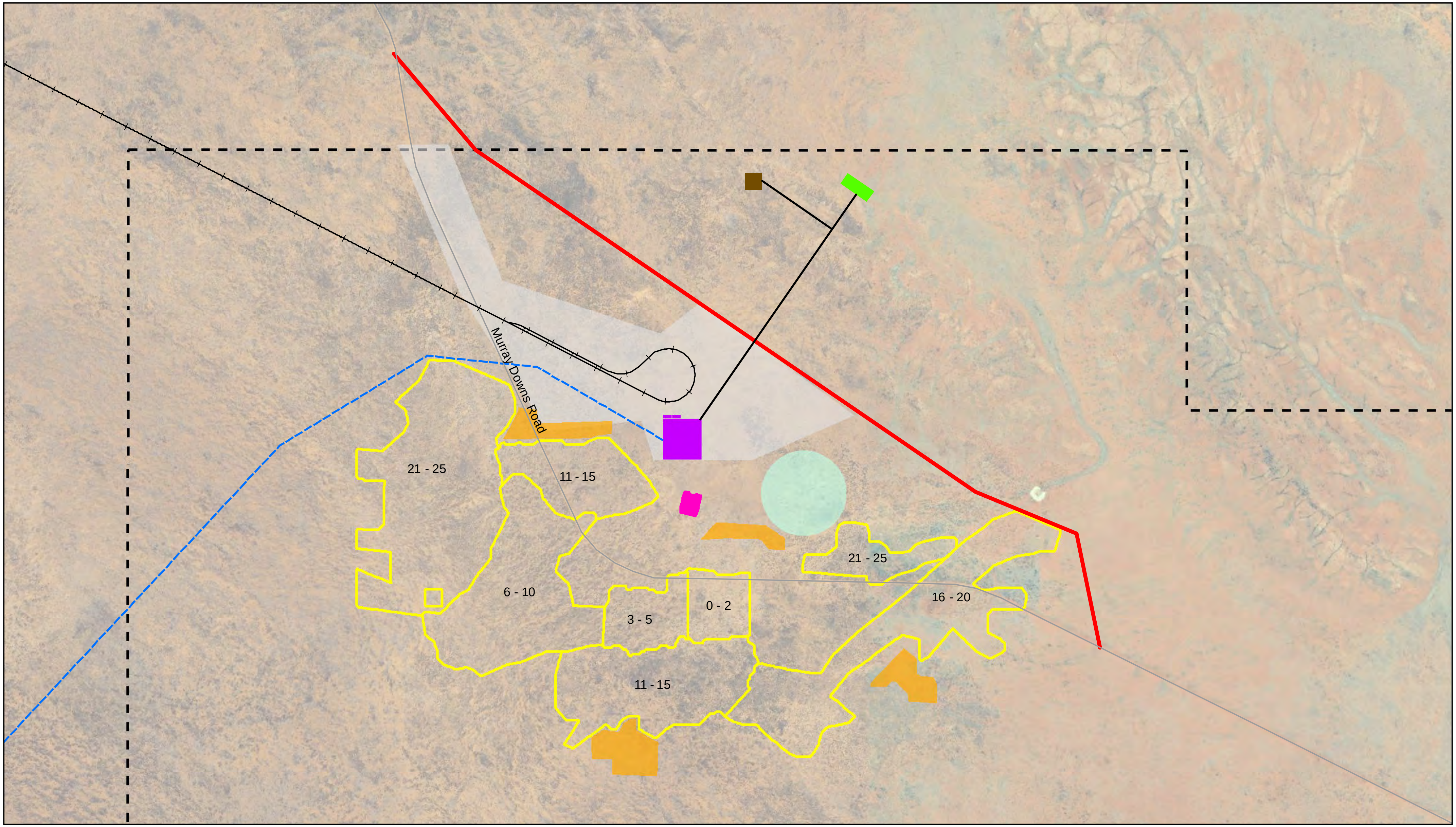
Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 19/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM



1:75,000 @ A4

0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Access road
- Rail connection
- Existing roads
- Water supply pipeline
- Proposed realignment
- Accommodation camp
- Landfill
- ROM
- Temporary waste stockpiles
- Beneficiation plant
- Construction area
- Surface tailing storage facility
- Mineral lease
- Pit extent (years)

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Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Murray downs
road realignment

Figure 2-4

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 16/08/2017). VML - Proposed Corridor, Project Site, Pit Footprint (2017). Created by: CM

2.3 Project construction schedule

The main construction activity from early site and access corridor clearance, mine pre-strip and construction of the process plant, rail spur and pipelines will be carried out over an estimated 2 year period.

Table 2-2 Indicative construction schedule

Project element	Time to construct	Start	End
Project mile stones			
Financial investment decision (FID)		June 2018	
Project start up			June 2020
Key activity time frames			
Project construction	2 years	June 2018	June 2020
Murray Downs Road alignment	6 months	Q3 2018	Q1 2019
Rail spur incl. formation and track work	12 – 18 months	Q3 2018	Q4- 2019
Borrow pits	12 months	Q3 2018	Q3 2019
Gas pipeline	9 months	Q2 2019	Q1 2020
Mine pre–strip for borrow	9 months	Q3 2018	Q2 2019
Process plant	18 months	Q4 2018	Q2 2020
Accommodation camp	6 months	Q3 2018	Q1 2019
Power station	9 months	Q1 2019	Q4 2019
Mining pre-strip	3 months	Q1 2020	Q2 2020

2.4 Mine operation

The basis for design for the Ammaroo phosphate mine is to deliver a ROM product that, when beneficiated, will produce 32% P_2O_5 rock concentrate, at a given rate. This product will be produced at a project start up rate of 1 Mtpa in years 1-5, and at a full scale rate of 2 million tonnes per annum (Mtpa) from year 6 onwards.

Two ore grades have been used to classify the phosphate resource:

- High Grade (HG) which is greater than 15% P_2O_5
- Low Grade (LG) that exceeds 10 % P_2O_5 and is less than 15% P_2O_5.

Estimates at P_2O_5 cut-off grades of 10% and higher is based on identification of continuous mineralisation grading more than 10% P_2O_5, with a comparatively small internal higher grade domain interpreted at approximately 23% P_2O_5 cut-off.

Table 2-3 Mine design basis

Description	Unit	Design Basis
Design Production Rate (P_2O_5 concentrate)	Mtpa	1 Mtpa in years 1-5 2 Mtpa in years 6-25
Product Grade (concentrate output)	%wt	32% P_2O_5
Average ROM Grade	%wt	14-16% P_2O_5
P_2O_5 Recovery	% P_2O_5	75
Beneficiation Feed Rate (average plant capacity)	Mtpa	2.5 in years 1-5 5 in years 6-25
Cut-off Grade	% wt	10% P_2O_5
Mining Rate	Mtpa	6.5 in years 1-5 18-20 in years 6-25
Life of Mine (LOM)	Years	25 years
Pre-production period	Years	6 – 9 months

2.4.1 Pre mining

Construction of required mining infrastructure for the first 2 years of mining will be conducted during pre-production. Suitable overburden will be used in the construction of site infrastructure including road bases, surface tailing storage facilities and ROM pad. The main requirements for pre-production are to:

- Establish the haul roads to enable heavy mining fleet to travel between the pits and the ROM pad, and to and from maintenance and refuelling facilities.
- Drill water production wells and install distribution pipelines and catchments, noting one production bore is already in place.
- Generate sufficient waste rock material from the overburden to build infrastructure items required for the operation of the mine, e.g. above ground tailings dam embankments, roads, foundation pads, wind-walls, water diversion berms etc.
- Murray Downs Road realignment will be completed to segregate pre-production activities from the public road.
- Provide waste and low grade ore for the construction and screeding of the ROM pad
- Create the outline of the initial pit boundaries and build access ramps and benches to enable efficient mining of the ore body within the initial pit areas.
- Establish a stock of ore feed material equivalent to approximately two (2) weeks process plant feed ready for commissioning the process plant.

The project will commence pre-mining during the project construction phase, stripping overburden to expose the ore body. Gravel will be sourced from project borrow pits for areas where overburden is not suitable for use.

Areas beneath footings, slabs and pavements will be stripped of unsuitable materials and, where fill is required to raise levels to design levels, the exposed subgrade will be proof rolled, filled and compacted.

Fill will be sourced from the mine. The overburden waste ore, estimated at 1.0 million cubic metres (MCM), will be stripped from the first pit shape to be used as fill for earthworks required for the process plant construction. Fill will comprise material such as, gravel, sand, clay or weathered sedimentary rock. The majority of the site materials encountered will be suitable for general fill.

Silt and silty sand material are not suitable for general fill due to the difficulty in achieving sufficient compaction. These less desirable materials will be stockpiled as overburden waste.

Road construction materials for Murray Downs Road will be locally sourced, under existing road easement agreements.

2.4.2 Mine staging

The mine schedule is designed to provide run of mine ore (ROM) so as to be able to produce 1 Mtpa of phosphate concentrate ore through years 1 to 5, and 2 Mtpa of phosphate concentrate through years 6 to 25. Pit preliminary planning has been completed by Mining Plus (2017) on the measured and indicated resources to provide a basis for mine scheduling. Pit locations, pit shapes and sequencing has been developed by considering the economic returns including consideration of phosphate grades/ impurities/ stripping ratios, beneficiation recovery rates and sales price.

The relationship between pit shapes and the mining sequence is described below in Figure 2-5

Material movement within each pit shape is summarised in Table 2-4.

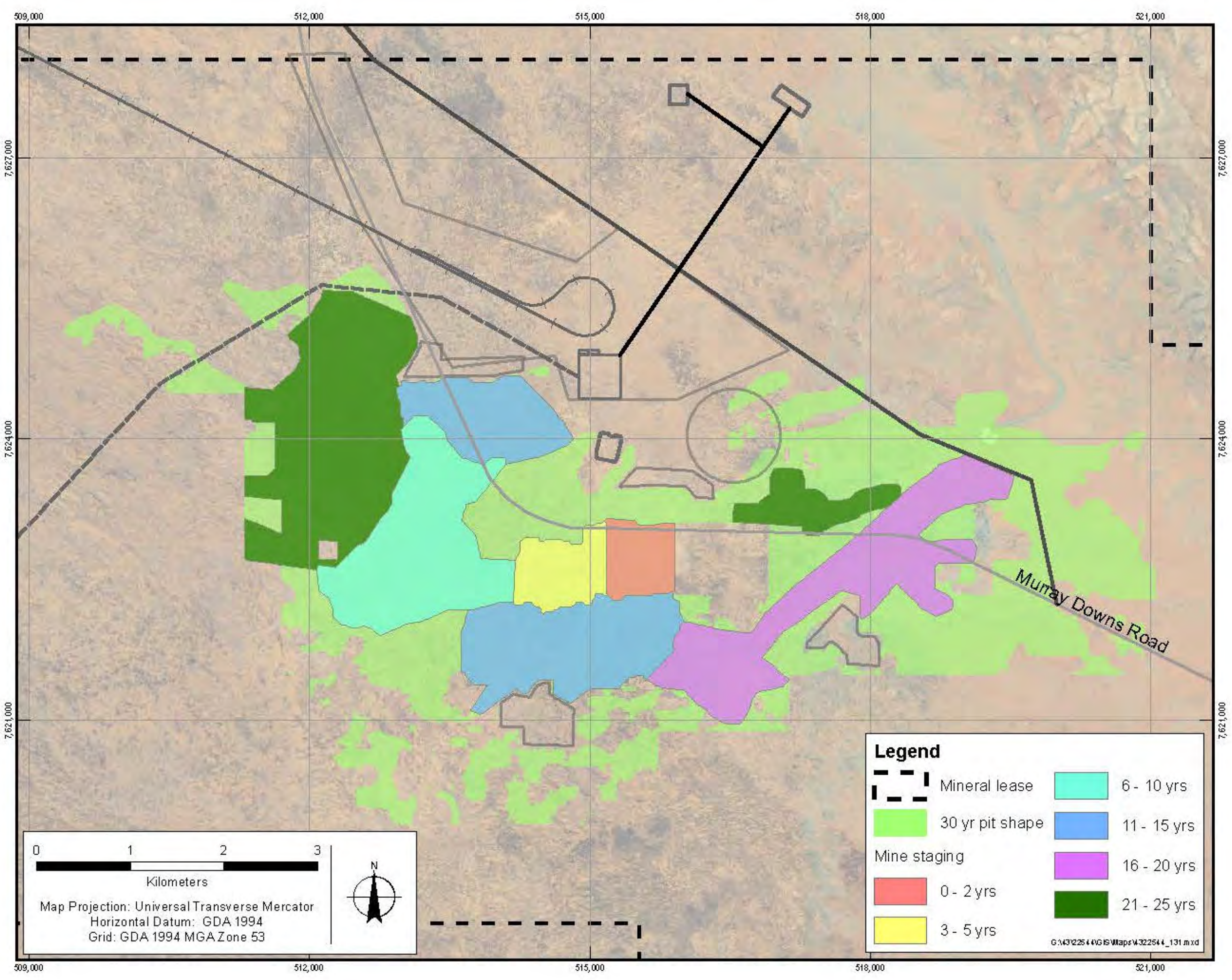


Figure 2-5 Mine staging plan - 25 years

Table 2-4 Summary mine plan

Pit shape	Year /stage	Total tonnes mined (Mt)	Overburden (Mt)	Total Mined ore (Mt)	Stockpiled Ore (Mt)	Plant Feed ore (Mt)	Tailings (Mt)	Total product (conc) (Mt)
1	0-2	13.1	7.6	5.5	0.0	0	3.5	2.0
2	3-5	25.5	18.2	7.3	0.8	0.8	3.5	3.0
3	6-10	103.3	76.8	26.5	3.7	3.7	12.8	10.0
4	11-15	91.3	65.9	25.5	0.2	0.2	15.3	10.0
5	16-20	91.7	68.8	22.8	0.2	0.2	12.6	10.0
6	21-25	113	85.1	28	-3.9	-3.9	21.9	10.0
LOM total		**437.8**	**322.3**	**115.6**	**0.8**		**69.6**	**45.0**

2.4.3 Mining method overview

The mining method will be open cut strip mining in defined pit areas (Figure 2-5) using traditional truck and shovel operations to remove overburden and transport ROM ore to the beneficiation plant. Overburden and tailings will be used to backfill the open cut pits. Thus, it is intended that rehabilitation will be progressive during mining once individual pits have been economically depleted.

A surface tailings storage facility will be constructed to hold the first three years of tailings, after which time tailings will be placed in-pit and capped with overburden during the rehabilitation process.

Table 2-5 Overburden and tailings disposal over Life of Mine

Pit Stages / Years	In Pit Overburden Storage (Mt)	Surface Overburden Storage (Mt)	Total Overburden (Mt)	Surface Tailings Storage(Mt)	In Pit Tailings Storage (Mt)	Total Tailings (Mt)
0-2	0.0	7.6	7.6	4.0	0.0	4.0
3-5	18.2	2.5	18.2	1.3	2.7	4.0
6-10	76.8	0.0	76.8	0.0	14.5	14.5
11-15	66.9	0.0	66.9	0.0	17.3	17.3
16-20	68.8	0.0	68.8	0.0	14.3	14.3
21-25	85.1	0.0	85.1	0.0	24.9	24.9
LOM Total	314.7	10.1	322.4	5.3	73.6	78.9

In year 0, overburden will be removed to expose the phosphate ore in Pit 1. This overburden will be used, where appropriate, for various bulk earthworks requirements across the project site. E.g. internal haul roads, windwalls, diversion bunds.

Once the mine is in operation, and new mining areas are progressively opened, fresh waste rock will be removed and used to backfill previously mined pits, with the excess being stockpiled adjacent to mining areas. The location of the waste rock stockpiles will be optimised to reduce disturbance areas, minimise the haul distance to transport the material and to avoid sterilisation of future mining areas. Whole pits or large areas of depleted pits will be progressively backfilled and rehabilitated once mining in the pit is complete.

Some depleted pits or areas of depleted pits will be designated for the in pit storage of tailings as soon as possible, and before the end of year 3. These pits will remain open until they are filled with tailings and then they will be given time to dry out prior to capping with overburden and rehabilitating.

In-pit waste disposal will commence once sufficient floor space or working width has been developed. Waste rock will be dumped by truck and contoured by track dozers. The active mining area will be kept small to minimise haulage. The waste rock will be mined ahead of the ore mine face.

Topsoil management

Before mining, the topsoil and cleared vegetation will be stripped and stored in windrows for subsequent placement during rehabilitation. The soil and cleared vegetation will be systematically managed to provide capping material.

Over the life of the mine, clearing and soil removal is planned each year. As mining and rehabilitation will be a continuous process, and topsoil will be routinely used in the rehabilitation, topsoil storage will be limited in volume. Topsoil storage heights will also be limited to maximise stability and minimise erosion potential. Deposited topsoil will be placed using elevating scraper or graded into rows to minimise compaction. Retained topsoil will be kept away from drainage lines and site boundaries.

2.4.4 Pit design description

A conventional truck and shovel mining method will be used. Drilling and blasting is not anticipated to be required for any stage of this project. Waste rock and ore will be excavated in most areas or ripped by dozer in areas where mineralised material is less easily excavated. Table 2-6 provides a summary of in pit design parameters. Figure 2-6 provides a conceptual schematic of a strip mine.

The height of the mining benches is usually determined according to physical characteristics of the mineralisation, and the equipment size required to achieve the planned mining rate. It is envisaged that 8 metre benches will be mined in two 4 m flitches, or passes. The mining process will be the same for both ore and waste.

Table 2-6 Pit design parameters

Element	Parameters		
Haul road design	Width (m)	Dual lane	26 m
		Single lane	14 m
	Gradient (%)		10%
	Minimum radius of turning circle (m)		25 m
Working widths	Minimum pit base width (m)		100 m
	Minimum working width (m)		50 m

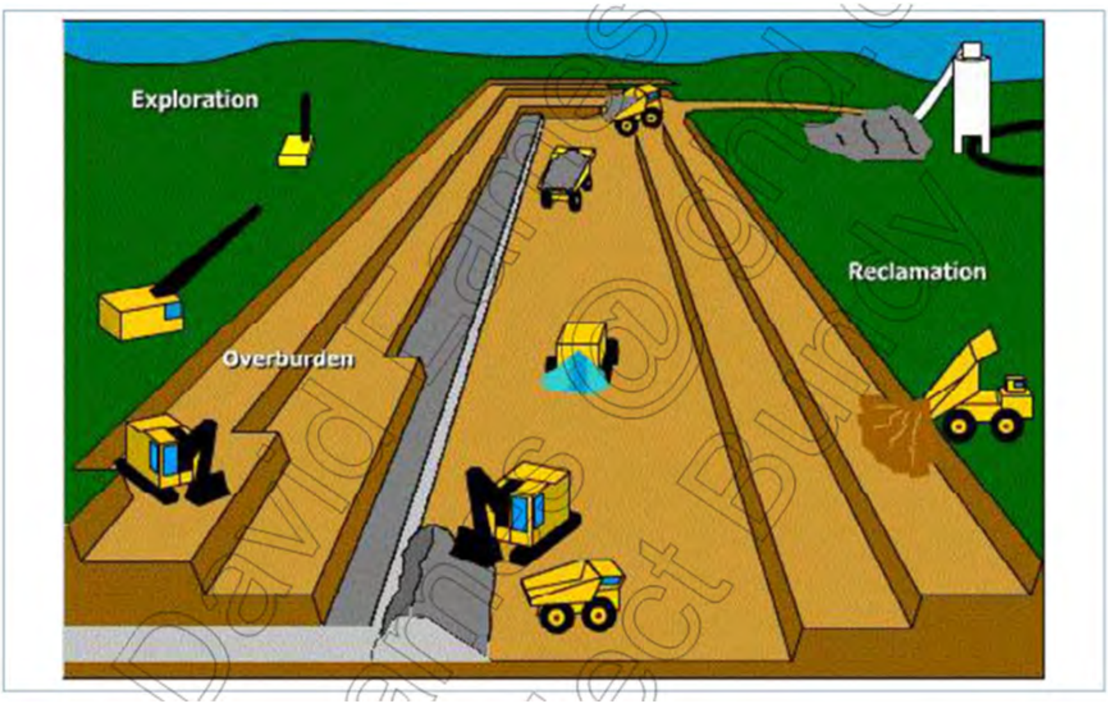


Figure 2-6 strip mine schematic

In a typical open cut mine design, a key design constraint is the location and impact of ramps on the final wall locations. One of the key characteristics of a strip mine such as this, is that it is possible to incorporate the (temporary) ramps within the pit, which minimises waste development.

Mine haul roads to service access to each pit will be constructed at the onset of mining in a particular area of the resource. Typically haul roads will be 26 m wide including drainage. Roads will be designed to allow all-weather trafficability. This will include regular spreading and compaction of suitable crushed rock road base. Mine overburden will be suitable for haul road surfacing across the project site.

2.4.5 Ore grade control

For the beneficiation process to achieve a stable output grade of 32% P_2O_5 (phosphate concentrate rock) the process plant feed must also be kept stable. The run of mine (ROM) ore will be extracted from either a single or a number of pits, and delivered to a ROM pad adjacent to the process plant. The plan is for most of the ROM to be fed directly to the process plant, but some ores of different qualities may be stockpiled, and then blended so that the project can meet a consistent feed quality into the beneficiation plant.

The ore body has also been found to have other trace amounts of elements such as aluminium, silica, iron, magnesium, lead, sulphur, cadmium, sodium, strontium, potassium, arsenic and chlorine, which are typically reacted oxides. Details of the geochemical assessment of ore, waste rock and tailings associated with the project is contained in the Ammaroo project acid, metalliferous and saline drainage assessment report appended to this EIS, and discussed in some detail in Chapter 8: Groundwater.

2.4.6 Mining Equipment

Based on the material strength (i.e. relatively weak and easily excavated) and required volumes, the conventional mining fleet will consist of 200 tonne sized hydraulic excavators combined with 140 tonne off highway dump trucks, supported by standard open-cut auxiliary equipment (graders, water carts, dozers, front end loader etc.). The heavy mining equipment that is required to deliver the mining plan is outlined in Table 2-7. Mining equipment will typically operate 10-11 hours per day, 7 days per week if economically beneficial to do so.

Table 2-7 Heavy mining equipment requirements

Equipment Type	Manufacturer Model	Operational Weight (Tonnes)	Quantity Required
Primary equipment			
Excavator	Caterpillar - 6020B	220	3
Haul Truck	Caterpillar - 785D	Payload - 140 Operational – 250	5 increasing to 10
Ancillary equipment			
Front End Loader	Caterpillar – 992K	100	1
Tracked Dozer	Caterpillar - D9T	50	1
Grader	Caterpillar – 16M	26	3
Water Truck	Caterpillar - 773	Payload - 55 Operational – 102	2

2.4.7 Materials Handling

Mobile mining equipment will be used for handling of mined overburden waste rock, and ore.

Excavators and loaders will be used within the pits to excavate and then load the haul trucks, which will move the mined material between the mine pit and either the waste rock stockpiles adjacent to the pit, or to the ROM pad. At the ROM pad, the haul trucks will either dump directly into the feed hopper of the beneficiation plant, or to a storage location on the ROM pad.

ROM ore will be screened and if required primary crushed at the ROM prior to being transferred by conventional belt conveyer to the front end of the beneficiation plant. The ore will remain dry and be transferred by conveyer through the process until reaches the grinding mill section. At this stage, the beneficiation process becomes a wet process through the addition of process water. The ore concentrate with water is pumped as a slurry between processing steps in piping.

In the final processing steps, the product concentrate is dewatered in a decant thickening tank followed by a filtration stage. Further drying may be required at this stage to meet the product moisture requirements for storage, transportation and export. Should drying be necessary, a number of alternatives are being considered including gas fired rotary dryers or using waste heat from the power station. Once the produce is dewatered and/or dried, it is stored in the load out facility.

Tailings will be partially dewatered and then pumped to a surface tailing storage facility in early years or the allocated mine pit for drying and storage. Decanted process water from thickening, tailings storage facility and mine pit will be directed to the process water pond for storage and recycling back into the beneficiation plant.

Further details on process water and tailings storage facilties are provided in Section 2.6.

2.4.8 Stockpiles and product handling

To ensure smooth and continuous operation of the various sections of the process plant requires a number of intermediate stockpiles and surge tanks, namely:

- Run of Mine (ROM) stockpile of approximately 200,000 t will hold a combination of ore grades suitable for either direct feed or blending into the process plant. The ROM stockpile will be configured in a number of fingers to enable segregation of the various grades of ore coming from the pits. The total area of the ROM is likely to be maximum 2.5 ha.
- Milling circuit stockpile (10,000 t) provides beneficiation plant feed of 16 hours live (6,500 t) and 8 hours dead (3,500 t) capacity. The milling stockpile provides a buffer from the crushing circuit ensuring a continuous feed to the process plant.
- Phosphate concentrate tanks (wet), which decouple the flotation and filtration/drying circuits providing a buffer between the two. A number of tanks will provide 8 hours of concentrate capacity ahead of the filter section
- Final concentrate product storage comprising at least one full train consignment of 9000 t.

2.5 Processing

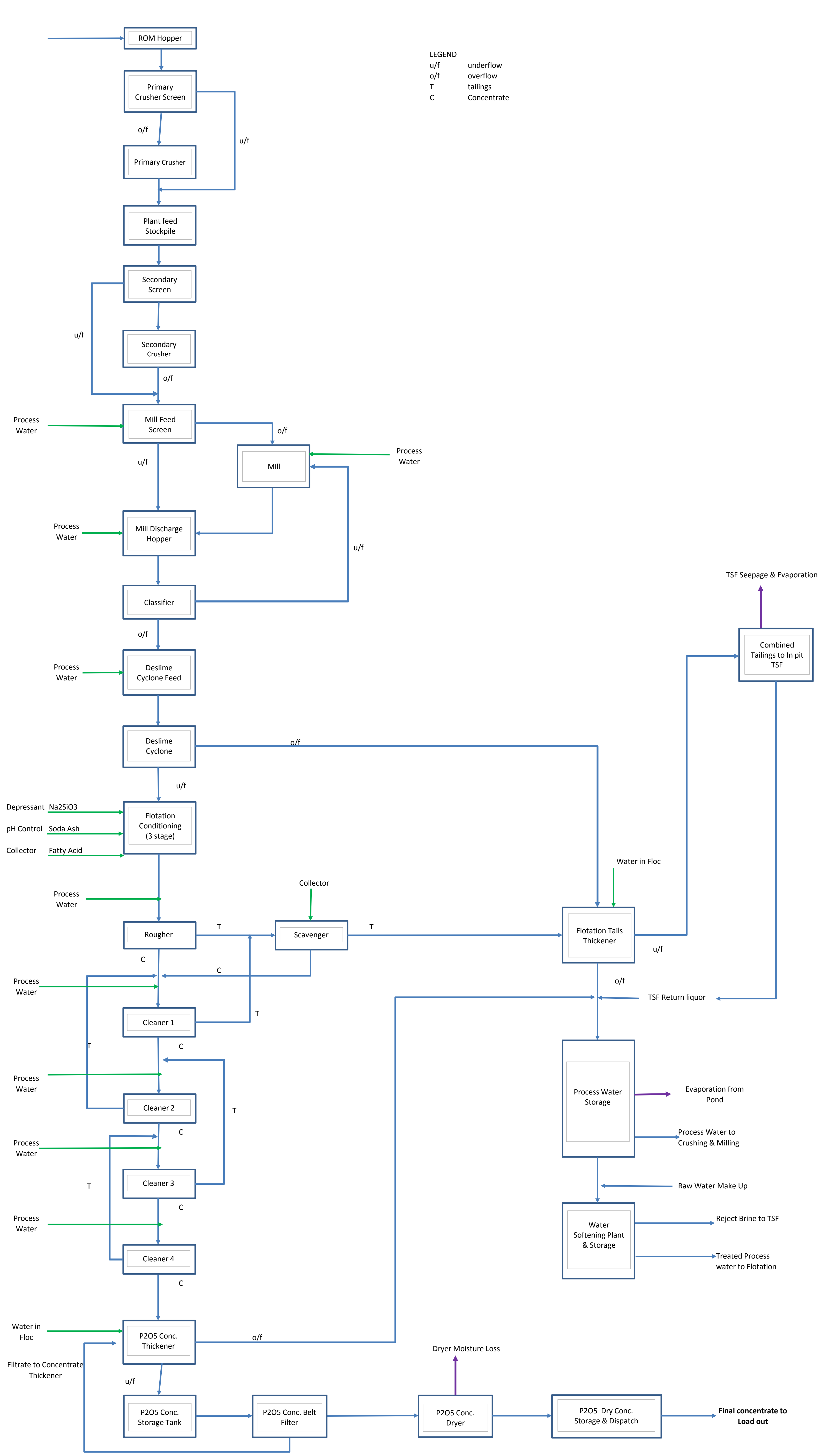
This section describes the process plant and associated facilities (collectively referred to as the process plant). The process flow sheet is based on established international process technology and the outcomes from the metallurgical test work. The flow sheet includes a split water circuit for controlling the quality of the water used in the flotation circuit.

Key process stages (Figure 2-7) comprise:

- Upfront ore preparation including crushing, screening and stockpiling facilities
- Wet screening, scrubbing, grinding and classification
- Flotation, thickening and filtration
- Tailings disposal and storage
- Drying and final product load out.

The process plant will be constructed and developed in two stages. Stage one will produce 1.0 Mtpa of P_2O_5 rock concentrate from a single train. The second stage development will occur in time to commence in years 6, and includes the addition of a further two processing trains, bring the processing capacity up to the maximum rate of 2.0 Mtpa P_2O_5 rock concentrate.

The process plant is designed to operate continuously, 24 hours every day, over a 25 year design life. It is designed to be a closed circuit operation.



Doc Desc:	Phase 1 Block Flow Diagram - Base case	Doc No.	201010-00710-00-PR-DBD-2001
Project	AMMAROO PHOSPHATE PROJECT	Revision	A
Project No.	201010-00710	Description	Issued For Review
Location	Ammaroo, NT, Australia	PREP. BY/DATE	E Wingate 26/6/17
Client:	Verdant Minerals Ltd	CHKD. BY/DATE	R Atmuri 27/6/17
		APPD BY/DATE	M Burfield 28/6/17

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2.5.1 Beneficiation

The beneficiation plant will include the following infrastructure.

- Run of Mine (ROM) stockpile pad and primary crusher
- secondary crushers
- Scrubbers
- Milling circuit stockpile and reclaim system
- Milling
- Flotation
- P_2O_5 rock concentrate thickener, filter and dryer (depending upon final product specification)
- Process water storage pond
- Reagent storage
- Tails thickener, pumping and storage facilities

The key inputs into the beneficiation process include:

- the mined phosphate ore,
- Sodium silicate (n-Grade) as a silica depressant
- Sodium carbonate as a pH modifier
- Emulsified fatty acid phosphate collector
- Process water
- Gas if drying is required
- Power supply

The key outputs of the beneficiation process are:

- 32% P_2O_5 phosphate concentrate rock
- Tailings with recycle process water including traces of reagent chemicals

2.5.2 Area 2100 – Crushing, Stockpile and Reclaim

Ore preparation

The ore from the mining area is delivered by haul trucks to the run of mine (ROM) pad and tipping station comprising the ROM stockpile, feed bin and crusher feeder and associated equipment. The ROM facility is located at the edge of the mining area (Figure 2-2).

The ore is processed through two stages of crushing and screening to produce a sized material for the downstream grinding circuit. The crushed ore is conveyed by open conveyor to the beneficiation stockpile

Run of Mine

The ore from the mine is direct dumped or blended into a ROM bin. The bin has a nominal 30 minute residence time and feeds the ore via an apron feeder into a 1st stage sizer. The sizer reduces the size of the ore from 200 mm to 50 mm. The apron feeder has a vibrating grizzly screen at the head of the feeder that removes any minus 50 mm material prior to the 1st stage crusher.

Beneficiation Plant Scrubber Feed Stockpile

The ore from the 1st stage crusher and the <50 mm ore from the grizzly is conveyed by overland conveyor to the rotary drum scrubber feed stockpile. The stockpile acts as a buffer between the dry crushing area and the wet beneficiation plant. The stockpile is fed via feeders under the stockpile to a collection conveyor for delivery to the rotary drum scrubber. The live capacity of the stockpile is maintained at 8 hours (3,600 t) with 16 hours (7,200 t) of dead stock available for pushing in by means of dozers and front end loaders should it be necessary.

Scrubbing, Screening and Crushing Plant

Process water is added to the scrubber to dilute the solids concentration to 50% (w/w). The discharge from the scrubber passes over a vibrating screen. The screen separates the minus 5 mm ore from the scrubber discharge, with the oversize material conveyed to a double rolls crusher. The discharge from the rolls crusher is fed to a further screen where the cut size is 5 mm. The screen is a wet screen so as to remove the fine phosphate from the larger particles. The oversize is discharged onto a belt conveyor and transported to a waste stockpile. The screen under size is pumped to the agitated slurry storage tanks. The 5 mm material from the scrubber discharge screen is pumped to a series of agitated slurry storage tanks.

2.5.3 Area 2300 – Grinding

The scrubber discharge screen undersize product from the agitated slurry storage tanks is delivered via slurry pump to the mill classification hydrosizer. The hydrosizer feed is adjusted with dilution water to 40% (w/w) solids. The cut point of the hydrosizer is 200 µm. The hydrosizer over flow is pumped to a dewater hydrocyclone cluster. The underflow from the hydrosizer flows at 60% (w/w) solids into the mill feed pump hopper. The slurry is pumped into the mill. The dewatering cyclone overflow forms the feed to the flotation section. The cut point for the mill classifying cyclones is P_{100} 212 µm (P_{80} =106 µm). The solids content is 32 % by mass of the flotation reagent conditioning circuit.

Mill

The minus 5 mm material from the scrubber discharge screen is held in slurry form in tanks ahead of the milling section. Slurry is transferred via pump to the mill feed hydrosizer classifier where the minus 200 µm material is removed as overflow. The plus 200 µm material leaves the hydrosizer at 60% (w/w) solids and flows into the mill feed pump hopper. The mill slurry density is controlled to 60% solids by mass. The discharge from the mill flows into the mill hydrosizer feed pump hopper. Dilution water is added to control the solids density of the slurry at 40% as it is fed to the mill classification hydrosizer.

The mill is equipped with grinding media loading facilities using an overhead crane and kibble. The mill is equipped with automated lubrication systems for the various gears, bearings and drive system. The milling area will be designed with a large spillage sump and containment bund so as to prevent spillage outside of the area. The sump area will be able to be accessed by small mobile cleaning equipment once the liquid levels have been pumped away.

Grinding Control

The grinding circuit will be equipped with an on line chemical and particle size analyser. The units will be fitted to the classification hydrosizer overflow stream. The online particle size analyser will be used to monitor the P_{80} grind size nominated for the operation of the plant. This information is fed back to the process control room where operators can monitor the performance of the mill and its grinding. The online chemical analyser will extract slurry samples from the classification cyclone overflow and analyse for P_2O_5, MgO, CaO, Al_2O_3, Fe_2O_3 and

SiO_2. This information will form the basis of the downstream flotation plant control with respect to monitoring the P_2O_5 content in the feed to the flotation circuit.

2.5.4 Area 2400 Reagent Conditioning and Floatation

The primary purpose of the reagent conditioning section to contact the slurry with the reagents required to recover the P_2O_5 in the downstream flotation circuit. The reagents are added in a scheduled sequence into three agitated tanks in series.

Reagent Conditioning Tanks

The slurry from the dewatering hydrocyclone cluster overflow enters the first of a series of three stirred tanks. Here the flotation reagents (Silica depressant, pH regulator and P2O5 collector) are added one per tank. The traditional method for conditioning is to make use of high solids (>50% by mass) in conjunction with agitators rated at 2.5 to 5.0 kWh/m^3 of tank volume. The slurry overflows from tank to tank via launders. The slurry from the final conditioner tank flows by gravity into the feed box of the rougher flotation section.

Flotation Circuit

The reagentised slurry from the third conditioner tank flows into the feed box in the rougher sections. Dilution water is added to adjust the incoming slurry to the required solids density for rougher flotation. The flotation circuit consists of a rougher scavenger and three stages of cleaning to produce a 32% P_2O_5 rock concentrate. The tailings from the first cleaner are combined with the rougher tailings and processed through the scavenger circuit to recover any lost P_2O_5 units. The flotation circuit makes use of 30 m 3 mechanical flotation tank cells. This is due to the fine particle sizes being floated in this operation. The P 100 is 212 µm with a P 80 of 106 µm. The flotation cells are forced aerated by means of external low pressure air blowers. The concentrates and tailings are transferred between stages using centrifugal slurry pumps designed for handling froths. The launders are all equipped with push water feed pipe lines.

Flotation Circuit Control

There are two sampling positions in the flotation circuit where slurry samples are extracted for analysis using the inline chemical analyser. The samples are based on final tailings and final concentrate. The samples are analysed for P_2O_5, MgO, CaO, Al_2O_3 , Fe_2 and SiO_2 . This allows for the P_2O_5 losses to be monitored in the final tailings, the P_2O_5 grade and the minor element ratio of the final product.

2.5.5 Area 2500 - Concentrate Thickening, Filtration and Drying

Concentrate from the final cleaner flotation circuit is pumped to the concentrate thickener. Flocculant is added to assist in settling of the solids. The over flow water is recovered to the process water system. The under flow is pumped to the filter feed tank. The concentrate slurry is filtered to further reduce the moisture content of the P_2O_5 concentrate. Should further drying be required, the filter cake is transferred via belt conveyors to the gas fired rotary driers. The filtrate from the filters is recycled to the concentrate thickener.

Concentrate Thickener

The P_2O_5 concentrate from the final cleaner circuit is pumped from the concentrate hopper to the concentrate thickener by means of centrifugal slurry pumps designed to pump mineral slurry froths. The concentrate contains 24% solids by mass. This is diluted down to 15% by mass in the feed well of the thickener using internal dilution liquor drawn from the thickener surface. A dilute poly acrylamide flocculent is added to the feed of the thickener to assist in agglomerating the fine solids in suspension.

The underflow is discharged at a solids concentration of 40% by mass. The underflow pumps are centrifugal slurry pumps. The pumps are VSD driven so as to allow the even extraction of slurry at the correct density. The underflow is fitted with a density gauge and a flow meter to be able to monitor and control the under flow density fed to the filter feed tanks.

The thickener under flow piping is designed to allow the underflow to be recycled back to the thickener if the slurry density drops below the target value required for filtration. The filter feed slurry tank is designed to act as a buffer between the flotation section and the downstream dryer and load out section.

Filtration

There are two filters, which receive the concentrate slurry at 40% solids by mass and dewater the material to produce a filter cake containing final moisture of approximately 15%. The filter cake is discharged from the filters onto a series of collection belt conveyors. The filtrate is recycled back to the concentrate thickener so as to recover any lost P_2O_5 material.

Concentrate Drying (if required)

Should the concentrate require drying, the filter cake will be conveyed to a rotary gas fired dryer. The filter cake is fed into each drier via weigh belt feeders to control the rate of solids delivery. The filter cake has a moisture of approximately 15% and is dried down to final product moisture of between 6 and 3 %.

The dryers will have primary heating using natural gas at 150 GJ/hour, although designs are being considered to utilise waste heat. The dryers are fitted with off gas dust collection systems, which clean the discharged gas to recover any lost P_2O_5 units. The recovered dust is combined with the dryer discharge onto a common collection belt conveyor.

2.5.6 Area 2600 – Phosphate Concentrate Load Out

The phosphate concentrate rock from the process plant will be transported via conveyer to a storage area adjacent to the rail loop to facilitate loading of the rail wagon. The concentrate will be stored on a hard standing and will be covered either with a dome type structure or a purpose built shed.

The storage on site will be sized initially to facilitate the loading of 3 trains per week via front end loaders directly into the rail wagons. In time and in readiness for a production rate of 2 Mtpa of P_2O_5 rock concentrate, these facilities will be upgraded to enable automated loading of the rail wagon, using a combination of silos and train loading bins.

2.5.7 Areas 2700 Beneficiation Plant Reagents

The beneficiation function of the process plant requires a series of reagents in the flotation and thickening circuits. The materials will be delivered to site in bulk (Table 2-8) either as dry bulk solids or as bulk liquids. The site will have storage facilities for 14 days' supply. Each reagent will have a daily make up facility where a 24-hour supply of material is prepared.

Table 2-8 Consumables - annual requirements and storage quantities

Reagent	Storage for 2 Mtpa (14 days storage)	Annual Consumption at 2 Mtpa
Flotation chemicals		
Collector (fatty acid)	280 t	6400 t
Flocculant (Poly acrylamide)	15 t	360 t
Si Depressant (sodium silicate)	280 t	6400 t
PH Regulator (soda ash)	140 t	2800 t
Fuel		
Diesel	417 t	9240 t
Water treatment chemicals		
Sodium Hypochlorite	10 kl	225 kl
Ferric Chloride (coagulant)	39 kl	875 kl
Polymer (flocculant)	1 kl	15 kl
Sodium Metabisulphite	6 kl	138 kl
Hydrex 4104	7 kl	150 kl
Sodium Chloride	0.5 kl	11 kl
Caustic	11 t	250 t

2.5.8 Area 2900 Tailings and Tailings Storage

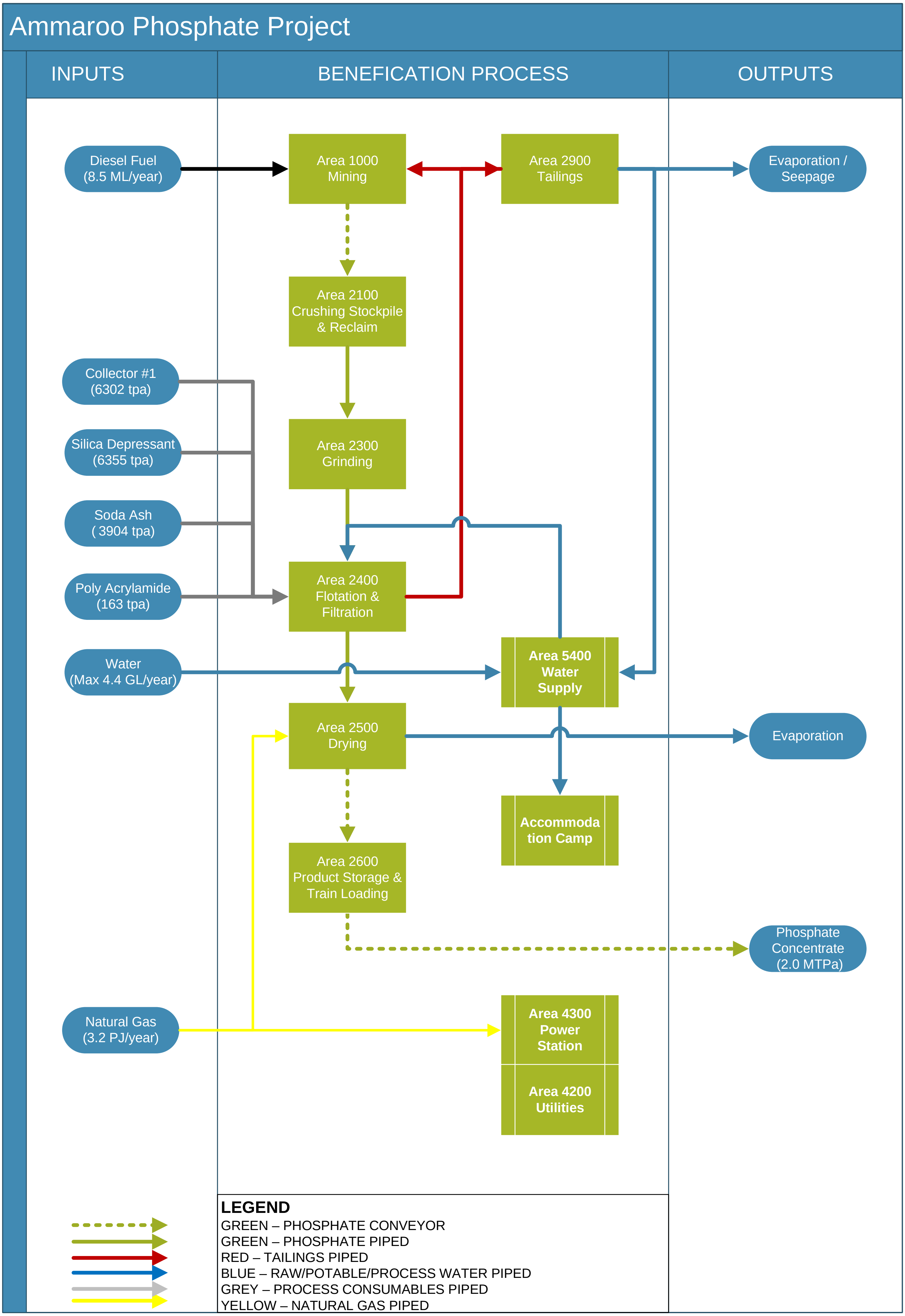
The waste stream from the flotation plant is pumped from the scavenger tailings pump hopper to the tailings thickener feed well inlet. The material is mixed with a dilute poly acrylamide flocculants to assist in agglomeration and settling of the solids in the slurry. The underflow from the thickener at a solids concentration of 40% by mass, is pumped to an intermediate tank from where the thickened slurry is pumped to a tailings storage facility. Water not part of the thickened slurry, is recovered from the waste stream via the thickener overflow launder.

Tailings Disposal System

The first three years tailings will be stored above ground in a surface tailings storage facility. The mining operations will open up large voids in the mine which will then form the tailings storage ponds for the life of the mine. At certain points in the life of the mine the tailings disposal pipe line will need to be extended as the disposal distance grow. The tailings disposal pump station and associated pumps will need to be expanded as the distance to the point of disposal increases over the life of the mine.

2.5.9 Summary process plant mass balance

Figure 2-8 provides an overview of the projects core material inputs and outputs.


Ammaroo Phosphate Project
INPUTS
BENEFICATION PROCESS
OUTPUTS
Diesel Fuel (8.5 ML/year)
Area 1000 Mining
Area 2900 Tailings
Evaporation / Seepage
Area 2100 Crushing Stockpile & Reclaim
Collector #1 (6302 tpa)
Silica Depressant (6355 tpa)
Area 2300 Grinding
Soda Ash (3904 tpa)
Poly Acrylamide (163 tpa)
Area 2400 Flotation & Filtration
Water (Max 4.4 GL/year)
Area 5400 Water Supply
Area 2500 Drying
Evaporation
Accommodation Camp
Area 2600 Product Storage & Train Loading
Phosphate Concentrate (2.0 MTPa)
Natural Gas (3.2 PJ/year)
Area 4300 Power Station
Area 4200 Utilities
LEGEND
GREEN – PHOSPHATE CONVEYOR
GREEN – PHOSPHATE PIPED
RED – TAILINGS PIPED
BLUE – RAW/POTABLE/PROCESS WATER PIPED
GREY – PROCESS CONSUMABLES PIPED
YELLOW – NATURAL GAS PIPED

2.6 Waste rock and tailings management

Waste overburden production rates will vary over the life of the mine in accordance with the ore depth, in-pit grade and pit geometry. Strip ratios are expected to range from 1.0 to 3.0, which will equate to waste overburden rates in the region of 3.0 to 19.0 Mtpa over the life of mine. Overburden removed to gain access to the ore during mining will be progressively returned to the mine pit. Mining in the initial stages of the project aims to minimise the overburden removed to expedite the creation of in-pit storage of process tailings.

To produce 1 Mtpa of phosphate rock concentrate, the process plant will process 2.7 Mtpa of ore and will generate approximately 1.0 to 1.2 Mtpa or 750,000 to 980,000 m^3 per year of tailings.

To produce 2 Mtpa of phosphate rock concentrate, the process plant will process between 4.5 and 6.3 Mtpa of ore and will generate between 2.0 and 2.5 Mtpa or 2.5 and 3.1 Mm^3 of tailings per annum.

A surface tailings storage facility will be constructed to hold a nominal three years of tailings, equivalent to 3 million m3 of tailings at approximately 1 million m^3 per year. After the first two years, it is expected that tailings will first be placed in in-pit tailings facilities and subsequently capped with overburden when dry. Detailed mine planning and optimisation will determine the most effective sequence of pit mining and subsequent conversion to in-pit tailings storage. The volume of material mined and tailings produced at different mine stages is summarised in Table 2-4.

The in-pit tailings storage facilities will need to provide sufficient storage capacity to match the ongoing production of tailings for a duration until a future pit is available for conversion to tailings storage. Approximately 52 million cubic metres or 65 million tonnes of tailings will be generated over the 25 year mine life.

The TSF facilities (surface and in-pit) will be designed to include water recovery (estimated to be approximately 20- 30% of the water discharged in the tails to the TSF) from collection ponds using a decant or floating pump station.

TSF embankments will be constructed from compacted silt/clay fill, sourced from either within the storage facility footprint areas or from mine overburden as part of the mining operations. Given the geochemical composition of the tailings (see detailed geochemical assessment report appended to this EIS), the tailings facilities will be unlined.

Table 2-9 TSF concept design parameters

Parameter	Design
Storage capacity	1 million lcm/pa (year 1-3, surface TSF) 2.5 million lcm/pa (year 6 -25, in-pit)
Water recovery	Yes, pontoon pump or similar
Crest width (surface TSF)	6 m
Embankment slopes	1:2 (V:H) internal 1:3 (V:H) external
Freeboard (from top of tailings to crest)	1 m
Spill way inlet	0.5 m below crest
Tailings beach slope	0.5%
Slurry density	40% solids
Design dry density	0.75 t/m^3

2.6.1 Surface TSF design and operation

The surface TSF will be of a circular design to minimise construction materials as compared to other TSF layouts. It has a nominal design life of 3 years, with the location and design suitable to enable an increase in the containment walls should further capacity be required before reverting to in-pit tailings disposal. It will have a radius of approximately 500 m to the inside wall (occupying an area of and a wall height of 3 metres providing an initial capacity of approximately 3 million tonnes of tailings. occupying an area of 100 ha.

To protect the TSF perimeter embankment from seepage, a 1.5-2 m deep barrier of compacted silty/clayey fill will be installed at the internal toe of the embankment. The surface TSF will have a series of collection points at the toe of the impoundment wall where run off water will be collected and returned to the process water circuit.

The provisional design of the TSF embankments will have a crest width of 6 m, an internal slope of 1:2 (vertical to horizontal V:H) and a downstream slope of 1:3 (V:H).

Tailings will be deposited into the surface TSF via a centralised arrangement, allowing for lower containment wall heights. This type of tailings facility makes use of a central riser pipe in the middle of a circular impoundment. The slurry (concentration approximately 40% water) then flows out of the raiser and forms its own beach slope which then dictates the future slurry flow patterns and water recovery at the toe of the impoundment wall.

The surface TSF, by the nature of its design, will have a series of water collection points at the toe of the empoundment wall where run off water will be collected and returned to the process water circuit.

The deposited dry density of the tailings is likely to be in the order of 0.9 t/m^3 after 24 hours of deposition, with marginal increase in the time thereafter. The water available for recovery during this period is expected to be in the order of 30% of the total slurry water discharged.

2.6.2 In pit tailings storage

In pit tailings storage facilities will be constructed within the confines of the mined out pits, using engineered tailings walls within the pits to enable simultaneous mining and tailings disposal safely within the same pit. Table 2-5 defines the tailings volumes by mine pit over the LOM.

In–pit deposition of tailings will commence once a sufficient void has been established. The process will include construction of mine waste embankments along the sections of the pit which are to be mined in the future, to separate future mining areas from the voids and avoid ore steralisation by tailings. The embankments will be constructed from mine waste rock compacted by loaded mining fleet.

The in-pit TSF design will seek to use natural gradient to allow excess water to collect at the low point of the TSF impoundment. I.e. tailings will be deposited at one end of the pit and water recovered at the other. Water will be recovered using pontoon mounted water pumps. As the deposited tailings approach the pit crest, the tailings discharge points will be relocated around the pit to enable better distribution in the pit and to maximise the storage volume of the pit.

As the pits are filled, the density of the deposited tailings will be monitored over time to inform future tailings storage facility design. It is expected the tailings will be consolidated to a dry density in the order of 0.7 t/m^3 to 0.9 t/m^3 over a period of several years. Once the tailings are sufficiently stable they will be capped with a layer of waste rock up approximately 1-2 m higher than the surrounding land.

Sequencing and design details for the in-pit storage will be developed as the mine sequence and material movements schedule is confirmed.

For the in-pit tailings deposition, it is expected that the tailings will discharge from a series of spigots located on one wall of the facility, but moved around the walls from time to time to ensure even distribution and maximum use of the facility volume.

2.6.3 ANCOLD guidelines

Tailings storage design has been prepared in consideration of the Australian National Committee on Large Dams (ANCOLD) Guidelines on Tailings Dams: planning, design, construction, operation and closure, May 2012.

In accordance with ANCOLD, the surface TSF can be classified as having a hazard category of High C (due to the presence of project personnel working in the area downstream). The in-pit TSF is classified as having a hazard category of Low. The hazard category assessment and design freeboard and storm water management requirements for the facilities, based on the hazard category assessment is summarized in Table 2-10.

Table 2-10 Hazard category assessment

Factor	Surface TSF	In-pit TSF
Population At Risk	>1 to 10 Due to the location of the process plant	<1
Severity of Damage and Loss	Medium $10M - $100M Significant Business Impacts	Medium $10M - $100M Significant Business Impacts
Classification	High C	Low
Extreme Storm Allowance	1 in 100 f, 72 hr = 295.2 mm	Determine by risk assessment allow for 1 in 100 AEP, 72 hr = 295.2 mm
Additional Freeboard	300 mm	300 mm
Minimum Total Freeboard (excluding wave run-up)	595.2 mm	595.2 mm
Spillway Capacity	1 in 100,000 AEP or PMF = 12.2 mm/hr	Nil*
Note:	*In accordance with Table 5 of ANCOLD (2012) TSFs with a classification of Low do not require a spillway to be constructed.	

Emergency spillway

An emergency spillway will be installed in the surface TSF to provide a controlled point of discharge in the event of extreme rainfall events. It will be located to ensure protection of the facility walls and any downstream infrastructure.

2.6.4 Tailings storage facilities closure

Following completion of tailings deposition within the surface and in-pit facilities, the deposited tailings will be left to dry and consolidate. Given the fine nature of phosphate tailings, it is expected that the tailings will have little strength for a considerable period of time. It is expected that water will continue to pool at the periphery of the surface facility and at the lowest point in the in-pit facilities, where tailings level is the lowest. Water recovery will be achieved using skid mounted decant pumps to periodically remove any free standing water that has collected.

The surface of the facilities will be capped such that the final profile will be a slightly domed structure to allow for further settlement. Contouring of the final surface and downstream perimeter embankments (for the above ground facilities) will aid in reducing the likelihood of rainwater run-off eroding the exposed surfaces.

Following completion of the reshaping and contouring the tailings surface and downstream embankment slopes, topsoil is to be placed over the facility and revegetation/ with local plant species. Spreading of any timber throughout the facility, which was cleared as part of the construction works, will also aid in the establishment of vegetation throughout the facility. Contour ripping the exposed surfaces will aid in enabling the vegetation to establish and reduce the risk of the topsoil being eroded by wind and runoff water.

2.7 Other site infrastructure

Buildings to be provided on site will be made from typical pre-fabricated modularised sections or fully contained building units. The following buildings are likely to be required:

- Administration (typical office type construction and finishes)
- Warehouse/Workshop (steel frame building, external cladding, concrete slab floor)
- Change House (similar style construction and finishes as the Administration building, to suit the building purpose)
- Canteen (similar style construction and finishes as the Administration building, to suit the building purpose)
- Security and emergency services (More robust construction, security features included such as strengthened doors and windows, secure entrances).

Waste water treatment plant for utility oily water and process contaminated water as well as a sewage treatment facility (Section 2.11).

There will also be a reverse osmosis (RO) plant to provide conditioned process water and another plant associated with providing potable water around the site ad accommodation facilities.

Power station (see Section 2.9) and potential overhead transmission lines between the mine, accommodation village, and bore field.

2.8 Infrastructure corridor

The import and export of bulk products during the operational phase will be via a private rail spur off the Adelaide to Darwin railway, however a purpose built haul road, along the same route as the proposed rail spur, to support the trucking of product to the main Adelaide to Darwin railway line remains an option, particularly for the first 5 years of production at the 1 million tonne per annum rate.

The spur rail will be a direct line from the mine site to the railhead on the main Alice Springs to Darwin railway, approximately 15 km south of the Stuart Highway railway crossing. The rail spur is 105 km in length with a loop at the mine to facilitate loading of the trains and a small siding for offloading supplies/freight wagons.

The access corridor easement will be 70 m wide during construction, and 50 m wide during operation, and will contain a railway, maintenance track, a natural gas supply line and communications link.

Natural gas from the Amadeus pipeline 137 km to the east will be conveyed to site in a fibreglass reinforced epoxy piping system capable of transmitting 3.2 PJ per year of natural gas (See section 2.9). The route from the mine site is shown on above.

The rail siding will be designed to provide a 23 tonne axle load standard gauge rail track allowing wagons to load at the mine, and continue directly to the Darwin to Adelaide rail line intersection uninterrupted, at a speed of 20 to 40 km/h. Once on the main line the train and wagons will be able to travel at speeds up to 100 km/hr as per the mainline conditions.

Train and wagons will be operated by the contracted Operator using their operational and maintenance services. Operational consumables including diesel and hazardous chemicals such as oil and other lubricants will be stored by the Operator. The maintenance of the rail spur will be undertaken in a similar manner and with the same or similar equipment to that used by Genesee and Wyoming Australia. Track maintenance requirements will align with GWA network shutdowns/ maintenance practices.

2.8.1 Railway design specifications

Key railway design specifications are provided in Table 2-11.

Table 2-11 Key railway design specifications

Component	Specifications
Flood level	Rail spur will be low set, and built to withstand flood levels 25 year average recurrence interval (ARI) at rail level
formation	375 mm capping
formation	Width of formation at ballast level to be approx. 3 metres
rail	50 kg/m rail (i.e. 100 tonnes per km track) for 23 tonne axle load at speeds up to 40 to 50 km/h
Sleepers	Steel sleepers at spacing 650 mm, 10 mm thickness, uninsulated, with fastenings (hook in shoulder and clip)
Ballast quantity	0.5 cubic metres per metre minimum
Ballast profile	150-250 mm

2.8.2 Railway construction

Construction of the rail spur is expected to take approximately one year, and will be fully commissioned for plant start up. Site preparation and construction of earthworks will start in a number of locations along the length of the corridor concurrently, and will proceed in a westerly direction from the mine site towards the existing rail line. Construction of track work will proceed sequentially in an easterly direction from the existing railway to the mine site. It is recognised that the final rail design will need to incorporate an agreed length of track at the junction of the main Adelaide to Darwin Railway that is built to the same standard as the main line.

The construction program for the Rail comprises:

- Site preparation including site clearance, construction camp establishment, installation of temporary fencing, installation of temporary drainage and water management controls and construction of site access where required.
- Civil works including bulk earthworks, soil removal, construction of cuts and embankments, installation of permanent drainage controls, water course crossing construction and development of quarries and borrow areas.
- Track work including installation of the rail, signalling and maintenance infrastructure.

Site Preparation

Site clearing including removal of vegetation and debris and modification, diversion or realignment of existing infrastructure will occur prior to the main earthworks construction program. Topsoil and other organic material shall be stripped from the site and stockpiled in discrete locations for reuse within the rail area.

At least one mobile construction camp will be used, in addition to the mine site accommodation village and potentially exiting accommodation at regional centres such as Barrow Creek or Wycliffe Well.

A construction access track will be constructed along the rail embankment within the rail corridor, and will be sized to allow the flow of all construction and support vehicles and machinery.. The access road will cater for the movement of:

- Construction equipment and vehicles
- Personnel transport for staff and labour to access the works
- Maintenance vehicles
- Water deliveries
- Deliveries of materials including, but is not limited to, fill material, sub-base and capping material, equipment, fuels and lubricants
- Servicing temporary construction facilities along the route

Temporary site drainage and water management controls will be employed in order to manage surface water flows and sedimentation from the rail construction activities in existing waterways.

Civil Works

Site civil works includes ephemeral water course crossing construction, bulk earthworks and construction of cuts and embankments, installation of permanent drainage controls, and construction of temporary haul roads. Civil works will be undertaken in the following general order:

- Bulk earthworks including cuttings and embankments.
- The capping layers, on the embankments and pavements to access roads, will be constructed by dedicated crews comprising graders, compaction equipment and water trucks.
- Dedicated drainage crews will install drainage pipe work or culverts and concrete headwall structures.
- Rail systems conduit installation will commence prior to formation capping activities.
- Rail track works will be commenced as soon as the capping layer is completed on embankments and cut zones.

Borrow Materials

The earthworks for the rail formation will require balancing “cut” to “fill” along the rail corridor where practicable, to minimise the creation of spoil and the need to import fill. Construction material such as sub-base (general fill, formation), select fill, capping material, scour protection and ballast will be sourced from local borrow pits. Fill may also be required for a flash butt welding yard near to the rail junction, a permanent ballast stockpile along the siding and the balloon load out loop at the mine.

Ballast will be quarried, crushed and screened to produce material of the required specification, which will be transported either via the access track to the rail corridor or by rail wagons. Depending on the quantities of viable hard rock remaining, the ballast quarries may be retained to meet ongoing maintenance ballast requirements.

A number of quarry and borrow locations have been identified for investigation as shown in Figure 2-3. Geotechnical investigations are ongoing to better determine the nature of the potential resource and the quantity of resource available. Typical volumes of required materials are described in Table 2-12.

Table 2-12 Borrow pit material quantities for infrastructure corridor

Material	Quantity (tonnes)
Ballast	127,500
Substructure	170,000
Base	1,700,000
Total	1,997,500

Catch drains will be installed to separate water from the construction corridor where necessary. Excavation will then progress depending on the in-situ material types. Blasting is not considered likely to be needed along the corridor. Additional drains and access roads will be completed as the construction proceeds. Protection measures for exposed slope and batters, such as geotech mats, will be installed if the in-situ materials are unsuitable.

The drainage structures will be a mix of installation prior to and post bulk earthworks. Drainage structures will be dependent upon site specific need, loading, hydraulics, and alignments.

Drains will be designed to move surface flow to dedicated drainage ditches to reduce the likelihood of water ingress to the permanent works. The diversion of water courses for the purpose of construction will be confirmed during detailed design and undertaken in accordance with detailed erosion and sediment control works undertaken by a certified practitioner..

Temporary facilities will as far as practicable be located in previously cleared and/or disturbed areas (i.e. non-remnant vegetation areas), away from watercourses and floodplains or within areas intended for use as part of permanent operations.

Concrete will be supplied from the concrete batch plant located at the mine site.

The installation of drainage infrastructure will be programmed during the dry season to reduce the likelihood of civil works occurring in wet conditions within drainage lines.

Track Works

A mechanised tracklaying methodology is envisaged. This will enable the supply of sleepers and linear rail infrastructure to be transported and installed via specialised rail construction equipment for the majority of the needs of the spur. This will help reduce the number of truck movements along the corridor during construction.

Based on the continuous operation of a specialist tracklaying machine and encompasses daily supply of track construction materials. This eliminates significant numbers of heavy truck movements along the corridor.

The mechanised track construction will be linear from the western tie-in point to the mainline and travel east towards the mine site. The logistics of material supply will be critical to the efficiency and speed of construction and it is likely rail materials will be transported from Darwin by rail and stockpiled at the spur to main line junction.

Other temporary track laydown areas will be required to store material, equipment and machinery at locations along corridor. Temporary facilities will, as far as practicable, be located in previously cleared and/or disturbed areas, away from drainage lines and flood out areas, or within areas intended for use as part of permanent operations.

Flash Butt Welding Yard

A dedicated flash butt welding yard will be developed close to the junction of the spur line to the main line, and within a temporary construction facility area. The setup will be capable of welding short rails of 25 m lengths into 300 m to 400 m long welded rail strings that may be transported by road or rail. The flash butt welding yard will have:

- Dedicated gantries for unloading the short rail
- Automatic short rail feeder
- Power roller line for deeding the short rails to the flash butt welder and to grinding
- Inspection stations
- The long welded rail stockpile
- All movements of the rail will be done by gantries and roller line.

Construction Train Control

Safety of the construction crews and rail operators during construction will be paramount and the primary control measures will be to designate the track area either;

- Construction zone track, or
- Open railway track (commissioned railway).

Once the spur is connected to the main line and if this connection is used to supply equipment and materials for the construction of the spur, then a block point will be established between the current track laying location and the mainline connection point.

Track between the block point and the construction area will be classified as construction zone track and will be subject to the control of the track construction team.

Track between the block point and the mainline connection will be classified as commissioned railway and will fall under the control of the train controller.

Only after the track has been completed, inspected and passed, can a section of track be reclassified from construction zone track to commissioned railway and the block point moved forward.

Temporary Construction Utilities

Local construction bores will be made available approximately every 20 km along the corridor if suitable bore locations can be located. If not, construction water supply will be sourced from the project borefield system and delivered via truck.

Diesel fuel required to maintain the earthmoving fleet during the construction period, will be stored along the corridor, and in accordance with AS 1940 the storage and handling of flammable and combustible liquids.

Mobile construction camps will be used in addition to the main construction camp located at the mine for the project site, and potentially existing accommodation at Barrow Creek and Wycliffe Well. Construction teams will travel a maximum of 60 km to the furthest work point from the camp(s). The final location of camp(s) will be agreed with the appropriate landowner, and located in a previously cleared location.

All utilities and temporary facilities will comply with Northern Territory regulations, guidelines and standards relating to, for example, health requirements, fuel transport and storage and sewerage treatment and disposal

The construction work force for the rail is expected to peak at approximately 80 to 100 personnel over a 12-18 month duration.

Potable water for consumption and camp use will be sourced and supplied by tanker and/or mobile tanks and stored in local storage tanks as appropriate.

Treated effluent will be reticulated to designated areas (dust suppression) leached underground or pumped to evaporation ponds. Discharge limits and thresholds will be dependent on the site location, ground conditions, proximity to watercourses and groundwater sources, and the nature of vegetated areas. Temporary sewerage treatment works will be required, which require approval as an environmentally relevant activity.

Communications during construction will be generally via UHF/VHF radio. Duplex capacity may be required ensuring full length communications are available for train control during construction with separate channels of train operations and general construction activities. In general, mobile telecommunications is not reliable in this location. Satellite phones will be used for emergency communications.

All solid waste produced during the construction activities and during the operation of the camps will be collected and placed into segregated bins for wood, steel, glass, other recyclables and general waste. These bins will be regularly collected and disposed of to the nearest licensed landfill.

Impact of At Grade Crossing during Construction

The rail will cross the public road known as Taylors Creek Road. The method for constructing level crossings will be to a Standard determined by the Northern Territory authorities. Based on typical delivery profiles for the construction of level crossing it is expected that a temporary closure of one lane is likely to be required during the construction of the rail and crossing. To mitigate any impact associated with this construction, it is proposed that site specific traffic management plans will be developed prior to construction.

Road and Stock Crossings

The rail will need to cross pastoral tracks and stock crossings. Given the established methods for determining the type of crossing required for these and the low frequency of slow moving trains, the low levels of local traffic and the likely good visibility around any crossing, it is expected that only at grade passive control crossings will be necessary.

The project will go through the appropriate measures to confirm the conditions and criteria to support this basis.

2.8.3 Railway operation

The rail will have a capacity for 23 tonne axle load standard gauge rail rolling stock allowing fully load wagons to load rock concentrate at the mine site and travel directly to the Darwin Port uninterrupted.

Running trains directly to and from the mine site avoids the need for double handling of the product once loaded at the mine, where a rail loop and loading arrangement will simplify loading. .

It is expected that the product will be hauled in bottom dump hopper wagons similar to that used currently in iron ore projects but potentially modified for the finer material, with covers on the wagons to avoid wetting, contamination and loss of product on route. The table below describes the potential train consist and configuration.

A typical train will comprise 110 product wagons, fuel tanker, crew van and other freight wagons as required and 3 locomotives with a product payload of approximately 9000 tonnes per train. It is expected 120 loaded trains per year will be required to meet the 1 Mtpa demand and approximately 240 trains per year to meet the 2 Mtpa demand (Table 2-13). Total length of a train will be approximately 1.8 km and will take less than 5 min to pass through any crossing en-route.

Table 2-13 Product rail freight demand

Demand	# Consists bottom dump hopper	Trains per year	Ships per year Handymax
1 Mtpa (year 1-5)	1 train hauling 9000 t payload	120	20
2 Mtpa (year 6 – 25)	2 trains hauling 9000 t payload	239	40

2.9 Energy demand

The mine will require its own dedicated power generation from a new central power facility with an installed capacity of approximately 24 MW, supplying an average load in the region of 16 MW/hr. for 2 Mtpa production from year 6.

In addition, the phosphate rock concentrate may require a drying process that will use gas fired dryers to remove free moisture from the beneficiated rock, and there will be other remote energy requirements which may be individually powered.

For the initial production of 1 Mtpa in years 1-5, the power plant will comprise multiple high efficiency gas engines (probably of ~2.5 MW each) totaling approximately 12 MW of installed power with a load of approximately 8 MW/hr. At least two of these machines will have dual fuel capacity, and an option to use diesel in the event of gas supply-chain interruptions and operational needs.

The power plant will be expanded when production increases to 2 Mtpa, with either similar sized gas engines or gas engines of a larger frame size to provide a base load generating capability, configured to provide greatest power plant efficiency and reliability.

Solar power will be integrated into the overall power system to augment the central power plant and will be used in areas of the project that require lower base loads / are remote and/or have mobile power needs, in combination with local gas/diesel generators. Typical applications for solar power areas would be accommodation facilities, workshops and in-pit facilities.

Should the product (gas fired) dryers be required, options are being explored to utilize the exhaust gas heat from the central power generators to either eliminate the need for gas or to greatly reduce the demand.

Gas to fuel the central power facility and the product dryers if required is proposed to be piped in via a small, dedicated, low pressure gas pipeline connecting the mine with the Amadeus gas pipe line near Barrow Creek 137 km to the west. Should this not be commercially viable for the 1 Mtpa period of production, alternative methods of transporting gas to site are being considered, either LNG or CNG by road or rail.

Based on gas fired power generation and gas drying of the final condensate product, the site is expected to consume in the region of 3.2 PJ per year of natural gas at 2 Mtpa. The project will approach the energy supply market and potential power station build- own- operate entities to configure the optimum configuration of renewable and conventional energy to the mine.

A diesel storage tank along with two filling stations will be provided adjacent to the mine to supply heavy mining equipment. A separate diesel storage and dispensing system will be provided for non-mining vehicle fleet.

2.10 Water

Water will be sourced from a bore field 12 km to the south-west (as shown on Figure 2-2) of the processing site. The bore field will comprise three high flowing water bores equally spaced over 1.5-2.0 km run. The bore water supply system will consist of bore water lift pumps, bore water collection tank, bore water transfer pumps and bore water supply line.

2.10.1 Water requirements

The project water requirements during operations are detailed in Table 2-14 and Figure 2-9, including raw water, treated water and potable water. The main water requirement will be:

- Raw water for dust suppression and primary ore processing.
- Treated water for general process plant use, pump gland sealing, power station, fire water and wash down requirements.
- Potable water for domestic use and safety showers.
- Treated Fire water, safety shower water and wash down requirements.

Water requirements for processing will be driven by the amount of ROM feed to the processing plant. The raw water demandfor 1Mtpa phosphate rock concentrate production is approximately 220m3/hr and approximately 440 m^3/hr for 2 Mtpa concentrate production

A maximum allowance of 500 m^3/hr water extraction has been allocated for the project at full 2 Mtpa production, and is the basis for modelling groundwater impacts in the groundwater technical report that is appended to this EIS.

Raw water will be pumped via aboveground water pipeline from the borefield to a collection tank at the processing plant site. Water from the collection storage tank is distributed to several uses.

- **Primary filtration treated water -** the raw water from collection tank is filtered in sand filters and sent to be treated water storage tank. Treated water will be supplied to the power station, processing plant and reverse osmosis (RO) plant.
- **Potable water** – A chlorination plant will create potable water for using within the administration buildings and accommodation camp, with waste water returned to the process water ponds. The potable water is used in the administrative area and for the safety equipment such as safety shower and eye washes, drinking water and sanitary water. The potable water package produces 10 m^3 /hr of potable water and is reticulated to the administration area and the accommodation village via pumps.
- **Recycled process water** will be stored in process water ponds for reuse in the processing plant. Process water will be extracted from the pond at a rate of 1,685 m^3/hr using floating pontoon pumps.

Water recycle

The tailings will be 40% water. Currently there is no allocation in the water balance (Figure 2-9) for water recycle off the tailings facilities. Seepage from tailings is currently assumed to be minimal due to the finely ground nature of the tailings, with most moisture lost through evaporation.

VRM is exploring additional water recycling opportunities to recover a proportion of the water from the tailings facilities. Test work will establish the capacity of the tailings water to separate from the tailings and the capability to extract/recover this water from the tailings facilities, using pumps.

Table 2-14 Project water requirements

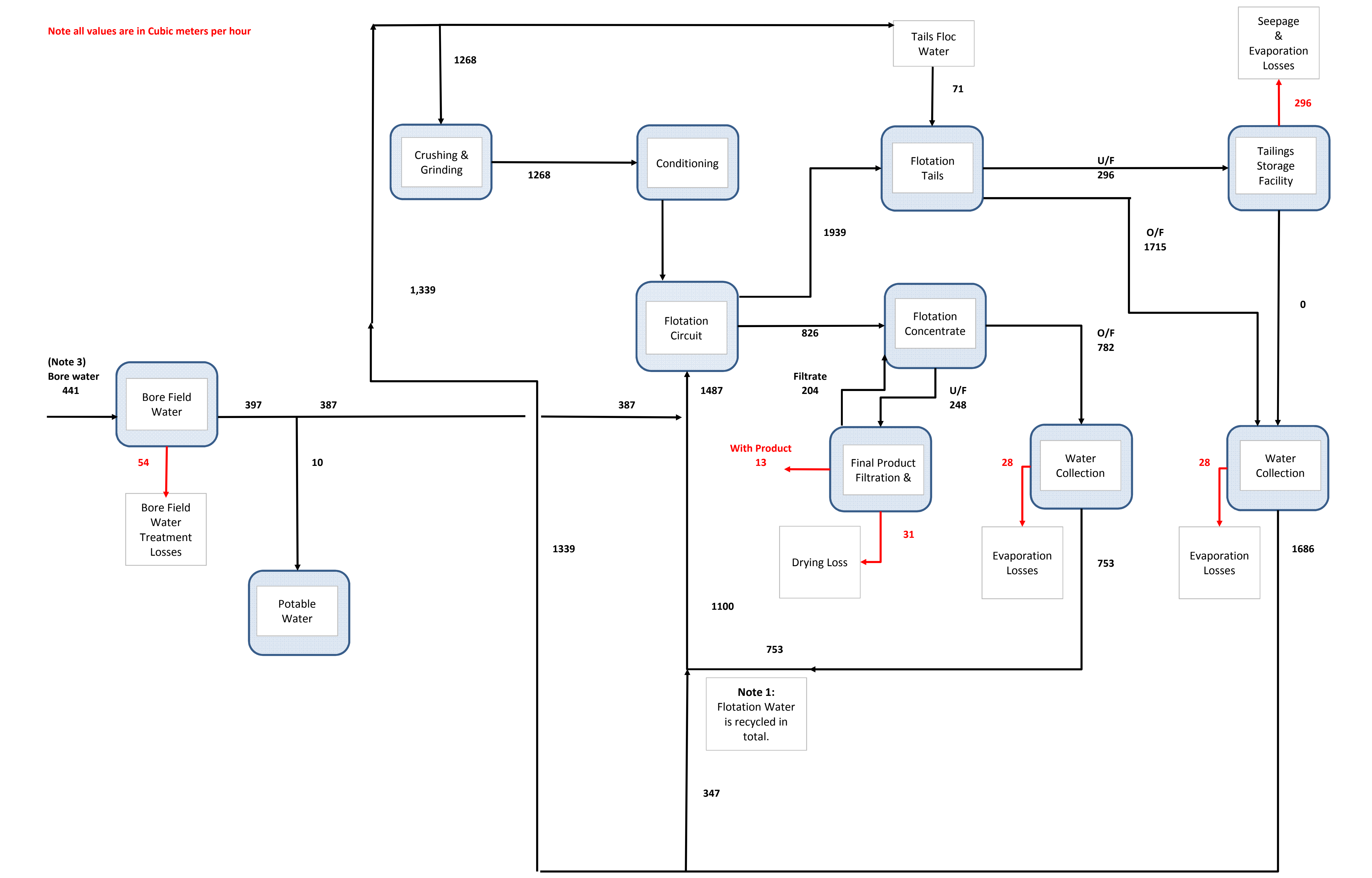
Water quality	Use	Demand (m^3/hr)	Treatment
Raw water from borefield	Filtered raw water for process and general plant use including pump gland seal water and fire water.	500*	Coagulation/settlement for treatment of filtered raw water
Potable water	Potable water for human consumption and ablutions.	10	Chlorination plant for potable water.

The project in normal operations has no need to discharge process water to the receiving environment. The project is a net consumer of water.

Surface water runoff will be diverted away from the storage facility, with any rainfall captured from with the TSF recovered and returned to the processing plant. The spillway will be sized to prevent surface water overflow 100 year ARI storm event.

Similarly, the in-pit TSF and mine will be protected from surface water flow using ramps and berms of adequate height to prevent 1 in 100-year ARI event. Water captured in the TSF storage within the pit will be returned via floating pumps to the process water ponds for use within the process plant.

Water drainage management details are contained in Chapter 7: Surface water. The project water balance is detailed below in Figure 2-9.



WorleyParsons
resources & energy

Doc Desc:	Case "A" BENEFICIATION WATER BALANCE	Doc No.	201010-00560-00-PR-DSK-2001
Project	AMMAROO PHOSPHATE PROJECT PFS PHASE 2	Revision	A
Project No.	201010-00560	Description	For Review
Location	Ammaroo, Australia	PREP. BY/DATE	E Wingate 01/09/2014
Client:	Rum Jungle Resources Ltd	CHKD. BY/DATE	R Atmuri
		APPD BY/DATE	David Gillett

2.11 Wastes and hazardous materials

Waste streams comprise waste water from the process and water treatment plant, tailings and brine water from the RO plant.

2.11.1 Waste water discharge

Waste streams will comprise waste water from process plant and water treatment plant, tailings and brine waste from RO plant. Effluent from the process plants and utility units will be collected and treated before use as dust suppression water. The anticipated waste water from the plants are segregated into the categories listed below:

- Surface water (SW)
- Process water (PW)
- Process oily water (POW)
- Foul drain (FD).

SW is primarily diverted, and any captured water used for dust suppression.

PW and POW are sent to effluent treatment facilities and the FD is routed to various septic tanks. Packaged waste water treatment plant shall be sized and installed to meet the site total demand.

Typical waste water treatment steps include oil separation, sludge removal, neutralisation and pH control.

The surface water management system would be constructed to manage runoff generated from disturbed catchment areas which are located outside of the processing plant and tailings storage facilities.

The water management system would generally consist of:

- Catch drains to intercept runoff generated from disturbed catchment areas
- Sediment dams to temporarily store sediment-laden runoff

Catch drains are typically designed to safely convey the peak runoff generated by the catchment during the 20 year ARI critical duration design storm event. Ideally, flow velocities would be below about 1.5 metres per second to minimise scouring and avoid the need to place scour protection measures within the catch drains.

Sediment dams would be sized to safely manage runoff generated by the 100 year ARI 72 hour design storm event (IECA 2008), and maintained in a generally drawn-down state. Water captured within the sediment dams may be transferred (by pump) to other storages on site for reuse, or treated and discharged off-site. During large rainfall events or periods of extended wet weather, the sediment dams would overtop and discharge (via a constructed spillway) into the downstream environment.

The process water system manages water from the process, including the tailings storage facilities, processing plant and process water storages. Process water storages will be turkey's nest dams (i.e. have no external catchment) in order to minimise intercepted external water volumes. The process water storages will be managed to maintain a minimum freeboard equivalent to the total inflows expected during a 100 year ARI 72 hour design storm event. Where a process water storage is used as a receiving dam for a number of other storages across the site, additional freeboard storage may be required.

Surface water runoff from the processing plant will be directed towards sumps or dams prior to being pumped to the process water dam for reuse on site. Runoff generated within the tailings storage facilities would be collected and managed with recovered tailings water for reuse within the processing plant.

No discharge of process water would occur without suitable treatment. During extreme flood events, all reasonable efforts to avoid discharging of process water would be undertaken. This would include the transfer of process water into the open cut pits

2.12 Air

Assessment criteria for dust emissions are summarised in Table 2-15. These criteria are considered industry standard for the assessment of particulate matter levels. These criteria will relate particularly to bulk material handling and hauling during mining operations.

Table 2-15 Assessment criteria for dust

Pollutant	Averaging period	Return interval (design GLC)	Criterion
Total suspended particulates (TSP) (State of NSW and Environment Protection Agency, 2016)	Annual	Maximum	90 µg/m^3
Particulates as PM_{10} (EPA Victoria, 2007)	24-hours	Maximum	60 µg/m^3 (for area sources)
Particulates as $PM_{2.5}$ (Department of the Environment, 2016)	24-hours	Maximum	25 µg/m^3
Dust deposition (State of NSW and Environment Protection Agency, 2016)	Annual	Rolling 12-month average	2.0 g/m^2/month (increment) 4.0 g/m^2/month (maximum)

Assessment criteria for gaseous constituents of the power plant are listed in Table 2-16. If the plant achieves these compliance limits, the other gaseous constituent pollutants will also be within limits.

Table 2-16 Assessment criteria for gaseous emissions

Pollutant	Averaging period	Return interval (design GLC)	Criterion
Carbon monoxide – CO (Victoria Government, 2001)	1-hour	99.9%ile	29,000 µg/m^3
Nitrogen dioxide – NO_2 (Victoria Government, 2001)	1-hour	99.9%ile	190 µg/m^3
Nitrogen dioxide – NO_2 (State of NSW and Environment Protection Agency, 2016)	Annual	Maximum	62 µg/m^3
Sulphur dioxide – SO_2 (Victoria Government, 2001)	1-hour	99.9%ile	450 µg/m^3

Dust emissions from mining sources will comprise TSP and PM_{10}. Potential emission sources include material handling activities at the pit(s), hauling, wind erosion from stockpiles and disturbed areas and dust emission sources during processing. Combustion emissions will be from natural gas and diesel generators, and the rotary driers (If required). A detailed description of emission sources is contained in Chapter 15: Air Quality.

Emission control techniques for mining sources (dust control) will comprise watering and water sprays on haul roads and at the crushers, and progressive rehabilitation of pit areas. No emission controls are required for combustion emissions. For details refer to Chapter 15.

2.12.1 Workforce and accommodation

The project will create a maximum 300 direct jobs in the peak construction phase, with an average of 150 over the construction period.

Based on feedback from consultation and the social impact assessment, it is estimated that jobs could comprise:

- 20% local (Alyawarre communities across the Barkly and Tennant Creek)
- 25% Alice Springs
- 30% rest of the Northern Territory
- 25% Australia, including Mount Isa.

Construction jobs will include a large component of civil works (plant operators, truck drivers) and trades, such as mechanics and electricians. There will be hospitality, cleaning, kitchen jobs in the workers' accommodation village, administration, a small number of professionals in Darwin, project management and engineering.

During operations, there will be approximately 165 jobs when the project is operating at full production i.e. 2 Mtpa. It's likely to be about half for the first 3-5 years. Operational jobs will comprise mine operators, trades, accommodation village, administration plus professionals such as engineers, a small number of jobs in rehabilitation, rail and loading at Darwin Port.

It is assumed that the construction workforce will be accommodated in a combination of temporary, mobile and permanent camp accommodation at the mine site and along the rail corridor.

The construction and operational workforce will be based on a fly-in, fly-out (FIFO) arrangement, working a typical three (3) weeks on and one (1) week off roster and 12 hours shifts. Some of the local workforce may work an alternative roster to fit work and community needs.

The workforce will be transferred by bus from Alice Springs and Tennant Creek, or alternatively use will be made of the local airstrips at Ampilatwatja or Ali Curung, if they offer a practical and viable option.

Where possible, the aim will be to use the most local airstrips in-order to reduce the driving times to site. Darwin and inter-state workers will utilise commercially available flights to the nearest regional centre, before transfer to the mine.

At this time, no upgrades are proposed to airports in the vicinity of project nor at the regional centres of Alice Springs and Tenant Creek. The project has assumed inherent capacity exists within the regional facilities for the small volume of travellers created by the project. However, the option remains to construct minor extensions to a regional facility, such as the RFDS airstrip at Ampilatwatja to support the project.

Table 2-17 Operational phase workforce

Item	Unit	Value
Mining (direct and indirect)	Number	74
Process plant technicians (direct and indirect)	Number	91
Total		**165**
Roster	Days on/ day off @ hrs per shift	21 / 7 @ 12

The accommodation camps for construction and operation will be based on the modular approach used for typical remote mine site operations. The camp will provide full accommodation including messing and social amenities. The accommodation will comprise:

- Nominal 170 long term ensuite rooms (to be confirmed)
- Up to 300 temporary ensuite rooms to augment the camp for construction workforce
- Kitchen, food storage and dining facilities that meet regulatory licensing requirements
- Social amenities including wet bar, games room, reading room, shop
- Fitness room
- Laundry and ablution facilities
- Outdoor areas
- Administration and storage

The accommodation camps will comply with the requirements set out in the *Environmental Health Fact Sheet No. 700. Requirements for Mining and Construction Projects* (Department of Health, Northern Territory Government July 2013).

2.13 Transport logistics

2.13.1 Construction traffic

The peak traffic generation during the construction phase is likely to be associated with the transporting of plant, equipment and material deliveries along Murray Downs Road. Estimated heavy vehicle movements associated with the construction phase are described in detail in Chapter 13: Transport.

Other light vehicle traffic movements will also be generated by service vehicles supplying the construction camps. This would typically include services such as food transport, linen laundering, fuel supplies, waste management contractors and maintenance servicemen. There would be approximately 10 service vehicle (light vehicle) movements per week to and from the construction camps.

2.13.2 Operational traffic

Freight for general goods and reagents will be via rail direct to the mine site. Fuel deliveries for the site will be sourced from Darwin in 50 kL tank wagons, most other reagents will be sourced from southern Australia. Operational rail traffic coming into the site is detailed in Table 2-18.

Table 2-18 Consumables transport during operations

Reagent	Delivery	Point of origin	Transport hazard class
Diesel	Liquid 23 kL tankers	Darwin / Adelaide	-
Collector (fatty acid)	Liquid delivered to site in bulk tanker loads (23 kL isotainer)	VIC	-
Flocculant (Poly Acrylamide)	Dry solid 750 kg bulk bags, dry powder	SA	-
Silica depressant (sodium silicate)	Liquid delivered to site in bulk tankers (23 kL isotainer)	NSW	-
pH regulator (soda ash)	Dry solid, delivered in 750 kg bulk bags	NSW	-
Sodium Hypochlorite	Liquid, 1000 L isotainer	VIC	8 - Corrosive
Ferric chloride (coagulant)	litre	VIC	8 - Corrosive
Polymer(flocculant)	Liquid, 210 L drum	VIC	-
Sodium metabisulphite	Liquid, 1000 L isotainer	VIC	-
Hydrex 4104	Liquid, 1000 L isotainer	VIC	8 - Corrosive
Sodium chloride	Bulk per tonne	Darwin / Adelaide	-
Caustic	Liquid, 1000 L isotainer	VIC	-8 - Corrosive

3. Regulatory context

3.1 Commonwealth legislation

3.1.1 Aboriginal Land Rights (Northern Territory) Act 1976

The *Aboriginal Land Rights (Northern Territory) Act 1976* (Land Rights Act) governs the grant and administration of Aboriginal land in the Northern Territory. Aboriginal land is a form of freehold estate vested in Aboriginal Land Trusts. The Land Rights Act empowers Land Councils to administer Aboriginal Land Trusts and provides that Land Councils are to consult traditional Aboriginal owners in relation to proposals that affect Aboriginal land. The Land Rights Act also mandates the protection of sacred sites irrespective of whether the site is located on Aboriginal land.

Each of the Northern Territory's four Land Councils also has statutory functions with respect to land within their administrative boundary. The functions of a Land Council include:

- Assisting Aboriginals in taking measures likely to assist in the protection of sacred sites.
- Protecting the interests of traditional Aboriginal owners of land.
- Ascertaining and expressing the wishes and the opinion of Aboriginals living in the area of the Land Council with respect to Aboriginal land (Section 23).
- The study area is within the administrative boundary of the Central Land Council (CLC) but is not located on Aboriginal land.

The CLC has recorded various categories of Cultural Exclusion Zones in the project site.

3.1.2 Aboriginal and Torres Strait Islander Heritage Protection Act 1984

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (ATSIHP) assists in the preservation and protection of Aboriginal and Torres Strait Islander heritage.

ATSIHP empowers the Federal Minister administering the Act (i.e. Minister of Indigenous Affairs) to make declarations to preserve and protect from a threat of injury or desecration those areas and objects of particular significance to Aborigines in accordance with Aboriginal tradition (Section 4). An Aboriginal person or group can make an application to the Minister and the Minister may make an emergency declaration or a declaration for any period of time (Sections 9-12). The Minister's decision is personal and discretionary.

The Federal Minister must not make a declaration under ATSIHP if satisfied that a State or Territory law provides effective protection of areas or objects from threats (Section 13). ATSIHP is therefore only relevant where the relevant State or Territory's Aboriginal heritage protection regime is inadequate.

No places within the study area are currently subject to a declaration under ATSIHP.

3.1.3 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires a person not to take an action that has or will have a significant impact on a Matter of National Environmental Significance (MNES) unless that action is approved. An action means any project, development, undertaking or any activity or series of activities (Section 523).

The project will not significantly affect any of the following MNES

- World Heritage properties

- National Heritage places
- Wetlands of international importance
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions
- A water resource in relation to coal seam gas development

The project (proposed action) was referred to the Commonwealth Department of the Environment and Energy (DoEE). On 3 August 2014 the then Commonwealth Minister for the Environment determined that the action was a “controlled action” and, as such, it requires assessment by Preliminary Documentation under section 95A. The proposed action has been deemed as having the potential to impact on listed threatened species and communities (sections 18 and 18A) including the following listed species:

- Greater Bilby (*Macrotis lagotis*)
- Southern Marsupial Mole (*Notoryctes typhlops*)
- Black-footed Rock-wallaby (*Petrogale lateralis* - MacDonnell Ranges race)
- Crest-tailed Mulgara (*Dasycercus cristicauda*)
- Great Desert Skink (*Liopholis kintorei*)

Listed threatened species and communities protected under the EPBC Act include species and communities that are considered to be extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent.

The additional information requested by the Commonwealth will not be assessed under the current Bilateral Agreement between the Commonwealth of Australia and the Northern Territory. Information that addresses the request for additional information is contained in Chapter 10 of this draft EIS.

Environmental approval under the EPBC Act, as well as Northern Territory approval from the responsible Minister, is required prior to commencement of the project.

3.1.4 National Greenhouse and Energy Reporting Act 2007

Corporate entities, corporate groups or entities that have operational control of facilities are required to be registered (section 12) and report emissions and energy use (section 19) if such emissions or use exceeds statutory thresholds contained in the *National Greenhouse and Energy Reporting Act 2007* (NGERA).

A facility emitting more than 25,000 tonnes of carbon dioxide equivalent, producing 100 terajoules of energy, or using more than 100 terajoules of energy annually is required to report under the NGERA (section 13). A corporate group emitting more than 50,000 tonnes or carbon dioxide equivalent, producing 200 terajoules of energy, or using more than 200 terajoules of energy annually is required to report under the NGERA (section 13).

The project may be required to undertake NGERA reporting.

3.1.5 Native Title Act 1993

The *Native Title Act 1993* (NTA) provides for the recognition and protection of native titles.

The grant of a mineral lease on an area where native title has been determined to exist (or where such area is subject to a registered native title claim) is a “future act” (Section 233) and will trigger the ‘right to negotiate’ process (Part 2, Division 3, Subdivision P).

The right to negotiate process requires good faith negotiations between the proponent, government party and native title party (together, the negotiation parties) with a view to obtaining the agreement of the native party to the doing of the future act or the doing of the future act subject to conditions (Section 31).

If agreement is reached, the negotiation parties will execute an agreement in accordance with Section 31(1)(b) of the NTA and the future act will be valid for the purposes of the NTA. A copy of such agreement is to be provided to the National Native Title Tribunal (NNTT) (Section 41A).

The NTA also provides for Indigenous Land Use Agreements (ILUA). An ILUA may provide for the non-application of the ‘right to negotiate’ process and include consents to the doing of future acts (or validate certain historical acts). An ILUA that has the effect of a contract between the parties and an ILUA that is registered in accordance with the NTA has the effect that all persons holding native title in relation to any area covered by the ILUA will be bound by the agreement (whether or not they are a party to the agreement) (Section 24EA).

The future act subdivision of the NTA also mandates certain processes of notification, consultation and or consideration of comments in relation to other types of future acts. Notification under Section 24MD of the NTA is likely to be relevant to the project in respect of infrastructure related mineral leases, extractive mineral permits and access authorities.

Native title does exist over the project site.

3.2 Northern Territory legislation

3.2.1 AustralAsia Railway (Third Party Access) Act

The *AustralAsia Railway (Third Party Access) Act 1999* and the supporting *AustralAsia Third Party Access Code* provide for the regulation of third party access to the portion of the Adelaide to Darwin Railway that is within the Northern Territory. The Code sets out the rights and responsibilities of above-rail operators (access seekers) and the access provider (APT), and covers matters such as the negotiation process, dispute resolution, and the terms and conditions of access.

GWA runs six intermodal freight services a week between Adelaide and Darwin and hauls bulk fuel and bulk minerals from mines along the railway to Darwin Port to link with shipping routes to Asia.

3.2.2 Bushfires Management Act

The *Bushfires Management Act 2016* relates to the prevention and suppression of bushfires. In the event VRM requires controlled burning, VRM will seek a permit through Bushfires NT.

3.2.3 Control of Roads Act

The *Control of Roads Act 1979* provides for the processes of opening and closing public or gazetted roads in the Northern Territory. Any roads that will be opened or closed as a result of construction or operations for the project will be subject to the provisions of this Act.

3.2.4 Dangerous Goods Act

The movement and handling of explosives and fuel gas is governed by the *Dangerous Goods Act 1998* and the *Dangerous Goods Regulations*.

Dangerous goods will be handled during construction and operation of the project. VRM will obtain licences for storage or transportation of any dangerous goods, and project blasting permits if required.

3.2.5 Electricity Reform Act

The *Electricity Reform Act* regulates the electricity supply industry and provides for the establishment of safety and technical standards for electrical installations. The operation of a gas-fired power plant will require a licence under the Act. The plant must also comply with the *Electricity Reform (Safety and Technical) Regulations,* including gaining a certificate of compliance issued under the regulation.

3.2.6 Energy Pipelines Act

The *Energy Pipelines Act 1981* provides for the construction, operation, maintenance and end of life activities for high pressure natural gas pipelines. The project will develop a 35 km natural gas supply pipeline to connect the power plant to the Amadeus gas pipeline. Under the Act, constructing, operating and maintaining a gas pipeline requires a Pipeline Licence.

3.2.7 Environmental Assessment Act

In March 2014, VRM submitted a Notice of Intent to the NT EPA for consideration under the *Environmental Assessment Act 1982* (EA Act). The Minister of Land, Planning and Environment (now Environment and Natural Resources) decided that the project required assessment under the EA Act at the level of an Environmental Impact Statement (EIS).

Terms of Reference (TOR) for the draft EIS were issued by NT EPA in June 2014. These detailed the scope and limitations of the proposed project in relation to regulatory context, existing environment, risk assessment and environmental management. This draft EIS addresses the TOR.

This draft EIS is submitted to the NT EPA for assessment in accordance with relevant legislation and the requirements of the EA Act and the associated EA *Administrative Procedures*.

3.2.8 Food Act

The *Food Act 2004* defines a food business as ‘any business or activity that handles food intended for sale or selling regardless whether the business is of a commercial, charitable or community nature, or whether it involves handling or selling on one occasion only’. Consequently the accommodation village’s commercial food preparation area is considered to be a food business and therefore requires registration with Environmental Health in accordance with the Act. The term ‘sale’ includes supplying food as a meal or part of a meal to an employee.

The Act also requires all food businesses to meet the minimum standards prescribed by the *Food Safety Standards*. A camp’s commercial food preparation area must be registered with the Chief Health Officer prior to operation.

3.2.9 Heritage Act

The *Heritage Act 2011* provides a system for the identification, assessment, protection and conservation of the Northern Territory’s natural and cultural heritage. Under the Act, if any archaeological places or objects are to be disturbed, permission must be sought to carry out work on a heritage place or object. An application must be made with the consent of the owner of the place or object.

- A search of the NT Heritage Register was undertaken on 27 October 2016. No declared heritage places are within or in the vicinity of the subject area.

3.2.10 Liquor Act

The *Liquor Act 1978* regulates the sale, provision and consumption of liquor. Any liquor provided at the project site will require licensing.

3.2.11 Mineral Royalty Act

The *Mineral Royalty Act 1982* imposes royalties on minerals recovered in the Northern Territory and will apply to the project.

3.2.12 Mineral Titles Act

The *Mineral Titles Act 2010* (MT Act) and the *Mineral Titles Regulations* establish a framework for granting and regulating mineral titles that authorise exploration for and extraction and processing of, minerals and extractive minerals.

VRM will require the following:

- Mineral lease titles for areas of the project associated with the mine site, process plant and borefield and associated infrastructure, any quarry off the mineral lease which extracts hard rock material below 3 m.
- Extractive mineral permits for areas associated with the supply of gravel.
- Access authority titles for the provision of a infrastructure corridor and water pipeline corridor.

Titles will not be granted until compliance with the aforementioned NTA processes have been completed.

VRM will abide by any specific conditions or requirements described in the grant documents of tenements under the MT Act.

VRM will report to the Minister about the activities conducted under the mineral lease and will require written consent if it wishes to disturb improvements on land in the title area or damage or otherwise disturb a Northern Territory or Council road.

3.2.13 Mining Management Act

The *Mining Management Act 2001* (MM Act) and the *Mining Management Regulations* regulate mining activities and the management of mining sites. The legislation is administered by the Department of Primary Industry and Resources (DPIR).

An operator of a mining site that proposes to undertake works that would cause “substantial disturbance” (as defined in the MM Act) requires an authorisation under the MM Act (Section 35). An application for an authorisation must include a Mining Management Plan (MMP) (Section 36). The MMP must describe the mining activities proposed and management systems to protect the environment, health and safety, details of ownership, plans for the mine workings and infrastructure, and a plan and costing of closure activities (Section 40).

Section 43 of the MM Act provides that an operator who carries out mining activities under an authorisation must provide a security to the Minister to secure compliance with the MM Act and cover the costs and expenses of preventing, minimising or rectifying environmental harm caused by mining activities.

A draft Environmental Management Plan (EMP, Appendix E) has been submitted as part of this draft EIS. An approved MMP will be required prior to commencement of proposed works if the project is approved.

A draft Closure Plan has been prepared and is the first iteration of the plan for closure as required under the MM Act. It is important to note the plan will be reviewed and updated throughout the life of the project. Closure criteria have been developed as part of the Closure Plan and are set out in Chapter 17: Rehabilitation. A Certificate of Closure would be required based on achievement of closure criteria.

3.2.14 Northern Territory Aboriginal Sacred Sites Act

The *Northern Territory Aboriginal Sacred Sites Act 1989* (Sacred Sites Act) protects sacred sites. It does this by establishing a procedure for the registration of sacred sites, and establishing a procedure for the avoidance and/or protection of sacred sites in the development and use of land.

Under the Act, an Authority Certificate can be issued by the Aboriginal Areas Protection Authority (AAPA) that provides legal indemnity against possible prosecution in relation to damage to sacred sites resulting from the works or uses covered by the Certificate, so long as any imposed conditions are followed. AAPA administers Authority Certificates in consultation with the relevant custodians under the Act.

An AAPA Register Search has been undertaken for areas affected by the project.

3.2.15 Planning Act

The *Planning Act 1999* (and the Planning Scheme made under that Act) does not apply to the conduct of mining activity under any mining interest (where the terms “mining activity” and “mining interest” have the same meaning as in the MM Act).

The land use controls under the Planning Act do not apply to unzoned land where activities are proposed to be undertaken. Exceptions, where consent is required, include a subdivision of land, a clearance of in excess of one hectare of native vegetation that is not otherwise controlled by legislation, or (in certain circumstances) the use or development of land within 500 metres of a designated road.

Proposals for the gas pipeline and logistical support infrastructure in Tennant Creek and/or Darwin may fall under the Planning Act and will be subject to a separate approvals process.

3.2.16 Public and Environmental Health Act

The *Public and Environmental Health Act 2011* (PEHA) and Public and *Environmental Health Regulations* (PEHR) are applicable to the project, in particular, the associated accommodation.

All sewage systems installed as part of mining operations must be approved by the Department of Health. Waste water treatment systems at the accommodation village may be subject to requirements under the PEHA and the PEHR.

Water bores outside a Water Control District are also required to be notified to the Department of Health.

The project will address these objectives and ensure the requirements of the applicable legislation are met. Additional information regarding human health and safety is detailed in Chapter 11: Health and safety of this draft EIS.

3.2.17 Soil Conservation and Land Utilisation Act

The main purpose of the *Soil Conservation and Land Utilisation Act 1969* is to prevent soil erosion and to conserve and reclaim the soil. To minimise impacts on soil erosion, an erosion and sediment control plan and mine Closure Plan will be prepared prior to project construction to meet the objectives of this Act.

3.2.18 Territory Parks and Wildlife Conservation Act

The *Territory Parks and Wildlife Conservation Act 1978* (TPWC Act) protects Northern Territory parks and reserves, animals and plants (including wildlife and protected wildlife).

Areas protected under the Act include a park, reserve, sanctuary, wilderness zone or area of essential habitat.

The TPWC Act defines wildlife as a vertebrate that is indigenous to Australia (other than fish), or is specifically prescribed as being protected by the *Territory Parks and Wildlife Conservation Regulations*. The Act prohibits the intentional killing of any terrestrial or marine vertebrate (with the exception of fish).

All threatened species are classed as protected wildlife. The TPWC Act precludes the taking of and interference with protected species of wildlife. The TPWC Act includes “Principles of Management”. These require that a threatened species be managed in a manner that “maintains or increases their population or the extent of their distribution at or to a sustainable level”. Threatened species are defined under the regulations as being species that are ‘extinct”, “critically endangered”, “endangered” and “vulnerable”.

Under the TPWC Act, permits will be required to take or interfere with protected plants or animals. This may apply if protected plants or animals are encountered during the project’s life. TPWC listed species and the associated impacts and mitigation measures are detailed in Chapter 9: Biodiversity.

3.2.19 Traffic Act

The *Traffic Act 1987* requires that consent be obtained prior to the erection and operation of traffic control devices if required by the project, including during the construction phase.

3.2.20 Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act

The movement and handling of chemicals outside of workplaces is governed by the *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act* (TDG Act) and the *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations* (TDG Regulations).

The TDG Act creates certain offences in relation to the movement of dangerous goods including:

- Failure to hold a dangerous goods driver’s licence.
- Transporting goods too dangerous to be transported.
- Failure to transport dangerous goods in a safe way.

The TDG Regulations also creates a number of specific offences, including:

- The sale or supply of dangerous goods in non-compliant packaging.
- Labelling dangerous goods incorrectly.
- Failure to segregate dangerous goods from food or food packaging.

This legislation applies to the project as dangerous goods will be handled and transported during construction and operation of the project. The appropriate licences will be acquired and the legislation adhered to.

3.2.21 Waste Management and Pollution Control Act

The *Waste Management and Pollution Control Act 1998* (WMPCA) is the primary piece of environmental protection legislation in the Northern Territory. The WMPCA:

- Imposes general environmental duties
- Requires the licensing of certain activities
- Establishes offences relating to the environment
- Contains material enforcement, penalty and extension of liability provisions.

The WMPCA does not apply to a contaminant or waste resulting from a mining activity (as that term is defined in the MM Act) that is confined within the land on which the mining activity is being carried out.

This draft EIS addresses waste in Chapter 2, air emissions in Chapter 15 and noise in Chapter 16.

3.2.22 Water Act

The *Water Act 2004* provides for the investigation, allocation, use, control, protection, management and administration of surface and groundwater resources, as well as the administrative process for licensing these activities and related purposes.

Pursuant to Section 7 of the Water Act, mining activities (as defined by the MM Act) or another activity for a purpose ancillary to that mining activity, including the use of water as drinking water, are exempt from a number of provisions of the Act, including Parts 5 and 6 regarding surface water and ground water respectively.

Under the Act a Water Control District can be declared. The infrastructure corridor passes through the Western Davenport Water Control District.

3.2.23 Weeds Management Act

The *Weeds Management Act 2001* (WM Act) aims to prevent the spread of weeds and to ensure that the management of weeds is an integral component of land management. This is to be conducted in accordance with the *Northern Territory Weeds Management Strategy 1996-2005* (NRETA, date unknown) and any other current strategy adopted to control weeds in the Territory.

Declared noxious weeds in the NT are plants proclaimed under the WM Act. Declared weeds are placed into classes based on the risk of harm they could cause and how difficult they are to control. The following are the three classes of weeds in the NT:

- Class A - to be eradicated
- Class B - growth and spread to be controlled
- Class C - not to be introduced into the NT

All Class A and Class B weeds are also Class C weeds.

One declared species, Rubber Bush (*Calotropis procera*), has been identified in the project area. It is a Class B weed and will be controlled in accordance with the WM Act, as detailed in Chapter 9 of this draft EIS.

3.2.24 Work Health and Safety (National Uniform Legislation) Act

The *Work Health and Safety (National Uniform Legislation) Act 2011* (WHS Act) and *Work Health and Safety (National Uniform Legislation) Regulations* (WHS Regulations) regulate health and safety in the workplace.

The WHS Act requires the submission of a Risk Management Plan to NT WorkSafe covering the occupational health and safety aspects of the operation. The WHS Act also requires incident notification and compliance with health and safety duties.

Activities on the project site will be conducted in accordance with a Risk Management Plan approved and certified in accordance with Chapter 10 of the WHS Regulations.

If any facilities proposed as part of the project use above certain minimum quantities of specified chemicals the project may be considered to be a Major Hazard Facility and require licensing under Chapter 9 of the WHS Regulations.

The WHS Regulations apply to the use, handling and storage of hazardous chemicals at a workplace. In accordance with the WHS Regulations, VRM will when necessary maintain a Hazardous Materials chemical register and use material safety data sheets.

3.3 Local government requirements

The project is within the jurisdiction of the Barkly Regional Council, covered by the Local Government Regional Management Plan for the Central Australian Region. The Local Government Regional Management Plan is a statutory instrument under part 3.1 of the *Local Government Act* (NT). VRM will adhere to relevant Regional Council by-laws or requirements.

3.4 Policies and guidelines and standards

3.4.1 Northern Territory Environmental Protection Authority assessment guidelines

The NT EPA issues assessment guidelines to assist proponents in understanding and complying with the information requirements for the environmental impact assessment process.

The guidelines relevant to the project are:

- *Guidelines for the Preparation of an Economic and Social Impact Assessment*
- *Guideline for the Preparation of an Environmental Management Plan*
- *Environmental Assessment Guidelines on Acid and Metalliferous Drainage*
- *Guidelines on Conceptual Site Models*
- *Guidelines for Assessment of Impacts on Terrestrial Biodiversity*
- *Guidelines for Consultants Reporting on Environmental Issues*
- *Guidelines on Environmental Offsets and Associated Approval Conditions*

This draft EIS and all the appendices have been prepared in accordance with the relevant guidelines.

3.4.2 Mine closure guidelines

Mine closure guidelines include the following:

- ***Guidelines for Preparing Mine Closure Plans* (Western Australia Department of Mines and Petroleum 2015)** - The DME published guidelines on *Mine Closure and Completion* and *Mine Rehabilitation* in November 2006. GHD understands that these documents have been withdrawn and are being updated. In the absence of NT guidelines, the Western Australia 'Guidelines for Preparing Mine Closure Plans, May 2015' are used. The content and scope of the Mine Rehabilitation, Closure Plan (MRCP) follows the requirements of the WA guidelines.
- ***Rehabilitation and Closure Requirements for the Extractive Industry*** - Provides an advisory note outlining the minimum rehabilitation and closure requirements for the extractive industry.
- ***Strategic Framework for Mine Closure* (ANZMEC 2000)** - Presents a high level framework for the development of mine closure planning. The MRCP is within this framework.
- ***Leading Practice Sustainable Development Program for the Mining Industry - Mine Closure and Completion* (DRET 2006)** - Provides guidance and Case Studies on sustainable approaches to mine closure across Australia.
- ***Environmental Notes on Mining* (Western Australia Department of Mines and Petroleum updated September 2009)** - A Care and Maintenance Plan is required as part of the MRCP (see Chapter 17: Rehabilitation and Closure). This is informed by the requirements and advice in this guidance note.
- ***Mine Close-out Objectives, Life of Mine Planning Objectives* (NT DME 2006)** – Sets out general requirements for setting closure objectives for mines in the Northern Territory.

3.4.3 Other guidelines

Other guidelines that may be applicable to the project include:

- Department of Sustainability, Environment, Water, Population and Communities *Survey Guidelines*
- Department of the Environment *Significant Impact Guidelines*
- The Australian and New Zealand Environment Conservation Council (ANZECC) *Guidelines for fresh and marine water quality*
- *Australian National Committee on Large Dams Incorporated* (ANCOLD)
- Mineral Council of Australia's 2014 *Water Accounting Framework for the Minerals Industry*
- Northern Territory Department of Health 2014 Environmental Health Fact Sheet 700 *Requirements for Mining and Construction Projects*
- The Department of Land Resource Management (DLRM) *Guidelines and Field Methodology for Vegetation Survey and Mapping*
- Department of Health *Guidelines for Preventing Mosquito Breeding Sites Associate with Mining Sites*
- *Managing Acid and Metalliferous Drainage* (DITR 2007)
- *The Global Acid Rock Drainage Guide* (INAP 2011)
- *Radiation Protection and Management of NORM Residues in the Phosphate Industry* (IAEA 2013)

3.4.4 Australian Standards

The Australian Standards (AS) that are applicable to the project include:

- AS/NZS 4801:2001 Occupational health and safety management systems – Specification with guidance for use
- AS/NZS ISO 31000:2009 Risk Management
- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines

3.5 Environmental history

3.5.1 Proceedings

VRM has no proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources.

3.5.2 Association with the Mining Management Act

VRM has MLs and ELs (as described in Chapter 2 of this draft EIS) under the MT Act which are associated with the MM Act.

3.5.3 Accreditations

VRM has developed management system processes and protocols to guide and manage its exploration activities. These are not yet refined to a point where they comply with International Standard certified management systems. As VRM transitions to the construction and operational phase of the project, it intends to design and roll out its final operating management system.

VRM's activities and systems are based on the management of risk. VRM has developed risk management, safety and environmental management plans, and all safety, environmental and community related incidents are routinely recorded. Audits are also completed during construction and operational activities.

Meetings are convened on a regular basis with all key stakeholder groups to report on current and planned activities.

3.6 Ecologically sustainable development

As defined by the Commonwealth Government in 1990, Ecologically Sustainable Development (ESD) in Australia can be seen as:

> *Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.*

The National Strategy for ESD (Department of the Environment, 1992) was developed to encourage the sustainable use of Australia's natural resources for economic purposes whilst simultaneously increasing the range, variety and quality of the resource.

The guiding principles of ESD development are:

- Precautionary principle: namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- Inter-generational equity: namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- Conservation of biological diversity and ecological integrity; namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration.
- Improved valuation, pricing and incentive mechanisms: namely, that environmental factors should be included in the valuation of assets and service.

4. Environmental context

This chapter describes the general environmental context of the study area surrounding the project.

Section 4 and Section 4.1 of the draft EIS TOR provided the following environmental objective in relation to existing environment:

> *The draft EIS should outline the environmental context of the Project area. Description should include:*
>
> - *climate and atmospheric characteristics relevant to the Project, such as temperatures; rainfall / evaporation; flood / drought / fire regime, winds, extreme weather events*
> - *regional landscape characteristics and features*
> - *proximity / downstream connection to sites of ecological, social or cultural significance or sensitivity, surface / groundwater resources, conservation reserves.*
>
> *The draft EIS should describe and map geology, topography, soils and significant landscape features of the project area and surrounding areas.*

This chapter describes the climatic conditions, including seasonal conditions, extreme of climate, and rainfall conditions in the study area. The regional geological conditions, including geology, soils and landforms are described.

Sites of ecological, social or cultural significance and regional landscape characteristics have been discussed in Chapter 1: Introduction.

4.1.1 Climate

The climate of the region is typified by the project's location in central Australia, which is widely accepted as being an arid or desert climate. Although the study area at a high level is a desert climate, at a more refined level, the study area receives more than 250 mm of annual rain, and is therefore classified as grassland under the Köppen climate classification system.

Rainfall and evaporation

The nearest Bureau of Meteorology (BOM) rainfall gauge to the mine site is located at Ammaroo Station (015585) approximately 30 km south east of the project. The mean annual rainfall is approximately 315 millimetres (mm). Regionally, most of the rain is associated with the monsoonal wet season and cyclonic activity. Over some drought years, there is minimal or no rainfall. The BOM gauge at Alice Springs Airport (015590) is located about 280 km south west of the project, and has monitored pan evaporation records since 1959. Evaporation is greatest during months of higher mean rainfall with the highest average evaporation peaking in January at 400 mm. Rates of evaporation are significantly lower from May to August corresponding with lower average rainfall.

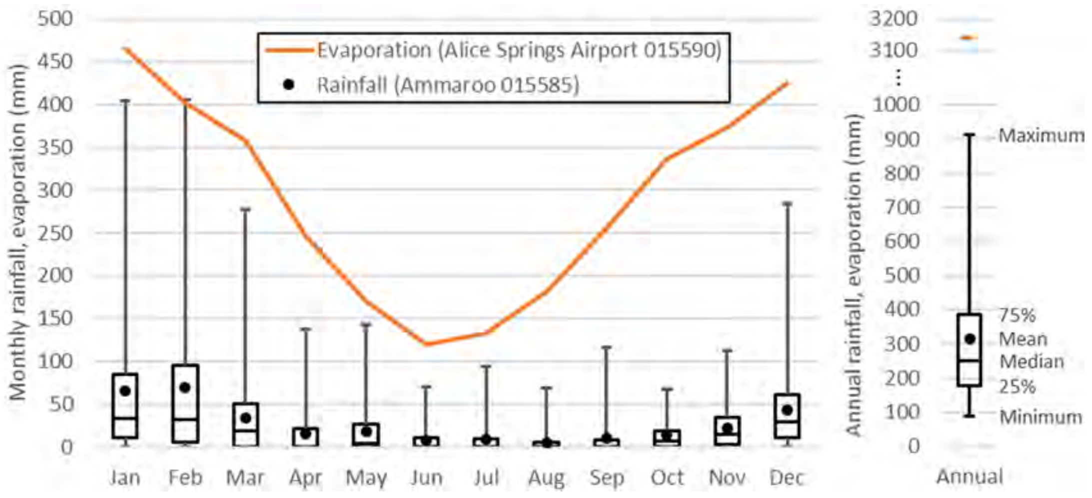


Figure 4-1 Monthly and annual rainfall and evaporation

Temperature and humidity

The nearest BOM station that collects temperature data is located at Ali Curung, approximately 100 km north west of the project site. Typical of central Australian arid climates, the study area has high summer maximum temperatures (average of 37°C) and low minimum winter temperatures (average 8°C). The hottest months are November to March with monthly average daily maximum temperatures above 35°C, and monthly daily minimum temperatures not dropping below 20°C. The coolest months are May to August with monthly average daily maximum temperatures remaining at or below 25.4°C and monthly average daily minimum temperatures not rising above 12.9°C. Sub-zero temperatures occur occasionally during July and August and there have been instances of surface water freezing at night.

The average monthly relative humidity at 9:00 am typically ranges between 31% - 52% with an average of 42%. The average monthly relative humidity at 3:00 pm is about 11% (peak of summer) to 21% (winter) lower than the 9:00 am recorded humidity.

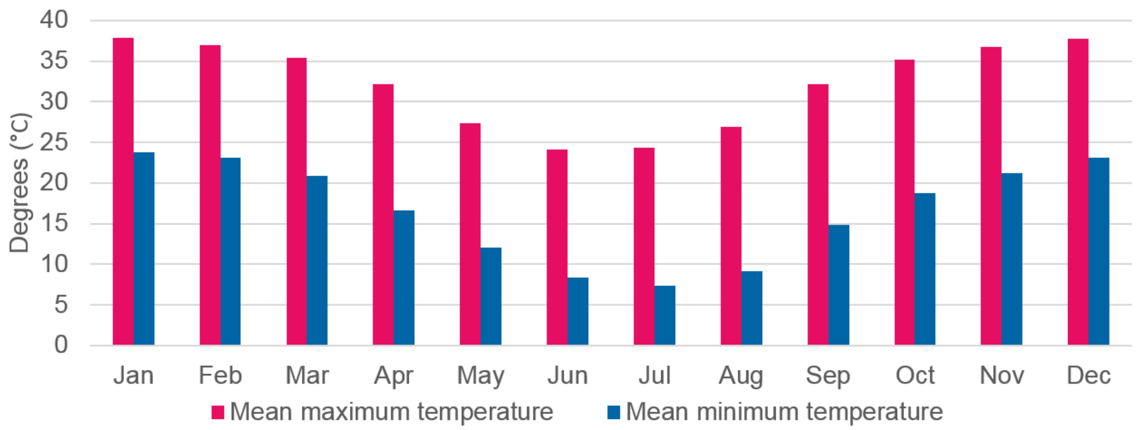
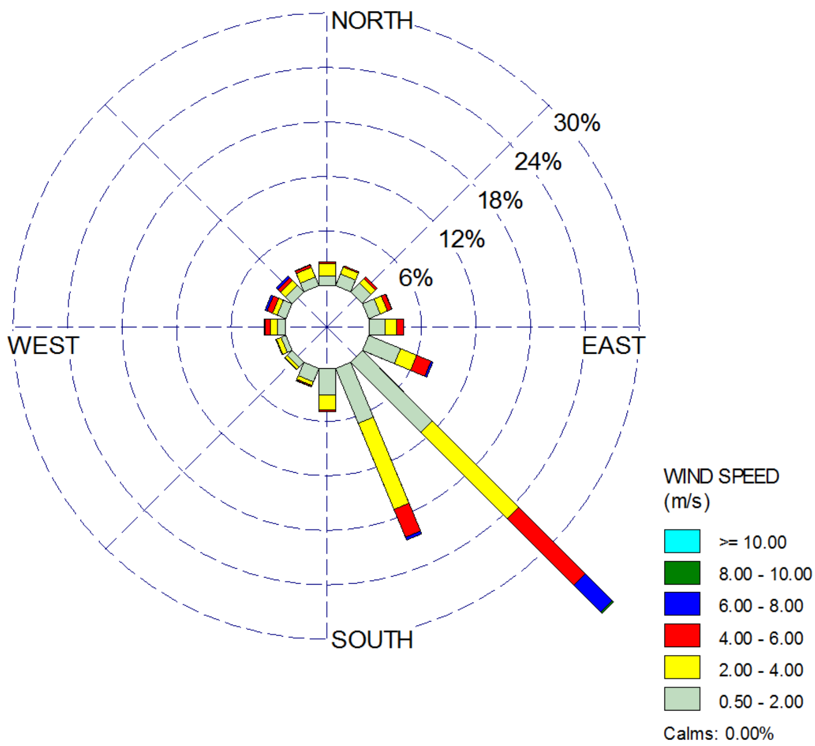


Figure 4-2 Average temperatures

Wind

No data for wind directions and speeds was available in proximity to the study area. Instead, this draft EIS has used The Air Pollution Model (TAPM) (CSIRO) to develop a prognostic model of the wind conditions at the project site (Figure 4-3) which is discussed in detail in Chapter 15: Air. The winds at the project site primarily originate from the southeast throughout the year and are generally in between 2.0-4.0 m/s.



Source: BOM 2017

Figure 4-3 Annual wind rose

4.1.2 Geology and Physiography

The project is located in the Georgina Basin, which extends across the Northern Territory into Queensland. The Georgina Basin includes rocks of Neoproterozoic to Devonian age, with Cambrian platform carbonate rocks dominating the basin fill. The basin-edge Cambrian carbonates contain the largest sedimentary rock phosphate deposits in Australia and account for over 95% of Australia's economic demonstrated rock phosphate resources.

Cambrian phosphate deposits geologically comparable to Ammaroo include Wonarah/Arruwurra (NT), Paradise South (Qld) and Phosphate Hill (Qld).

The project is located on the south western edge of the Georgina Basin where it overlaps the geologically older Davenport Province. Based on published mapping, the main Ammaroo phosphate deposit is hosted in Arthur Creek Formation, which is Middle Cambrian or approximately 520 Ma to 500 Ma years old. The host rocks are a mixed carbonate / silty siliciclastic shallow water facies mosaic that was deposited on a Cambrian shoreline as phosphatic waters upwelled from the depths.

The Cambrian rocks in the study area are generally more geologically altered than similar phosphate deposits in Queensland and at least some of the economic Ammaroo phosphate is secondary.

The Cambrian rocks in the study area are unfaulted and considered flat to gently undulating and very gently folded, with an overall 0.25% downward inclination towards the south west as they dip into the basin. Outcrop of Cambrian aged sediments, comprising of dolomitic limestone and siltstone, is restricted to the north, along the flanks of the Davenport Ranges.

The north west of the project area also contains limited outcrop of Neoproterozoic and Paleoproterozoic arkosic sandstone and volcanic rocks. These have also been intersected in deeper drillholes beneath the phosphate deposit.

A generalised composite Cambrian geological profile for the area south of the Davenport is contained in Figure 4-4. Not all the formations shown are present within the project area.

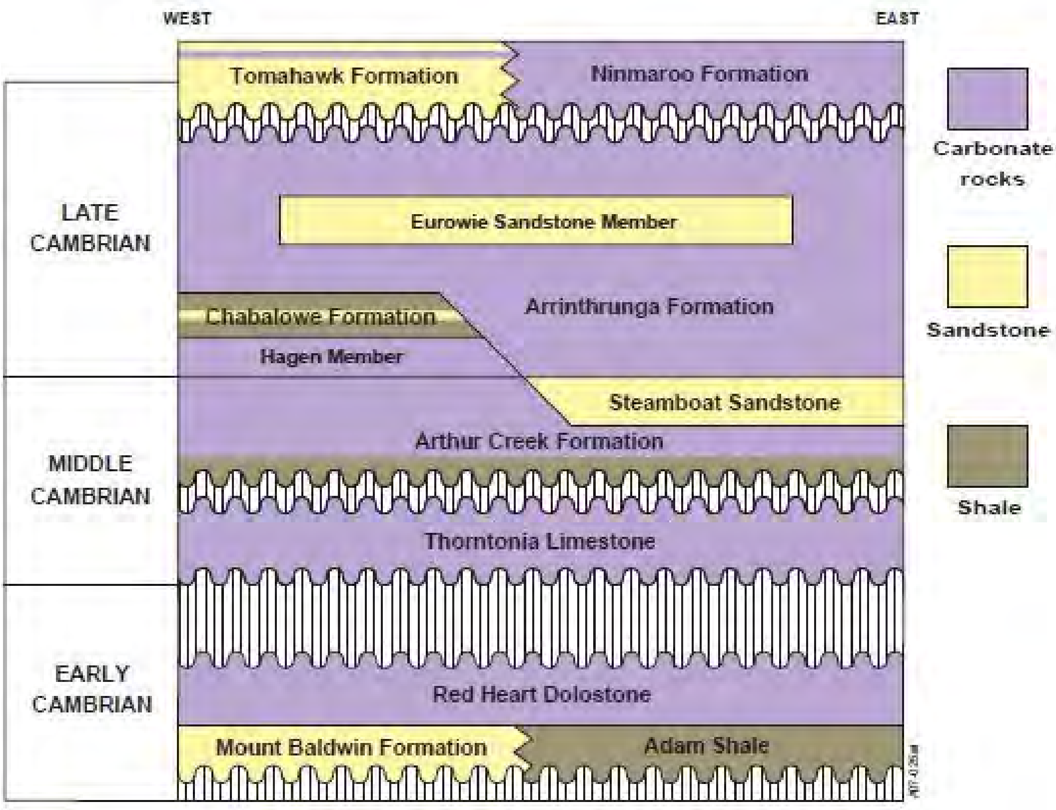


Figure 4-4 Geological profile

The Southern Georgina Basin carbonate sediments comprising the Arrinthrunga, Hagen, Chabalowe, Arthur Creek and Red Heart Dolostone sequence are a very significant regional aquifer. The sandstone, limestone and dolostone units host the aquifers that are the target water supply for the mine borefield (Jeuken 2017). Regional geology is depicted in Figure 4-5.

The regional topography (Figure 4-6) is dominated by the Davenport Ranges, which are located approximately 15 km to the north of the mine site and consist of a series of sandstone and siltstone hills rising to an elevation of approximately 100 m above the surrounding plains. Closer to the site a series of minor sandstone foothills form low isolated sandstone outcrops.

The project site is located within the vicinity of a local low point that receives flows from a number of unnamed first, second and third order watercourses. The eastern portion of the mining area generally drains to the south-east towards the Sandover River, whilst the west side of the mining area, including the access corridor generally drains to the north-west. Longitudinal gradients along local watercourses within the vicinity of the project site are typically less than 0.5 percent with steeper gradients of about 10 percent on isolated reaches.

VRM acquired a high resolution digital terrain model of the mine site and access corridor. This data has been used to estimate catchment areas upslope (Chapter 7: Surface water). Regional topography is depicted in Figure 4-6.

The project site's surface geology consists predominantly of sediments from the Cenozoic era, comprising of residual alluvium, quartz sand sheets, calcrete, laterite, colluvium, silcrete and silt.

4.1.3 Land systems

The region consists of four land systems as shown in Figure 4-7. These are described in Table 4-1. Only the Singleton, Alinga, and Sandover are present in the study area. Detailed information relating to landform mapping and a description of habitats is contained in Chapter 9: Biodiversity.

Table 4-1 Land system descriptions

Land system	Bioregion	Land system description	Landscape class	Vegetation description	Acid sulphate soils
Alinga	Tanami	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products; sandy and earth soils	Lateritic plains and rises	Mainly short grass-forb under mulga, some soft spinifex	No occurrence of acid sulphate soils
Ilbumric	Davenport Murchison Range	Low hills, hills and stony plateaux on sandstone, siltstone, quartzite and conglomerate (deeply weathered in places); outcrop with shallow stony soils	Sandstone hills	Mulga country	No occurrence of acid sulphate soils
Singleton	Tanami	Level to undulating sandplains with red sands	Desert sandplains	Mainly hard spinifex, some feathertop and soft spinifex pastures	No occurrence of acid sulphate soils
Sandover	Davenport Murchison Range	Alluvial floodplains, swamps, drainage depressions and alluvial fans; sandy, silty and clay soils on Quaternary alluvium	Alluvial floodplains	Mainly short grass-forbs under sparse low trees	No occurrence of acid sulphate soils

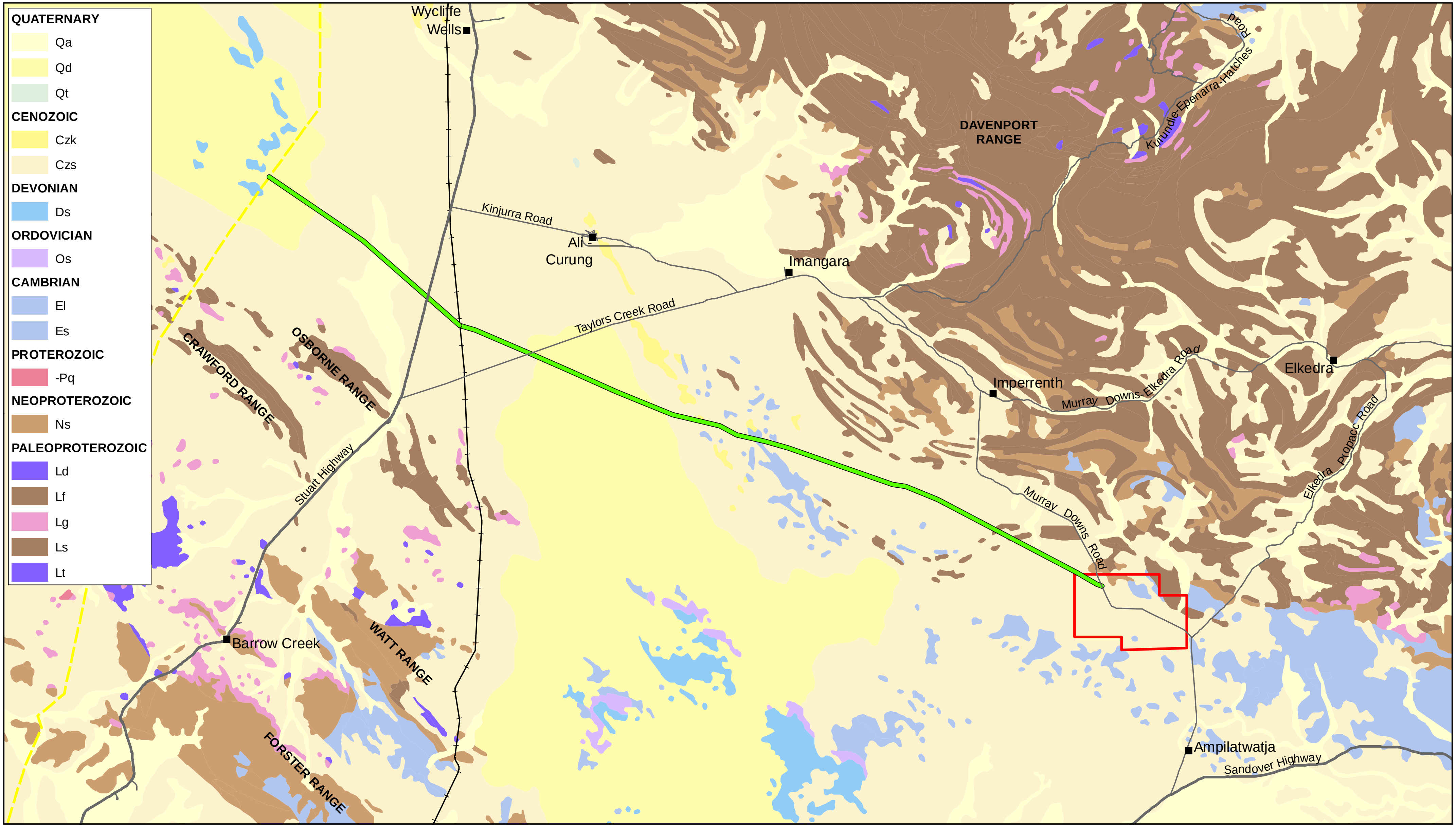
4.1.4 Soils

The following information is sourced from Worley Parsons (2017). The Northern Territory Geological Survey, 1:250,000 scale, Elkedra map sheet indicates the materials present at the site comprise the following geological units:

- Quaternary age colluvium deposits comprising gravel, sand, silt and clay
- Quaternary age aeolian sand plains and dunes
- Quaternary age red earth deposits / ferruginous gravel

Results from test pits and boreholes at the process plant site locations have concluded a typical soil profile comprised of a surficial layer of silty sand and sandy silt of low plasticity between 0.5 m and 1.0 m thick. Underneath this was found to be silty or clayey sand to an average depth of 2.0 m. A thick gravel layer approximately 0.5 m thick was found below the sand later at 75% of test locations. At some locations, a layer of clay up to 1.0 m thick was found between the sand and gravel layers.

Based on the results of the investigation for the project, the ground conditions in the general area are likely to be composed of sandy soil between 2 m and 5 m deep, overlying extremely to moderately weathered sandstone, siltstone and conglomerate rock. The weathering and strength of the rock are highly variable, with the consistency of the material varying between dense sand / very stiff clay and medium strength rock material.



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0 5 10 15 20 25

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Major road
- Local road
- Access corridor
- Amadeus gas pipeline
- Rail
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

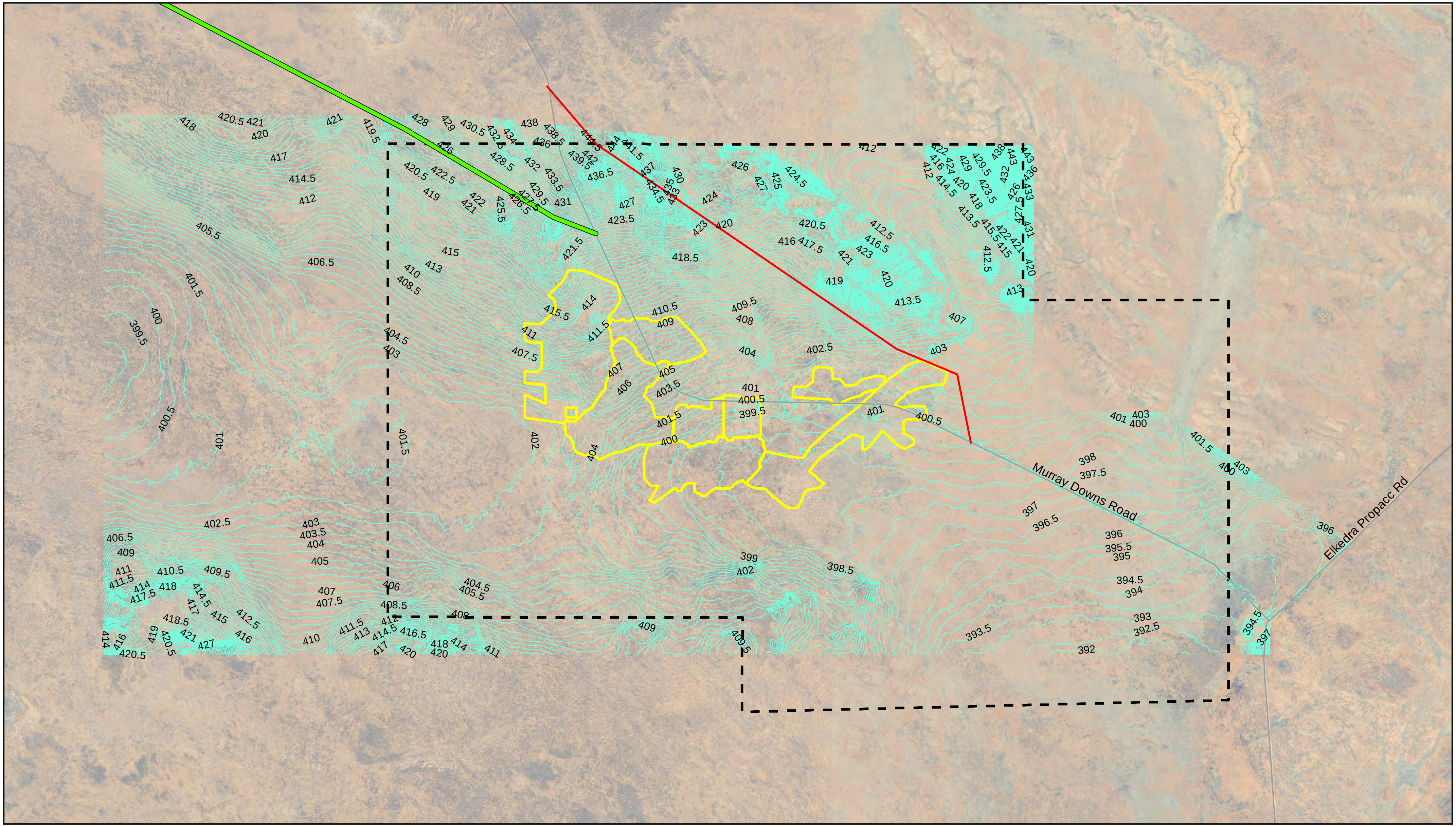
Land systems

Figure 4-5

G:\43\22544\GIS\Maps\4322544_106.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Geology, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 07/07/2017). VML - Proposed Corridor, Project Site, (2017). Created by: CM



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0 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Access corridor
- Contours (50cm)
- Existing roads
- Road realignment
- Mineral lease
- Pit extent (years)

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Contour capture

Figure 4-6

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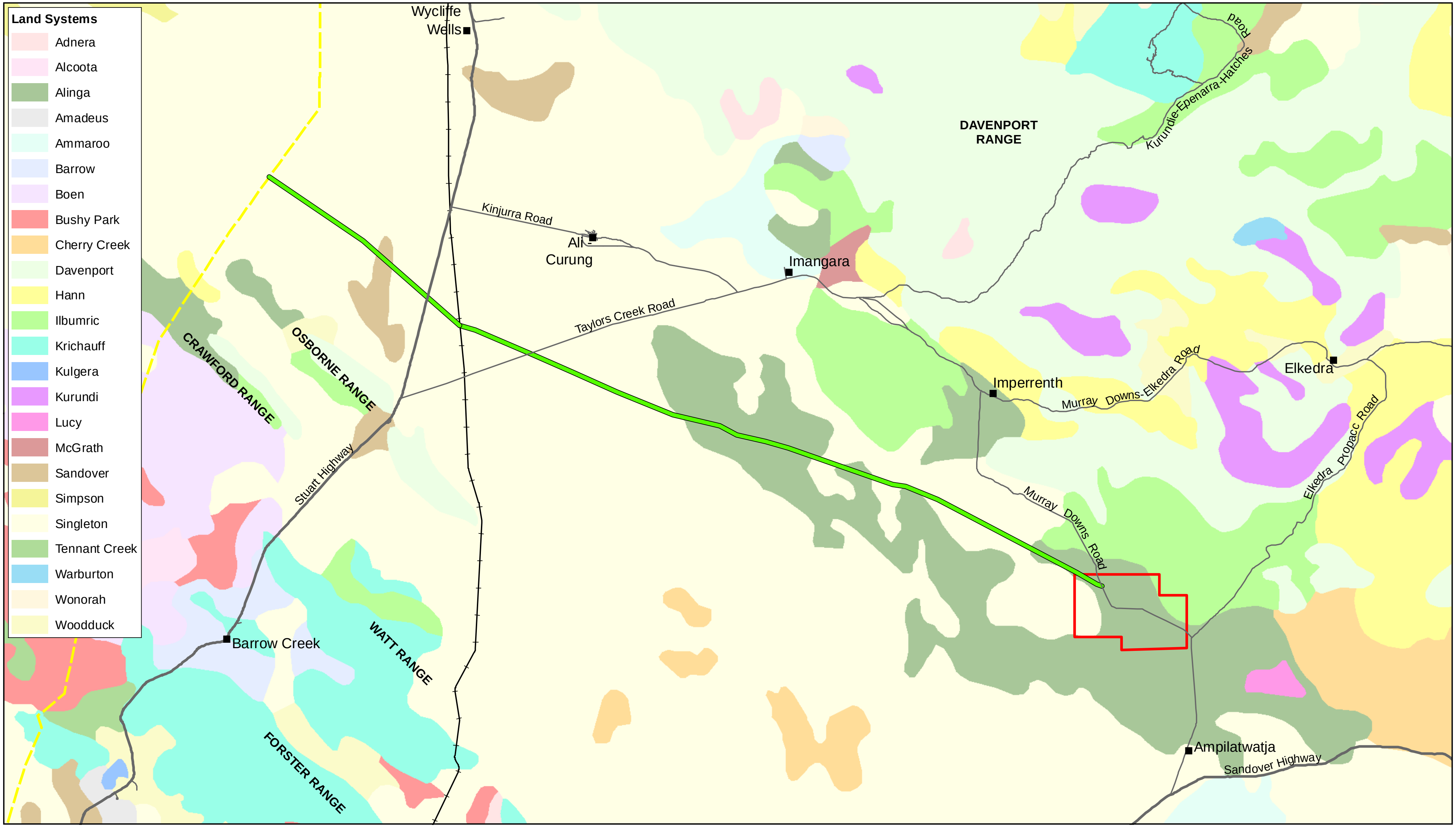
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads (2015), Google Earth Pro - Imagery (Date extracted: 30/08/2017). VML - Proposed Corridor, Mineral lease, Pit extent, Contour capture area (2017). Created by: CM



1:750,000 @ A4

0 5 10 15 20 25

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and communities
- Major road
- Local road
- Rail
- Amadeus gas pipeline
- Access corridor
- Mineral lease

GHD

VERDANT MINERALS

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Land systems

Figure 4-7

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Geology, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 07/07/2017). VML - Proposed Corridor, Project Site, (2017). Created by: CM

5. Community consultation

5.1 Introduction

This chapter describes the community consultation undertaken for the project. A Community Consultation Report was prepared by True North Strategic Communication (2017) and is provided in Appendix F of this draft EIS.

Section 7.3 of the draft EIS TOR provided the following environmental objective in relation to consultation:

The draft EIS must include information on any consultation about the Project, including:

- *Any consultation that has already taken place.*
- *A list of persons and agencies consulted during the draft EIS.*
- *If there has been consultation about the Project, any documented response to, or result of, the consultation.*
- *Proposed consultation about relevant impacts of the Project.*
- *Identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.*

5.2 Consultation objectives

Consultation for the project was informed by the principles and core values of the International Association for Public Participation (IAP2) and the International Association for Impact Assessment's 2015 *Social Impact Assessment: Guidance for assessing and managing the social impacts of projects*. Consultation was also in line with the Northern Territory Environment Protection Authority's 2013 *Guidelines for the preparation of an Economic and Social Impact Assessment*, which refers to consultation and recognising the specific needs of Indigenous people.

The objectives for the consultation carried out for the draft EIS included, but were not limited to:

- Listen to and understand the perspectives of all stakeholder groups.
- Identify local knowledge that might contribute to improved project design.
- Support delivery of a project that is environmentally, economically, culturally and socially acceptable to the community and key stakeholders.
- Provide regulators with confidence that all positive and negative impacts are well understood and can be managed through all phases of the project.
- Provide guidance to the company's long-term social performance.

5.3 Consultation program

Consultations for the social impact assessment and draft EIS more broadly were conducted between March and June of 2017. Consultation activities included:

- Community meetings in Arlparra and Ampilatwatja.
- In person meetings with service providers, local and state government officials, local business and tourism representatives and associations.
- In person and telephone meetings with pastoralists.

- A presentation at a Regional Mining Seminar, organised by Central Australian Chamber of Commerce and Greenglass Consulting.

Prior to formal consultation for the draft EIS, consultation for the project, particularly with traditional owners and in Ampilatwatja, occurred between 2011 and 2016.

A number of briefings are also scheduled to occur after the publication of this draft EIS.

5.4 Stakeholders

In preparation for consultation for the draft EIS, True North Strategic Communication prepared a consultation and communication strategy that outlined likely issues, key stakeholders, consultation and communication objectives and a methodology for consultation and communication. As part of this exercise, groups, organisations and individuals likely to be impacted by the project were identified. These groups, organisations and individuals are identified in Table 5-1.

Table 5-1 Draft EIS stakeholder list – identified stakeholders

Stakeholder group	Organisation / representative
Pastoralists and occupiers	• Ammaroo Station • Elkedra Station • Murray Downs • Neutral Downs.
Indigenous stakeholders	• Traditional owners • Central Land Council • Urapuntja Aboriginal Council • Ampilatwatja and Arlparra community members and service providers • Aherrenge Store • MyPathway (employment support services) • Centrefarm • Health services.
Regional communities	• Tennant Creek • Alice Springs
Northern Territory and local government	• Member for Barkly, Gerry McCarthy • Department of the Chief Minister • Department of Education • Department of Health • Northern Territory Police, Fire and Emergency Services • Department of Housing and Community Development • Department of Trade, Business and Innovation • Power and Water Corporation • Environment Protection Authority • Barkly Regional Council.
Federal government	• Department of the Environment and Energy.
Business associations	• NT Chamber of Commerce • NT Industry Capability Network • Regional Economic Development Committees • Mining Summit • Barkly Regional Tourism Association • Tourism NT.

Stakeholder group	Organisation / representative
Industry	• Emmerson Resources • Jemena (gas pipeline)
Environmental groups	• Arid Lands Environment Centre.

5.5 Key themes raised

A summary of key themes raised during stakeholder consultation is provided below. Detail regarding the matters raised per stakeholder group is provided in Section 3.7 of Appendix F (True North Strategic Communication 2017).

Table 5-2 Key themes raised by the community

Aspect	Issues / themes	Addressed in draft EIS
Economic development	• Aspirations and expectations for local / regional business development and employment.	Chapter 12
Jobs and training	• Feedback on ways to achieve employment targets in an area characterised by disadvantage, low educational outcomes and high levels of long-term unemployment	Chapter 12
Social infrastructure / housing	• The potential for impacts on social infrastructure from an in-migration of Alyawarre families to Ampilatwatja in expectation of jobs or other benefits.	Chapter 12
Traffic	• Widespread concerns about the state of local roads, particularly Murray Downs Road and the potential for further degradation from project activities.	Chapter 13
Ground water	• Potential impacts on bore water infrastructure.	Chapter 8
Cultural heritage	• Potential impacts on sacred sites in the project footprint.	Chapter 14
Community cohesion impact / worker behaviour	• Impacts from worker behaviour on local communities. • The potential for increased alcohol abuse, conflict between families, and potential violence associated with cash royalty payments. • Potential opportunities from the distribution of royalties in the form of community development funds that support commercial enterprises and scholarships.	Chapter 12

5.6 Ongoing consultation

VRM is committed to developing and/or maintaining relationships with key communities and stakeholders for the life of the project. This draft EIS will be formally exhibited and open for public comment on the Northern Territory's Environmental Protection Authority's website. Copies of the draft EIS are available for public viewing at the locations indicated in Table 5-3. Consultation with key communities and other stakeholders will be ongoing in line with project development. Should the project receive approval, a formal engagement and social impact management plan would be implemented during construction and operation (refer Chapter 12: Socio-economics).

Table 5-3 EIS public viewing locations

Town	Location
Darwin	NT EPA, Level 2 Arnhemica House, 16 Parap road, Parap
	Mines and Energy Information Centre, Department of Mines and Energy, 3rd Floor, Paspalis Centrepoint, 48 Smith Street Mall
	Northern Territory Library, Parliament House
	Environment Centre Northern Territory, Unit 3, 98 Woods St
Alice Springs	Department of Lands, Planning and the Environment, Floor 1, Alice Plaza Building, Todd Street Mall
	Central Land Council, Main Office, 27 Stuart Highway
	Arid Lands Environment Centre, 18 Warburton St, Alice Springs
Tennant Creek	Tennant Creek Public Library, Peko Road
	Central Land Council, Regional Office, 63 Patterson Street
Ali Curung	TBC
Ampilatwatja	TBC

6. Risk assessment

6.1 Introduction

This chapter provides a description of the whole-of-project risk assessment undertaken for the identification, assessment and management of project environmental risks associated with the project.

The risk assessment provides a framework for identifying components of the project with the potential for greater environmental risk, and highlights areas of focus for environmental impact assessment and project specific control measures to minimise the likelihood and consequence of these identified risks.

Section 5.1 of the draft EIS TOR for the preparation of an environmental impact assessment issued by the NT EPA for the project required a risk assessment process that:

- Identified and discussed a range of risks presented by the project, including relevant potential direct and indirect impacts.
- Assessed the risks with regard to their relative ranking to gain an understanding of the potential severity of impact. This ensured the reasons for the associated control measures were apparent.
- Assigned levels of certainty about estimates of risk, incorporating consideration of the effectiveness of the planned controls.
- Where applicable, recognised members of the community are expected to accept residual risks and their consequences.

This chapter describes the risk assessment methodology, outlines the key outcomes and rankings, and summarises the findings of the risk assessment.

The results of the risk assessment have provided a basis for evaluation and justification of the proposed controls or management measures to modify the risk. The impact pathways and proposed controls have been used to inform the Environmental Management Framework for the project, including the Environmental Management Plan (EMP) and associated sub plans.

6.2 Risk assessment methodology

The risk assessment process has been undertaken using a systematic approach consistent with *AS/NZS ISO 31000:2009 Risk management – Principles and guidelines*, which is schematically presented in Figure 6-1.

The early steps in the process involved establishing the context. Key considerations were setting the boundaries and the scope of the risk assessment, including an initial Project description (Chapter 2) which formed the basis for the impact and environmental risk assessment.

After the context was established, technical specialists systematically identified potential cause-and-effect ‘pathways’ associated with the project, determining the links between project activities and the potential to impact on a given value or issue.

Once a preliminary risk register was completed by each technical specialist, a risk workshop was held to discuss the full range of risks. This workshop allowed technical specialists from key areas to discuss risks which were interrelated.

Risk workshops facilitated independently of the project team were conducted over two days and attended by a cross-section of internal stakeholders and technical specialists.

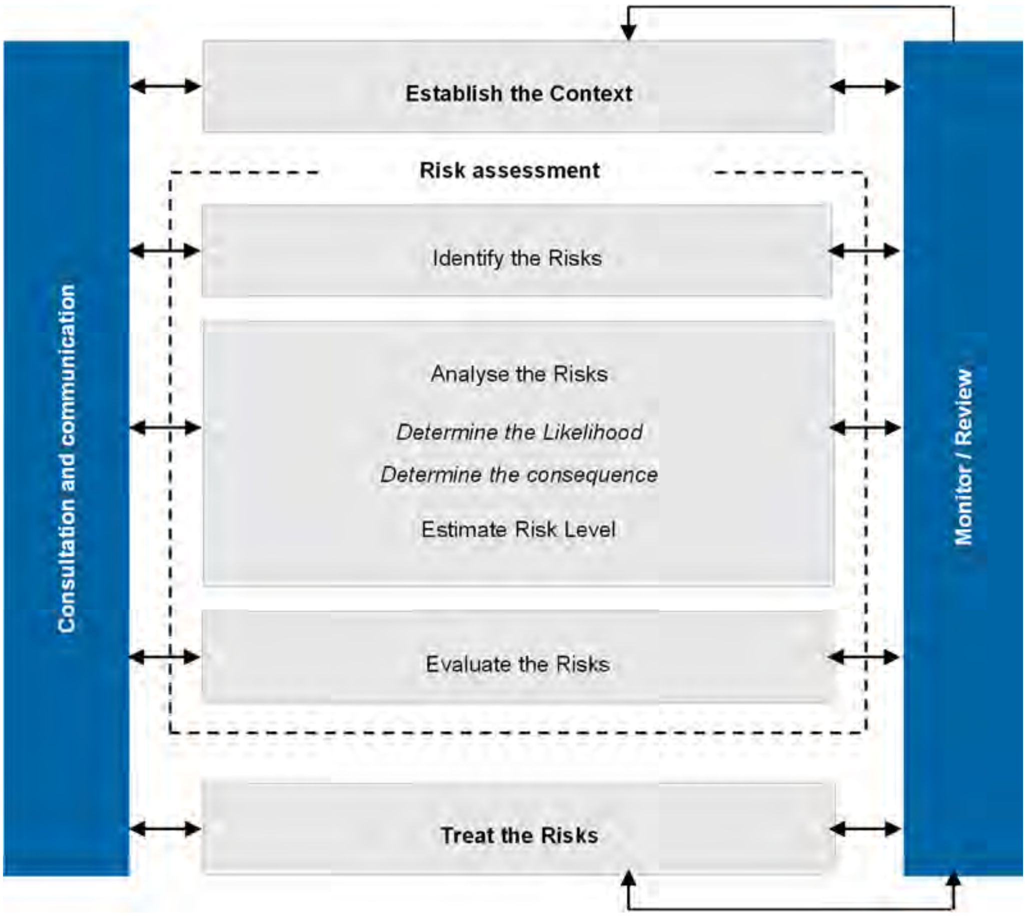

Figure 6-1 Risk management process (AS/NZS ISO 31000:2009)

6.2.1 Context establishment

The scope of the risk assessment included construction and operation, decommissioning, closure and post-closure risks of the project in relation to environmental, social and economic values on both a local and regional scale. An initial project description was used as a basis for the risk assessments. The project description provided details of the project footprint, project infrastructure requirements as well as construction and operational activities and processes. The project description also established the base level of planned controls that are inherent in the project design.

6.2.2 Risk identification

To determine risks, it is necessary to identify and describe cause and effect pathways for the project. Impact pathways identify the activity or event associated with project phases, and give consideration to assets, values and uses. This was done systematically for each discipline area to determine links between project activities and their subsequent consequences. The list of identified risks was developed using knowledge of the specific activities proposed for each component of the project across the phases, the local environmental context and understanding of the potential environmental or socio-economic impacts.

The risk assessment for socio-economic impacts identified both the negative impacts and positive opportunities that may accrue from the project, in order to minimise the socio-economic costs and maximise the benefits. This approach is in line with NT EPA *Guidelines for the Preparation of an Economic and Social Impact Assessment.*

6.2.3 Risk analysis and evaluation

Risk ratings were established for each pathway by technical specialists assigning a level of consequence in accordance with consequence criteria for the project (Table 6-1) and a level of likelihood in accordance with likelihood descriptors (Table 6-2).

Consequence criteria range on a scale of magnitude from ‘insignificant’ to ‘catastrophic’. Magnitude was considered as a function of the size of the impact, the spatial area affected and expected recovery time. These were influenced by the requirements of relevant legislation and guidelines.

The initial risk rating considered the consequence and likelihood of the risk event with planned controls in place. These controls are consistent with the project description, regulatory requirements and management measures for projects of this nature.

Risks were assessed considering the maximum credible consequence level. Combining the assessed level of consequence and the likelihood of that consequence occurring provides guidance on the risk rating (Table 6-3). The risk was then assessed against relevant criteria as shown in Table 6-4 to determine if additional actions are required to be taken, or if the risk is at a tolerable level.

In addition to the risk ratings, the assessment applied a certainty level to each overall risk rating based on the information and data available, as listed in Table 6-5. The certainty assessment incorporated consideration of the effectiveness of the planned controls to manage the risk and was able to be used to assist in determining if further actions should be focused on in order to manage risks.

6.2.4 Risk treatment

Where practicable, additional control measures were developed to further reduce the risk. In the case of the social risk assessment where the impacts are positive in nature, the risk treatment included actions to optimise or enhance these benefits for local and regional communities.

The risk was reassessed with planned and additional controls in place to confirm the effect of the additional control measures. This second rating is known as the residual risk rating.

The control measures have been used in developing the environmental management plan (EMP) and associated monitoring programs, where applicable. The controls are actions to be implemented in the delivery of the project through the construction, operation, decommissioning, closure and post-closure phases.

6.3 Risk register

A risk register was established to document the findings of the risk assessment process. The risk register contains details of impact pathways, their consequences, planned controls inherent in the project description, an initial risk assessment, additional controls, and the residual risk rating. Table 6-8 contains the project risk register.

Table 6-1 Ammaroo project consequence descriptors

Category of impact	Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Air	***Air quality***	No measurable air quality impacts or exceedance of air quality standards.	Local short term and approaching exceedance of air quality standards.	Local minor long term, or widespread minor short term or exceedance of air quality standards.	Widespread (regional) major short term exceedance of air quality standards.	Regional long term change in air quality or exceedance of air quality standards.
Air	***Noise***	Applicable standards / guidelines met at all sensitive receptors at all times.	Isolated and temporary increase in noise levels exceeding relevant noise standards / guidelines at a sensitive receptor.	Short term, local increase in noise levels exceeding relevant noise standards / guidelines at a sensitive receptor.	Long term, local increase in noise levels exceeding relevant noise standards / guidelines at a sensitive receptor.	Long term, regional increase in noise levels exceeding relevant noise standards / guidelines at a sensitive receptor.
Biodiversity	***Listed flora species***	Minor local habitat modification and/or lifecycle disruption for a listed species.	Moderate local habitat modification and/or lifecycle disruption for a listed species.	Substantial local habitat modification and/or lifecycle disruption for a listed species.	Moderate regional habitat modification and/or lifecycle disruption for a listed species.	Substantial regional habitat modification and/or lifecycle disruption for a listed species.
Biodiversity	***Listed threatened fauna species***	No loss of individuals of listed fauna species.	Minor local decrease in size of population(s) of listed fauna species.	Moderate local decrease in size of population(s) of listed fauna species.	Substantial local decrease in size of population(s) of listed fauna species.	Moderate or substantial regional decrease in size of population(s) of listed fauna species.
Biodiversity	***General flora and fauna***	Insignificant or imperceptible effects on ecosystem integrity* **as measured by abundance and/or diversity of species, and cognisant of the existing condition of the ecosystem.*	Small scale and/or short term reduction in ecosystem integrity.	Medium scale and/or medium term reduction in ecosystem integrity.	Large scale and/or long term reduction in ecosystem integrity.	Regional and/or permanent reduction in ecosystem integrity, resulting in the dominance of only a few species.
Historic and cultural heritage	***Aboriginal and cultural heritage***	Minor repairable damage to more common structures or sites. No disturbance of historic and / or cultural heritage sites.	Moderate or repairable damage or infringement to sensitive structures or sites of cultural significance or sacred value.	Considerable damage or infringement to sensitive structures or sites of cultural significance or sacred value.	Major damage or infringement to sensitive structures or sites of cultural significance or sacred value.	Irreparable and permanent damage to sensitive structures or sites of cultural significance or sacred value.
Human health and safety	***Health and safety***	Low level short term subjective inconvenience or symptoms. Typically a first aid and no medical treatment.	Reversible injuries requiring treatment, but does not lead to restricted duties. Typically a medical treatment.	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a lost time injury.	Single fatality and/or severe irreversible damage or severe impairment to one or more persons.	Multiple fatalities or permanent damage to multiple people.
Radiation	***Occupational exposure***	<1 mSv/y Measurable increase in radiation dose with outcomes below public dose limit.	<5 mSv/y Measurable increase in radiation dose with outcomes remaining below dose constraints.	>5 mSv/y and <20 mSv/y Measurable increase in radiation dose with outcomes between dose constraint and dose limit (averaged over five years).	>20 mSv/y and <50 mSv/y Measurable increase in radiation dose with outcomes between dose limit (averaged over five years) and maximum annual dose.	>50 mSv/y Measurable increase in radiation dose with outcomes greater than the maximum annual dose.
End of life	***Rehabilitation***	Use Biodiversity, Socio-economic and Water descriptors as appropriate to the risk.				
End of life	***Decommissioning***	Use Human health and safety and Socio-economic descriptors as appropriate to the risk.				
End of life	***Closure***	Use Human health and safety and Socio-economic descriptors as appropriate to the risk.				
Socio-economic	***Community***	Local, small-scale, easily reversible change on social characteristics or values of the communities of interest or communities can easily adapt or cope with change. Local small-scale opportunities emanating from the project that the community can readily pursue and capitalise on.	Short-term recoverable changes to social characteristics and values of the communities of interest or community has substantial capacity to adapt and cope with change. Short-term opportunities emanating from the project.	Medium-term recoverable changes to social characteristics and values of the communities of interest or community has capacity to adapt and cope with change. Medium-term opportunities emanating from the project.	Long-term recoverable changes to social characteristics and values of the communities of interest or community has limited capacity to adapt and cope with change. Long-term opportunities emanating from the project.	Irreversible changes to social characteristics and values of the communities of interest or community has no capacity to adapt and cope with change.

Category of impact	Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Socio-economic	***Visual and landscape***	Almost imperceptible or no visual change from sensitive receptors or places of cultural and natural value. No loss of / or change to features or characteristics of the landscape.	Minor visual change from sensitive receptors or places of cultural and natural value. Minor loss or alteration to key landscape characteristics, or introduction of elements that may be visible but not uncharacteristic.	Moderate visual change from sensitive receptors and places of cultural and natural value. Discernible changes in the landscape due to partial loss or change to characteristics of the landscape.	Significant visual change from sensitive receptors and places of cultural and natural value. Discernible change which is out of scale with the landscape, at odds with landform and will leave an adverse impact.	Catastrophic visual change from sensitive receptors and places of cultural and natural value. A substantial change to the landscape due to total loss of elements or characteristics, causing the landscape to be permanently changed and its quality diminished.
Transport	***Traffic and transport operations and conditions***	Negligible adverse impact on traffic and transport conditions. No perceptible deterioration of road integrity.	Detectable adverse changes in traffic and transport condition (decrease in Level of Service) at one or two locations at any one point in time during the construction period or at a single location during operations. Seasonal, local deterioration of road integrity.	Detectable adverse change in traffic and transport conditions (decrease in Level of Service) at multiple locations. Short term, local deterioration of road integrity.	Traffic and transport congestion and delays exceed acceptable levels at multiple locations. Short term, regional deterioration of road integrity.	Traffic and transport congestion and delays severely restrict the safe operation and efficiency of the transport network. Long term, regional deterioration of road integrity.
Transport	***Road safety***	No increase in vehicle incidents along relevant haulage routes above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of five per cent above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of ten per cent above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of twenty per cent above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of greater than twenty per cent above historical baseline trend.
Water	***Surface water***	Minimal contamination or change with no significant loss of quality.	Local minor short term reduction or change in water quality. Local contamination or change that can be immediately remediated.	Local minor long term or widespread minor short term or local major short term reduction or change in water quality. Local contamination or change that can be remediated in long term.	Widespread (regional) major short term reduction or change in water quality. Local contamination or change that cannot be remediated in long term. Widespread contamination or change that can be remediated.	Regional long term reduction or change in water quality. Widespread contamination or change that cannot be immediately remediated.
Water	***Groundwater***	Negligible change to groundwater regime, quality and availability.	Changes to groundwater regime, quality and availability but no significant implications.	Changes to groundwater regime, quality and availability with minor groundwater implications for a localised area.	Groundwater regime, quality or availability significantly compromised.	Widespread groundwater resource depletion, contamination or subsidence.

Table 6-2 Ammaroo project likelihood descriptors

Descriptor	Explanation
Almost certain	The event is expected to occur in most circumstances This event could occur at least once during a project of this nature 91-100% chance of occurring during the project
Likely	The event will probably occur in most circumstances This event could occur up to once during a project of this nature 51-90% chance of occurring during the project
Possible	The event could occur but not expected This event could occur up to once every 10 projects of this nature 11-50% chance of occurring during the project
Unlikely	The event could occur but is improbable This event could occur up to once every 10-100 projects of this nature 1-10% chance of occurring during the project
Rare	The event may occur only in exceptional circumstances This event is not expected to occur except under exceptional circumstances (up to once every 100 projects of this nature) Less than 1% chance of occurring during the project

Table 6-3 Ammaroo project risk matrix

Likelihood	Risk consequence level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Table 6-4 Ammaroo project risk criteria

Risk response	
Extreme	Intolerable – Risk reduction is mandatory wherever practicable. Residual risk can only be accepted if endorsed by senior management
High	Intolerable or tolerable if managed to as low as reasonably practicable – Senior management accountability
Medium	Intolerable or tolerable if managed to as low as reasonably practicable – Management responsibility
Low	Tolerable – Maintain systematic controls and monitor

Table 6-5 Ammaroo project data availability descriptors

Certainty descriptors	
High level	Risk ranking is based on testing, modelling or simulation, use of prototype or experiments. Analysis is based on verified models and/or data. Assessment is based on an historical basis
Medium level	Risk ranking is based on similar conditions being observed previously and/or qualitative analysis
Low level	Risk ranking is based on subjective opinion or relevant past experience

6.4 Discussion of key outcomes

6.4.1 Risk assessment workshop

A hazard identification and risk assessment workshop was conducted over two days, on 28 and 29 November 2016 at the GHD Darwin office. The purpose of the workshop was to review the identified hazards associated with the proposed Ammaroo project, identify any additional hazards and assess the risk associated with these hazards.

The workshop was facilitated by GHD and included a cross section of project personnel. A list of attendees is provided in Table 6-6.

Table 6-6 Environmental risk assessment workshop attendees

Attendees	Role	Company	28 November 2016 Session 1	28 November 2016 Session 2	29 November 2016 Session 3
Henry Reynolds	Facilitator	GHD	◆	◆	◆
Fiona Duncan	Scribe / Health and Safety Specialist	GHD	◆	◆	◆
Glen Ewers	Ecology Specialist	EcOz Environmental Consultants	◆		
Chris Tziolis	Managing Director	VRM	◆	◆	
John Dunster	Geologist	VRM	◆	◆	◆
Jane Munday	Social Impact Specialist	True North	◆	◆	◆
David Eames	EIS Coordinator	GHD	◆	◆	◆
Nicole Conroy	EIS Coordinator	GHD	◆	◆	◆
Nigel Doyle	Exploration Manager	VRM	◆	◆	◆
Ben Jeuken	Hydrogeologist	Groundwater Science	◆	◆	
Rob Virtue	AMD Specialist	GHD		◆	
Rob Longey	Mine Closure Specialist	GHD		◆	

6.4.2 Risk assessment results

The environmental risk assessment identified 101 risk events, which had potential impacts on environmental receptors. All these events were assessed through the environmental risk assessment process. An additional 11 risk events were initially identified, however on discussion during the risk workshop were excluded as being not relevant to the project. A summary of the risk register is presented in Table 6-7. The full risk register is presented in Table 6-8.

Nine events related to social / community aspects identified and assessed had potential positive impacts. Table 6-8 reflects these positive impacts.

The residual risk rating for over half of the risks was rated as low (Table 6-7 and Figure 6-2). Those rated medium or high were the subject of particular attention in the development of further control measures and management plans.

Table 6-7 Summary of residual risk ratings

Rating	Initial risk	Residual risk
Low	58	58
Medium	40	40
High	3	3
Extreme	0	0
Total	**101**	**101**

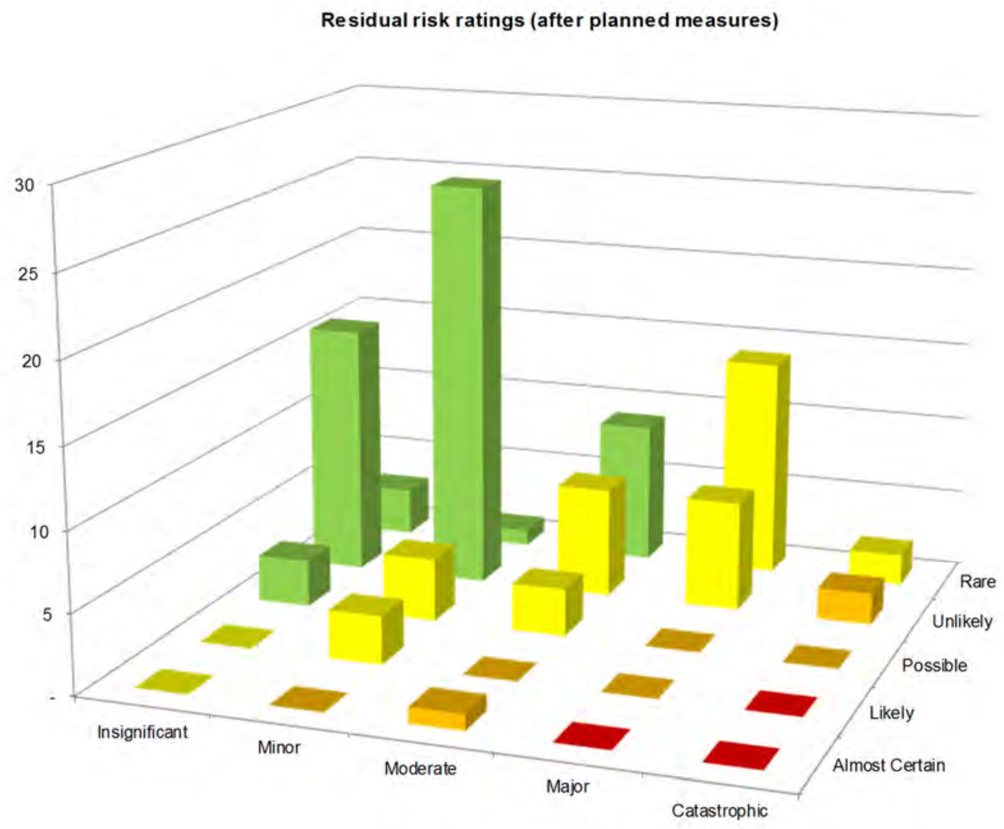

Figure 6-2 Distribution graph of residual risk ratings

Key risk areas that were subject to detailed impact assessment and risk management planning include the following:

- Road accidents from increased traffic during construction and operation activities.
- Health and safety of project personnel from interaction with equipment as well as mobile and fixed plant, during construction and operation activities.
- Dust fallout and deposition, including impacts to flora, fauna and nearby sensitive receptors, from wind erosion of exposed operational surfaces and vehicle movement along haul roads.
- Flora, vegetation communities and fauna habitat impact from land clearing during construction.
- Flora, vegetation communities and fauna habitat impact from spread of weeds and feral animals due to vehicle movements and/or inappropriate waste management.
- Changes in hydrological characteristics from construction of linear assets (e.g. rail spur).
- Decline in availability of water to existing and/or future users, within the Southern Georgina basin from progressive water table drawdown arising from groundwater extraction rates.
- Disturbance and or damage to archaeological sites or cultural exclusion zones during construction and operation activities.
- Social and family tensions from increased disposable income and distribution of benefits payments in the local communities.
- Employment impacts to existing local businesses (e.g. retail, hospitality, council) due to recruitment of project personnel.
- Wellbeing of project personnel due to living away from home and lack of family / support networks.

The risk profile across the study area is presented in Figure 6-3, which highlight the distribution of project risks per environmental aspect. This shows that the highest number of risks is associated with human health and safety followed closely by socio economics.

There were no risks identified and assessed with an extreme risk rating. It demonstrates that:

- The majority of risks are unlikely or may occur only in exceptional circumstances.
- The maximum credible consequence of most risks is no greater than a minor impact.

The majority of risk did not identify any additional control measures beyond the planned controls, and as such, the residual risk profile did not change substantially.

There are however, a range of medium level risks which will be actively managed through identified control measures. No risk was assessed as having an initial or residual risk rating of extreme. Three risks have a residual risk rating of high, and have been acknowledged as key areas for management:

- Vehicle incident associated with the transport of materials and personnel off-site on public roads.
- Rail crossing incident associated with the transport of product on railway.
- Loss of vegetation during the lifecycle of the project, but particularly during construction.

6.4.3 Key control measures

Key controls for the management of identified risks are covered in the EMP (Appendix E) for the project, which encompasses the following sub plans:

- Air and Dust Management Plan
- Biodiversity Management Plan
- Cultural Heritage Management Plan
- Fire Management Plan
- Hazardous Substances Management Plan
- Waste Management Plan
- Water Management Plan
- Weed Management Plan
- Social Impact Management Plan

A mine closure planning framework is also included in the draft EIS (see Chapter 17: Rehabilitation).

6.5 Action tracking

Actions identified during this draft EIS should be recorded into an action register for ongoing management, particularly as the project engineering design advances. Systematic action tracking ensures that the identified risk is assigned an owner, is suitably managed and has formal closeout. An action register will also allow for an audit trail, so that a verification can be carried out at a later stages of the project.

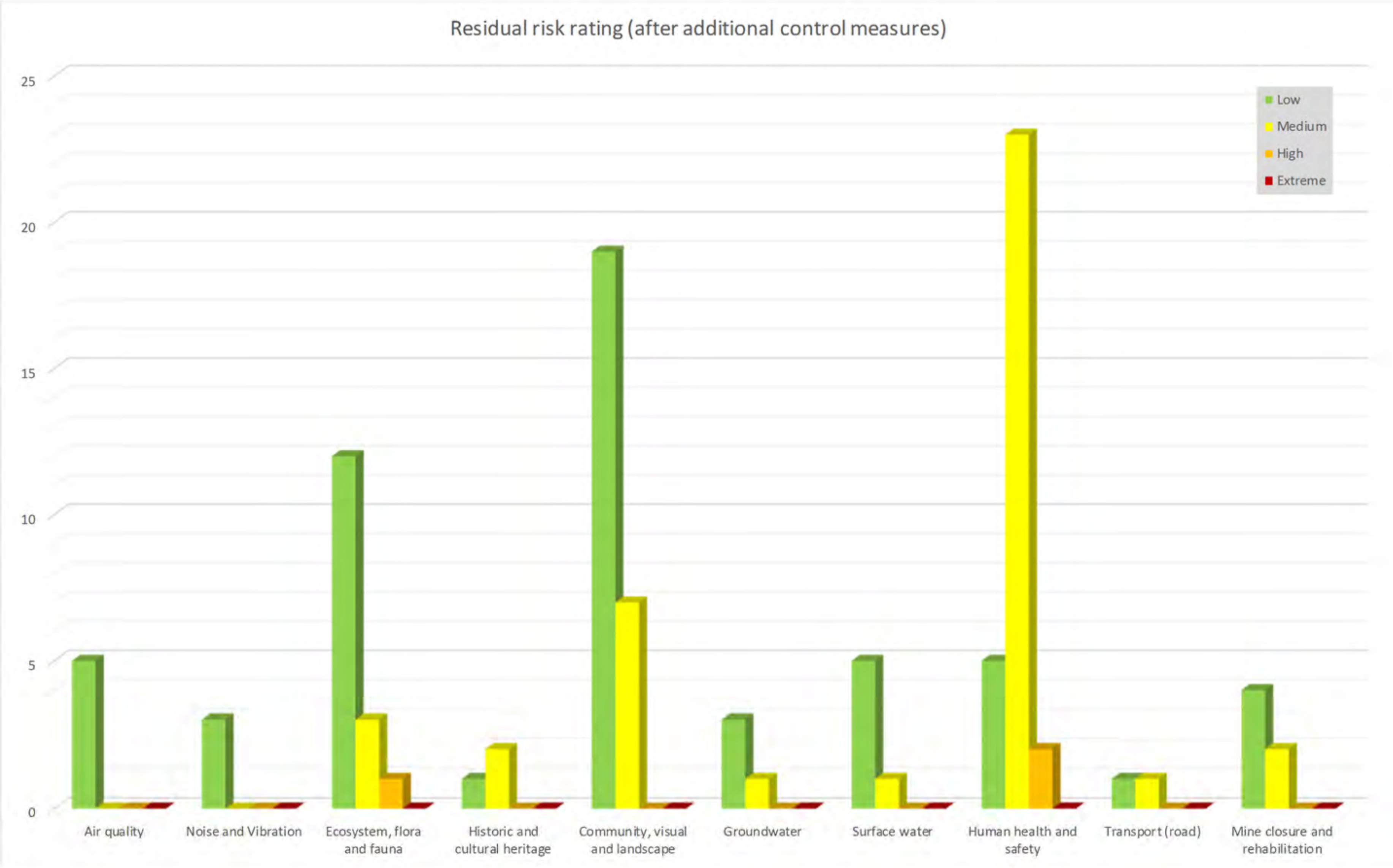

Figure 6-3 Summary of residual risk rating per environmental aspect

6.6 Conclusion

A risk based approach was adopted to identify and assess potential impacts associated with the project, in terms of their credible worst case consequence and the likelihood of that consequence occurring.

The risk assessment was conservative in approach, to provide reputable results. A summary was developed of the findings that describe the activities of the project and the prioritisation of the associated risks. The results of the risk assessment have been reported in the individual impact assessment report for each specialist study area, providing justification for the rating and outlining additional control measures to manage the risk.

The risk identification and additional control measures have been used to inform the Environmental Management Framework for the project.

	Impact pathway							Initial Risk					Residual Risk		
Ref.	**Potential event** (how the Project interacts with assets, values, uses and location. Include clear description of the cause)	**Specialist Area**	**Environmental Factor / Receptor**	**Phase** (construction, operation or closure)	**Description of consequences** (Clearly understand what is the final impact)	**Planned Controls to Manage Risk** (as per Project Description, and elements of Standards / Codes of Practice	**Comment**	**Consequence**	**Likelihood**	**Risk Rating**	**Level of Certainty**	**Additional Controls Recommended to Reduce Risk**	**Consequence**	**Likelihood**	**Risk Rating**
1	Drawdown of shared groundwater aquifers in order to supply water to the project	Water	Groundwater	All	Negatively impacts other groundwater users.	- Draw down cones - Audit of other users including communities, pastoral requirements - Uncertainty analysis - Modelling will be for the mine life, plus recovery recharge time post mine .	4.4 GL water is expected to be extracted (worst case), but currently there is no reuse included in the water requirements, so water requirement is likely to be less than 4.4 GL. This does not include the slurry pipeline, however there will be water recovery). Not many communities in close proximity to site	**Minor**	**Possible**	**Medium**	Medium Level		**Minor**	**Possible**	**Medium**
2	Reduced environmental groundwater availability caused by extraction of groundwater aquifers to supply water to the project	Biodiversity	Ecosystem	Construction & Operation	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of groundwater-dependent flora and fauna species.	- Source water from approved sources in accordance with agreements. - Prior to construction, assess the sustainable yields for proposed groundwater extraction bores. - Measure the standing water level in bores prior to, during, and immediately following extraction to provide insight into drawdown. - Any new bores required will be drilled by a driller licensed under relevant legislation (e.g. NT Water Act).	Not considered a risk - standing water level depths are deep (60 to 80 m) and there are not considered to be any groundwater-dependant ecosystems.	**Insignificant**	**Rare**	**Low**	High Level		**Insignificant**	**Rare**	**Low**
3	Project's use of water for construction and processing impacts on groundwater and stock and domestic bores.	Socio-economic	Groundwater	Construction & Operation	Reduced pastoral productivity and negativity towards the project. More stringent regulatory controls.	- Draw down cones - Environmental Management Plan		**Moderate**	**Rare**	**Low**	High Level		**Moderate**	**Rare**	**Low**
4	Altered landscape character and surface water quality caused by site establishment (including vegetation clearing) combined with rainfall run-off resulting in erosion and/or sedimentation	Biodiversity	Ecosystem	Construction	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species	- Erosion and Sedimentation Control Plan outlines management of soil to minimise erosion and sedimentation (included in Mine Management Plan) - Staging of Construction to occur in the dry season. - Use of soil binding polymers applied to areas left cleared for any period of time.	Includes road construction. Noted that except for a pasterial man-made dam, there is no permanent surface water in the area.	**Minor**	**Unlikely**	**Low**	Medium Level		**Minor**	**Unlikely**	**Low**
5	Operation of the mining areas combined with run off from rainfall event(s) results in altered hydrology during rainfall event	Water	Surface water	Operation	Local minor short term reduction or change in water quality. Local contamination or change that can be immediately remediated.	- LIDAR and hydrological model of surface water flow including drainage line determination for different rail fall events (up to 1 in 100 yr event over 72 hours) - Nil discharge site under normal operations. - In-mine drainage - TSF to include sufficient capacity to manage runoff generated by the 100 year ARI flood event. - Pits will include flood protection measures (bunds) to protect the pit from inrush during the 100 year ARI flood event.	Sheet flow erosion limited by relatively flat gradients within the project area. Due to the existing soils in the area, surface water sheet flow will potentially have a high sediment content. Rainfall events are infrequent	**Minor**	**Unlikely**	**Low**	Medium Level		**Minor**	**Unlikely**	**Low**
6	Construction and operation of linear infrastructure (e.g. access roads, tracks and utilities corridors) combined with rainfall event(s) results in altered hydrology during rainfall event	Water	Surface water	Construction & Operation	Potential for crossing drainage structures associated with linear infrastructure to impede or divert natural flow and/or increasing channel flow velocity.	- Use of buffer zones, sediment fences and sediment ponds to arrest the transport of water borne sediment from the site. - Stage clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP. - Staging of Construction to occur in the dry season. - Use of soil binding polymers applied to areas left cleared for any period of time. - Provision of suitable outlet scour protection measures as per ESCP. - Maintain natural surface water flows in minor watercourses by the use of floodways at creek crossings. - Adoption of appropriately sized culverts to maintain flows at major creek crossing. - Appropriate consideration of surface water flow in the design and placement of infrastructure. - Develop and implement an Erosion and Sediment Control Plan.	As best as possible access road alignment general along the ridge of the local terrain and closes direct route. Sheet flow erosion limited by relatively flat gradients within the project area. Due to the existing soils in the area, surface water sheet flow will potentially have a high sediment content. Rainfall events are infrequent throughout the year.	**Moderate**	**Unlikely**	**Medium**	Low Level		**Moderate**	**Unlikely**	**Medium**
7	Failure of TSF batters / embankment during operation, leading to erosion or seepage loss of material to the environment. Or failure of inpit TSF concept, excessive settlement or contaminated seepage discharge.	Water	Surface water	Operation	Contamination of the surrounding environment and waterways from an uncontrolled release resulting in the degradation of the quality of surface water.	- Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance. - Adherence to prescribed maximum operating level and retention freeboard. - Selection of Probable Maximum Precipitation (PMP) for design is maximum theoretical rainfall event. - Embankment piezometers and survey pegs. - Regular dam inspections. - Monitoring program for pheatic levels within embankments. - Develop and implementation of a Water Management Plan.		**Minor**	**Unlikely**	**Low**	Medium Level		**Minor**	**Unlikely**	**Low**
8	Failure of post-closure surface TSF batters (not likely to be covered), leading to erosion or seepage loss of material to the environment. Or failure of inpit TSF concept, excessive settlement or contaminated seepage discharge.	End of life	Mine closure	Decommissioning	Erosion and dispersion of particulate matter via air, surface, or groundwater flows, with resultant downstream effects on dependant ecosystems.	- Refine the engineering design for all TSF designs including evaluation of suitable materials; - Improve confidence in tailings/waste geochemical characterisation; - Develop staged backfill plans and settlement estimates and final landform for inpit tailings.		**Moderate**	**Rare**	**Low**	Low Level		**Moderate**	**Rare**	**Low**
9	Poor management of waste materials during operations leads to closure plans being unachievable or costly.	End of life	Mine closure	Operation	Delays to effective rehabilitation by Project proponent, including erosion, or seepage resulting in non sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years.	- Undertake a closure materials balance based on the mine plan and closure design, understand worst case liability or non-rehabilitated pit at any point in LOM; - Review the long-term progressive inpit backfill schedule in relation to the long-term closure plan; - Operational controls on mine waste management (i.e.; waste classification); - Competent operational management personnel and systems - Progressive rehabilitation of landforms during operations to limit area of active disturbance and provide proofing of closure designs through field performance (e.g. surface tails storage completed in year 1, then rehabilitate and monitor in operational phase, particularly any visible outer faces, similar for inpit backfill monitoring)	Strip mining process where not a large amount of waste rock is left lying (i.e. it goes back into rehabilitated mine areas / in-pit storage) and there will only be approximately one year storage at the start of the mining. There is a 30-40 % removal of material during mining Capping is not expected to be required.	**Moderate**	**Unlikely**	**Medium**	High Level		**Moderate**	**Unlikely**	**Medium**
10	Contaminated sites not adequately remediated, including process plant, workshops, fuel farm or storage areas.	End of life	Mine closure	Decommissioning	Delays to effective rehabilitation by Project proponent, including erosion, or contaminated seepage resulting in non sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years. Inability to relinquish, leading to damage to reputation, not able to get bond, ongoing environmental damage.	- Reporting of spills; - Contaminated sites register; - Contaminated sites report; - Contaminated sites rehabilitation designs; - Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria - Undertake further sampling/monitoring to accurately define level and extent of any ground contamination during operations and improve volumetric estimates.		**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**

			Impact pathway					Initial Risk					Residual Risk		
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11	Closure designs not developed in detail to enable appropriate closure execution, including ineffective implementation of design, poor rehabilitation execution or design failure, resulting in significantly higher closure cost above closure provisioning.	End of life	Mine closure	Decommissioning	Insufficient closure cost provision resulting in inability to execute closure plan. Delays or inability to achieve effective rehabilitation by Project proponent, (e.g. closure design or materials not adequate causing erosion, or seepage resulting in non sustainable ecosystems and downstream effects). Delays in achieving rehabilitation criterion and or relinquishment and could be a period of years, with un-remediated Project site potentially acting as source of ongoing environmental hazard.	- Conceptual closure plan developed for the project at start-up. - Increase level of detail in closure designs during operations (detailed design level 5 yrs prior to closure) - Prepare decommissioning and rehabilitation plan - Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. - Regular monitoring of identified key environmental aspects of operation that are potentially most problematic during operation and at closure i.e. surface/in-pit tailings, waste rock, seepage to ensure these aspects are fully understood and accounted for in all closure designs and proposals. - Strip mining methodology allows for progressive rehabilitation and review, include in mine plan showing open areas, replacement and order of fill etc. - Employ closure project manager; - Undertake inspections & monitoring - Performance monitoring of progressive rehabilitation and correction of designs/execution if required		Moderate	Rare	Low	Low Level		Moderate	Rare	Low
12	Reduction in the quality of ecosystems due to inconsistent / inadequate rehabilitation	End of life	Fauna	Decommissioning	A decrease in the abundance of flora and fauna ecosystem.	- Rehabilitation Plan which details how land will be cleared, vegetation stored, and land reinstated in the optimal way to give rehabilitation the best chance of being successful. Reinstatement will be audited against strict acceptance criteria. - Rehabilitation bond required by Government. - Progressive rehabilitation throughout the mine life will allow improvements to be made to the process as lessons are learnt.	Potential opportunity to improve local ecosystem. Will depend on the land use after rehabilitation. Additionally, current rehabilitation of exploration tracks in the area shows good results.	Minor	Unlikely	Low	Medium Level		Minor	Unlikely	Low
13	Unexpected early closure of the Project, due to delays or falling commodity prices.	End of life	Mine closure	All	Delays to effective rehabilitation by Project proponent, including through erosion or seepage resulting in non sustainable ecosystems and groundwater effects. Potentially exacerbated by closure designs not yet developed in detail at time of early closure.	- Long term offtake arrangements for clients; - Strategic long term investors; - Concept closure plan; - Commit to developing/refining closure designs through operations; - Closure materials topsoils etc. stockpiles at start-up of operations; - Surface TSF design conservative and in-pit tailings/waste limited impact should they enter early closure as closure concept does not significantly change; - Progressive rehabilitation; - Bonds held by NT Government requires 110% of estimated closure cost reviewed and provided annually.		Moderate	Unlikely	Medium	Low Level		Moderate	Unlikely	Medium
14	Insufficient funds / bonds for Project closure activities, due to - inadequate closure plan designs, poor assumptions or failure to recognise impact of changes to operations on closure plans	End of life	Rehabilitation	Decommissioning	Delays to effective rehabilitation, with un-remediated Project site potentially acting as source of ongoing environmental hazard. Worst credible consequence is involuntary administration, with NT Government to complete remediation with bonds shortfall and consequential budgetary impact.	- Robust closure costs estimate with realistic assumptions; - Closure plan/designs planned to be refined during operations; - Closure costs estimate revised annually; - Closure plans audited by regulator prior to approval; - Bonds held as bank guarantee or cash in NT - Progressive rehabilitation planned which enables reduction in liability during operations and identification of design issues		Moderate	Rare	Low	Medium Level		Moderate	Rare	Low
15	Resource competition and habitat modification due to weed introduction or proliferation caused by soil disturbance and movement of vehicles/machinary during construction and operations.	Biodiversity	Flora	Construction & Operation	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Weed Management Plan outlines strategies to limit the introduction of new weeds within the project area and limit the spread of existing weeds during project activities	The mine is in a cattle area, so there is some level of degradation from grazing. Despite historic mineral exploration being widespread in the area and involving creating numerous tracks, field surveys have noted very few weeds.	Minor	Unlikely	Low	High Level		Minor	Unlikely	Low
16	Clearing and start of construction reduces pastoral productivity through noise, dust, introduction of weeds, traffic disrupting mustering and other pastoral activities.	Socio-economic	Community	Construction	Reduced pastoral productivity and negativity towards mining through competing land uses.	- Management plans - Good communication with pastoralists	Should be managed with good community relations and management plans. However this rating could change given new ownership of Murray Downs and the fact that a pipeline and road run across the property. May need its own risk rating if there's opposition.	Minor	Unlikely	Low	Medium Level		Minor	Unlikely	Low
17	Mortality of flora and fauna due to interactions with machinery used in land clearing	Biodiversity	Ecosystem	Construction & Operation	Decrease in the diversity and/or abundance of flora and fauna species.	- Vegetation Clearing Procedure involving a fauna spotter-catcher		Minor	Likely	Medium	High Level		Minor	Likely	Medium
18	Creation of an edge effect as a result of vegetation clearing	Biodiversity	Ecosystem	Construction & Operation	A reduction in surrounding habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Vegetation Clearing Procedure	Apart from the increased likelihood of weed infestation (addressed elsewhere in this register), edge effects are more pronounced in forested areas where exposure to wind and sunlight (which change micro-climates, reduce soil moisture and encourage lower canopy plant species), and increased vulnerability to fire (because of more understorey). Therefore, it is assumed the open, sparsely vegetated habitats within the project footprint will not experience any significant or substantial edge effects.	Insignificant	Rare	Low	High Level		Insignificant	Rare	Low
19	Habitat fragmentation as a result of vegetation clearing	Biodiversity	Ecosystem	Construction & Operation	A reduction in surrounding habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Vegetation Clearing Procedure	The vegetation communities within the project footprint are regionally common and widespread	Minor	Likely	Medium	High Level		Minor	Likely	Medium
20	Increased resource competition and/or predation caused by a proliferation of feral fauna species due to inadequate management of putrescible waste	Biodiversity	Ecosystem	All	A reduction in habitat quality and/or direct mortality of fauna leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Waste Management Plan ensures that access to food waste is not available for fauna	The region is already populated by the array of vertebrate pest animal species likely to occur in the arid zone	Insignificant	Unlikely	Low	High Level		Insignificant	Unlikely	Low
21	Reduction in the quality of habitat due to reduced ground or surface water quality caused by spills of chemicals or hazardous substances, including wastewater and contaminated tailings water	Contamination / Environment	Flora	All	A decrease in the abundance of flora and fauna ecosystem.	- Spill Management Plan will be developed that outlines chemical spill response management plus Water Management Plan that outlines management of chemicals, wastewater and fuels in proximity to water	No surface water in immediate area of mine site. Ground water level is deep (approximately 60 - 80 m). Due to their potential impacts on humans and the environment, both of these activities are well regulated, and therefore the potential for the accidental release of chemicals to impact upon flora and fauna, is low and the probable scale is small, resulting in, at worst, a minor reduction in ecosystem integrity.	Minor	Unlikely	Low	High Level		Minor	Unlikely	Low
22	Fears of health impacts of chemical spills or contamination of local surface and groundwater	Socio-economic	Community	All	Negativity towards the project. More stringent regulatory controls.	- Emergency Response plans and good communication with community (CLC and pastoralists) about potential impacts - Community forum and liaison committee / officer during operation	Doesn't appear to have the issues of larger or more controversial projects	Minor	Unlikely	Low	Medium Level		Minor	Unlikely	Low

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23	Local businesses fail to win contracts because they lack capacity, specialist skills, are ill-prepared or not competitive - or because they gear up and the project doesn't proceed.	Socio-economic	Community	All	Local content plan not achieved, ill-feeling towards the project for failing to deliver benefits. Potential for businesses to over-extend in expectation of work then blame the project for them going broke.	- Industry participation plan. - Good communication with locals during project set-up and planning. - Project scale is more conducive to local skills. - Early management of expectations for the community.	Businesses may have unrealistic expectations of the contracts likely to be available short-term and longer-term.	Moderate	Unlikely	Medium	Medium Level		Moderate	Unlikely	Medium
24	Worker misbehaviour strains police resources.	Socio-economic	Community	All	Existing services unable to meet existing demand or need more staff to meet capacity constraints.	- Code of behaviour - Code safety education, particularly in Ali Curung.	If FIFO workers are taken straight to site, this impact will be minimal.	Insignificant	Unlikely	Low	Medium Level		Insignificant	Unlikely	Low
25	Mobilisation of workforce puts pressure on social services in nearby communities in towns, in particular demand for health clinics.	Socio-economic	Community	All	Pressure on existing services to meet demand. Government may feel it has to invest in increased capacity.	- Project to provide internal health services. - Community liaison committee.		Insignificant	Unlikely	Low	Medium Level		Insignificant	Unlikely	Low
26	Increased risk of road trauma, bushfires, chemical spills and project incidents creates pressures for local emergency services, which may limited capacity to respond.	Socio-economic	Community	All	Compromised capacity of emergency services.	Emergency Response Management Plans including: -Site to have first responders -Site to transport own personnel if injured (with own ambulance or equivalent) -Site will have their own fire trucks and personnel to use them -Site to have its own medical team, including a registered nurse or equivalent -joint training with emergency services (if appropriate)	Sparsely populated area increases the impact of unlikely events. Emergency responders are generally not volunteers in the local area (mostly paid personnel)	Moderate	Unlikely	Medium	Medium Level		Moderate	Unlikely	Medium
27	Low take up of jobs by local Aboriginal people through skills shortages, lack of work-readiness, structural issues in employment practices that disadvantage Aboriginal workers, issues with transport, rosters and other barriers.	Socio-economic	Community	All	Dashed expectations, jealousies, ill-feeling towards the project (particularly if local people see Aboriginal workers from other areas), failure of the project to deliver on expectations. Lost opportunities.	- Employment and training plan. - Work with local employment and training providers. - Good communication that allows for advance planning.	It is highly likely that there is a mismatch between local expectations of a job and actual success with recruitment and retention, particularly short-term. Highly automated mining processes will require fewer menial jobs, and more specialised and trained personnel, although many other jobs are likely to be available through the supply chain i.e. not just direct mining jobs.	Moderate	Possible	Medium	Medium Level		Moderate	Possible	Medium
28	"Honeypot" effect of Alyawarre families moving into or back to the region in expectation of jobs and other benefits from the project puts pressure on the already overcrowed public housing.	Socio-economic	Community	All	Overcrowding, tensions and increased demand for public housing in communities and nearby towns.	- Good communication to manage expectations about what work is available and timelines. - Community liaison committee.	Effect is likely to be short-lived (low numbers of jobs initially and if they don't get a job are likely to move away again). Plan to manage royalties in a different way (no "handouts") and the local community is considered cohesive	Insignificant	Unlikely	Low	Medium Level		Insignificant	Unlikely	Low
29	Mobilisation of workforce changes the composition of the local population, leading to reduced community cohesion.	Socio-economic	Community	All	Reduced cohesion causes new tensions or exacerbates existing tensions, depending on the extent of change and the community's ability to absorb it.	- Community liaison committee	This is likely to be less than other projects given nearby communities are predominantly Alyawarre (except Ali Curung) and any demographic changes in towns such as Alice Springs and Tennant Creek should be absorbed. Workers are most likely to either come from nearby communities or be FIFO.	Insignificant	Unlikely	Low	High Level		Insignificant	Unlikely	Low
30	Mobilisation of workforce leads to negative interaction with nearby communities through poor behaviour, trespassing on pastoral properties, consumption of alcohol, bringing in drugs, fights.	Socio-economic	Community	All	Reduced community cohesion. Reduced quality of life in communities and on pastoral properties.	- Strict codes of worker behaviour that is enforced. - Reduce interaction of FIFO workers with local towns on days off (straight to plane or bus).		Minor	Unlikely	Low	Medium Level		Minor	Unlikely	Low
31	Recruitment for the project draws good workers away from existing jobs in the region which are then hard to back-fill, including council, government, pastoral, retail and businesses.	Socio-economic	Community	All	Reduced productivity and service delivery from loss of key staff. It is already hard to recruit to many positions in this region.	- Monitor for adverse effects. - Look at joint training initiatives that help with back-filling.	Not something that the company can do much about. Existing residents either have jobs already and may be tempted by the higher wages or are unemployed and likely not work ready. However, the consequences would be short-term, during construction only. Will be influenced by other factors outside company's control such as general economic conditions and other projects.	Insignificant	Possible	Low	Low Level		Insignificant	Possible	Low
32	Reliance on a FIFO workforce leads to mental health issues and potential self-harm and suicide among workers living in accommodation camps due to loneliness and being away from families.	Socio-economic	Community	All	Self-harm and suicides. Impacts on worker morale and retention. Maximum reasonable consequence would be severe, reversible health effects (a single fatalities may occur e.g. suicide, however the more reasonable outcome is assumed to be severe, reversible health effects).	- HR plan to support workers living away from families - Communication plan, including availability to communication tools (Skype etc.)	Hard to influence as workers' mental health as may be influenced by factors away from the workforce.	Moderate	Unlikely	Medium	Medium Level		Moderate	Unlikely	Medium
33	Mobilisation of workforce displaces other economic activities, in particular tourism, as FIFO workers take up flights and local accommodation.	Socio-economic	Community	All	Displacement of other economic sectors in nearby towns such as Tennant Creek or Alice Springs.	- Accommodation plan; - Manage transport to reduce impacts, with workers likely to fly from Mount Isa, Tennant Creek or Alice Springs to nearby airstrip.	Given that the workforce is likely to come from local communities or be FIFO, impacts on towns like Tennant Creek should be easily monitored and managed.	Insignificant	Unlikely	Low	Medium Level		Insignificant	Unlikely	Low
34	Mobilisation of workforce causes inflationary pressures in nearby communities, e.g. on availability and affordability of private housing (rental and purchase), services such as childcare or through scarcity of workers and goods.	Socio-economic	Community	All	Inflationary pressures cause hardship for the rest of the population from higher prices, not being able to compete with wages or trouble finding tradespeople for non-project work. Inflationary pressures could make it harder to recruit staff for government, council, business and NGO positions in towns.	- Monitoring of project's impacts, e.g. through community liaison committee	This is particularly the case if company staff are provided with subsidies to relocate. Given the workforce will be mostly from local communities or FIFO, this should be minimised.	Minor	Unlikely	Low	Medium Level		Minor	Unlikely	Low
35	Distribution of royalty payments, including rumours and misinformation causes tensions and disagreements between families.	Socio-economic	Community	All	Family tensions over who has the right to negotiate and receive benefits, or over perceived nature and equity of agreements being negotiated. Disruption to community cohesion and ill-feeling towards the project.	- Follow CLC guidance, which is encouraging royalties to be invested in community development. - Work closely with the CLC which has responsibility for identifying native title holders with the right to negotiate and ensure native title holders are well-informed. - Good communication, not over-promising or raising expectations.	This can be a difficult issue to manage, given that rumours may start once the project is publicised and given the spread of families. Good communication and coordination with the CLC will be important. Project location helps. Traditional owners are Alyawarre, with well-known and strong leaders like Banjo Morton. Local community considered cohesive.	Minor	Possible	Medium	Medium Level		Minor	Possible	Medium
36	Higher levels of disposable income contribute to increased consumption of alcohol and drugs in workers' communities and towns, where workers may indulge in binge drinking on days off.	Socio-economic	Community	All	Higher levels of crime and antisocial behaviour and fights between workers and other community members, including potentially higher levels of domestic violence, in turn straining local police resources.	- Workers code of behaviour. - Limit access to towns between rosters by taking FIFO workers straight to flights.	More likely if FIFO workers gather in hotels between rosters. Given the workforce will be most likely be from local communities (most of which are dry) or FIFO, this should be minimised.	Minor	Unlikely	Low	Low Level		Minor	Unlikely	Low
37	Project evokes negative perceptions towards the use of water by mining in an arid area that may have other beneficial users.	Socio-economic	Community	All	Negativity towards the project. More stringent regulatory controls.	- Environmental Management Plan - Open and transparent communication about hydrological studies and monitoring results	Doesn't have the issues of larger or more controversial projects	Insignificant	Unlikely	Low	Medium Level		Insignificant	Unlikely	Low

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38	Human rights breaches (including inadvertent) through racism experienced in the workplace, inequitable work practices (including families and genders), breaches of labour laws (e.g. internships, work experience) on the project or with contractors.	Socio-economic	Community	All	Negativity towards the project. Impacts on morale, employment and retention rates for local workers.	- Cross-cultural inductions. - Codes of Conduct. - HR practices		**Insignificant**	**Unlikely**	**Low**	Low Level		**Insignificant**	**Unlikely**	**Low**
39	Cumulative impacts creates pressure on workforce availability, services, inflationary pressures, e.g. TNG, Arafura Resources.	Socio-economic	Community	All	Cumulative impacts on workforce availability, services, inflationary pressures		Out of proponent's control, although perhaps opportunities for joint planning, depending on timing.	**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**
40	Mobilisation of exploration and construction workforce leads to increase crime such as thefts from company workplaces, vandalism or theft of equipment, increased petrol-sniffing and using access tracks for grog-running.	Socio-economic	Community	All	Increased pressure on already stretched police services in Ali Curung and Ampilatawatja. The nearest hotel is Wycliffe Well. There is already an issue with people using station tracks to travel between communities. The level of grog-running to Ali Curung and other communities and road safety issues. The company has experienced thefts of fuel and other equipment during exploration.	- Staff and contractors required to use diesel or low aromatic fuels and good security to prevent thefts. - Liaise with community and police on road safety and use of access tracks for non-project traffic.		**Minor**	**Possible**	**Medium**	High Level		**Minor**	**Possible**	**Medium**
41	Clearing of roads and start of construction reduces access, disrupts environmental flows or disturbs habitat that is important for traditional activities such as camping, hunting, gathering bush medicine.	Socio-economic	Community	All	Loss of traditional uses of land and negativity towards the project.	- Environmental Management Plan - Worker code of behaviour - Liaison with community to understand what access is important	Any impact is likely to be short-term and readily managed through controls	**Insignificant**	**Unlikely**	**Low**	High Level		**Insignificant**	**Unlikely**	**Low**
42	Mobilisation of workforce leads to reduced participation and volunteering in local and regional communities, including sport.	Socio-economic	Community	Construction & Operation	People being away from communities, particularly on shift work, reduces the number of volunteers, who are already hard to find. This includes emergency services, community and sport groups.	Verdant will work with communities where possible to consider the availability of volunteers to their communities or compensate for their loss through community relations activities, but in general this impact is not easy to mitigate.	Baseline conditions suggest that attracting volunteers is an issue in a number of communities. Given the high proportion of FIFO workers, it will be mitigated to a large extent. The main issue may be drawing promising footballers away from local teams. This could be partly accommodated through rostering	**Insignificant**	**Unlikely**	**Low**	Low Level		**Insignificant**	**Unlikely**	**Low**
43	The short-term construction period creates a 'boom bust' impact on local businesses who over-capitalise to win work.	Socio-economic	Community	Construction	Businesses may over-invest based on anticipation of contracts or through winning project work, and then be unable to meet payments once the scope of work is completed	Work with ICN to ensure businesses have the financial capacity for the work they take on. Provide clear communication about the nature and scope of contracts to provide for good planning	The scale of the project means that tenders are likely to suit the capability of small businesses, which mitigates this risk to an extent. However, it could still be a risk for people investing in heavy equipment to get work on the project, particularly small Aboriginal businesses.	**Insignificant**	**Unlikely**	**Low**	Low Level		**Insignificant**	**Unlikely**	**Low**
44	Disruption to nesting/ roosting/ foraging habitats or displacement of fauna into sub-optimal habitats, increasing their susceptibility to predation and competition due to vibrations and/or noise disturbances from machinery and plant	Biodiversity	Noise	All	A reduction in surrounding habitat quality and/or direct mortality of fauna leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Noise Management Plan (consideration of NT EPA Noise Guidelines) - Quiet equipment selection, including the selection of gas turbines unit with noise attenuators. - Scheduled maintenance as per OEM requirements - Procedure to limit high-impact noise to daylight hours only where possible (this could reduce the impact on nocturnal fauna). - Although not expected to cause adverse noise impacts, a complaint management system will be implemented. Including the implementation of management measures adopted should noise complaints be received.	Noise modelling predictes short term, local increase in noise levels	**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**
45	Processing plant construction activities and mining operations, including earthworks (excavation, haulage, etc.), power station and other processing plant and equipment resulting in audible airborne noise at elevated levels	Socio-economic	Noise	All	Excessive noise levels at nearby sensitive receptors, including nearby communities, homelands and outstations, resulting amenity disturbance, annoyance, sleep disturbance, etc.	Noise Management Plan - mitigation measures will be included in site wide EMP. Consideration of NT EPA Noise Guidelines for Development Sites in the Northern Territory noise management plan - Minimising noise wherever possible - Quiet equipment selection, including the selection of gas turbines unit - where required, equip gas turbines exhaust stacks with noise attenuator. - Scheduled maintenance as per OEM requirements - Broadband reversing alarms should be used for all site equipment, subject to meeting occupational health and safety requirements. - Procedure to limit high-impact noise to daylight hours only where possible (this could reduce the impact on sleeping). - Although not expected to cause adverse noise impacts, a complaint management system will be implemented. Including the implementation of management measures adopted should noise complaints be received.	Sensitive receptors not close to mine site	**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**
46	Project personnel exposed to increased noise levels during operation of the mine site, processing plant and associated infrastructure.	Noise and vibration	Human health and safety	Operation	Consequences of cumulative noise exposure will be an increased risk of industrial noise induced hearing loss (NIHL).	Develop and implement operational work safety procedures in the workplace that comply if WHS regulations on noise, including the following: - Equipment design specifications include noise limits and associated acoustic attenuation requirements etc. - Sealed mobile equipment cabs with noise suppression - Preventative maintenance program for cabins (seals, pressure, noise level test) - Hearing protection - Hearing protection training - Signage to indicate areas where hearing protection is required - Mobile and fixed plant inspection and maintenance program - Job rotation - Noise monitoring program - Worker audiometry testing - Site induction coverage		**Major**	**Unlikely**	**Medium**	Low Level		**Major**	**Unlikely**	**Medium**
47	Construction and mining operations resulting in ground-borne vibration at elevated levels	Noise and vibration	Vibration	All	Excessive vibration levels at nearby sensitive receptors, including nearby communities, homelands and outstations resulting in reduced amenity.	Develop and implement construction work and operational procedures including the following: - Where applicable and possible, vibration intensive activities during the least sensitive time periods - Where applicable and possible, operations sequenced so that vibration intensive activities do not occur simultaneously		**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**

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48	Increased dust deposition on vegetation due to de-stabilised soils from vegetation clearing	Air	Air quality	Construction & Operation	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Air Quality Management Plan includes stabilising soils and cross referenced in ESCP and rehabilitation plan	A study by Matsuki et al. (2016) reached a similar conclusion to other similar studies – that it is likely that short-term dust generation in arid and semi-arid environments does not result in negative impacts on vegetation.	**Insignificant**	**Unlikely**	**Low**	High Level		**Insignificant**	**Unlikely**	**Low**
49	Increased dust deposition on vegetation due to increased vehicle use	Air	Air quality	All	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Air Quality Management Plan includes the use of dust suppression activities consistent with standard mining activity mitigative controls	A study by Matsuki et al. (2016) reached a similar conclusion to other similar studies – that it is likely that short-term dust generation in arid and semi-arid environments does not result in negative impacts on vegetation.	**Insignificant**	**Unlikely**	**Low**	Low Level		**Insignificant**	**Unlikely**	**Low**
50	Increased traffic on unsealed roads causes dust and reduced amenity for pastoralists and communities.	Air	Air quality	All	Dispersion of particulate matter in the air (TSP and PM10), resulting in reduced air quality at sensitive receptors with impacts to human health. Impacts from dust fallout and deposition, including to flora, and amenity at sensitive receptors.	- Air Quality Management Plan includes the use of dust suppression activities consistent with standard mining activity mitigative controls - Traffic Management Plan to include speed limits, road watering. Mainly an issue during construction as potentially longer-term will be a slurry pipeline. - Use water cart as appropriate. - Additional studies, including dust contours for impacts on residences and communities (sensitive receivers) to clarify impacted areas for mine site construction haul roads and export haul roads.	Mainly a construction impact. No communities in the immediate vicinity of the mine site or haul roads. Murray Downs Station is the closest residence. Some haul roads may need to upgraded for use (Murray Down Road and Sandover Road), but route still to be defined and these roads may not be used. Export transport road not expected to be impacted. The mine access road does not have any communities in the vicinity. Potential opportunity to improve community infrastructure (roads) due to increased economic benefits.	**Moderate**	**Rare**	**Low**	High Level	Potentially seal or resurface with low silt content crushed rock on high impact haul roads in close proximity to residences.	**Moderate**	**Rare**	**Low**
51	Site establishment (including vegetation clearing) results in physical disturbance of sites / objects of heritage significance, heritage items or places and/or sacred sites during construction of the Project	Historic and cultural heritage	Historic and cultural heritage	Construction	Damage, destruction or removal of heritage items or sacred sites. Non compliance of legislative requirements.	Development and implement a Cultural Heritage Management Plan, including: - Buffer distances and / or fencing surrounding identified archaeological sites and/or sacred sites - Appropriate signage - Pre-clearing / disturbance visual investigations - Procedures to avoid significant sites or areas - Procedures to protect key sites - Procedure to manage discovery of unexpected surface or sub-surface items - Research plan for an appropriate recording and salvage program if requested - Consultation and engagement with Traditional Owners and custodians AAPA Clearance certificate and CLC clearance certificates; Approval to Carry Out Work on Heritage Place or Object will be sourced from NT Heritage Branch prior to construction. Archaeological survey	There are two major sacred sites in the mineral lease. One near the actual mine site location. There are scattered sites around the transport corridor. The exploration drill holes / lines have been cleared by traditional owners. There are no soaks near the project footprint.	**Major**	**Unlikely**	**Medium**	High Level		**Major**	**Unlikely**	**Medium**
52	Mobilisation of workforce and start of construction leads to destruction of sacred or special site of cultural or spiritual importance	Socio-economic	Historic and cultural heritage	Construction	Angst and anger towards the project and reduced cultural connections to country.	- Culture and heritage management plan. - Code of behaviour. - Cross-cultural training as part of induction. - Sites clearly marked and traditional owners to work with company for all new works.	Some aspects of the project e.g. proposed pipeline route can change to accommodate sacred sites.	**Major**	**Unlikely**	**Medium**	Medium Level		**Major**	**Unlikely**	**Medium**
53	Unexpected find of sacred, heritage, cultural or indigenous cultural significance during construction or site rehabilitation	Historic and cultural heritage	Historic and cultural heritage	Construction	Damage, destruction or removal of heritage items or sacred sites. Non compliance with legislative requirements.	- AAPA clearance certificate and CLC clearance certificate will be sourced prior to construction. - Archaeological survey Development and implement a Cultural Heritage Management Plan, including: - Procedures to avoid significant sites or areas - Procedures to protect key sites - Procedure to manage discovery of unexpected surface or sub-surface items - Research design for an appropriate recording and salvage program if requested - Consultation and engagement with Indigenous stakeholders and Traditional Owners		**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**
54	Altered landscape from clearing and mining reduces access to cultural or recreational areas and changes sense of place.	Socio-economic	Visual and landscape	All	Reduced sense of place and quality of life. Negative feelings towards the project. Reduced cultural connection to dreamings and special sites.	- Environmental and cultural and heritage management plans	Low level of landscape disruption and can be altered according to community feedback. However, any change is permanent.	**Minor**	**Unlikely**	**Low**	High Level		**Minor**	**Unlikely**	**Low**
55	Light pollution from mine site impacts local community	Socio-economic	Visual and landscape	All	Excessive light levels at nearby sensitive receptors, including nearby communities, homelands and outstations, resulting in amenity disturbance, annoyance, sleep disturbance, etc.			**Minor**	**Unlikely**	**Low**	Low Level		**Minor**	**Unlikely**	**Low**
56	Increased mosquito breading from new standing water locations	Human health and safety	Human health and safety	All	Consequence will vary from increased nuisance to increased mosquito-born disease transmission The maximum reasonable consequence is illness	- PPE - long sleave - Tailings dam is not standing (recycled process water) - DH fact sheet compliance		**Moderate**	**Rare**	**Low**	Low Level		**Moderate**	**Rare**	**Low**

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57	Mobile equipment incident on site including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on severity of impact between minor injury to fatality. Maximum reasonable consequence could be a single fatality event when multiple vehicles are involved or multiple personnel in the vehicle(s).	- Vehicle design specifications and associated procurement management; - Vehicle maintenance program including pre-start inspections and routine maintenance; - In vehicle monitoring systems; - Proximity detection and alarms; - Segregation between vehicles and vehicles / pedestrians e.g. one way roads, dedicated walkways; - Site speed restrictions; - Mine designed to segregate traffic from different sections of the mine; - Dedicated laydown / hardstand areas; - Traffic management plan; - Access restrictions to operational areas e.g. through the use of barricades; - High vis PPE; - Road design to relevant standards; - Road maintenance program, including dust suppression; - Authorisation process for vehicles to enter site; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Unlikely**	**Medium**	Medium Level		**Major**	**Unlikely**	**Medium**
58	Personnel falling from height or into depth on site including mining, processing, maintenance and administration areas.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the height and location of the fall between minor injury to fatality. Maximum reasonable consequence would be a single fatality (multiple fatalities may occur e.g. failure of scaffold with multiple personnel on it, however the more reasonable outcome is assumed to be a single fatality).	- Equipment design specifications and associated procurement management; - Equipment maintenance program including pre-start inspections and routine maintenance; - Fixed plant design to relevant standards; - Fixed plant inspection and maintenance program including structural integrity inspections; - Engineered platforms for specific tasks; - Change management; - Work at heights procedure; - Work at heights training and competency assessment (including ongoing refresher); - Work at heights PPE (fall arrest / fall restraint) including rated anchor points; - Work at heights PPE inspection regime; - Scaffolding training and competency assessment; - Scaffold inspection and management program; - Fitness for work management system including hours of work, drug & alcohol policy etc.); - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
59	Personnel exposed to a confined space incident e.g. engulfment, irrespirable or noxious atmosphere.	Human health and safety	Human health and safety	Operation	Personnel exposed to a confined space incident e.g. engulfment, irrespirable or noxious atmosphere. Exposure in the confined space may occur as a result of the pre-existing environment or due to changes that occur while personnel are present.	- Confined space entry procedure and permit; - Confined space entry training and competency assessment including ongoing refresher; - Isolation procedure and associated training; - Restricted access to confined spaces (including signage); - Confined space register; - Pre-entry inspection; - Gas monitor for use during entry; - Adequate ventilation; - Spotter present; - Fitness for work management system including hours of work, drug & alcohol policy etc.); - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
60	Personnel struck by ground failure or rock fall event in mining operational areas. Includes material falling from high and low walls, dumps and ramps.	Human health and safety	Human health and safety	Operation	Consequences will vary depending on the size of material falling and how personnel are impacted (e.g. on foot or in vehicle) and will range between injury to fatality. Maximum reasonable consequence would be a single fatality event as it is unlikely that more than one person will be impacted by a failure.	- Mine design (including review and sign-off processes); - Mine modelling & mapping (hydrogeological, geological, exploration data etc.); - Mine geological and geotechnical monitoring e.g. GPS tracking of faults, daily inspections, ground monitoring systems (prism, extensometers, radar, piezometer, survey); - Geotechnical hazard maps; - Trigger action response plans; - Mine drainage design and systems; - Water management plan; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - FOPS on mobile equipment; - Access restrictions to slopes & crests; - Hazard reporting; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	Medium Level		**Major**	**Rare**	**Medium**

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61	Personnel in contact with an electrical source (low or high voltage) resulting in electrocution or arc flash burns. This includes all electrical sources on site where exposure may occur during construction or operations.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the type of contact and energy level associated with the equipment. This would include a range of minor injuries e.g. electric shock, through to electrocution or fatality from arc flash events. The maximum reasonable consequence would be a single fatality.	- Electrical asset design specifications and associated procurement management (including extra low voltage used where possible, remote switching, arc flash containment); - Electrical equipment maintenance program including pre-start inspections and routine maintenance; - Electrical protection systems (earth leakage, earth continuity, RCD etc.); - Change management; - Electrical workers training and competency assessment (including ongoing refresher); - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - Penetration / dig permit; - Signage and demarcation of electrical cables; - Procedure for working in proximity to power lines; - Isolation procedure and associated training; - Arc flash PPE; - Switching sheets; - Access restrictions to electrical infrastructure (e.g. substations); - Operations supervision; - Emergency response procedures, team and equipment.		Major	Unlikely	Medium	High Level		Major	Unlikely	Medium
62	Personnel struck by a dropped or swinging load during lifting by a lifting device or tipping a lifting device.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the size of the load and how personnel are impacted and will range from an injury e.g. crushed hand or foot to a fatality. The maximum reasonable consequence would be a single fatality.	- Lifting device design specifications and associated procurement management; - Lifting device maintenance program including pre-start inspections, routine and statutory maintenance; - Lifting gear (slings / ropes etc.) design specifications; - Lifting gear maintenance program including pre-start and routine inspections; - Change management; - Lifting activity (e.g. dogman, rigger, crane operator) training and competency assessment (including ongoing refresher); - Equipment and task specific procedures / work instructions; - Lift and critical lift plans; - Spotter for lifting activities; - Fit for purpose load restraint devices; - Access restrictions to lifting activities (signs and barricades); - Operations supervision; - Emergency response procedures, team and equipment.		Major	rare	Medium	Medium Level		Major	rare	Medium
63	Personnel impacted by a tyre or rim incident associated with mobile equipment.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the type of exposure and proximity to the event. Personnel may experience projectile / pressure impacts due to tyre pressure release, burns or pressure impacts from tyre fires and crush injuries due to dropped tyres. Consequences may range from minor injury through to fatality. The maximum reasonable consequence is a single fatality.	- Tyre and rim design specifications and associated procurement management; - Tyre & rim inspection and maintenance regime including pre-start inspections and routine maintenance / change out; - No hot work on rim when tyre is fitted; - Signage & demarcation of electrical cables; - Procedure for working near overhead power lines; - Tyre management standard; - Wheel change procedure; - Tyre fire procedure; - Tyre and rim safety procedure; - Fire extinguishers & suppression on mobile equipment; - TKPH monitoring of tyres; - In vehicle monitoring systems; - Fit for purpose tyre handling equipment and dedicated tyre handling facility; - Mobile equipment operating procedures and operator competency; - Competency of tyre maintainer; - Tyre cage; - Operations supervision; - Emergency response procedures, team and equipment.		Major	Unlikely	Medium	High Level		Major	Unlikely	Medium
64	Personnel exposed to a flood event into the pit or personnel exposed to flooding within the mine lease e.g. low lying vehicle crossings	Human health and safety	Human health and safety	Operation	Consequences will vary depending on the extent of material released and the material being released. Ground water and flooding events may result in injury e.g. due to slips, trips & falls through to fatality e.g. due to being trapped in a submersed vehicle / drowning. Dam failures may result in injury e.g. due to exposure to tailings products through to fatality from engulfment. The maximum reasonable consequence is a major injury on the basis of the proximity of personnel to dams and anticipated volumes of material released.	- Drainage and pump system design; - Drainage and pump system inspection and maintenance regime; - Water management plan; - Trigger action response plans; - Weather monitoring; - Adverse weather procedure; - Mine design (including review and sign-off processes); - Mine modelling & mapping (hydrogeological, geological, exploration data etc.); - Tailings & residue storage facility level management plan; - Tailings & residue storage facility design including HDPE liner, basin drainage & leakage collection system; - Tailings & residue storage facility inspections including monitoring bores, embankment piezometers, embankment survey pins; - Operations supervision; - Emergency response procedures, team and equipment.	Due to area, flooding will be from a known system and the mine can prepare for its arrival through change in operations.	Moderate	Rare	Low	Low Level		Moderate	Rare	Low

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65	Personnel struck by falling or dropped objects including structural failure.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the size of the item that falls and the height from which it falls, ranging from an injury to a fatality. The maximum reasonable consequence would be a single fatality.	- Structural and equipment design specifications; - Structural and equipment inspection and maintenance regime including corrosion control; - Housekeeping including regular wash down: - Process plant design e.g. weightometers, limit switches & interlocks, vibration monitoring, level sensors; -Catch trays / mesh above walkways; - Plant operational process control; - Adverse weather procedure; - Change management; - Restricted access / barriers in locations with risk of falling objects; - Hazard identification; - Tool belts & bags; - Tool restraint devices (lanyards, mats etc.); - Kickboards and mesh between handrails on elevated walkways; - Task specific procedures; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
66	Personnel caught in rotating or moving equipment.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the equipment personnel are drawn into and how they are drawn in, potentially resulting in entanglement and entrapment. This may lead to crush injuries e.g. fingers, amputation of limbs or fatality. The maximum reasonable consequence would be a single fatality.	- Equipment design specifications and associated procurement management includes guarding & interlock requirements; - Equipment maintenance program including pre-start inspections and routine maintenance; - Fixed plant design to relevant standards; - Change management; - Guarding audits; - Isolation procedure and associated training; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - Area layout and design to provide sufficient space; - Operations supervision; - Emergency stops / pull wires; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
67	Personnel impacted by a high pressure release (stored energy).	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the pressure at time of release, proximity of personnel to the release and the material released. This may lead to fluid injection injuries if personnel are in close proximity or they may be struck by flying debris resulting in either an injury or fatality if the object is large enough or where it strikes the person. The maximum reasonable consequence would be a single fatality.	- Equipment design specifications and associated procurement management - includes pressure rating, pressure relief, exclusion zones etc., based on relevant design standards; - Equipment maintenance program including pre-start inspections, routine maintenance and statutory pressure vessel inspections; - Change management; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - Isolation procedure and associated training; - Hot work procedure and permit; - Fire detection and suppression systems, fire extinguishers and fire fighting training; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
68	Personnel exposed to liquid while working in or around liquid bodies.	Human health and safety	Human health and safety	All	Consequences may include minor injuries e.g. due to trips and falls through to fatality (drowning). The maximum reasonable consequence would be a single fatality.	- Adverse weather procedure; - Tailings & residue storage facility level management plan; - Tailings & residue storage facility design including liner, basin drainage & leakage collection system; - Tailings & residue storage facility inspections including monitoring bores, embankment piezometers, embankment survey pins; - Working in and around liquid bodies procedure; - Portable edge protection; - Restricted access to tailings & residue storage facility; - Sump / pit design including demarcation and barricading; - Sump / pit inspection and maintenance program; - Personal flotation device; - Life rings installed around liquid bodies; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**			**Major**	**Rare**	**Medium**
69	Personnel exposed to hazardous materials, including rock concentrate dust via all means e.g. ingestion, inhalation or skin contact.	Human health and safety	Human health and safety	Operation	Consequences will vary depending on the material personnel are exposed to, the means of exposure and the duration of exposure e.g. soda ash The maximum reasonable consequence would be a major injury	- Storage, handling and spill management requirements as specified in the Safety Data Sheets, ChemAlert database and legislative requirements for the transport and storage of dangerous goods; - Hazardous substance storage and handling system design specifications; - Inspection and maintenance of hazardous substance storage systems; - Spill kits; - Procedure for transport and storage of hazardous substances; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - Isolation procedure and associated training; - Plant process control; - PPE (eye protection, breathing apparatus, gloves etc.); - Signage / labelling of equipment containing hazardous substances;		**Moderate**	**Rare**	**Low**			**Moderate**	**Rare**	**Low**

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70	Engulfment of personnel in materials while working on site on stockpiles, ROM or around bins, hoppers, chutes etc. Personnel may be engulfed while on foot or in mobile equipment.	Human health and safety	Human health and safety	Operation	Consequences will vary depending on the volume of material in which personnel are engulfed and the ability to self rescue. The maximum reasonable consequence would be a single fatality	- Materials storage systems design specifications; - Materials storage systems inspection and maintenance regime; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - Isolation procedure and associated training; - Plant process control; - Confined space entry procedure; - Stockpile & ROM management procedures and associated competency; - Dust suppression; - Stockpile design including angle of repose, drainage etc.; - Restricted access to stockpiles; - Area lighting; - Dozers including oxygen self rescuers & GPS; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	Medium Level		**Major**	**Rare**	**Medium**
71	Failure of backfilled pit area / poor slope stability following major rain event	Human health and safety	Human health and safety	Operation	Consequences will vary depending on the instability and how personnel are impacted (e.g. on foot or in vehicle) and will range between injury to fatality. Maximum reasonable consequence would be a single fatality event as it is unlikely that more than one person will be impacted by a failure.	- Mine design (including review and sign-off processes); - Mine modelling & mapping (hydrogeological, geological, exploration data etc.); - Mine geological and geotechnical monitoring e.g. GPS tracking of faults, daily inspections, ground monitoring systems (prism, extensometers, radar, piezometer, survey); - Geotechnical hazard maps; - Trigger action response plans; - Mine drainage design and systems; - Water management plan; - Access restrictions to slopes & crests; - Hazard reporting; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	Low Level		**Major**	**Rare**	**Medium**
72	Personnel exposed to hazardous flora or fauna including snakes, spiders, mosquitoes, biting insects, bees, wasps, larger animals such as dingoes / wild dogs / cats etc.	Human health and safety	Human health and safety	All	Consequences will vary depending on the flora or fauna to which personnel come into contact and whether or not they have an allergic reaction to bites / stings. The maximum reasonable consequence would be a single fatality.	- PPE - Safety boots, long pants etc.; - Vegetation management program; - Snake bites kits and associated first aid training; - Pest control program (insects, spiders etc.); - Lone and isolated workers procedure; - Communication protocols; - Operations supervision; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
73	Unauthorised site access / security breach during construction and operation.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the location of unauthorised access and the reason for access (e.g. if they are deliberately causing harm). Personnel may be exposed to many of the site hazards including mobile equipment movements, residue storage facilities, hazardous chemical etc. The maximum reasonable consequence would be a single fatality.	- Site security and access restrictions including signage and fencing; - Security management plan; - CCTV monitoring; - Additional access restrictions to high risk areas e.g. substations, explosives magazine; - Procedure for escorting visitors; - Contactor management system; - Media communication protocols / plan; - Employee assistance program; - Community engagement program; - Operator observations and reporting; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	Medium Level		**Major**	**Rare**	**Medium**
74	Personnel exposure to whole body vibration during operation of mobile equipment in mining operations.	Human health and safety	Human health and safety	Construction & Operation	Consequences of whole body vibration will ultimately be muscular skeletal disorders.	- Vehicle design specifications and associated procurement management includes vibration criteria; - Vehicle maintenance program including pre-start inspections and routine maintenance; - In vehicle monitoring systems; - Traffic management plan; - Road design to relevant standards; - Road maintenance program, including dust suppression; - Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management etc.); - Job rotation; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher);		**Moderate**	**Unlikely**	**Medium**	High Level		**Moderate**	**Unlikely**	**Medium**
75	Personnel exposed to increased risks due to the remote location of the site and / or undertaking lone and isolated work.	Human health and safety	Human health and safety	Construction & Operation	Although the initial injury may not be immediately life threatening, there is potential for the situation to escalate due to the distance and time it takes for medical aid. The maximum reasonable consequence would be a single fatality.	- Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management etc.); - Weather monitoring; - Adverse weather procedure; - Trigger action response plans; - Lone and isolated workers procedure; - Communication protocols; - Communication equipment suitable for the area and activity; - Emergency response procedures, team and equipment.		**Major**	**Rare**	**Medium**	High Level		**Major**	**Rare**	**Medium**
76	Heat related illness due to desert climate	Human health and safety	Human health and safety	All	Consequence will vary depending on the extent of heat related illness The maximum reasonable consequence is a injury	- Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management etc.); - Pre-employment health check; - Potable water readily available; - Heat stroke procedure; - Weather monitoring; - Adverse weather procedure; - Emergency response procedures, team and equipment.		**Moderate**	**Possible**	**Medium**	High Level		**Moderate**	**Possible**	**Medium**

			Impact pathway					Initial Risk					Residual Risk		
Ref.	**Potential event** (how the Project interacts with assets, values, uses and location. Include clear description of the cause)	**Specialist Area**	**Environmental Factor / Receptor**	**Phase** (construction, operation or closure)	**Description of consequences** (Clearly understand what is the final impact)	**Planned Controls to Manage Risk** (as per Project Description, and elements of Standards / Codes of Practice	**Comment**	**Consequence**	**Likelihood**	**Risk Rating**	**Level of Certainty**	**Additional Controls Recommended to Reduce Risk**	**Consequence**	**Likelihood**	**Risk Rating**
77	Manual handing injuries during manual work conducted on site across the operations.	Human health and safety	Human health and safety	All	Manual handling injuries may include back injuries such as injuries to nerves, bones, joints and soft tissue hernias, ruptured discs and torn back muscles. Other consequences may include sprains of ligaments, strains of muscles or tendons, tendonitis, spondylolisthesis, carpel tunnel syndrome and Repetitive Strain Injury (RSI). The maximum reasonable consequence would be musculoskeletal effects to bones and soft tissue structures.	- Manual handling training; - Plant and equipment design specifications include manual handling / ergonomic requirements; - Fit for purpose lifting aids; - Change management; - Equipment and task specific procedures / work instructions; - Equipment and task specific training and competency assessment (including ongoing refresher); - Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management etc.); - Job rotation; - Area layout and design to provide sufficient space; - Operations supervision.		Moderate	Possible	Medium	High Level		Moderate	Possible	Medium
78	Personnel impacted by fire or explosion. This includes equipment and substance fire and explosions. This may occur during construction or operations. Mining operations fires would typically involve mobile equipment fires. Processing plant fires would typically involve fixed plant fires. This also includes the gas fired power generation plant and high pressure gas pipeline.	Human health and safety	Human health and safety	Construction & Operation	Consequences will vary depending on the size and type of fire and extent of exposure. Personnel may be impacted by smoke, heat radiation from the fire or explosion overpressure. Consequences may range from smoke inhalation, minor burns through to fatality. The maximum reasonable consequence is a multiple fatality event as there is potential for multiple personnel to be impacted in a large fire or explosion event.	- Fixed plant & mobile equipment design specifications and associated procurement management; - Fixed plant & mobile equipment maintenance program including pre-start inspections and routine maintenance; - Electrical protection systems; - Thermographic monitoring; - Change management; - Lightning arrestors; - Fire resistant & anti static equipment e.g. conveyor belts; - Dust suppression; - Housekeeping; - Hazardous substance storage and handling system design specifications e.g. pressure rating, pressure relief, exclusion zones, hazardous area rating including dedicated dangerous goods storage; - Inspection and maintenance of hazardous substance storage systems; - Operational procedures including transport and storage of hazardous substances, isolation, excavation / dig permit; hot work procedure and permit; - Gas pipeline design and SMS (AS 2884); - Signage and demarcation of gas pipeline; - Competent maintainers; - Fire breaks; - Fire detection and suppression systems, fire extinguishers and fire fighting training; - Fire management plan; - Emergency response procedures, team and equipment.		Catastrophic	Rare	Medium			Catastrophic	Rare	Medium
79	Bushfire from natural or human causes	Human health and safety	Human health and safety	All	Consequences will vary depending on the size of fire and extent of exposure. Consequences may range from smoke inhalation, minor burns through to fatality. The maximum reasonable consequence is a single fatality event as there is limited fuel to allow for an unexpected fire of substantial size	- Lightning arrestors; - Fire resistant & anti static equipment e.g. conveyor belts; - Housekeeping; - Fire breaks; - Fire detection and suppression systems, fire extinguishers and fire fighting training; - Fire management plan; - Emergency response procedures, team and equipment.		Major	Rare	Medium	Low Level		Major	Rare	Medium
80	Higher fuel loads (and therefore more intense bushfires) due to the proliferation of weeds caused by soil disturbance and movement of vehicles/machinary	Biodiversity	Ecosystem	All	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Weed Management Plan outlines strategies to limit the introduction of new weeds within the project area and limit the spread of existing weeds during project activities		Minor	Unlikely	Low	High Level		Minor	Unlikely	Low
81	Increased frequency of bushfires caused by machinery or personnel	Biodiversity	Ecosystem	All	Large scale reduction in ecosystem integrity.	Bushfire Management Plan will include: - All construction activities, including establishment and operation of temporary camps, will occur within a cleared project footprint to minimise the risk of ignition sources coming into contact with flammable material (such as cleared vegetation). - Fire ratings and warnings in the area will be monitored and the proponent will liaise with Bushfires NT as required.		Major	Unlikely	Medium	High Level		Major	Unlikely	Medium
82	Rail incident during transport of final product	Transport	Human health and safety	Operation	Railway crossing a road results in at least one fatality, potentially multiple	- Emergency response plan.		Catastrophic	Unlikely	High	Medium Level		Catastrophic	Unlikely	High
83	Loss of ecosystem from vehicle interactions / road strikes	Transport	Fauna	All	A decrease in the abundance of flora and fauna ecosystem.	- Traffic Management Plan	Development of standard operating procedures for management of fauna road-strikes to fully address animal-welfare and safety objectives, including: A) Risk of leaving large animal carcasses on the road, which presents risks of causing further accidents for other road users, particularly at night, on un- lit highways, B) Risk of attracting scavenger fauna, such as eagles, and kites onto the highways risking further fauna strikes, and further accidents for other road users, C) Avoiding preventable fauna deaths by providing effective procedures for rescue of injured wildlife, and /or recovery and care of orphaned wildlife that may still be present in the pouch of a freshly killed or injured parent. (example of activities from Wonarah project).	Insignificant	Unlikely	Low	High Level	Potential to fence haulage road if necessary, night driving could be limited	Insignificant	Rare	Low

Ref.		Impact pathway						Initial Risk					Residual Risk		
	Potential event (how the Project interacts with assets, values, uses and location. Include clear description of the cause)	**Specialist Area**	**Environmental Factor / Receptor**	**Phase** (construction, operation or closure)	**Description of consequences** (Clearly understand what is the final impact)	**Planned Controls to Manage Risk** (as per Project Description, and elements of Standards / Codes of Practice	**Comment**	**Consequence**	**Likelihood**	**Risk Rating**	**Level of Certainty**	**Additional Controls Recommended to Reduce Risk**	**Consequence**	**Likelihood**	**Risk Rating**
84	Increased industrial traffic on Stuart Highway, Sandover Highway and across Murray Downs creates road safety risks e.g. through incompatible mix of industrial and local traffic accessing Ali Curung, including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.	Transport	Human health and safety	All	Increased risk of road trauma, negativity towards the project. Delays to other road users. Worst case scenario is a vehicle accident with multiple fatalities (including pedestrians)	- Traffic Management Plan that separates construction from local traffic where possible, including a community education / awareness communication. - Install Trucks Entering signs at identified locations where concentrations of heavy vehicles are expected. - Codes of behaviour for project drivers. - Explore with locals whether certain times of day help.	A heightened risk around Ali Curung where community members may be on the road as pedestrians or local traffic. Issues with drink-driving, unregistered vehicles already. Construction has increased truck movements which will impact locals more	Catastrophic	Unlikely	High	Medium Level	Potential to improve road condition as a result of the project Construct a new road from Stuart Highway to mine site that by-passes Ali Curung community Monitor crash rates. Install further mitigation measures if crash rates increase.	Catastrophic	Unlikely	High
85	Public road damage due to increased heavy vehicle use for project	Transport	Road	All	Acceleration of wear and tear on road pavement due to project vehicles causes routine maintenance to be brought forward (i.e. shortening of design life)	- Monitor road pavement condition throughout life of project and repair as needed (to condition as agreed with road authority)	Roads will be returned to agreed conditions, so no long term impact expected	Minor	Likely	Medium	Medium Level		Minor	Likely	Medium
86	Additional traffic generated by the project leads to a reduction in operating performance on the road network	Transport	Road	All	Economic and safety reduction as a result of congestion	- Upgrade intersections as needed to maintain existing operating performance	Further investigations will be required	Insignificant	Possible	Low	Low Level		Insignificant	Possible	Low
87	Increased traffic from workers driving to work or driving to and from home at the end of rosters increases road safety risk, particularly if workers drive home fatigued at the end of shift.	Transport	Human health and safety	All	Increased road safety injury from worker traffic.	- All workers to be bussed to accommodation camp and possibly to work between shifts to minimise additional vehicles on roads and road safety risks.	Most workers are likely to come from nearby communities or FIFO	Moderate	Rare	Low	High Level		Moderate	Rare	Low
88	Project activity puts pressure on existing infrastructure, such as roads, which pastoral properties and Barkly Council can't afford to address.	Socio-economic	Community	All	Impacts on quality of local roads. Financial pressure on council and pastoralists to maintain. Expectations on the project for user-pays contributions.	- Consultation with service providers and contribution towards road maintenance.	Poor state of local roads, apart from the Stuart Highway. However impacts short-term during construction.	Minor	Possible	Medium	Medium Level		Minor	Possible	Medium
89	Aircraft incident with FIFO from areas beyond road travelling distances e.g. Mount Isa)	Human health and safety	Aviation	All	Multiple fatalities			Catastrophic	Rare	Medium	Low Level		Catastrophic	Rare	Medium
90	Discharge or seepage of poor quality water from mine infrastructure	Water	Flora	Operation	A decrease in the abundance of flora and fauna ecosystem.	- In mine design to manage discharge and seepage	Given the low sulfur content, generally low metal toxicant content and low metal and salt leachability of waste rock and tailings, the primary (pre-management) risk level is currently low.	Minor	Unlikely	Low	Medium Level		Minor	Unlikely	Low
91	Harmful elements present within the Tailings Storage Facility	Contamination / Environment	Flora	Operation	A decrease in the abundance of flora and fauna ecosystem.	- The TFF will only be used for 2-3 years. The in-pit TSF is unlikely to be attractive to most fauna; and the geochemical analysis found that the material can be managed as non-acid forming, non-saline, non-metalliferous waste	If the water quality of the tailings storage facilities (TSF) contains harmful elements, there is the potential for some fauna species to be negatively impacted when coming into contact with that water.	Insignificant	Unlikely	Low	Low Level		Insignificant	Unlikely	Low
92	Discharge of sediment-laden water from sediment dams or catch drains.	Water	Surface water	Operation	Potential impacts to downstream water quality could occur as a result of discharges of sediment laden water from sediment dams or catch drains.		Discharges will occur following rainfall that exceeds the design rainfall depth. During these events, the wider area is expected to be flooded with sediment-laden runoff. Consequently, the discharges from mine infrastructure will mix with flood waters of similar quality, resulting in an unappreciable change to water quality.	Moderate	Rare	Low	Medium Level		Minor	Unlikely	Low
93	Discharge of process water	Water	Surface water	Operation	Process water will typically include elevated levels of phosphate, dissolved metals, elevated salinity, high or low pH, and suspended solids. The accidental, uncontrolled discharge of this water has the greatest potential to impact downstream water quality.	- Water management system includes a freeboard storage capacity equivalent to the 100 year ARI - During extreme fainfall events, excess process water will be directed towards the open cut mine put.		Minor	Unlikely	Low	Low Level		Minor	Unlikely	Low
94	Spill of hazardous material or chemical from mine operations or during transport.	Contamination / Environment	Surface water	All	A spill or other release of hazardous material or chemicals could contaminate the surrounding environment. In the case of the phosphate concentrate, this is only an issue when over surface water.	Activities that may result in contamination are regulated to the extent that the potential for accidental release is low. - Spill management plan. - Immediate reporting of spillages. - Spill kits to be carried by fuel tankers to assist in immediate containment of small spills.	There is no surface / standing water present in the area that is natural (there is one man-made dam in the vicinity). Issue will be water flow from a rain fall events.	Minor	Unlikely	Low	Low Level		Minor	Unlikely	Low
95	Dust generating sources in the mining and processing areas.	Air	Air quality	All	Dispersion of particulate matter in the air (TSP and PM10), resulting in reduced air quality at sensitive receptors with impacts to human health. Emission of fine particles and pollutants from the processing site, including PM2.5, SOx, NOx, CO. Dispersion resulting in reduced air quality at nearby sensitive receptors (< 5 km) with impacts to human health. Impacts from dust fallout and deposition, including to flora, and amenity at sensitive receptors.	A Dust Management Plan (DMP) will be developed in order to avoid, minimise and control impacts on air quality. The DMP will incorporate a number of controls including but not limited to: — Water trucks will water the primary emission sources (incl.haul road) at a rate greater than 2 litre/m2/hr. — All material processing equipment (excluding the rotary driers) will have water sprays. — A bag house will be installed on the rotary driers to reduce emissions and recover product. — Disturbed open areas will be progressively rehabilitated.	It is recommended that monitoring should be conducted at the mine camp receptor so that an evaluation of the local air quality (including the contribution from the mine) against the assessment criteria can be undertaken. This type of monitoring is conducted to confirm the modelling predictions and would only be conducted for a limited period of time (eg., 12 – 24 months). This compliance monitoring requires the use of monitoring equipment PM10 that complies with the Australian Standards. Monitoring should be conducted on a daily basis (24-hour periods) or in real-time.	Minor	Unlikely	Low	Low Level		Minor	Unlikely	Low
96	Combustion generating sources in the mining and processing areas.	Air	Air quality	All	Emission of fine particles and pollutants from fuel combustion, including PM2.5, SOx, NOx, CO. Dispersion resulting in reduced air quality at nearby sensitive receptors (< 5 km) with impacts to human health.	-Preference for natural gas generators '-Low NOx emissions generators will be selected.	Gas pollutants were modelled and did not exceed the criteria without any mitigation or control measures.	Insignificant	Unlikely	Low	Low Level		Insignificant	Unlikely	Low
97	Contamination of aquifers from acid, metalliferous and saline drainage	Water	Groundwater	All	Reduction in groundwater quality to third party users	Develop and implement a AMD Management Plan, which will include an allowance for separate storage of all separable PAG material, belding of any minor PAF with non-acid-forming and acid consuming material.	Saline tailing seepage will not be generated due to the low salinity of pr	Minor	Unlikely	Low	Low Level		Minor	Unlikely	Low
98	Accidental spill of hazardous material and chemicals	Water	Groundwater	All	Reduction in groundwater quality to third party users	- Spill management procedures - Immediate reporting of spillages. - Spill kits to be carried by fuel tankers to assist in immediate containment of small spills.	An accidental spill resulting in the contamination of groundwater is rare	Minor	Rare	Low	Low Level		Minor	Rare	Low
99	Radiation exposure to personnel on site.	Human health and safety	Human health and safety	All	It is not anticipated that worker exposure will reach (or exceed) the national worker dose limit of 20 millisieverts per year. Maximum reasonable exposure level may be frequent (daily) exposure at negligible concentrations less than 1mSv per year. It is not anticipated that worker exposure will reach (or exceed) the national worker dose limit of 20 millisieverts per year.	- Dust management plan - 4 environmental monitoring sites with passive gamma, radon and thoron detectors	This is supported by the historical evidence from other Australian sites that record annual doses of approximately 5% to 10% of occupational exposure limits. In accordance with the criteria for a radioactive material outlined by the IAEA (IAEA 2004), the Ammaroo ore is not considered to be radioactive. . The combined uranium and thorium concentrations are less than 1Bq/g, averaging approximately 0.3Bq/g. At these low concentrations, it is expected there would be negligible impact on human health.	Insignificant	Possible	Low	High Level		Insignificant	Possible	Low
100	Loss of vegetation due to land clearing	Biodiversity	Flora	Construction & Operation	Loss of habitat leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Ongoing rehabilitation of cleared land during the mining process	The vegetation communities within the project footprint are regionally common and widespread. The existing land is cattle country. The cleared land is expected to be 25 km2 in total over the 25 years - but with progressive rehabilitation from year 1	Moderate	Almost Certain	High	High Level		Moderate	Almost Certain	High

	Impact pathway							Initial Risk					Residual Risk		
Ref.	**Potential event** (how the Project interacts with assets, values, uses and location. Include clear description of the cause)	**Specialist Area**	**Environmental Factor / Receptor**	**Phase** (construction, operation or closure)	**Description of consequences** (Clearly understand what is the final impact)	**Planned Controls to Manage Risk** (as per Project Description, and elements of Standards / Codes of Practice	**Comment**	**Consequence**	**Likelihood**	**Risk Rating**	**Level of Certainty**	**Additional Controls Recommended to Reduce Risk**	**Consequence**	**Likelihood**	**Risk Rating**
101	Increased distribution of feral fauna species as a results of the creation of tracks (i.e. linear infrastructure)	Biodiversity	Fauna	Construction	A reduction in habitat quality and/or direct mortality of fauna leading to a decrease in the diversity and/or abundance of flora and fauna species.	- Biodiversity Management Plan (including monitoring and control actions)		**Insignificant**	**Unlikely**	**Low**	High Level		**Insignificant**	**Unlikely**	**Low**

7. Surface water

7.1 Introduction

This chapter describes the existing surface water characteristics within the project site and surrounding study area. This chapter also describes the potential direct and indirect impacts of the project on surface water resources within and around the project site. Mitigation measures that will be implemented in order to minimise the impact of project construction and operation are documented.

Section 5.3.1 of the draft EIS TOR provided the following environmental objective in relation to surface water:

> *Water resources will be protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained. This chapter addresses the biodiversity values, as required in the TOR for the Project.*

Detailed surface water assessment is provided in Appendix G including a detailed explanation of the surface water flood modelling across the mine site and access corridor alignment.

7.2 Existing environment

7.2.1 Surface water drainage

The project is located within the Diamantina-Georgina Rivers Basin, which includes:

- Atcherie Creek, which passes about 26 km east of the project site and is a tributary of the Sandover River.
- George Creek, which passes about 34 km north east of the project site and is a tributary of the Elkedra River, which feeds Boundary Dam (located about 100 km north east of the project).
- Taylor Creek, which intersects the western end of the access corridor.
- Sandover River, which passes about 33 km south of the project site (a tributary of the Georgina River via Bybby Creek and the Sandover River Floodout).

Within the vicinity of the project, creek beds tend to be mobile with deep sand deposition about 50 m wide, with banks that show signs of active erosion. Some watercourses include low flow channels that are about one metre deep with a base width of about five metres. These low flow channels appear to be actively migrating across the mobile sand bed. During infrequent, intense rainfall events out-of-bank flow can be expected leading to temporary and short-term flooding of adjacent lands. Watercourses in the region can be dry for several years.

No watercourses (i.e. channels with creek banks and obvious flow paths) cross the access corridor. The access corridor, to the west of Stuart Highway, is located in headwaters of Taylor Creek and intercepts a drainage floor. Three tributaries associated with Taylor Creek are the closest watercourse and are 1.3 km to the south, down-gradient of the access corridor.

There is one weakly defined drainage line present within the north eastern part of the project site. This drainage experiences sporadic and very temporary stream-flow from the local rocky hills situated to the north eastern of the project site. Although aerial imagery suggests a distinct watercourse is present, field survey confirms it as a drainage floor due to absence of defined channel, and soil type and vegetation observed in other drainage floors in the area. Currently, this drainage floor is dammed for pastoral activities (i.e. Woody's Dam).

7.2.2 Flooding

A two dimensional hydrodynamic flood model was developed and covers the mine site and surrounding area. The model has been used to estimate the maximum flood depths, extents, and velocities of the area surrounding the mine site for the existing conditions. This has been completed for both the one per cent Annual Exceedance Probability (AEP) (approximately equivalent to the 100 year ARI) and 0.1 per cent AEP (approximately equivalent to 1000 year ARI) critical duration design storm event.

The modelling indicates that within the proposed mining area, flood depths are estimated to reach about 0.5 metres for the 1% AEP flood event, with similar flood depths for the 0.1% AEP flood event (refer Figure 3-6 and 3-7 in Appendix G: Surface Water Report).

7.2.3 Water quality

The ephemeral nature of watercourses within the region means that no water quality samples have been collected from the project site. The water quality data for the surrounding catchments, available from the NT Government's *Water Data Portal,* indicates that when available, water quality is generally good with neutral pH, and low salinity (as electro-conductivity: EC), total dissolved solids (TDS) and total suspended solids (TSS).

7.3 Existing water users

The sporadic nature of rainfall and surface runoff means the local environment and agricultural operations have little dependence on surface water resources.

7.3.1 Environment

Local flora are either capable of surviving extended periods of drought or may be able to access perched water tables. Depth to groundwater is assumed to be greater than the reach of root systems of flora typical to the region. The aquifer has been intersected at 65 m (though the groundwater was at 80 m).

Along watercourses, the channel alluvium provides access to shallow groundwater by trees such as River Red Gum (*Eucalyptus camaldulensis*).

There are some clay pans and small ephemeral swamps associated with local depressions along the access corridor that are filled following some rainfall events, to provide a source of water for environmental use until depleted by evaporation.

7.3.2 Agricultural

The proposed mine site and borefield is not within a Water Control District declared under the Water Act. Water use in areas not within a Water Control District is not regulated and information supporting agricultural users of surface water in the area is limited.

There is currently a shallow 70 m x 70 m surface water dam (Woody's dam) located on a local drainage line north-east (upstream) of the project site. It is understood that this dam is used for stock watering. The dam will be retained during and following mining operations.

The access corridor passes through the Western Davenport Water Control District. The Western Davenport Water Action Plan includes ten licensed groundwater users and no licensed surface water users.

7.4 Surface water management

7.4.1 Surface water

Infrastructure areas, including the processing plant, are located outside of the 1% AEP flood affected area, or placed on pad areas raised above the 1% AEP flood level. Flood berms will be installed as required to protect the open-cut mining area from inrush from flooding resulting from design storm events up to (an including) the 1% AEP critical duration design storm event. The finished level of the berms will be, at a minimum, equivalent to the maximum modelled 1% AEP flood level plus a freeboard of 0.5 m. These will be constructed along the western and eastern edges of the mining area.

The sediment management system will be constructed to manage runoff generated from within the project site. The dirty water management system will generally consist of:

- Catch drains to intercept runoff generated from disturbed catchment areas.
- Sediment dams where required, to temporarily store sediment-laden runoff if required.

Catch drains are typically designed to safely convey the peak runoff generated by the catchment during the 20 year ARI critical duration design storm event, after which they discharge into the environment.

Runoff from processing facilities will be conveyed to sumps or dams prior to being pumped to the process water dam for reuse.

7.4.2 Process water

Process water will be directed to the process water dam. These storages will be constructed as turkey's nest dams (i.e. have no external catchment). The process water system manages water that is used in (and recaptured from) the process water system, including tailings water. Some reverse osmosis (RO) waste water will also be disposed in the process water dams. This water will be recycled through the processing facility.

The process water storages will be managed to maintain a minimum freeboard equivalent to the total inflows expected during a 100 year ARI 72 hour design storm event. During extreme flood events, all reasonable efforts to avoid discharging of process water will be undertaken. This will include the transfer of process water into the open cut pits.

7.4.3 Tailings storage and disposal facilities

An above-ground tailings facility will be used for the initial period of operation (approximately three years). The surface TSF will be designed in accordance with ANCOLD guidelines with an emergency overflow spillway to prevent overtopping in 100 year ARI storm event.

In-pit disposal of tailings will commence once a sufficient void has been established. Water will be recovered from in-pit tailings. This water will be directed to the process water dam for use in processing. Dry tailings will be capped with a layer of waste rock to a height higher than the surrounding land.

7.5 Potential impacts

7.5.1 Existing conditions

Land use within the project area is predominantly pastoral. Long-term pastoral presence in the region has resulted in a relatively-degraded drainage lines and vegetation communities across the study area (due to cumulative pressures from weeds, trampling, fire and low flora diversity), which has led to high sedimentation loads and creek bank erosion.

Taylor Creek floodplain has a moderate to high pastoral impact, due to the presence of several water points, yards, station tracks and bores.

A weakly-defined drainage line present within the north eastern part of the project site has been dammed (Woody's Dam) to serve as a stock watering point. This drainage line experiences sporadic and very temporary stream-flow from the local rocky hills (i.e. small catchment).

7.5.2 Project impacts

This section identifies the potential direct and indirect impacts on surface water presented by the project.

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

A summary of the risk assessment results is provided in Table 7-1. Multiple hazards may exist as a result of a one potential event. Refer to full risk assessment in the Environmental Risk Register (Table 6-8) for further detail.

Table 7-1 Qualitative risk – surface water

Potential event	Residual risk level
Alteration of hydrological regimes – mine pit	Low
Alteration of hydrological regimes – linear infrastructure	Medium
Erosion, sedimentation of watercourses	Low
Discharge of sediment laden water from sediment dams	Low
Discharge of process water	Low
Failure of the TSF	Low
Accidental spill of hazardous material and chemicals	Low

7.5.3 Impacts on hydrological regimes

Erosion and scouring of local watercourses may occur as a result of the concentration of flow paths by culverts along the access corridor or the narrowing of the flow path to the east of the open cut pit as a result of the flood protection berms. The localised increases in flow velocities have the potential to increase local areas of erosion and scouring.

Mine areas

It is expected that the flood protection berms will be implemented as required as the mine progresses.

The maximum modelled flood depths and extents for the 1% AEP (100 year ARI) critical duration design storm events for the proposed conditions are included in Figure 7-1. The modelling indicates that the proposed flood protection berms would be sufficient to protect the open cut pit from flood inrush during the 1% AEP event (Figure 7-1); however, flood depths and extents north of the project site are expected to increase. This area includes Woody's Dam.

Figure 7-2 shows that the proposed flood protection berms result in increased flooding east of the proposed open-cut pit, with local flood levels generally increased by about 300 millimetres (and up to about 1.5 metres within the vicinity of the proposed flood protection levee A. The modelling also indicates decreases in flood depths south of the open-cut pit of about 200 millimetres (up to about 400 millimetres immediately south of the open cut pit) (Figure 7-2). A summary of the change in maximum modelled flood levels at selected locations is summarised below in Table 7-2.

These results indicate that the proposed flood protection berms would push flood flows eastwards, with flows being concentrated within a slightly narrower floodplain. It should be noted that all modelled increases in flood depths are contained within the mineral lease area (Figure 4-4) and are therefore not expected to affect adjacent landholders. Refinement of the flood protection levees during detailed design may reduce the modelled increases in flood depths.

Table 7-2 Change in flood levels – 1% AEP flood event

Location	Existing Scenario Flood Level (mAHD)	Proposed scenario Flood level (mAHD)	Change in flood level (metres)
West of mine footprint area	402.79	402.79	-
North of mine footprint area	403.51	405.08	+ 1.57
North-East of mine footprint area	403.23	404.05	+ 0.82
South-East of mine footprint area	398.19	398.52	+ 0.23
South of mine footprint area	397.23	397.03	- 0.20
East of proposed processing plant and tailings storage facility	Nil	404.71	(newly flooded area)

The modelling indicates that the narrowing of the floodplain (as a result of the flood protection berms) has an impact on the maximum modelled flow velocities for the 1% AEP (100 year ARI) critical duration design storm event (Figure 7-3), with estimated increases in the maximum flood flow velocity or up to about 0.5 m/s east of the open-cut pit area. The modelling indicates that flood flow velocities generally remain below 1.5 m/s (Figure 7-3), and are therefore not expected to significantly affect watercourse stability during events up to the 1% AEP flood.

Residual impacts associated with an altered flood hydrology from flood berms protecting the mine pit results in a minor consequence.

Linear infrastructure

The access corridor contains both a gas pipeline and a low set rail spur. The gas pipeline will be buried and it would be rare that it would alter surface flows. The rail spur will include a constructed embankment (or formation) which is to be designed so that it is above the local flood level for events up to the 25 year ARI (about the 4% annual exceedance probability) flood event.

The construction of the rail spur will affect upstream and downstream flood depths and extents. The railway embankment may act as a type of levee bank across the floodplain, concentrating flows through the proposed culverts. Culverts will be sized, located and installed to manage surface flows, and may increase downstream flow velocities, thereby increasing localised erosion and scouring within the watercourses in the immediate vicinity of the culverts.

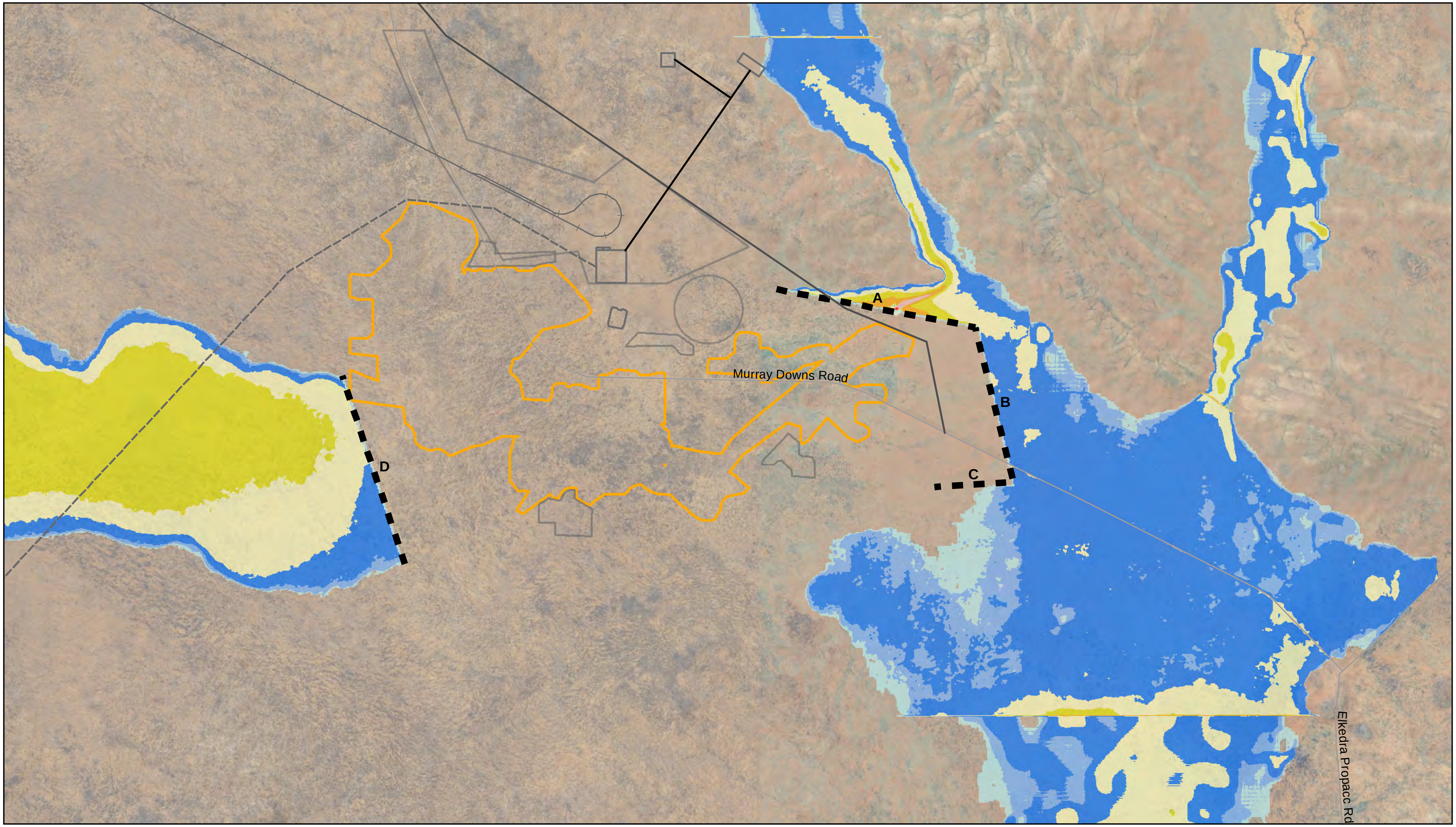
A hydraulic model has been used to estimate the indicative scour protection for each watercourse crossing along the access corridor. Scour protection associated with any built culvert would consist of placed rock (rip-rap) of a specified median diameter.

The residual risk associated with linear infrastructure altering surface water hydrology is medium.

Erosion and sedimentation

The establishment of the project site, including vegetation clearing and land disturbance, combined with occasional rainfall runoff has the potential to cause localised erosion and/or sedimentation. Where flow velocities reduce, sediment increased deposition could occur. The flood modelling indicates that maximum modelled flow velocities will be decreased within some locations, however these are typically outside of existing drainage paths and therefore sediment accretion is not expected to change appreciably.

Impacts associated with erosion and sedimentation are consider moderate with minor but long term impacts should eroded material deposit in drainage lines.



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0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Flood Protection Levees

Pit Footprint

Flood Extent and Depth (m)

0.00 - 0.05

0.05 - 0.15

0.15 - 0.50

0.50 - 1.00

1.00 - 1.50

1.50 - 2.00

2.00 - 3.00

3.00 - 4.00

GHD

VERDANT MINERALS

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	11 Oct 2017

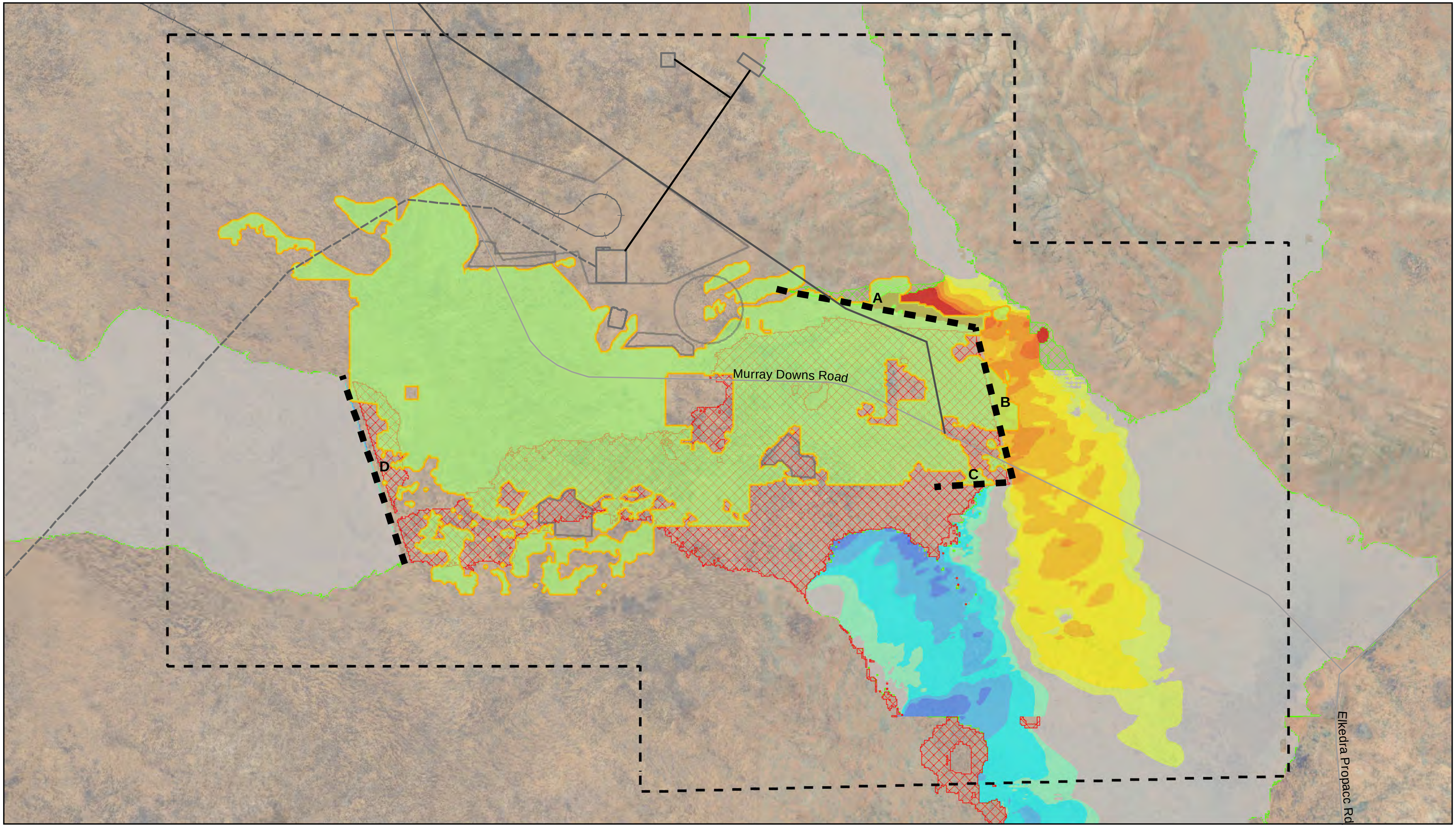
Maximum modelled 1% AEP
flood depths, proposed conditions

Figure 7-1

G:\43\22544\GIS\Maps\4322544_193.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Hillshade (2015). VML - Pit Footprint (2017). GHD - Flood Model Data (2017). Created by: CM



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0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Mineral lease
- 30 yr pit shape
- Pit Footprint
- Was wet now dry
- Proposed scenario flood extent

Change in Flood Level (mm)

- < -500mm
- -500mm - -400mm
- -400mm - -300mm
- -300mm - -200mm
- -200mm - -100mm
- -100mm - -50mm
- -50mm - +50mm
- +50mm - +100mm
- +100mm - +200mm
- +200mm - +300mm
- +300mm - +400mm
- +400mm - +500mm
- > +500mm

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VERDANT MINERALS

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
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Change in maximum modelled 1% AEP flood depth

Figure 7-2

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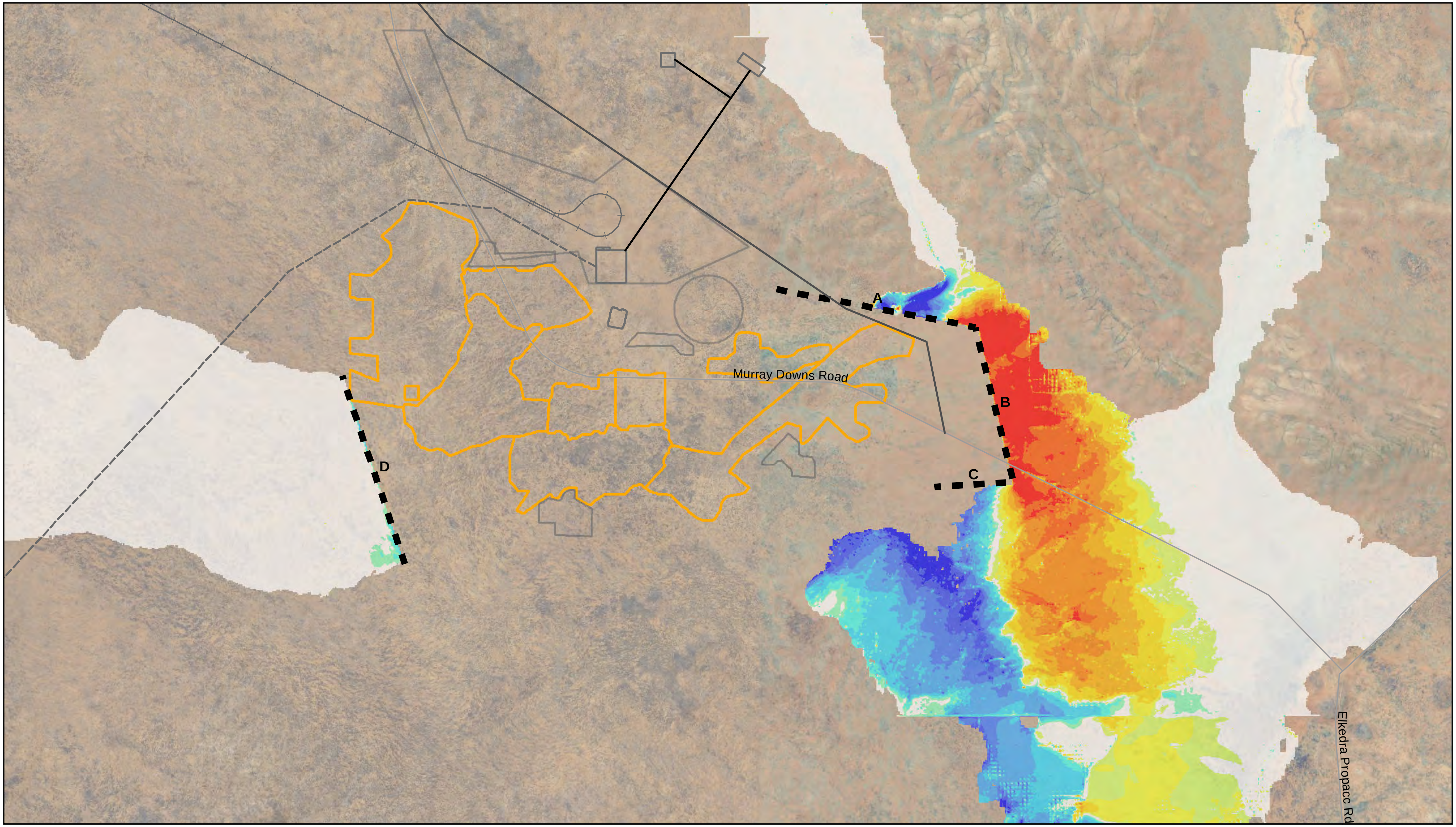
Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Hillshade (2015). VML - Pit Footprint (2017). GHD - Flood Model Data (2017). Created by: CM



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0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Flood Protection Levees

Pit Footprint

Change in Velocity (m/s)

> -0.5	-0.3 - -0.2	+0.05 - +0.10
-0.5 - -0.4	-0.2 - -0.1	+0.10 - +0.20
-0.4 - -0.3	-0.1 - -0.05	+0.20 - +0.30
	-0.05 - -0.025	+0.30 - +0.40
	-0.025 - +0.025	+0.40 - +0.50
	+0.025 - +0.05	> +0.50

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number 43-22544
Revision 0
Date 11 Oct 2017

Change in maximum modelled 1% AEP flood velocities

Figure 7-3

G:\43\22544\GIS\Maps\4322544_195.mxd

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Data source: GA - Roads, Places, Hillshade (2015). VML - Pit Footprint (2017). GHD - Flood Model Data (2017). Created by: CM

7.5.4 Impacts on water quality

Contamination from sediment laden water

Discharges from the sediment dams will still occur following rainfall that exceeds the design rainfall depth (i.e. the 100 year ARI 72-hour design storm event). During these periods of higher rainfall, the wider area is expected to be flooded with sediment-laden runoff. As a result, the discharges from the sediment basins would be mixed with similarly sediment-laden flood waters, resulting in an unappreciable change to water quality. This is considered to be an insignificant consequence.

Contamination from process water

Process water will typically include elevated levels of phosphate, dissolved metals, elevated salinity, high or low pH, and suspended solids. The accidental, uncontrolled discharge of this water has the greatest potential to impact downstream areas.

The proposed process water management system includes a freeboard storage capacity equivalent to the 100 year ARI critical duration runoff. This freeboard is intended to minimise the chance of uncontrolled discharges occurring. In addition, during extreme rainfall events excess process water will be directed towards the open cut mine pit in order to further minimise the risk of uncontrolled discharge of process water. If these management measures are followed, it is considered that the potential impacts to downstream water quality as a result of uncontrolled discharges of process water is low.

Contamination from tailings storage failure or overflow

The surface tailings facility will be used for the first three years of operation. The tailings produced after year 3 will then be deposited into the mined out pit void and will be progressively rehabilitated. The tailings geochemical analysis has concluded that the tailings material can be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste. As an in-pit facility the risk to surface water from a ‘failure of the TSF’ is considered low.

Contamination from spill of hazardous material or chemical

Project activities will involve the transport and storage of fuels and other chemicals. They will also involve the generation, transport and storage of chemical wastes. Due to their potential impacts on humans and the environment, both of these activities are well regulated, and therefore the potential for the accidental release of chemicals to impact upon surface water, is low.

7.5.5 Water users

Surface water resources are considered to have very limited potential to support environmental and agricultural uses. As a result, it is considered that the potential impacts to users of surface water resources is insignificant.

7.6 Mitigation measures

Mitigation measures will be required to avoid, control, reduce or minimise impacts of project activities on surface water. Monitoring may be required for some aspects, to evaluate the level of residual impact and effectiveness of mitigation.

This section provides guidance on the mitigation measures and monitoring that will be considered for all phases of the project. All mitigation and monitoring efforts will be described in detail in a Water Management Plan (see Appendix E, EMP).

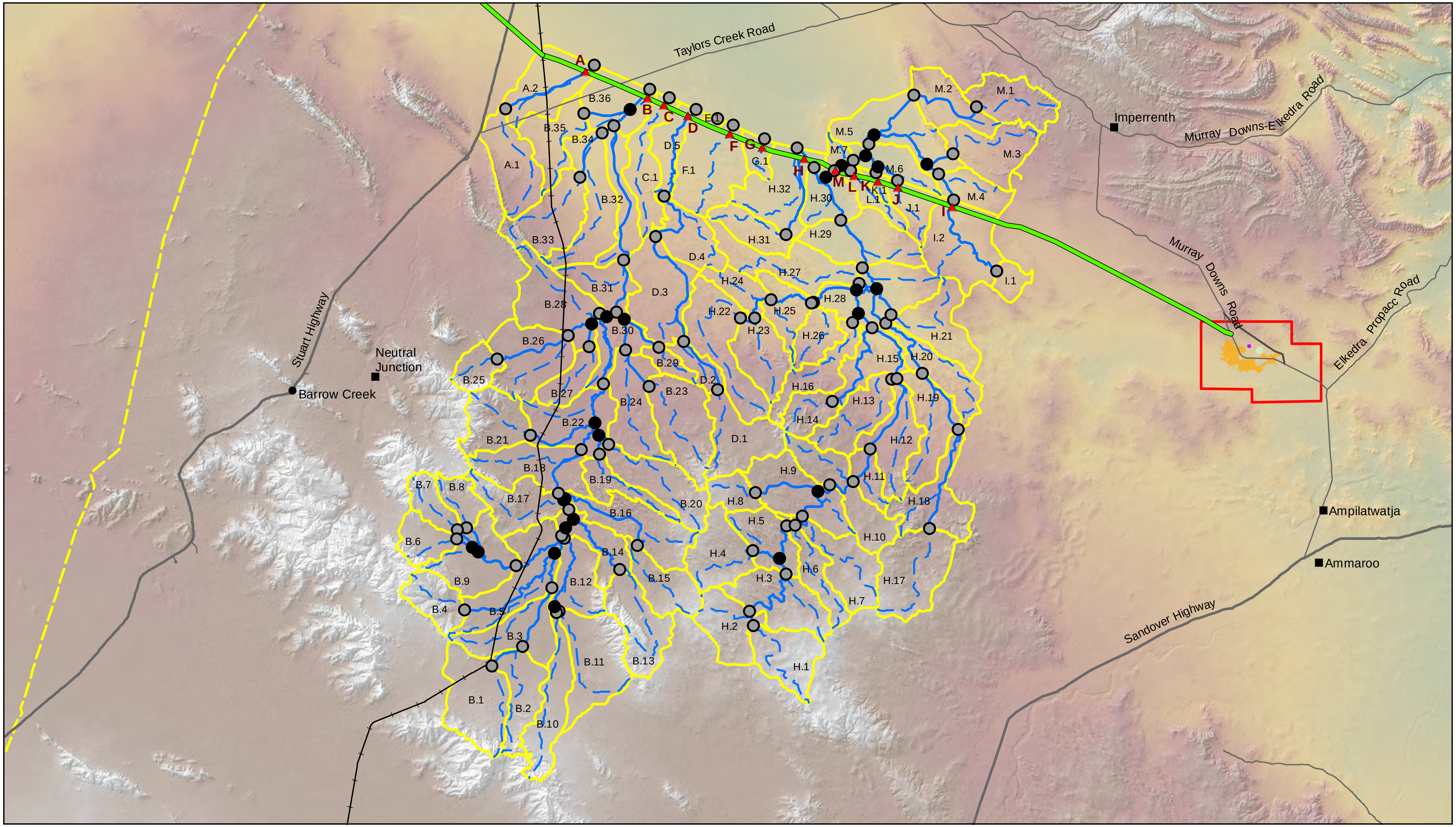
7.6.1 Mitigation of impacts associated with altered hydrological regimes

The greatest potential impacts to hydrological regimes are associated with the proposed access corridor, which would include a rail spur embankment with banks of culverts located at ephemeral watercourse crossings.

Current desktop modelling estimates that the rail line may require the construction of 17 watercourse crossing structures (Figure 7-4). Each watercourse crossing structure would include a suitable number and size of fit for purpose designed culverts (typically either metal corrugated bolted culverts and/or reinforced concrete pipe) with formation height (at the watercourse) required to remain flood free for the 25 year ARI event.

A hydraulic model has been used to estimate preliminary culvert and formation configurations for each watercourse crossing. The culvert and formation configurations are indicative and will be further refined during the detailed design stage.

Inspection of the culverts along the access corridor would be undertaken following runoff generating rainfall events to identify potential scouring and repairs (or upgrades) that may be required.



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0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and homesteads
- Indicative Culvert Location
- Catchment Outlet
- Stream Junction
- Major Road
- Local Road
- Access corridor
- Catchment Flowpath
- Stream Flowpath
- Catchment Area
- Beneficiation Plant
- Tails Storage Facility
- Pit Footprint
- Project Site

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Sheet 1

Access corridor model layout

Figure 7-4

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). VML - Proposed Corridor, Project Site, Pit Footprint (2017). GHD - Flood Data (2017). Created by: CM

7.6.1 Mitigation of impacts associated with flooding

Flood modelling has allowed for the estimate of the required heights of the proposed flood protection levees to protect the open cut pits from inrush during the one per cent AEP flood event (refer Appendix G). The finished level of the levees should be, at a minimum, equivalent to the maximum modelled one per cent AEP flood level plus a freeboard of 0.5 metres. Flood protection levees will include side batter slopes no steeper than one (vertical) in three (horizontal), and may incorporate light vehicle and / or haul roads (with suitable safety barriers) connecting the open cut pit to the nearby processing area. Scour protection measures (i.e. rip-rap) may be placed at the toe of the flood protection levee to reduce the risk of erosion and scouring of the levee during a flood event.

7.6.2 Mitigation of impacts associated with erosion

The design of scour protection required at each watercourse crossing along the access corridor will be assessed during detailed hydrological modelling and design of the access corridor. It is expected that some scour protection measures (rip-rap) may be required to reduce the discharge velocities from the culverts by increasing the flow depth and spreading discharges across a wider area. Typical scour protection would consist of placed rock (rip-rap) of a specified median diameter and ideally a hard wearing rock or other reliable and proven form of protection.

An Erosion and Sedimentation Control Plan (ESCP) will be developed during the detailed design phase by a certified practitioner. The draft ESCP will outline project surface water interactions and how soil will be managed to minimise soil compaction, erosion and sedimentation.

A draft ESCP will typically include, where appropriate, the following:

- Installation of erosion and sediment control measures prior to construction.
- Regular inspection of erosion and sediment control measures, particularly following rainfall events, to ensure their ongoing functionality.
- Staging of construction to occur in the dry season.
- Use of soil binding polymers applied to areas left cleared for any period of time.
- Runoff from disturbed and rehabilitated areas diverted into sediment ponds and not discharged into the natural system before monitoring.
- Construction of adequate bunds around potential contamination sources, to contain contaminated water in the event of heavy rainfall.
- Runoff from stockpiles and workshops would be directed to sediment basins.
- Siting of stockpiles away from natural drainage channels.
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP.
- Minimise surface water infiltration, water runoff and groundwater seepage.
- Spill clean-up and emergency management procedures developed and implemented.
- Personnel to be trained in the use of spill kits and emergency response procedures.

7.6.3 Mitigation of impacts associated with hazardous materials and chemical spills

A Hazmat Management Plan will be developed that outlines chemical spill response management and management of chemicals, wastewater and fuels in proximity to drainage lines. This plan will include as a minimum the following:

- Hazardous materials to be appropriately stored in bunded areas.
- Dedicated refuelling areas to include spill kits to allow for immediate clean-up of small spills.
- Bunding to have a storage capacity of 150% of the volume of hazardous materials being stored within.
- Inspection regime to monitor bunding capacity.
- Appropriate equipment available to remove fluids from bunding and secondary containments.

Monitoring will be undertaken in accordance with the Multiple Before-After Control-Impact (MBACI) approach. The monitoring program has been designed to include:

- Control sites: upstream / up gradient monitoring sites which monitor background concentrations. Multiple control sites will be utilised.
- Adjacent: monitoring points situated adjacent to potential point sources of contamination (i.e. locations storing process water and sediment laden dirty water), often called ‘point of discharge’.
- Impact site: downstream / down gradient monitoring sites. Multiple impact sites will be utilised.

All monitoring sites will be located in locations where the future project footprint will enable monitoring consistency throughout the project life.

7.6.4 Mitigation of impacts associated with discharge of process water

Process water dams would be maintained by dewatering of excess water into other water storages within the site or, under exceptional conditions, into the open cut pit. Discharging into pit reduces the potential for the uncontrolled discharge of process water into the downstream environment.

Uncontrolled discharge is considered to be a rare event of minor consequence.

Monitoring will be undertaken as detailed previously. Additional monitoring will be implementation if mine-associated water is disposed off-site (and as per the conditions of a Waste Discharge Licence).

8. Groundwater

8.1 Introduction

This chapter describes the groundwater present within the project site and in the surrounding study area, including a description of the characteristics of the aquifer, groundwater quality and existing users. This chapter also describes the potential direct and indirect impacts of the project on groundwater resources, including groundwater extraction and contamination. Mitigation measures that will be implemented in order to minimise the impact of project construction and operation are documented.

Section 5.3.1 of the draft EIS TOR provided the following environmental objective in relation to groundwater resources:

> *Proposed extraction of water will be within the sustainable limit of the aquifer or water supply to fulfil the Project needs over the predicted life-of-mine, without causing adverse environmental or social impacts.*
>
> *Water resources will be protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.*

This chapter addresses the potential impacts of the project on groundwater resources, as required for the TOR.

This chapter also considers the cumulative effects of extraction of groundwater during operation, and impacts beyond closure as required in the TOR for the project.

A detailed groundwater assessment report is provided in Appendix H, including a detailed methodology of groundwater flow modelling.

A detailed acid, metalliferous and saline drainage (AMD) assessment and management plan is provided in Appendix I.

8.2 Existing environment

8.2.1 Southern Georgina Basin

The Georgina Basin is regionally extensive and underlies approximately one quarter of the Northern Territory and northwest Queensland.

The Southern Georgina Basin fill is dominated by carbonate rocks. Southern Georgina Basin thickness near the study area approximates 200 to 400 m with an area of 20,000 km^2. The Georgina Basin carbonate associated aquifers are accessed by nearly all successful bores drilled in the region and are the target water supply for the mine borefield (Figure 8-1).

The Georgina Basin carbonate aquifer generally comprises carbonate rocks including limestone and dolostone with minor intercalated sandstone. The sandstone, limestone and dolostone units exhibit primary porosity, whilst fault structures and solution joints provide secondary porosity to facilitate well yields. It is a regional scale, thick, extensive and transmissive aquifer.

The aquifer depth varies from the top of the water table at 30 to 80 m below ground surface to over 1000 m deep at the deeper parts of the basin.

Conceptual hydrogeology

Regionally, the Georgina Basin carbonate aquifer is un-confined and the entire Basin is understood to comprise a connected aquifer system. Locally, the aquifer thins to the south of the mine site where it onlaps the basement rock to form, what is also, the northern margin of the Southern Georgina Basin. The aquifer extends regionally to the east to the broader Georgina Basin and extends to the west where it infills the stratigraphically-equivalent southern Wiso Basin.

The aquifer potentiometric surface exhibits a convergence of flow from fractured rock aquifers toward the South Georgina Basin and the Wiso Basin (Figure 8-2). There is a groundwater flow divide 50 km west of the mine site. To the west of the divide, groundwater flows northwest toward the Wiso Basin. East of the divide groundwater flows toward the east into the broader scale Georgina Basin. The inferred flow of the aquifer is illustrated in Figure 8-2.

A conceptual model of the Southern Georgina Basin is presented in Figure 8-3.

Capacity

The Southern Georgina Basin has an approximate area of 20,000 km^2 and thickness approximates 200 to 400 m. These dimensions produce a rock volume of four to eight thousand cubic kilometres. For a drainable porosity (specific yield) of 4%, this equates to a drainable groundwater volume of 160 – 320 km^3 or 160,000 - 320,000 GL.

Aquifer testing at the borefield site undertaken by VRM, indicates that the aquifer has the capacity to support well yields of over 75 L/s. This is reasonably consistent with a regional scale assessment by DENR, which reported potential well yields of 5 to 50 L/s in this area.

Recharge

The site lies in the arid region of Australia with an annual rainfall of around 350 mm with a high coefficient of variation and a pan evaporation rate of about 4,000 mm.

Groundwater recharge is generally via direct infiltration to outcropping or thinly covered aquifers such as the fractured rock aquifers outcropping in the Davenport Range to the north of the Southern Georgina Basin, and the Watt, Spring, and Tomahawk Ranges to the south.

Focussed recharge also occurs at watercourse flood-outs, where ephemeral streams flow from the ranges onto the plains after heavy rainfall events. The Sandover River Flood-Out, 35 km to the south of the project, is one such source recharge.

Recharge estimates in this region reported by other studies range from 0.2 mm per year up to 5–12 mm per year. An estimate for this project based on chloride as a chemical tracer of rainfall is an average recharge rate of 1.5 mm per year.

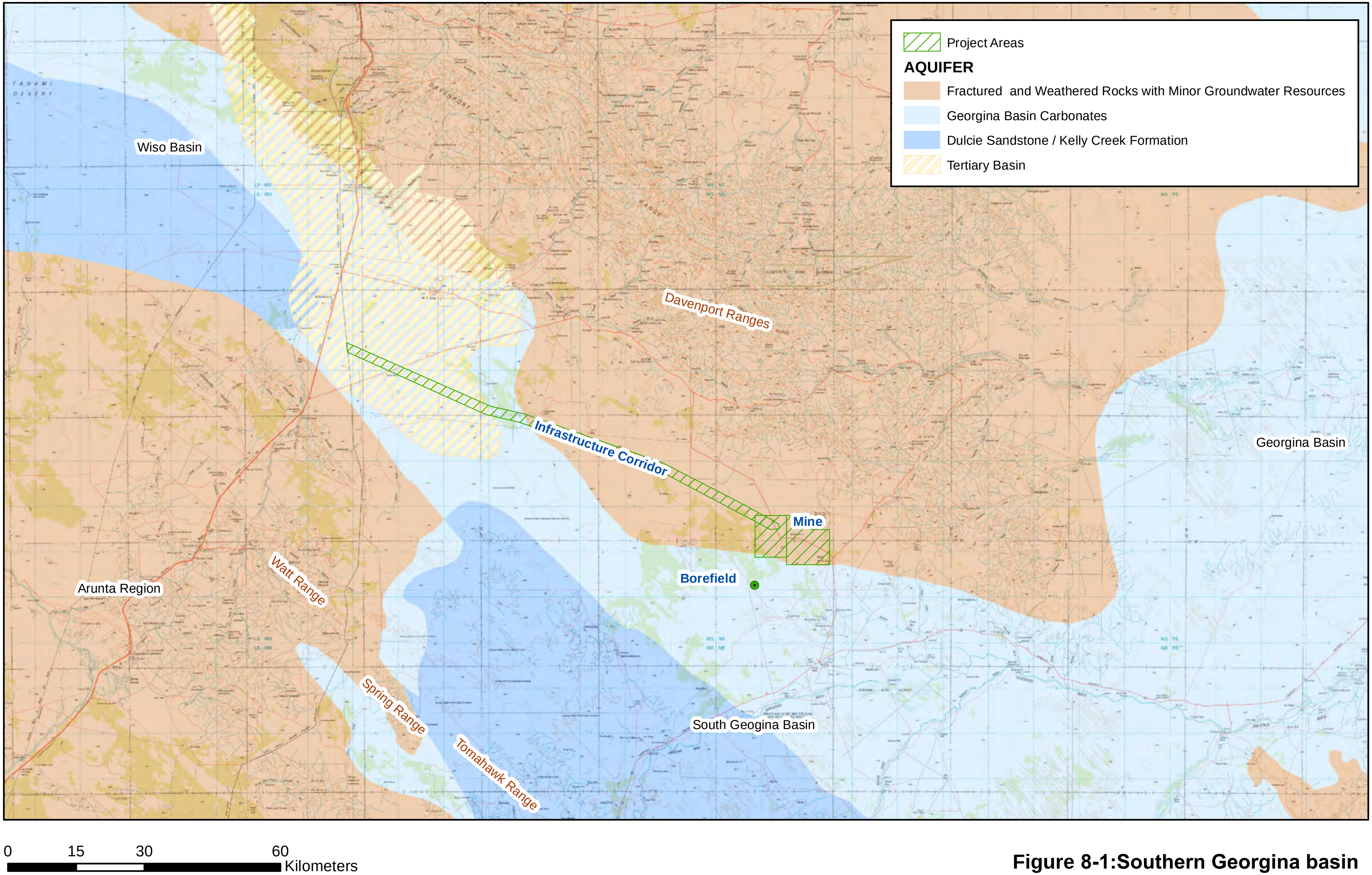


Figure 8-1:Southern Georgina basin

Tertiary Basin is from Tickell 2014 Groundwater of the Western Davenport Water Control District.
Aqufier Data is from Tickell 2013 Groundwater of the Northern Territory

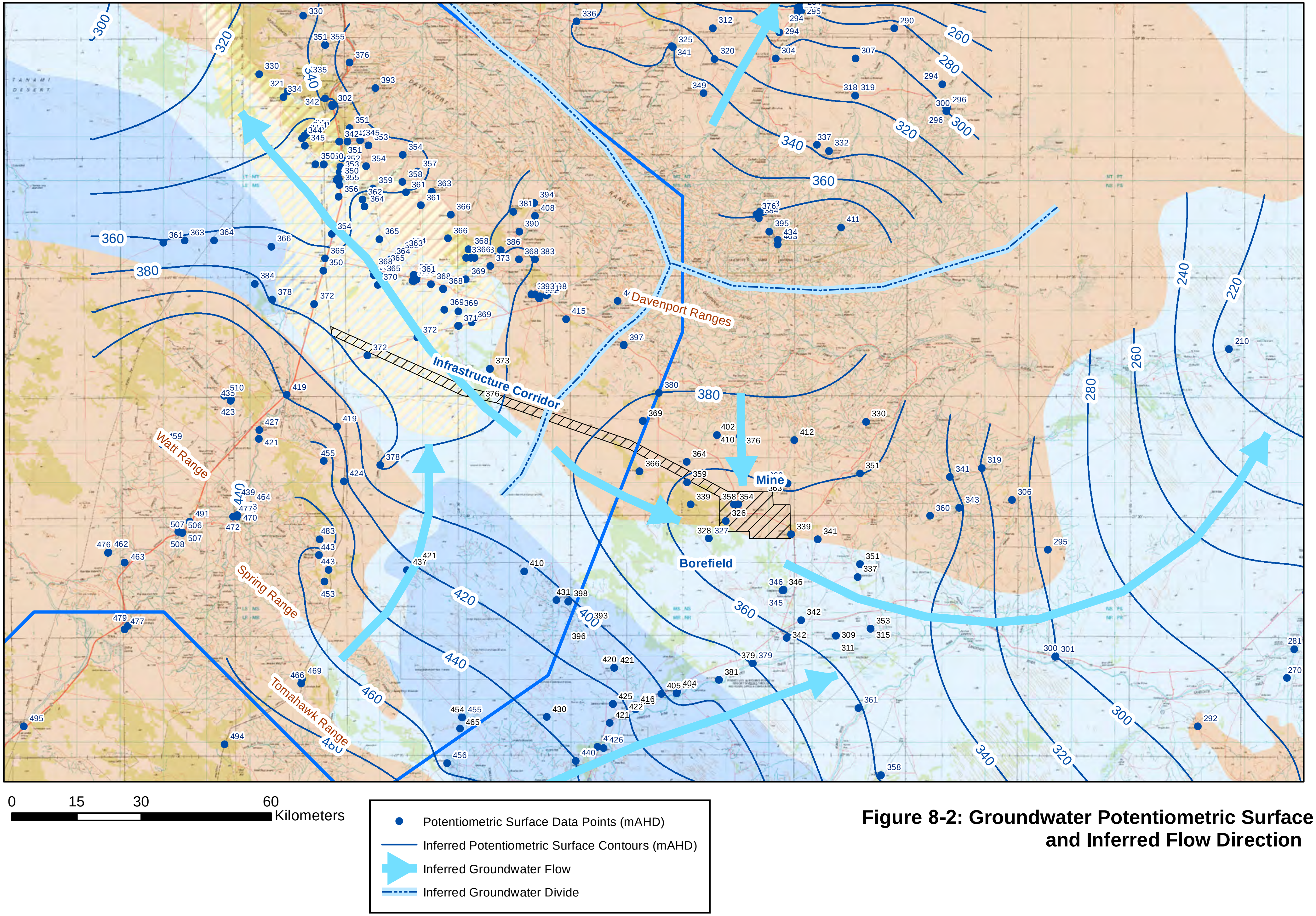
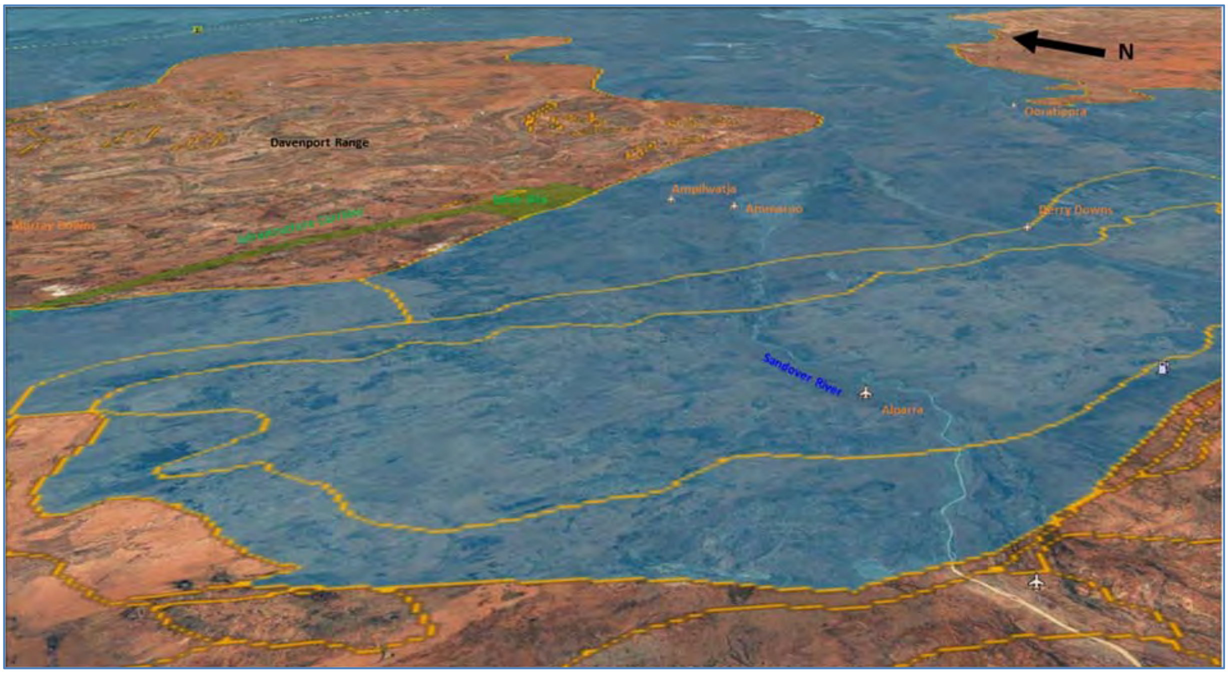


Figure 8-2: Groundwater Potentiometric Surface and Inferred Flow Direction



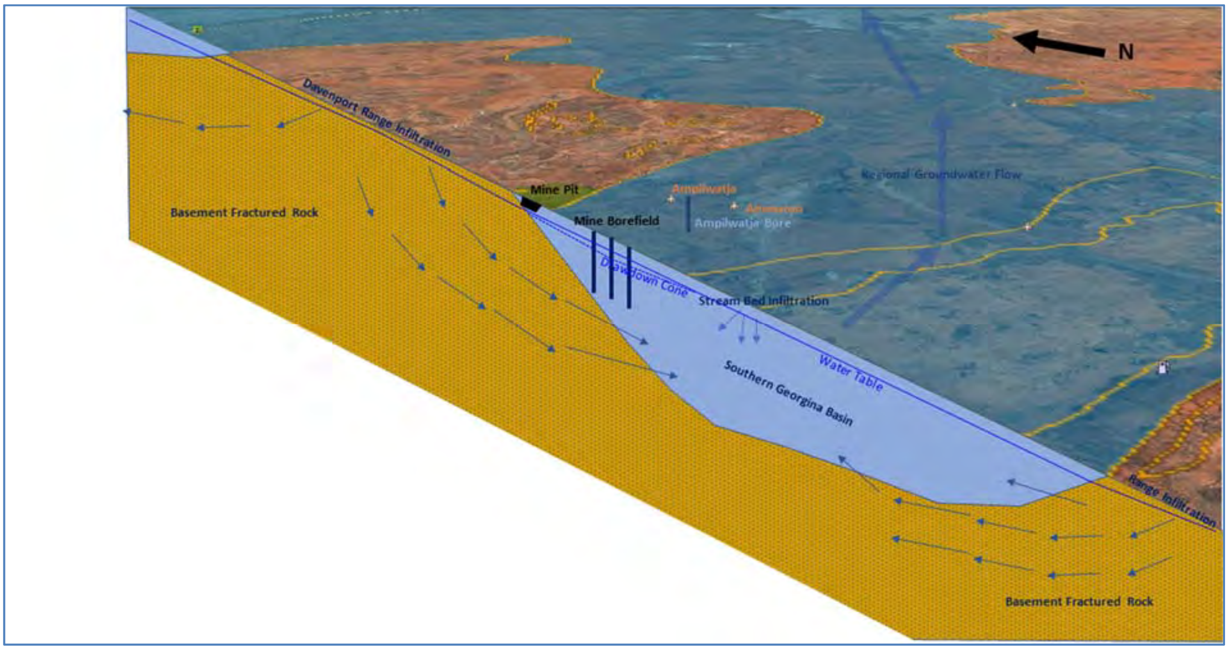


Figure 8-3: Conceptual Cross Section

8.2.2 Groundwater chemistry

Groundwater from pilot and investigation bores at the borefield site (WI03, WI04, WI05 and PB01) completed in the Georgina Basin carbonate aquifer exhibit marginal to non-potable water suitable for pastoral use. Data sourced from the NT Government's *Water Data Portal* and groundwater investigations undertaken by VRM indicate that groundwater is generally fresh to brackish (500–3,000 mg/L TDS). The salinity is suitable in many instances for potable use (less than 1,000 mg/L), and most bores report water suitable for stock watering. The water exhibits a chemical composition similar to the Proterozoic basement aquifer, however elevated in Ca, Mg and SO_4, indicative of equilibration with carbonates; calcite ($CaCO_3$) dolomite ($CaMg[CO_3]_2$) and gypsiferous rock ($CaSO_4$).

The groundwater within the low yielding Proterozoic basement aquifer immediately beneath and adjacent to the mine (Camp Bore, and Exploration Bore), which exhibits pastoral (stock) water quality with a mixed chemical composition dominated by Na-Mg-HCO_3-Cl. The water is not potable due to elevated fluoride, nitrate and boron.

8.3 Groundwater dependent ecosystems

There are no data available for southern and central NT in the *Atlas of Groundwater Dependent Ecosystems* (BOM 2012). There are no known wetlands or large Eucalypts that may indicate the presence of groundwater dependent ecosystems (GDEs) within the study area.

Biodiversity surveys within the Georgina Basin carbonate aquifer identified three tributaries (lined with River Red Gum, *Eucalyptus camaldulensis*) associated with Taylor Creek. These tributaries support large and mature River Red Gum, which are likely to be groundwater dependent. No other areas within the project site/biodiversity survey area contained features that would indicate groundwater dependency. Taylor Creek is located to the northwest of the mine site and is outside the predicted extent of drawdown from borefield pumping.

Other GDEs outside the study area of the biodiversity survey were reviewed in terms of their water level measurements i.e. within the regional water bore dataset maintained by the NT DLRM. This assessment concluded that there are no identified GDEs within at least 60 km of the borefield, as the water table depth in proximity is considered too deep to support GDEs.

The closest site that records a water level within 15 m of the ground surface is a bore located approximately 60 km northwest of the borefield. In this area and further to the northwest, the ground surface elevation is relatively low (less than 390 mAHD) and a shallow water table is evident in the bore levels.

The Proterozoic basement aquifer does support waterholes in the major creek lines in the Davenport Range to the north of the Southern Georgina Basin, and the Watt, Spring, and Tomahawk Ranges to the South. These waterholes are located more than 40 km from the planned borefield.

A waterhole is reported 40 km east of the borefield at the eastern margin of the Sandover River Flood-out. However, this feature is adjacent to a water bore that reports depth to water of 28 m below ground surface. It is likely that the water hole receives periodic surface run-off and is not connected to the regional water table. Aerial Imagery reveals a dry feature resembling a perennial flood pan that is sometimes inundated.

8.4 Existing users

Groundwater from the Georgina Basin carbonate aquifer is used for community water supplies, station water supplies and for stock watering. Pastoral bores, community water supply bores and Water Protection Area Boundaries are presented in Figure 8-4.

Ammaroo Station and Murray Downs Station use bores completed in the Georgina Basin carbonate aquifer for stock watering. The nearest stock bore (Hagen's Bore) is located 15 km south east of the borefield. The homestead at Ammaroo Station utilises groundwater from the same aquifer and is located 30 km from the borefield. Murray Downs Station utilises groundwater from the fractured rock aquifer in the Davenport Range and is located more than 60 km from the borefield.

The Ampilatwatja community is located 22 km southeast of the borefield and also uses groundwater from the Georgina Basin carbonate aquifer. There are records of two bores installed in 1976 to provide community water supplies to replace an older well, Honeymoon Bore, which is now derelict. In 2003, Power Water Corporation drilled two new bores to provide water to the community. All bores are drilled to 70–80 m depth and encounter the top of the aquifer, and the water table, at around 55 m depth.

The project borefield is not located in a Groundwater Protection District. Water Control Districts are areas, declared under the Water Act, where there is a need for enhanced management for the sustainability of groundwater reserves and river flows. Water allocation plans can be developed for these areas and water extraction licences are required (NTG 2016).

The Western Davenport Water Control District (WDWCD) boundary is located 20 km to the west of the project borefield. There are three distinct management zones within the WDWCD: Davenport Ranges, Southern Ranges and Central Plains. These management zones serve to delineate between the higher yielding and better quality aquifers in the plains, versus the poorer quality, and poorer yielding aquifers in the ranges (DENR 2017). The access corridor intercepts the Central Plains management zone.

The total allocation for licensed/unlicensed use for the Central Plains management zone is 51.219 ML/year, of which, 0.5 GL/year has been allocated to industry under the draft Western Davenport Water Allocation Plan. 0.2 GL/year is currently licenced in the Central Plains management zone (DENR 2017).

The Act does not require a licence for water extraction which is to be used for stock and domestic purposes. It is estimated that there are about 300 bores in the Water Control District that are or could be used to provide water for stock and domestic purposes.

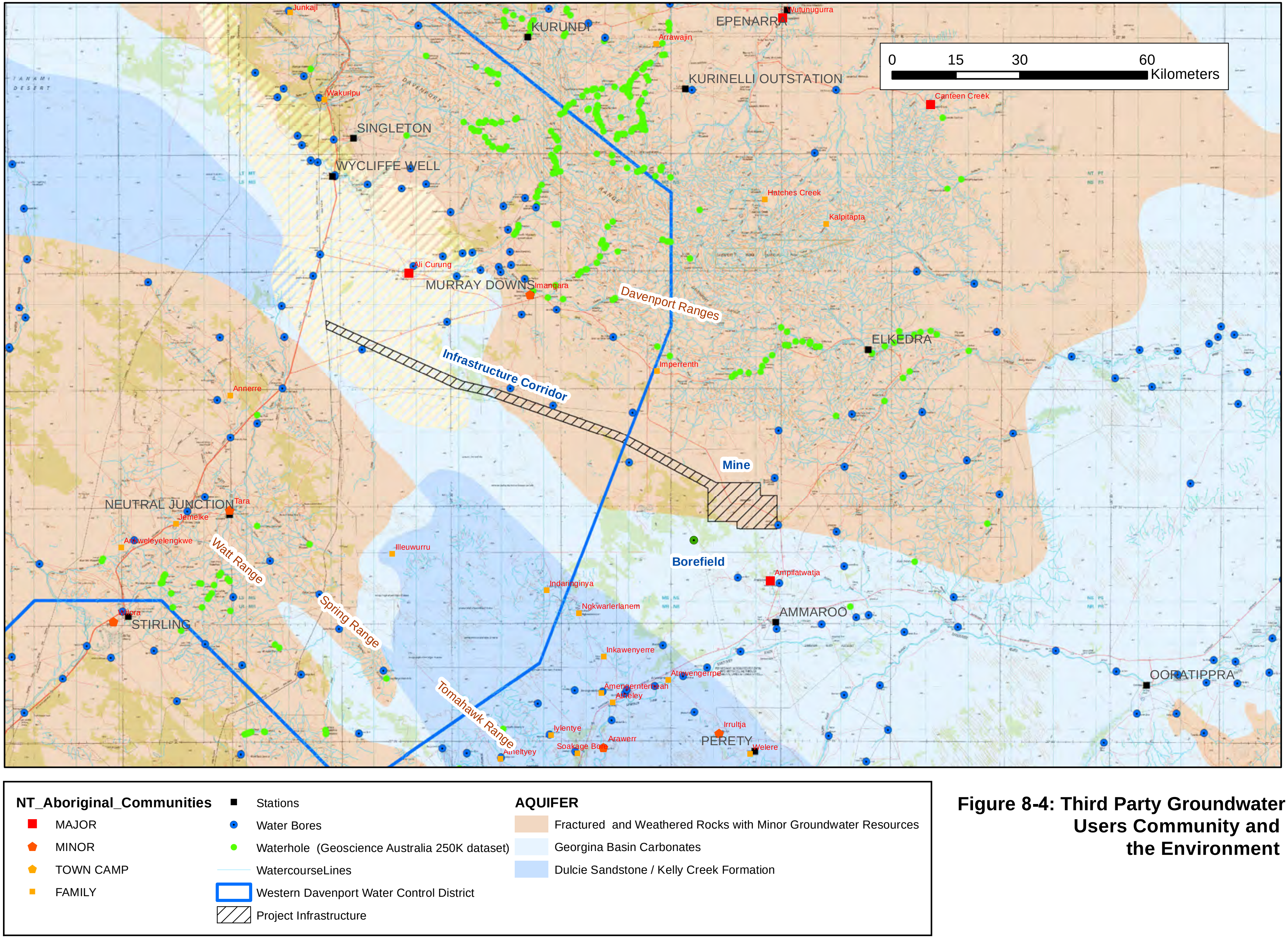


Figure 8-4: Third Party Groundwater Users Community and the Environment

8.5 Groundwater use

8.5.1 Construction

The construction water supply will comprise of a string of bores constructed at nominal 20 km intervals along the 137 km long access corridor. These bores will provide water for dust suppression and material compaction.

Each bore will yield approximately 0.4 ML/day (4.5 L/s) for a one year construction duration. This equates to an approximate cumulative total of 876 ML (0.8 GL) if it is assumed that all bores are operational for the entire period of construction.

Bores will be completed into the Georgina Basin carbonate aquifer.

8.5.2 Operation

The project water supply will comprise a borefield completed into the Georgina Basin carbonate aquifer at a site 12 km to the south of the project site. The borefield will comprise three high flowing water bores equally spaced over a 1.5-2.0 km run.

The borefield, when the mine is at full production, will yield, at most 12 ML/day (140 L/s). Maximum water demand from the borefield equates to 4.4 GL per year for a period of 25 years with a cumulative demand of 110 GL for the LOM. However, water demand is expected to be considerably lower as a result of process water recycling, which is being studied in the ongoing bankable feasibility study.

The borefield is located outside of the WDWCD.

8.6 Acid, metalliferous and saline drainage

8.6.1 Ore and waste rock

The AMD assessment (refer Appendix I) presents the findings of a review of historical resource geochemical data, an assessment of mine development information relating to the risk of development of AMD and detailed, specific geochemical analysis of potential for AMD.

The following key data sources were used in this assessment.

- Site-specific climate and hydrological data
- Geochemical analyses:
  - Assay data for metals and metalloids, sulfate and total sulfur and carbon
  - Stage 1 Static AMD testing of potential ore and waste rock material and one tailings sample for net acid producing potential (NAPP); net acid generation (NAG); and 1:5 electrical conductivity (EC) and pH
  - Stage 2 Waste rock single addition Australian Standard Leaching Procedure (ASLP) leachate analyses and one sequential batch leachate analysis of tailings and multiple extraction procedure (MEP) testing of selected waste rock samples
- Life of mine (LOM) plan and potential options relative to the above features
- Hydrogeological (including geological and geotechnical) data.

The assay data showed that there were slightly elevated metals concentrations present, in some samples of the main lithological units on site, relative to the median abundance of those same metals in similar lithologies.

The results of static NAG testing indicate that all of the material but one anomalous sample is non-reactive and non-acid-forming (NAF). The low total metal and sulfide content, neutral NAG, positive NAPP and high NPR also support a NAF classification for all samples. This is consistent with a high level of oxidisation and weathering of the material, which is above the long-term watertable.

Analyses of static 1:5 water leach and MEP testing indicated that some of the waste rock may produce leachate with concentrations of metals, primarily zinc, elevated relative to aquatic ecosystem or drinking water guidelines, although within levels suitable for unlined monofil management. Although phosphorus was naturally highly elevated in the waste rock compared with average crustal abundance, it was not elevated in the leachate, which is consistent with the low solubility of phosphate minerals.

Salinity levels were classified as *very low* to *medium* and although some leachate Sodium Adsorption Ratios are high, leachate and runoff could be re-used with clayey soil amendment with crushed limestone of gypsum to raise soluble calcium concentrations.

Total and leachable thorium and uranium analyses were available for the waste rock. All were less than concentrations equivalent to the limit of 1 Bq/g that would classify the materials as naturally occurring radioactive materials (NORMs).

Based on the overall geochemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is very low and the material can be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste. The material is suitable for management in unlined monofil waste rock dumps, with normal sediment and erosion control and monitoring of the key metals and metalloids noted as being elevated in acid and neutral leachate.

No AMD assessment has been carried out on construction materials other than material from within the pit area.

8.6.2 Tailings

One sample of synthesised tailings was analysed for total metals, sulfur NAG and NAPP. The sample was also subjected to a sequential batch leach and analysed for metals, major and minor ions, pH and EC. The tailings chemistry was consistent with that of the waste rock with some slightly elevated metals and fluoride but low salinity and was non-acid-forming. The uranium concentration was less than that equivalent to the limit of 1 Bq/g that would classify the materials as NORM.

8.7 Potential impacts

8.7.1 Existing threatening processes

Any existing processes that potentially threaten groundwater resources (e.g. unsustainable use, contamination) are considered rare and insignificant.

8.7.2 Project impacts

This section identifies the potential direct and indirect impacts on groundwater presented by the project. These include potential impacts during construction, operation and rehabilitation, and closure. The construction period is expected to last up to 24 months, and mining and processing operations will continue for a period of at least 25 years following construction.

The following potential events have been identified as potential impacts as a result of the project.

- Drawdown of shared groundwater aquifers reducing availability and quality to existing users.
- Drawdown of groundwater levels reducing availability and quality to the environment (i.e. GDEs).
- Discharge or seepage of contaminated water (i.e. AMD seepage into groundwater aquifer).
- Process outputs (i.e. tailings) contaminating groundwater.
- Accidental spill of hazardous materials contaminating groundwater.

8.7.3 Risk assessment summary

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

A summary of the risk assessment results is provided in Table 8-1. Multiple hazards may exist as a result of a one potential event. Refer to full risk assessment in the Environmental Risk Register (Table 6-8) for further detail.

Table 8-1 Qualitative risk – groundwater

Potential event	Residual risk level
Drawdown – existing users	Medium
Drawdown – environment	Low
AMD	Low
Failure of the TSF	Low
Accidental spill of hazardous material and chemicals	Low

8.7.4 Impacts to groundwater resources

Southern Georgina Basin

It has been estimated that the Southern Georgina Basin has a drainable groundwater volume of 160,000 to 320,000 GL. A water demand of 110 GL for the over the life of the project is in the order of 0.03% of the entire volume of the water resource.

Drawdown along the access corridor

Water demand along the access corridor will only exist during a one to two year construction period. Drawdown within the Southern Georgina Basin for a range of aquifer parameters has been assessed to consider the uncertainty of the drawdown estimate. After 1 year of pumping at 0.4 ML/day the distance from the pumped well to the calculated 0.5 m water table drawdown contour ranges from 4 m in a highly transmissive aquifer with low storage, to 250 m in a less transmissive aquifer with high storage.

Drawdown at the mine site

The mine pit remains above the water table and no impacts to groundwater from excavation are expected. The water table at the mine site has been measured at 358 mAHD (59 m below ground level). The base of the orebody is placed at a minimum of approximately 380 m AHD, which is some 20 m above the water table. The deepest actual mine floor during 25 years of mining will be at least 25 m above the watertable.

Drawdown at the borefield

Drawdown associated with pumping at 12 million litres per day for 25 years at the borefield has been assessed to demonstrate the lateral extent of the drawdown cone at the end of mining.

The aquifer parameters used in the impact assessment modelling were determined from:

- A long term pumping test at one bore in the vicinity of the borefield.
- Benchmarking against other pumping tests in the Southern Georgina Basin.
- Benchmarking to the aquifer properties implemented by NT DENR for the South Georgina Basin aquifer in modelling used to support the WDWCD Water Allocation Plan.

The modelling methodology implemented industry best practise uncertainty analysis. Drawdown was calculated for the full range of possible aquifer properties in 100 separate model runs.

Drawdown contours have been plotted at 0.5 m intervals and are presented in Figure 8-5.

The water table at the borefield is calculated to drawdown by 8.7 m. The distance to the 0.5 m contour ranges from 22 to 26 km from the borefield. There is expected to be a lag of up to 8 years between reaching maximum drawdown at the 8.7 m contour and the 0.5 m contour.

8.7.5 Impacts to existing users

Construction

There are no receptors within 850 m of the planned construction water supply bores. No existing users will be impacted by construction water use.

Borefield

The results from the drawdown analysis suggest that, for the 25 years scheduled life of mine, it is probable (5^{th} - 95^{th} percentile) that a maximum drawdown of:

- 1.5–3.7 m drawdown will be observed at the closest pastoral bore (Hagens Bore). Hagens Bore would have a maximum drawdown in 2045. This bore is located 15 km from the borefield.
- 0.6–2.7 m drawdown will be observed at the Ampilatwatja community. The Ampilatwatja bore would have a maximum drawdown in the year 2050. The Ampilatwatja borefield is about 22 km from the project borefield.

It is unlikely that significant drawdown (i.e. more than 3 m) will result at existing user bores due to groundwater abstraction. The groundwater model concludes that there is little measurable drawdown expected at any station homesteads or communities. The extraction therefore poses an insignificant risk of impact to other users with respect to reducing yields of adjacent bores (i.e. Hagen’s bore) and community water supplies (i.e. Ampilatwatja)..

Western Davenport Water Control District

Project water use is not within the WDWCD but is 20 km to the east of the boundary. Water table drawdown at the project borefield will induce flux across the WDWCD boundary. The rate of flux induced over the boundary was calculated for 100 random combinations of transmissivity and storage parameters.

Groundwater flux across the boundary of the Western Davenport Water Control District is predicted to range from 0 peaking at 0.5 GL/year at the completion of mining (Table 8-2). Predicted drawdown at the WDWCD boundary at the completion of mining is less than 1 m (Figure 8-5) which is considered a negligible impact given the significant (100s of meters) saturated thickness of the aquifer.

The 5th and 95th percentile groundwater fluxes across the boundary of the WDWCD are predicted to peak at between 0.44 and 2.5 ML/d (~160 – 910 ML/y) in the period between 1 and 8 years following mine closure.

Table 8-2 Calculated groundwater flux across the WDWCD boundary

Years of operations	Calculated flux (GL/year) Base-case (50th percentile) model
1-5	0.0
5-10	0.1
10-15	0.2
15-20	0.3
20-25	0.4
25-30 (post mining)	0.5
30-40	0.5
40-50	0.4
50-60	0.3
60-80	0.2
80-100	0.1

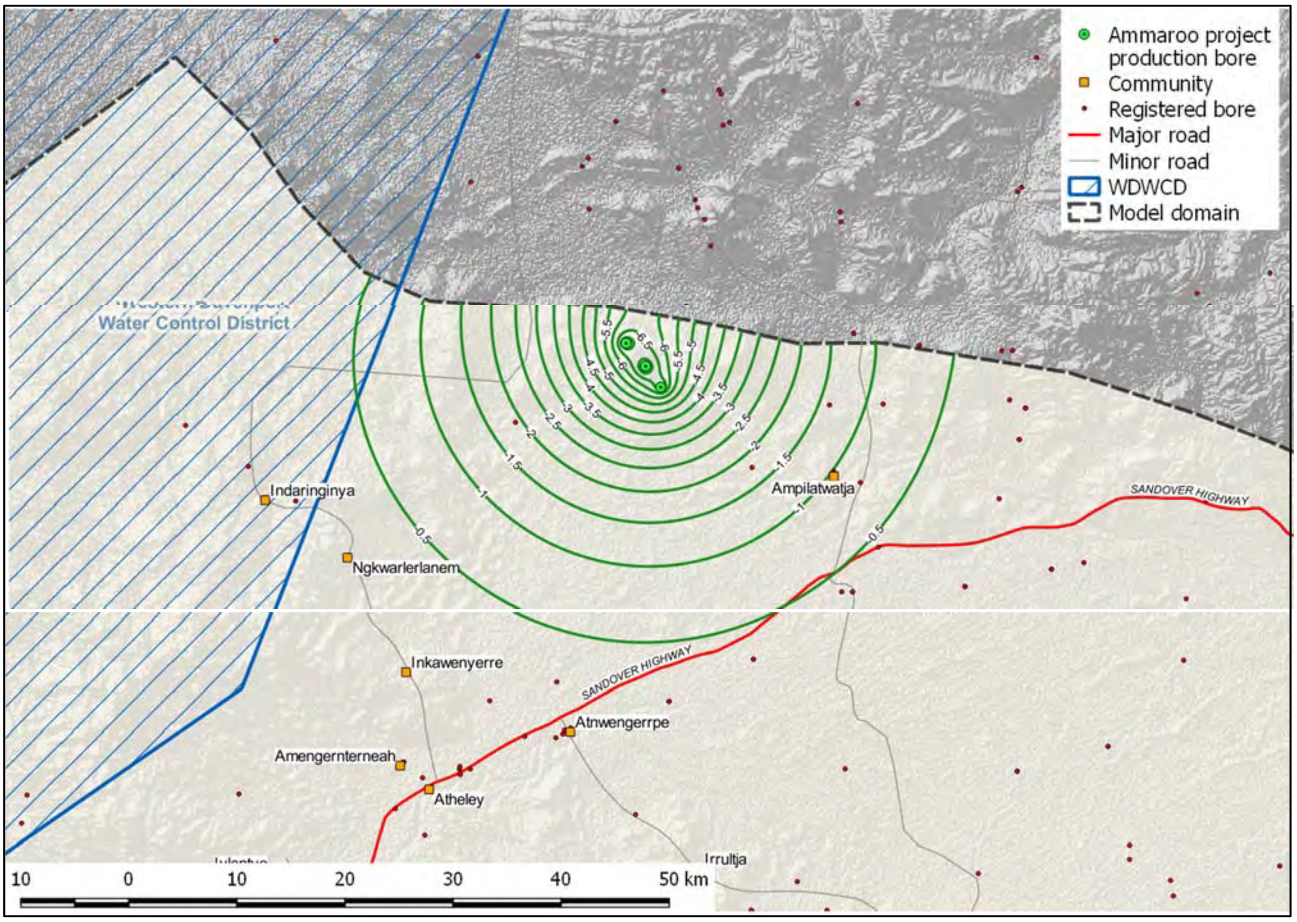


Figure 8-5: Drawdown contours at end of mining

8.7.6 Impacts to groundwater dependant vegetation

There are no GDEs located within the drawdown contour surrounding the borefield. No impacts to GDEs are predicted.

8.7.7 Impacts from acid, metalliferous and saline drainage

An AMD ecological and human health risk assessment was undertaken to determine the AMD risk. It has been undertaken within the context of, and considering:

- Lack of potentially acid forming (PAF) material identified during the geochemical assessment.
- Low total and leachable metal and metalloid content (including radioactive metals such as thorium and uranium) in the excavated material.
- Low salinity and moderate sodicity.
- The mine plan and schedule.
- Baseline environment and any sensitive receptors.

The AMD risk assessment has been completed to provide a high level understanding of AMD source risk. The risk assessment recognises the limitations of the input data, including the absence of kinetic ABA testing and column leaching tests. These tests are now being undertaken. However, the use of a large laboratory dataset and site sulfur (samples), static ABA testing and metal assay/XRF data sets has provided a suitably sized input for the stated purposes of assessing AMD risk, and developing high level management strategies for site implementation throughout the operational mine stage, and into closure.

The risk assessment concludes that, given the low sulfur content, generally low metal toxicant content and low metal and salt leachability of waste rock and tailings, the initial risk of groundwater contamination from AMD is low (refer to the AMD Assessment Report - Appendix I). It is likely that with additional pre-production testing, the initial risk score will be lowered further due to the greater certainty. Taking into consideration the proposed AMD Management Plan, including an allowance for separate storage of all separable PAF material if encountered, blending of any minor PAF with non-acid-forming (NAF) and acid consuming material (ACM) and routine dust, sediment and erosion control, the residual risk is low.

Saline tailing seepage will not be generated due to the low salinity of process water stream and tailing liquor.

8.7.8 Impacts from hazardous material and chemicals

Hazardous material, reagent and chemicals such as diesel, oil and lubricants will be transported to the mine for use in construction and operations. An accidental spill resulting in the contamination of groundwater is rare and would result in a minor impact due to the significant depth to the water table of 60 to 80 m providing a natural risk mitigation. Spills are considered a soil contamination risk rather than groundwater contamination.

8.8 Mitigation measures

This section provides guidance on the mitigation measures and monitoring that will be considered for all phases of the project. All mitigation and monitoring efforts will be described in detail in a Water Management Plan (Appendix E) and AMD Management Plan (Appendix I), prior to impact activities taking place.

8.8.1 Mitigation of impacts associated with drawdown

The groundwater flow model will be re-calibrated annually to increase the model confidence to a Class 2 model calibrated in transient state. The re-calibrated model will be used to predict drawdown on existing users bores with increased precision. The predicted drawdown at existing users bores can be defined as the leading indicator of impact.

Groundwater monitoring will comprise monitoring of drawdown in proximity to the borefield and proximal to existing users including:

- Hogan Bore
- Ampilatwatja
- Ammaroo Homestead
- Ilbumric

Water level will be recorded weekly using automated data loggers and downloaded at nominally 12 monthly intervals to allow analysis of the data for annual reporting and model re-calibration. The location of monitoring bores are presented in Figure 8-6.

It is possible (though unlikely given the very broad uncertainty analysis applied in this impact assessment) that groundwater impacts (water level drawdown and reduced groundwater availability to other users) exceed the magnitude predicted in this impact assessment.

Prediction of drawdown using the calibrated groundwater flow model will be a leading indicator of impact and monitoring of water level at the receptors will be used to confirm impacts. If impacts are greater than predicted, the following contingency measures will be implemented:

- Impact assessment – the revised magnitude of the impact will be assessed for the full project duration from mining to mine closure and aquifer recovery.
- Make-good measures will be assessed and implemented if required, for instance deepening of existing users bores to ensure ongoing water availability.
- Additional water recycling methods will be explored, for example enhanced water recovery from tailings and maximised process water recycling.
- Alternative water sources will be explored, for instance extending / relocating the borefield further from receptors into deeper parts of the Georgina Basin might be considered – though this is likely to be cost prohibitive.

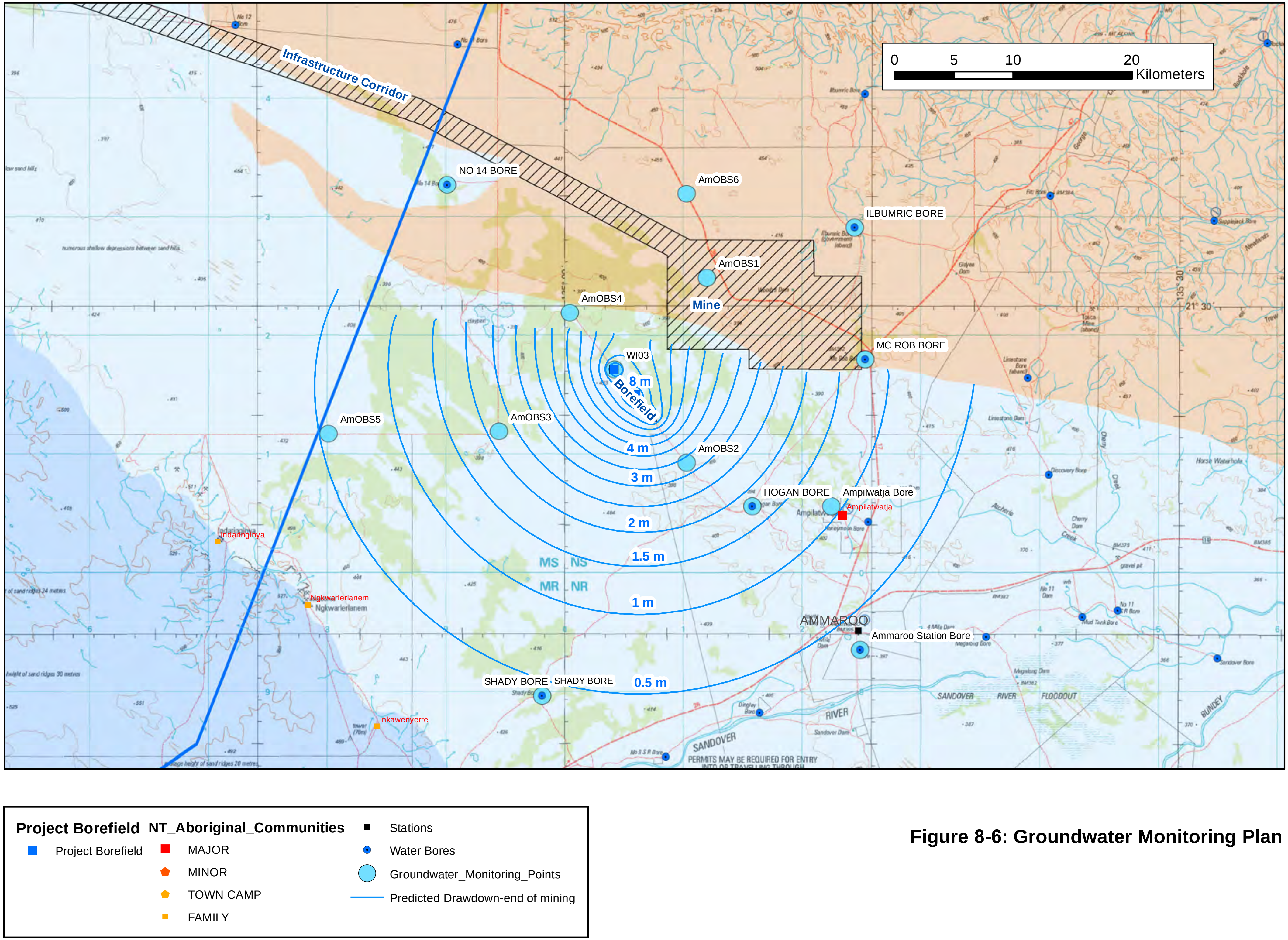


Figure 8-6: Groundwater Monitoring Plan

8.8.2 Mitigation of impacts associated with AMD

An AMD Management Plan is included in Appendix I. The Plan confirms that ore and waste rock are suitable for management in unlined monofil waste rock dumps. Waste rock and tailings will be disposed within the open void of the pit before being rehabilitated progressively.

Surface water and groundwater monitoring will be implemented as per the Water Management Plan (Appendix E). Monitoring will be undertaken in accordance with the Multiple Before-After Control-Impact (MBACI) approach appropriate to the scale of the project. The monitoring program has been designed to include:

- Control sites: upstream / up gradient monitoring sites which monitor background concentrations. Multiple control sites will be utilised.
- Adjacent: monitoring points situated adjacent to potential point sources of contamination (i.e. locations storing process water and dirty water), often called ‘point of discharge’.
- Impact Site: downstream / down gradient monitoring sites. Multiple impact sites will be utilised.

All monitoring sites will be located and installed in locations where the future project footprint will enable monitoring consistency throughout the project life. Analytes with specific reference to AMD monitoring include pH, EC, acidity and alkalinity, sulfate and metals.

Decreasing alkalinity is generally a good early indicator of deteriorating conditions in leachate from a WRD containing PAF material, and can therefore be tracked as an ‘early warning’ mechanism. Other trends that highlight the onset of AMD include increasing sulfate, increasing sulfate / alkalinity and sulfate to chloride ratio, decreasing pH values and an increase in soluble metals as a result.

Contingency plans specific to AMD management at the site would include an exceedance in the ground or surface water monitoring against site-specific trigger values. The approach would be to undertake a ‘root cause’ analysis whereby the causal link for the water quality exceedance would be determined. Adaptive management would then seek to implement an appropriate alternate management strategy to eliminate any future risk of a repeat, given the nature of the incident.

8.8.3 Mitigation of impacts associated with contamination

A Hazmat Management Plan will be developed that outlines chemical spill response management including:

- Compliance with all relevant legislation and standards.
- Hazardous materials to be appropriately stored in bunded areas, including certified self bunded facilities e.g. for liquid storage.
- Dedicated refuelling areas to include spill kits to allow for immediate clean-up of small spills.
- Bunding to have a storage capacity of 150% of the volume of hazardous materials being stored within.
- Inspection regime to monitor bunding capacity.
- Appropriate equipment available to remove fluids from bunding and secondary containments.

9. Biodiversity

9.1 Introduction

This chapter describes the flora, fauna and vegetation present within the project site and in the surrounding study area, including a description of biodiversity values at the species and ecosystem level, and in a local and regional context. This chapter also describes the potential direct and indirect impacts of the project on local and regional biodiversity, including listed threatened flora and fauna species. Mitigation measures that will be implemented in order to minimise the impact of project construction and operation are documented.

Section 5.4.1 of the draft EIS TOR provided the following environmental objective in relation to biodiversity:

> *The Project will maintain the conservation status, diversity, geographic distribution and productivity of flora and fauna, at the species and ecosystem levels, through the avoidance or management of adverse impacts.*

This chapter addresses the biodiversity values, as required in the TOR for the project.

The delegate of the Commonwealth Minister has determined that the project is a ‘controlled action’ that has the potential to significantly impact listed threatened species and communities (under Sections 18 and 18A of *the Environment Protection and Biodiversity Conservation Act 1999* – EPBC Act). The project will be assessed by preliminary documentation under section 95A (see Appendix B for further information).

Matters of National Environmental Significance (MNES) and other matters protected under the EPBC Act are discussed separately in Chapter 10: Protected matters under the EPBC Act. This chapter provides the environmental context and the detailed habitat information that is the background to a discussion of the impact on MNES.

Detailed biodiversity assessment is provided in Appendix J, including a detailed description of the methodology and results of flora, vegetation and fauna survey undertaken between 2011 and 2017.

9.2 Bioregional context

The study area falls within the Tanami bioregion. Tanami bioregion is comprised mainly of red sand plains with underlying rock strata occasionally exposed as hills and ranges. The sand plains are vegetated with mixed shrublands of *Acacia*, *Eucalyptus* or *Hakea* over spinifex hummock grasslands. In the ranges, *Acacia* shrublands occur over hummock grasses. However, the eastern extent of the bioregion, within which the project site occurs, only partially reflects this bioregional description, and is instead comprised of red earth soils dominated by Mulga or Gidgee plains, interspersed with red earth sandplains that support a mixture of hummock and tussock grass.

Land system mapping is included in Section 4.1.3.

9.3 Flora and vegetation

9.3.1 Habitats

Habitat mapping identified forty habitat units within the study area which fall within four main landform groupings and 11 habitat categories, as identified in Table 9-1 and mapped across the project site in Figure 9-1.

Table 9-1 Habitat units

Landscape class (ref Table 4-1)	Landform grouping	Landform description	Habitat categories
Desert sandplains	Red earth plains	Featureless, flat to slightly undulating surface with storm water runoff dispersed via sheet flow	Habitat category 1- red earth plains with tussock grass
			Habitat category 2- sandy red earth plains with tussock and/or hummock grass
Desert sandplains	Sandplains	Flat to undulating surfaces, with some areas forming linear broad rises that appear from aerial imagery as potential dune fields;	Habitat category 3 - red earth sandplains with hummock grass
			Habitat category - desert sandplains with hummock grass
Lateritic plains and rises	Rises and hills	Low rises (with variable rock content and soil depths) to hills and low ranges that have moderate relief and shallow soil cover.	Habitat category 5 - low rises with tussock grass
			Habitat category 6 - rocky rises with hummock grass
			Habitat category 7 - rocky hills with hummock grass
Alluvial floodplains	Drainage features	Alluvial plains, drainage floors, floodplains, seasonal swamps and defined drainage lines. All have relatively heavy soils; however the floodplains, swamps and drainages support soils with higher clay content that experience seasonal waterlogging.	Habitat category 8 - alluvial plains with tussock grass
			Habitat category 9 - drainage floors or floodplains with tussock grass
			Habitat category 10 - seasonal swamps)
			Habitat category 11 - drainage lines

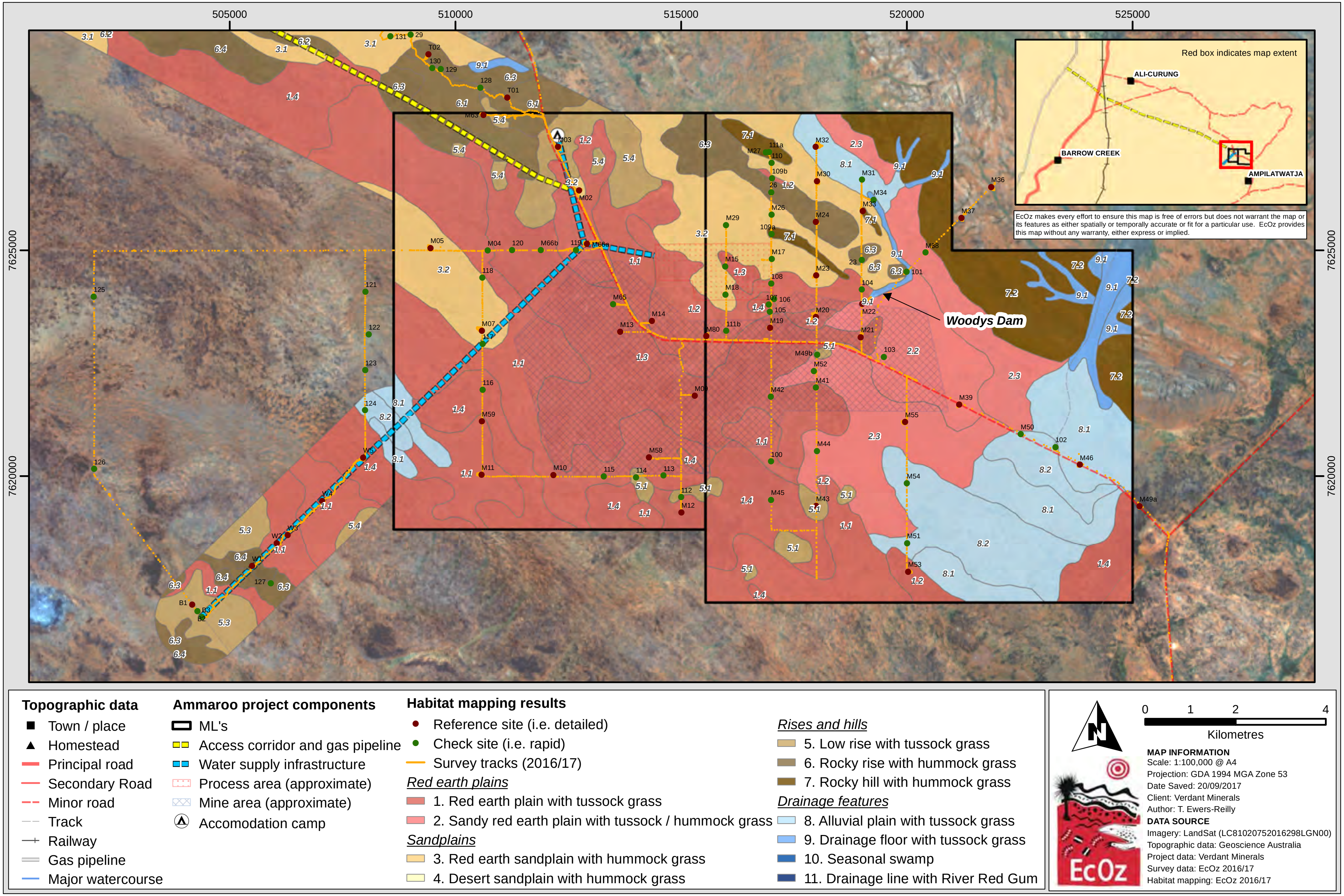


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Figure 9-1:Map 1 of 4 - habitat mapping survey results (2016-17)

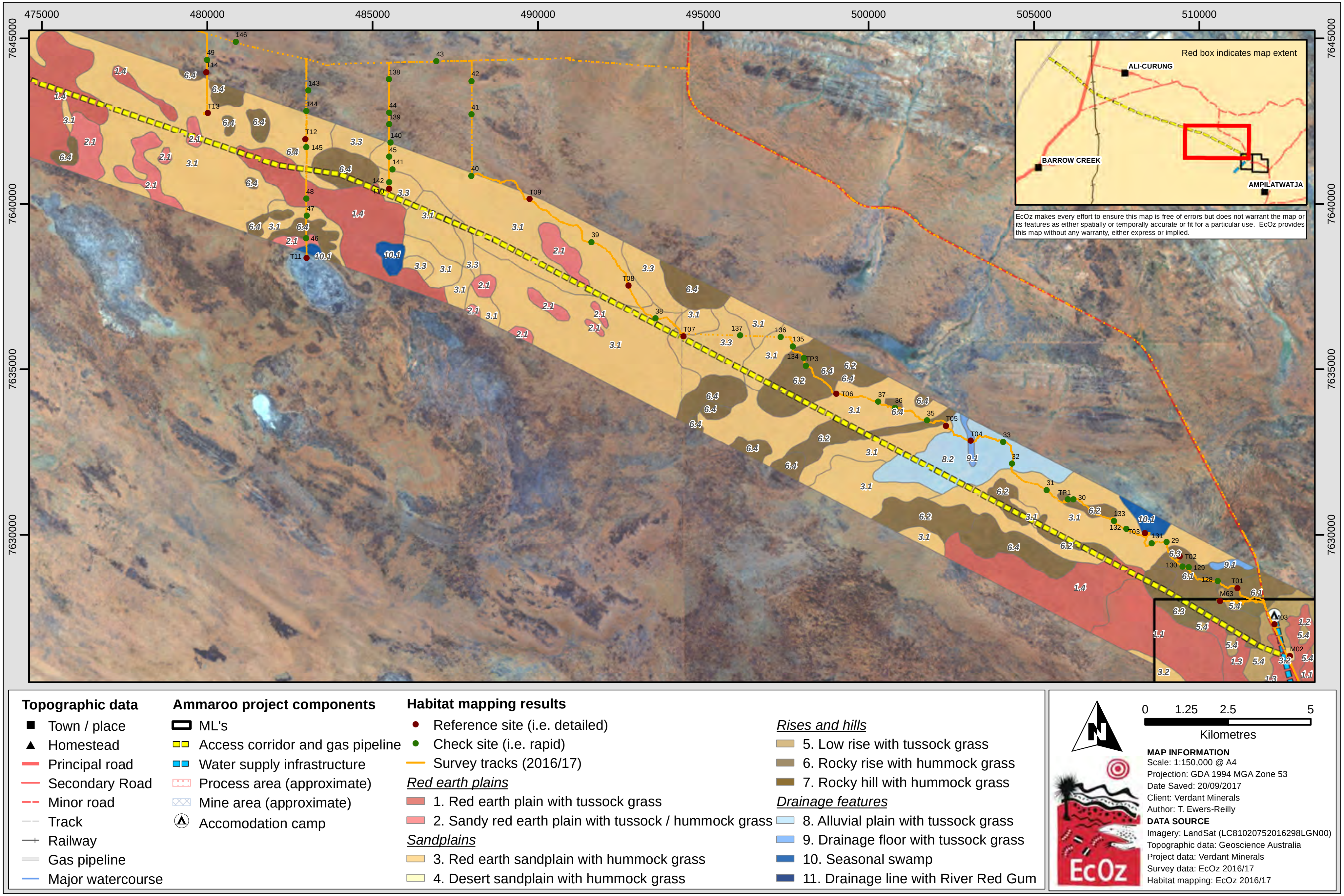

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Figure 9-1: Map 2 of 4 - habitat mapping survey results (2016-17)

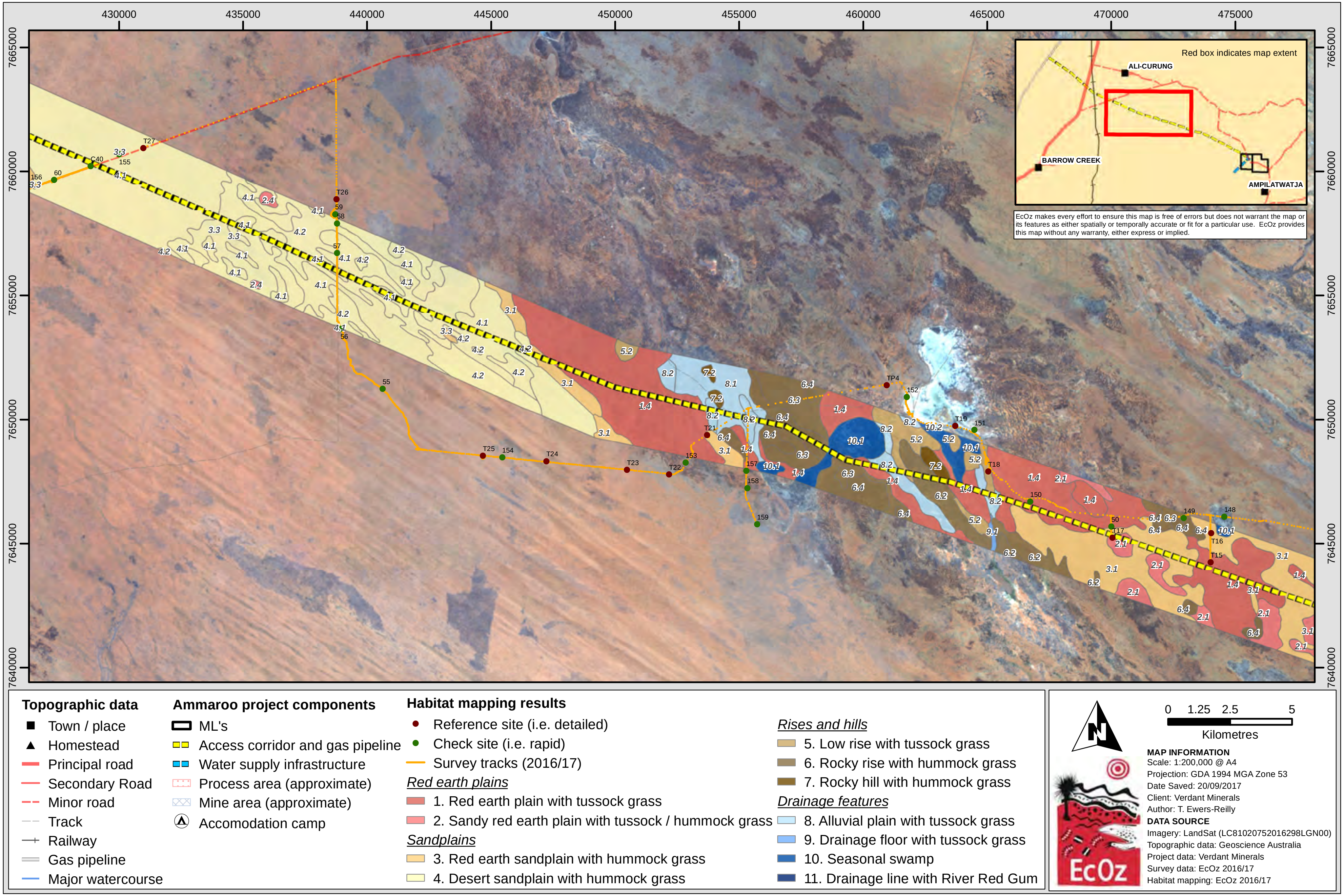

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Figure 9-1: Map 3 of 4 - habitat mapping survey results (2016-17)

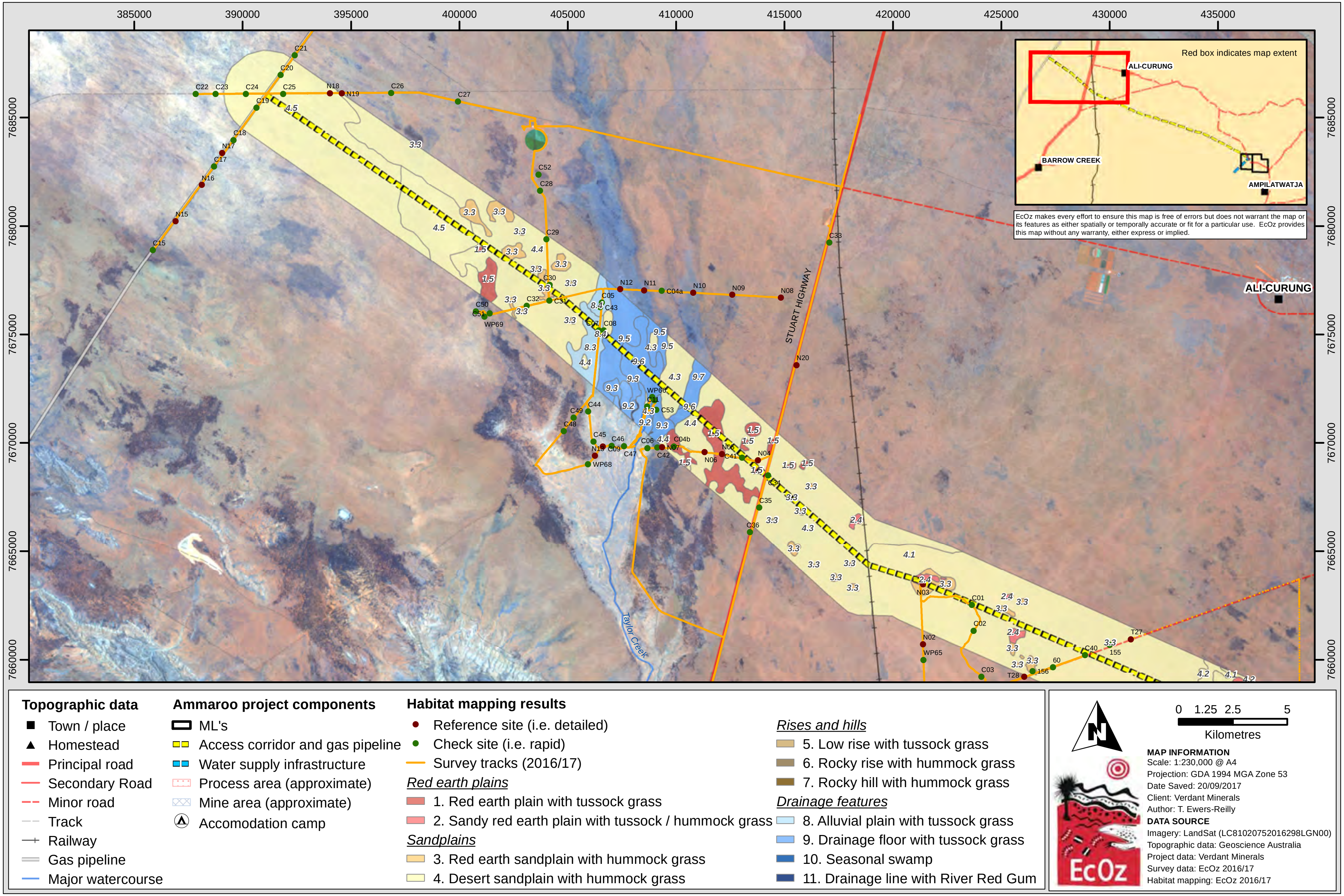

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Figure 9-1: Map 4 of 4 - habitat mapping survey results (2016-17)

9.3.2 Sensitive vegetation

The region in which the project site occurs contains only one potential sensitive vegetation type – riparian vegetation, i.e. vegetation associated with watercourses and wetlands. Habitat survey concluded that no riparian vegetation or wetland habitat occurs within the project site. Other habitat features thought to potentially support riparian vegetation or wetlands were drainage floors, floodplains and seasonal swamps (refer unit descriptions within habitat category 9 and 10). All these areas become seasonally (or infrequently) inundated, and support species adapted to wetter soil types. However, habitat surveys did not identify any of these areas to be of particular regional importance (such as presence of populations of significant species), nor to have habitat characteristics typical of wetland features.

Although these drainage features within the project site are not considered to be sensitive vegetation, it is likely they provide important seasonal (or permanent) refuge for native flora and fauna.

Habitat surveys identified riparian vegetation within the survey extent, but not within the project site, including:

- Tributaries of Taylor Creek (riparian vegetation)
- Small ephemeral swamps (wetlands)
- Drainage floors and floodplains (wetlands)
- Claypans (potential wetlands but dry most of the time)

Three tributaries of Taylor Creek were identified within the wider survey area for the infrastructure corridor. The western end of the corridor is associated with outfall areas of the Taylor Creek drainage system less than 1.3 km up-gradient, i.e. to the south of the infrastructure corridor. This habitat supported River Red Gum (*Eucalyptus camaldulensis*) along the creek banks. This generally constitutes one of the riparian vegetation types within the arid zone, however surveys noted that long-term pastoral land use in the region has resulted in a degraded watercourse vegetation community due cumulative pressures from weeds, trampling and fire.

There are no large wetlands within the project site; however, several claypans and small seasonal swamps occur in the vicinity of the infrastructure corridor; none are intersected by the project.

9.3.3 Flora species

Flora survey recorded a total of 348 flora species. A full list of species is provided in the Biodiversity Report (Appendix J). The *Poaceae* (grass family, 70 species), *Fabaceae* (pea family, 62 species), *Malvaceae* (29 species) and *Amaranthaceae* (24 species) were the most species-rich families recorded on the project site. The flora species identified were composed of:

- None that are threatened species under the EPBC Act and / or TPWC Act
- None that are 'Near Threatened' species in the NT (under the TPWC Act)
- Three that are 'Data Deficient'
- Five that are 'Not Evaluated'
- Thirteen that are introduced, of which one is a declared weed under the *Weed Management Act*
- Three that have an unknown status (i.e. but are generally considered as introduced species)

- Four endemic species found only in the Northern Territory:
  - *Austrobryonia centralis*
  - *Bonamia deserticola*
  - *Corymbia deserticola*
  - *Corymbia sphaerica*
- None that are considered to have a restricted range; and
- The remaining are listed as 'Least Concern' under the TPWC Act.
- The endemic species are widespread within the region and have been recorded both within and outside of predicted project disturbance areas.

9.3.4 Weeds

Despite a long history of cattle grazing and mineral exploration occurring throughout the region, there are very few weeds within the project site. A review of the NT Weed Branch weed dataset identified four declared weed species that have the potential to occur in the region of the Project site including:

- Parkinsonia (*Parkinsonia aculeata*) – Class B
- Rubber Bush (*Calotropis procera*) – Class B
- Athel Pine (*Tamarix aphylla*) – Class A
- Castor Oil Plant (*Ricinus communis*) – Class B

The most frequently reported species – with more than 1,300 records – is Parkinsonia.

The 2016 and 2017 field surveys identified thirteen introduced flora species, of which one is listed under the Weed Management Act as a Class B species (Rubber Bush, *Calotropis procera*). Previous surveys within the project site and surrounding area recorded the presence of Buffel Grass (*Cenchrus ciliaris*) in low densities.

9.4 Fauna

9.4.1 Fauna species

A total of 133 fauna species have been recorded during seven surveys within and surrounding the Project site between 2011 and 2017. These comprise 29 reptiles, 86 birds and 18 mammals (refer Appendix J for a complete species list). Sandplains and desert sandplains habitat areas recorded the highest activity and species' richness with all but 17 species recorded within the sandplain habitat.

The fauna species identified comprised of:

- None that are threatened species under the EPBC Act and/or TPWC Act
- Four that are 'Near Threatened' in the NT (under the TPWC Act)
- Two migratory species under the EPBC Act
- None that are 'Data Deficient' or 'Not Evaluated' under the TPWC Act
- None that are endemic species
- The remaining are listed as 'Least Concern' under the TPWC Act

9.4.2 Threatened fauna species

No threatened fauna species have been identified during the seven surveys completed between 2011 and 2017. There are several records of the Grey Falcon in the region and the entire project area constitutes suitable habitat. It is expected that foraging Grey Falcon (individuals or pairs) will occur within the project area at some time.

Nineteen threatened species (Commonwealth and/or Northern Territory-listed) were determined to have potential to occur in the region of the project site. For each of these species, the likelihood of it occurring within the project site was then assessed based on habitat requirements, distribution, and the number and dates of proximate records. The likelihood assessment concluded that:

- Five species were ranked as having a ‘high’ or ‘medium’ chance of occurring within the Project site. Therefore, these species were the focus of field studies.
- Four species were ranked as having a ‘low’ chance of occurring within the project site, so no specific surveys were carried out between 2011 and 2017.

On completion of targeted field surveys for the five high or medium ranked species and/or habitat suitability assessment, the likelihood assessment was reviewed and concluded:

- No threatened species were recorded within the project site.
- One threatened species – Grey Falcon – is considered likely to occur within the project site.
- Four threatened species that were considered by the preliminary assessment to have a medium chance of occurring within the project area are – post-field surveys – now considered to have a low likelihood of occurrence within the project site.

The procedure used for the likelihood of occurrence analysis is detailed in the Biodiversity Report (Appendix J).

Table 9-2 Threatened species 'likelihood of occurrence' assessment

Likelihood	Common name	Scientific name	Status[1] NT	Status[1] Cth
High	Grey Falcon	*Falco hypoleucos*	VU	-
Medium	No species			
Low	Australian Painted Snipe	*Rostratula australis*	VU	EN
	Night Parrot	*Pezoporus occidentalis*	CE	EN
	Princess Parrot	*Polytelis alexandrae*	VU	VU
	Red Goshawk	*Erythrotriorchis radiatus*	VU	VU
	Great Desert Skink	*Liopholis kintorei*	VU	VU
	Brush-tailed Mulgara	*Dasycercus blythi*	VU	-
	Greater Bilby	*Macrotis lagotis*	VU	VU
	Southern Marsupial Mole	*Notoryctes typhlops*	VU	-
Species identified by desktop database searches but considered to have no chance of occurrence within project area: *Typhonium sp. Sandover*; Australian Painted Snipe (*Rostratula australis*), Night Parrot (*Pezoporus occidentalis*), Curlew Sandpiper (*Calidris ferruginea*); Black-footed Rock-wallaby (*Petrogale lateralis (Mac. Ranges)*); Burrowing Bettong (inland subspecies) (*Bettongia lesueur grayi*); Central Rock-rat (*Zyzomys pedunculatus*); Common Brushtail Possum (South NT) (*Trichosurus vulpecula vulpecula*); Dusky Hopping-mouse (*Notomys fuscus*); Golden Bandicoot (*Isoodon auratus*); Mala (*Lagorchestes hirsutus*); Western Quoll (*Dasyurus geoffroii*).				

Note 1: CE – Critically Endangered; EN – Endangered; VU – Vulnerable

9.4.3 Introduced fauna species

Signs or sightings were made during ecological surveys of five introduced fauna species:

- Cat (*Felis catus*)
- Rabbit (*Oryctolagus cuniculus*)
- House mouse (*Mus musculus*)
- Fox (*Vulpes vulpes*)
- Cattle (*Bos taurus*)

Two predator species were identified during the 2016/17 surveys within the project area – Cat and Dingo. Of these, the Cat was widespread and well established within the project area while the Dingo were scarce. There have also been recent records of Red Fox (2011/12 survey) but signs were not observed during the 2016/17 survey.

9.5 Potential impacts

9.5.1 Existing threatening processes

Potential and existing threats to biodiversity that have been identified within the bioregion include:

- High frequency fires
- Cattle grazing

- Introduced flora and fauna

Most of the project area has burnt two to three times between 2000 and 2016 (including large scale fires), with some areas burnt four times, which is a high frequency. Therefore, it is expected that fire-sensitive flora and fauna species have been negatively impacted by the current fire regime in the region.

Pastoral stations cover the entire study area, apart from small areas of Crown land containing roads and rail infrastructure. Consequently, environmental impacts typically associated with cattle grazing occur within the study area (i.e. weeds, erosion and soil degradation, changes to soil surface structure/infiltration, surface water degradation and altered fire regimes. Cumulatively, these impacts can have a negative influence on biodiversity. The level of impacts from pastoral activities on biodiversity values is dependent on the management of stations (i.e. stocking rates, provision of artificial water points and prescribed burns), and also the sensitivity of vegetation communities to grazing.

Exotic flora species are widespread in the region, and there is one declared weed species currently listed under the *Weeds Management Act* that has been identified during the project site surveys. Weed species in the region mainly occur within watercourses, alluvial flats, disturbed areas (i.e. roadsides, fences and water-points), and on drainages or depressions. Sandplains and rocky rises generally do not support declared weed species. Although not a declared weed, introduced Buffel Grass (*Cenchrus ciliaris*) is common in the area and is considered a threat to biodiversity values in the region.

9.5.2 Project impacts

This section identifies the potential direct and indirect impacts on flora, vegetation and fauna presented by the project. These include potential impacts during construction, operation and rehabilitation, and closure. The construction period is expected to last up to 24 months, and mining and processing operations will continue for a period of at least 25 years following construction. The layout of the proposed project site is shown in Chapter 2: Project description.

Construction

The principal construction activities that will have the potential to impact on flora, vegetation and fauna are:

- Clearing vegetation and associated direct loss of vegetation
- Clearing of vegetation and associated direct loss of habitat
- Clearing of vegetation fragmenting habitat and limiting fauna movement
- Clearing of vegetation and soil disturbance resulting in erosion and/or sedimentation
- Introduction or spread of weeds resulting in habitat modification
- Machinery use and potential impact on individual fauna species via strike
- Trenching for the 137 km gas pipeline trapping fauna.

Operations

The principal construction activities may also be applicable to operations. Additional, potential to impacts on flora, vegetation and fauna as a result of principal operational activities are:

- Alteration of hydrological regimes associated with mining in the pit
- Alteration of hydrological regimes associated with linear infrastructure or other impediments altering surface flows

- Introduction or spread of weeds resulting in altered fire regimes
- Fragmentation of habitat resulting in an edge effect and reduction in habitat quality in uncleared areas
- Machinery and vehicles resulting in soil compaction
- Groundwater drawdown from the borefield and/or changes to groundwater flows reducing environmental water
- Noise from machinery disrupting roosting of foraging habitats and displacing fauna
- Dust from mining and vehicle movement increased dust deposition on vegetation
- Poor waste management increasing population of vertebrate pest species
- Linear infrastructure facilitating the movement of feral fauna across landscape
- Accidental chemical/hazardous material release contaminated surface or groundwater.

Closure

Post-closure of the mine, potential impacts to flora, vegetation and fauna are:

- Inconsistent or inadequate rehabilitation reducing the quality of ecosystems in a post-closure landscape.

A detailed description of the likelihood and consequence of these impacts is provide below.

9.5.3 Risk assessment summary

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

Of the twenty identified hazards, two were assessed as having a current risk rating of ‘high’, three rated as ‘medium’ with the remaining fifteen rated as ‘low’. A summary of the risk assessment results is provided in Table 9-3. Multiple hazards may exist as a result of a one potential event. Refer to full risk assessment in Chapter 6 for details.

Table 9-3 Qualitative risk – biodiversity

Potential event	Residual risk level
Vegetation clearing	High
Edge effect	Low
Fragmentation of habitat	Medium
Weeds	Medium
Bushfire	Medium
Feral fauna - increase in resource competition and/or predation of native fauna	Low
Machinery and vehicles striking fauna	Medium
Soil erosion	Low
Hydrological changes to surface water	Low
Hydrological changes to groundwater	Low
Accidental tailings release	Low
Accidental chemical/hazardous material release	Low
Noise	Low
Dust	Low
Rehabilitation	Low
Fauna interaction with TSF	Low

Potential event	Residual risk level
Discharge or seepage of poor quality water from mine infrastructure	Low

9.5.4 Impacts on flora species and vegetation

Vegetation clearing

Project activities will include vegetation clearing. The broad vegetation types Mulga woodlands and shrub lands, and hummock grasslands that will be cleared are common within the region. The project site is within pastoral stations, so there is existing habitat degradation typically associated with cattle grazing in central Australia. Table 9-4 presents the area of each habitat unit that will be cleared during the life of the project. The cleared land is expected to total 3,775 hectares over 27 years.

Although the site will be progressively rehabilitated, there will be a lag between topsoil reinstatement and species recolonisation and that lag will vary according to species. There will therefore be an effective loss of 3775 hectares of habitat for a number of decades. This corresponds to a major impact on the integrity of the eleven habitat categories within the clearing footprint, and one that can only be gradually mitigated as rehabilitation progresses.

Table 9-4 Area of each habitat unit that will be cleared

Habitat group and category	MLs				Access corridor			Water supply
	Mine pit	Process / admin / accomm.	TSF	MDR realignment	Gas/rail	Gas only	Borrow pits / ballast	15
Red Earth Plains								
1. Red earth plains with tussock grass	1,256	235	90	4	140	3.5	186	0
2. Sandy red earth plains with tussock and/or hummock grass	235	0	0	6	10	0	0	0
Sandplains								
3. Red earth sandplains with hummock grass	0	358	0	28.5	180	1.5	72	0
4. Desert sandplains with hummock grass	0	0	0	0	322	94	0	0
Rises and hills								
5. Low rises with tussock grass	8	0	0	6	9	0	85	1.5
6. Rocky rises with hummock grass	0	57	0	5	65	0	145	1.5
7. Rocky hills with hummock grass	0	0	0	0	3	0	0	0
Drainage features								
8. Alluvial plains with tussock grass	0	0	0	0	42	5	37*	2
9. Drainage floor and floodplains with tussock grass	1	0	0	0.5	0	11	0	0
10. Seasonal swamps	0	0	0	0	3	0	25*	0
11. Drainage lines	0	0	0	0	0	0	0	0
Total area of disturbance (hectares)	1,500	650	90	50	800	115	550	20

*not targeted for clearing, but within the general disturbance area

Edge effect

A potential consequence of vegetation clearing is the creation of an edge effect, where the disturbance of intact vegetation results in the newly-created edges between the intact and disturbed areas. These areas commonly become lower quality habitat for species occurring in that vegetation.

Apart from the increased likelihood of weed infestation, edge effects are more pronounced in forested areas where the consequences are increased through exposure to increased wind and sunlight (which change micro-climates, reduce soil moisture and encourage lower canopy plant species), and a greater understorey (increasing vulnerability to fire). It is considered that the open, sparsely vegetated habitats within the project site will not experience any significant or substantial edge effects that will have a perceptible effect on ecosystem integrity.

Weeds

There is the potential that soil disturbance and movement of vehicles and machinery, could lead to weed introduction or proliferation within the project site and adjacent areas. The consequence could be a reduction in habitat quality in areas adjacent to the project site, leading to a decrease in biodiversity because of resource competition and/or habitat modification. Weed proliferation can also result in higher vegetation fuel loads, and therefore more intense bushfires, which may cause a reduction in ecosystem integrity.

If weed management is not implemented consistently and effectively, it is possible there will be weed infestations within disturbed areas of the project site, with a moderate, impact upon ecosystem integrity.

Soil erosion, sedimentation and compaction

The establishment of the project site, including vegetation clearing and land disturbance, combined with rainfall run-off has the potential to cause erosion and/or sedimentation. In addition, throughout the life of the project the use of heavy vehicles could cause soil compaction. This could alter landscape character, reduce surface water quality and cause difficulty in vegetation re-establishment. These impacts could lead to a reduction in habitat quality for flora and fauna.

Adherence to an Erosion and Sedimentation Control Plan would result in impacts no greater than a minor (i.e. small area) reduction in ecosystem integrity.

Compromised groundwater-dependent ecosystems

The standing water level at the existing VRM production bore is 65 m depth (though the water table was at 80 m). Field observations reflect this depth to groundwater, showing no indication of interactions between aquifers and surface vegetation. No groundwater-dependent ecosystems have been identified within the project survey areas. Therefore, although the project will be drawing upon groundwater to supply much of its water requirements, the impact of this on ecosystem integrity is expected to be insignificant.

Alterations to hydrological processes

There is no permanent surface water within the project site, apart for a few stock dams supplied by bores or seasonal run off e.g. Woody's Dam. There are drainage lines throughout the project site which can contain large volumes of rainwater on occasion. Project infrastructure can be engineered to accommodate surface water flows as a result of these rainfall events.

For these reasons, the likelihood of project activities impacting on surface water such that ecosystem integrity is compromised would be rare, and any potential consequence would be insignificant. Additional information relating to hydrological characteristics within the project site, and mitigation measures that will be implemented to maintain hydrological processes, refer to Chapter 7: Surface water.

Discharge or seepage of poor quality water from mine infrastructure

There is the potential for surface or in pit TSF to leak poor quality water into the surrounding environment, compromising habitat quality. Given the low sulfur content, generally low metal toxicant content and low metal and salt leachability of waste rock and tailings, the primary (pre-management) risk level is currently low. With appropriate design controls in place (see Chapter 8: Groundwater), to manage discharge or seepage of tailings water into the surrounding environment, it is expected that the seepage would pose little harm to biodiversity values and therefore would be a minor consequence.

Dust

The main potential sources of dust are from trucks during mining operations and from de-stabilised soil stockpiles being mobilised by wind after vegetation clearing. However, the worst-case dust deposition rate is below the amenity criterion of 2 g/m^2/month (up to 12 grams of dust deposited over every square metre across an entire annual cycle), which is of the same order of magnitude that deposits naturally. Consequently, the impacts associated with dust deposition on flora and fauna are expected to be insignificant.

Fire

Project activities have the potential to provide an ignition source for bushfires, which can cause direct mortality to fauna, displacement of fauna, and/or reduction in ecosystem integrity. The latter is especially likely if project generated bushfires increase the frequency of bushfires that occur in the region.

Adherence to a Bushfire Management Plan will minimise the likelihood of project generated bushfires to very low. Should one occur, however, the consequence could be major (i.e. affecting many square kilometres of habitat).

Inappropriate / ineffective rehabilitation

Topsoil will be stripped and laid out in windrows. Mining involves progressive rehabilitation over the life of the mine. It is expected that the rehabilitation of the project site will be governed by a Rehabilitation Plan that details how land will be cleared, vegetation stored, land reinstated and active rehabilitation undertaken give rehabilitation the best chance of being successful.

Adherence to the Rehabilitation Plan would result in project activities not causing anything larger than a minor (i.e. small area) reduction in ecosystem integrity.

9.5.5 Impacts on fauna species

Fauna interactions with machinery and vehicles

There is the potential for interactions between the machinery used for vegetation clearing and fauna present in that vegetation. This could result in reductions in the local populations of some species that are less able to, or are reluctant to, evacuate their hiding places prior to them being cleared – such as nesting birds, nocturnal animals, and smaller reptile and mammal species that hide in burrows or tree hollows.

The use of vehicles during the life of the project to transport materials, personnel or equipment means there is the potential for them to collide with fauna. This could result in impacts on the local populations of some species that are more vulnerable to fauna strike because of their habits (i.e. those with preferences for open areas or those with slow reaction times). The scale is expected to be so low however, that there is an insignificant effect on ecosystem integrity.

It is concluded that there will be mortality of individuals from a broad range of species – i.e. a minor reduction in ecosystem integrity – with no particular species identified as being especially susceptible to this impact.

Noise

Project generated noise has the potential to reduce the quality of nearby nesting, roosting and/or foraging habitats for fauna, and therefore displace fauna into sub-optimal habitats, increasing their susceptibility to predation and competition. The environment surrounding the project site is such, however, that there are not expected to be any noise-sensitive species present in significant numbers (i.e. bat roosts).

It is difficult to quantify and measure noise disturbance to native fauna given that different species have different tolerances and different capacities to move away from a noise disturbance. None of the biodiversity surveys undertaken for the project have recorded any noise-sensitive species present in significant numbers (i.e. bat roosts). There will be an impact of noise on the surrounding environment – during construction the noise sources will be temporary and localised; during operations the noise sources (i.e. plants and generators) will likely be some buffered by distance from the natural environment. The expected consequence, therefore is a minor impact on ecosystem integrity. .

Habitat fragmentation

Habitat fragmentation due to vegetation clearing could result in the reduction in the quality of ecosystems. Habitat fragmentation is considered in this context to be the division of large, continuous habitats into smaller, more isolated remnants. These remnants are then subject to the complex processes of edge effects, habitat degradation and island biogeography, leading to loss of species' diversity.

Vegetation clearing for infrastructure corridor, process plant, accommodation camp and water supply utilities, and then for the mine site over a number of decades, will possibly fragment the project site and adjacent areas. Because the vegetation communities within the project site are regionally common, contiguous (i.e. occur in very large patches broken only by the occasional dirt track) and widespread, the consequence of any fragmentation will be minor in terms of areas of reduction in ecosystem integrity.

Fauna interactions with tailings water

If the water quality of the tailings storage facilities (TSF) contains harmful elements, there is the potential for some fauna species to be negatively impacted when coming into contact with that water.

However the surface TSF will only be used for 2–3 years, thus limiting the extent of any negative impact of the surface TSF on fauna. The in-pit TSF is unlikely to be attractive to most fauna species, and so is expected to contribute little to this potential impact. These factors, combined with the findings of the tailings geochemical analysis (i.e. the material can be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste. The material is suitable for management in unlined monofil waste rock dumps, with normal sediment and erosion control and monitoring of the key metals and metalloids noted as being elevated in acid and neutral leachate) The overall impact is concluded to result in a minor (i.e. short term and few species) reduction in ecosystem integrity.

Chemical waste and hazardous chemicals

Project activities will involve the transport and storage of fuels and other hazardous chemicals. They will also involve the generation, transport and storage of chemical wastes. Due to their potential impacts on humans and the environment, both of these activities are well regulated, and therefore the potential for the accidental release of chemicals to impact upon flora and fauna, is low and the probable scale is small, resulting in, at worst, a minor reduction in ecosystem integrity.

Vertebrate pest species

The project will require land fill for disposing of non-regulated (including putrescible) waste. This has the potential, if the land fill is poorly- managed, to encourage vertebrate pest animal species to use the site as an additional food resources. The result could be an increase in resource competition and/or predation of native fauna. Assuming that a Waste Management Plan is successfully implemented during construction and operations, it is considered unlikely that Project activities will cause an increase in vertebrate pest species, and so the effect on ecosystem integrity from that potential impact will be insignificant.

Linear infrastructure has the potential to increase the area of habitat used by non-native predators (e.g. cats) through the creation of an easily traversed corridor. Cats are already common throughout the entire project area and were identified in a variety of habitat types (via tracks and sightings). The establishment of linear infrastructure is unlikely to increase the distribution of the cat population.

9.6 Mitigation measures

Mitigation measures will be required to avoid, control, reduce or eliminate impacts of project activities on flora and fauna and their habitat. Monitoring may be required for some aspects, to evaluate the level of residual impact and effectiveness of mitigation.

This section provides guidance on the mitigation measures and monitoring that will be considered for all phases of the project. All mitigation and monitoring efforts will be described in detail in a Biodiversity Management Plan (Appendix E), which will be developed and approved prior to impact activities taking place.

9.6.1 Mitigation of impacts associated with land clearing

The amount of land disturbance and vegetation clearing will be minimised. Construction personnel will be briefed during inductions regarding the conservation value of surrounding habitats and their responsibilities with regard to protecting these habitats during construction.

Additional control measures will include:

- Vegetation Clearing Procedure will be developed in association with the Biodiversity Management Plan and include:
  - Procedures for demarcating the limits of clearing
  - Staged clearing of vegetation to minimise areas of bare ground.
- Strict fire prevention management protocols to prevent wildfire during clearing activities;
- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. lay down areas for construction).
- Development and implementation of a land stabilisation and revegetation strategy.

- Progressive revegetation of cleared land as project activities are completed.

A specific procedure will be developed for the unlikely event that a listed threatened species is encountered within the project footprint during construction or operations. This procedure will include the following actions:

- Notify DENR and (if relevant) DoEE.
- Undertake sufficient fieldwork by a suitably qualified ecologist to assess the significance of the occurrence and the degree to which project activities will likely impact upon the species.
- Develop, in consultation with DENR/DoEE an appropriate strategy for minimising any impact to the local occurrence of the species.
- Implement the strategy.

9.6.2 Mitigation of impacts associated with soil erosion

An Erosion and Sedimentation Control Plan (ESCP) and Water Management Plan will be developed which outlines project surface water interactions and how soil will be managed to minimise soil compaction, erosion and sedimentation.

A draft ESCP will include:

- Installation of erosion and sediment control measures prior to construction.
- Regular inspection of erosion and sediment control measures, particularly following rainfall events, to ensure their ongoing functionality.
- Staging of construction to occur in the dry season.
- Runoff from disturbed and rehabilitated areas diverted into sediment ponds and not discharged into the natural system before monitoring.
- Constructing adequate bunds around potential contamination sources, to contain contaminated water in the event of heavy rainfall.
- Runoff from stockpiles and workshops would be directed to sediment basins.
- Siting of stockpiles away from natural drainage channels.
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP.
- Minimise surface water infiltration and water runoff.
- Spill clean-up and emergency management procedures developed and implemented.
- Personnel to be trained in the use of spill kits and emergency response procedures.

9.6.3 Mitigation of impacts associated with chemical spills

A Hazmat Management Plan will be developed that outlines chemical spill response management and management of chemicals, wastewater and fuels in proximity to water. This plan will include as a minimum the following:

- Hazardous materials to be appropriately stored in bunded areas.
- Dedicated refuelling areas to include spill kits to allow for immediate clean-up of small spills.
- Bunding to have a storage capacity of 150% of the volume of hazardous materials being stored within.
- Inspection regime to monitor bunding capacity.

- Appropriate equipment available to remove fluids from bunding and secondary containments.

9.6.4 Mitigation of impacts associated with feral species

A Biodiversity Management Plan will be developed to outline the monitoring and control of feral species. The plan will include the following:

- Routine monitoring of feral species to record population changes.
- Implementation of performance indicators, specific to population growth, to trigger feral animal control within the Project site.
- Procedures for feral animal control.

The following Threat Abatement Plans will be considered in the development of the feral animal management:

- Threat abatement plan for predation by European red fox
- Threat abatement plan for predation by feral cats

A Waste Management Plan will also be developed, which will require that putrescible waste dumped in the land fill is not accessible or attractive to native or pest fauna.

9.6.5 Mitigation of impacts associated with weeds

A Weed Management Plan will be developed, in association with the Biodiversity Management Plan, which will detail strategies to limit both the introduction of new weeds within the project site and the spread of existing weeds during project activities. The plan will include the following:

- Information regarding type and location of weeds of concern within the project site.
- Measures to prevent the spread of weeds, including hygiene procedures for equipment, footwear and clothing.
- Mitigation measures to minimise the spread of weeds such as ensuring that any machinery entering the project site is free of weed seed. This would typically be managed through inspections and the use of vehicle wash down stations.
- Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road.
- Areas supporting existing weed infestations, or vulnerable to weed infestation, will be avoided where practicable.
- Protocols for weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site.
- Weed disposal protocols.
- Ongoing control of new weed outbreaks.
- Routine monitoring of the Project site (including stockpiles and rehabilitated areas) and surrounding vegetation to identify new weed populations and monitor the effectiveness of weed control measures.
- Topsoil from weed affected areas will be stockpiled in a designated area with appropriate signage and bunding. Weed infested topsoil will be treated as required to eradicate weeds prior to re-spreading in rehabilitation areas.
- All staff and contractors will be informed of weed hygiene measures and weed reporting requirements during the site induction.

9.6.6 Mitigation of impacts associated with fire

A Bushfire Management Plan will be developed, in association with the Biodiversity Management Plan, and will require that fire breaks are created and all possible measures to prevent the ignition of a bushfire are in place. The plan will include:

- All construction activities, including establishment and operation of temporary camps, will occur within a cleared project footprint to minimise the risk of ignition sources coming into contact with flammable material (such as cleared vegetation). Establishment and maintenance of fire breaks around high-risk areas / activities.
- All welding, cutting and grinding works undertaken will require approval via an internal hot works permit system.
- Fire ratings and warnings in the area will be monitored with liaison with Bushfires NT as required.
- Strict fire prevention management protocols to prevent wildfire during clearing activities.
- Installation / implementation of fire detection and suppression systems including dedicated fire extinguishers.
- All site personnel will be required to undertake fire control training, including the correct use of extinguishers.
- All mobile equipment to be fitted with fire suppression systems.
- All vehicles are required to carry a fire extinguisher and two-way radio.
- Emergency response procedures, team and equipment.
- Establishment of dedicated fire water system on site.
- Erosion control in waterways, if fire should occur and results in loss of vegetation that otherwise stabilises soil/sediments.
- Undertake active fire management and the use of cool-season control burns if needed.

9.6.7 Mitigation of impacts associated with water flows

A Water Management Plan will be developed and implemented. This will include the following:

- Undertake groundwater flow model validation to confirm the extent of groundwater extraction and drawdown.
- Establish ground water monitoring bores to assess impacts over time on water table.
- If significant impacts are identified consider mitigation options. This could include modification of the pumping regime to manage groundwater levels.
- Engineer linear infrastructure to manage catchment surface flows.
- Engineer mine site infrastructure are located outside of the 1% AEP flood affected area, or placed on pad areas raised above the one per cent AEP flood level.
- Maintain surface water so that clean water is diverted around the site using flood levees, implement a sediment control water management system across the site and treat process water prior to disposal (if required).

9.6.8 Mitigation of impacts associated with dust

A Dust Management Plan will be developed and implemented (refer to Chapter 15: Air). The Plan would include as a minimum, application of industry dust control measures including:

- Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials.
- Reduced vehicle speeds.
- Minimise open areas exposed to wind erosion.
- Minimise time between stripping and construction/mining operations.
- Progressive reinstatement of waste rock and top soil as construction works are completed.
- Ongoing dust deposition monitoring program.

9.6.9 Mitigation of impacts associated with noise

A Noise Management Plan will be developed and implemented (Refer to Chapter 16: Noise). This will have consideration of NT EPA Noise Guidelines, and include:

- Minimising noise wherever possible.
- Quiet equipment selection, including the selection of gas turbines unit with noise attenuators.
- Scheduled maintenance as per operating manual requirements.
- Procedure to limit high-impact noise to daylight hours only where possible (this could reduce the impact on nocturnal fauna).

9.6.10 Mitigation of impacts associated with tailings water ingestion

Design and management of the surface TSF should include the following:

- The reduction of impacts of TSF on wildlife by following best practice guidelines currently recommended for the Northern Territory where practicable.
- The reduction of the attractiveness of the dam landscape for wildlife via design that includes, but is not limited to, the reduction of the dam surface area, removing dam bank vegetation, creating steep dam walls if feasible, providing alternative adjacent ‘fauna friendly’ water sources, and avoiding the creation of islands in the dam.
- Monitoring of wildlife visitation of the TSFs and developing specific management responses if mortality of fauna occurs. This may include employing bird deterrence equipment and activities.

9.6.11 Mitigation of impacts to fauna injury and death from collisions with machinery and vehicles

A Site Traffic Management Plan will be implemented to minimise and mitigate the effects of increased road traffic or increased road network on the threatened species populations (refer to Chapter Transport). This will include the following actions:

- Keep the proposed road network to a minimum and upgrade and utilise existing vehicle tracks.
- Provide road safety and awareness training to all staff and contractors with respect to safe driving in areas where native wildlife occurs.
- Implementing and enforcing speed restrictions in high-use areas.

- Limiting the movement of vehicles at night (between the periods of one hour before dusk to one hour after dawn).
- Documenting location and time of day of roadkill within the project site e.g. along haul roads, to determine high-risk periods or locations (additional mitigation may be required).

9.6.12 Rehabilitation strategies

The Mine Closure Plan (Chapter 17: Rehabilitation) will detail how land will be rehabilitated including how vegetation stored, land reinstated and active rehabilitation undertaken in the optimal way to give rehabilitation the best chance of being successful. This plan will include the following:

- Areas not required for ongoing operations will be progressively rehabilitated.
- Locate and design landforms to be rehabilitated to optimise blending with the surrounding topography.
- Stockpile vegetative material and topsoil for later use.
- Topsoil stockpiled in a designated area away from drainage lines, to prevent erosion or run-off.
- Adherence to a Weed Management Plan in stockpile and rehabilitation areas.
- Minimise period of time of stockpiling of vegetation and topsoil.
- Seeds collected for the rehabilitation program will be sourced locally, wherever possible.
- Annual monitoring of rehabilitation areas, which would assess the species diversity, plant density and community structure against agreed completion criteria, which include:
  - Species richness, species diversity and plant density of the restored community exceeds the median in the range of values established for baseline vegetation communities.
  - Dominant species in the restored community are also dominant in the baseline vegetation communities.
  - If monitoring identifies that completion criteria are not being met, additional rehabilitation and monitoring would be completed until such criteria are met.

10. Protected matters under the EPBC Act

10.1 Introduction

This chapter addresses matters specific to the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), and in particular, potential impacts on Matters of National Environmental Significance (MNES). The EPBC Act focuses on Australian Government interests relating to the protection of matters of national environmental significance (MNES), whilst the states and territories have responsibility for matters of state and local environmental significance. The Act has been discussed in more detail in Chapter 3 of this draft EIS.

The project was referred to the DEE (formerly DOE) on the 6 June 2014. It was subsequently determined on 03 August 2014 that the project was a controlled action due to potential impacts to listed threatened species and communities (sections 18 & 18A).

The Project requires assessment and approval under the EPBC Act (EPBC 2014/7260). It will be assessed by the DEE as the referral/referral decision was completed prior to the development of a bilateral agreement between the DEE and NT EPA.

This chapter provides an assessment of the threatened fauna species listed under the EPBC Act that are present or considered likely to occur within the project site.

10.2 Background

10.2.1 Targeted surveys

Targeted threatened species' surveys were conducted in October/November 2016 and March/April 2017. They focused on populations of EPBC listed species that occur, or are likely to occur, within the project area. These species are:

- Greater Bilby (Vulnerable)
- Great Desert Skink (Vulnerable)

Survey methodology, survey effort and results are detailed in the Biodiversity Report (Appendix J). Survey methodology was discussed with Peter MacDonald (Flora and Fauna Division, NT Government) in October 2016. He advised that selected methods were satisfactory for the project area, providing that field ecologists were suitably experienced in identifying signs of the target species. The survey methodology included the adoption of the following Commonwealth guidelines:

- Australia's threatened mammals – Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 (DSEWPaC 2010)
- Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC 2010)

10.2.2 Likelihood assessment

For each of these species, an assessment of the likelihood that the species occurs within the project area was assessed based on habitat requirements, distribution, the number and dates of proximate records and survey findings.

The assessment assessed the likelihood that each species will occur in the project area by applying the following likelihood classifications:

- HIGH – it is expected that this species lives within the potential impact area because of the presence of suitable habitat, and/or there are recent proximate records.

- MEDIUM – this species may live within the potential impact area; however, there is evidence that lowers its likelihood of occurrence (i.e. lack of core habitat, no recent records with the search area, species is naturally-rare or occurs at a low density etc.).
- LOW – apart from the occasional transient, it is not expected that this species occurs within the potential impact area, as there is no suitable habitat for the species and/or there has been a known range contraction of the species in the region.
- VERY LOW – there is strong evidence (no suitable habitat and/or the species is considered likely to be regionally-extinct) that this species will not occur within the potential impact area.

10.3 Threatened species

10.3.1 Greater Bilby

In the NT, Greater Bilby have been observed in a wide range of habitats including stony uplands, lateritic areas, hummock grassland sand-plains, mulga scrub and woodlands, drainage depressions and palaeo-drainage systems. Greater Bilby move over a wide area according to available food and vegetation cover conditions (associated with seasons and fires); and the long-term seasonal home range of a group of Greater Bilby may be large (up to hundreds of square kilometres).

The project area falls on the edge of the eastern extent of the currently known population distribution. The likelihood assessment targeted the western parts of the access corridor especially, as likely to provide suitable habitat.

The project site predominantly supports red earth plains with Mulga (*Acacia aneura*) and/or Gidgee (*Acacia georginae*) over tussock grass interspersed with low rocky rises and Coolabah (*Eucalyptus victrix*) flood-outs. These vegetation types are not preferred for Greater Bilby in the NT and the likelihood of occurrence in this area is very low.

Although Greater Bilby signs were not identified during the tracking surveys, it is possible that desert sandplains situated in the western half of the access corridor could be periodically utilised by the species, due to presence of suitable habitat, food plants (mainly only temporary food sources present), and closer proximity (and better linkage) to existing populations in the Tanami Desert. However, the lack of evidence supporting the presence of the species, and also the absence of suitable refuge habitats (and known populations) in the region, indicate a <u>low</u> likelihood that Greater Bilby occupy these desert sandplain areas.

Three predator species, including foxes and cats, were identified within the project area. Predation is a major threatening process to the Greater Bilby.

10.3.2 Great Desert Skink

Within its arid zone habitat, the Great Desert Skink occupies a range of vegetation types. In the Tanami Desert and parts of the Great Sandy Desert, the species occurs in palaeo-drainage lines with lateritic soils and *Melaleuca* shrubs. Regenerating vegetation appears to be a critical habitat requirement and a mosaic landscape of different aged vegetation seems to be preferred.

The mineral lease areas, water supply infrastructure and the section of access corridor east of the Stuart Highway are not considered suitable to support a population of Great Desert Skink. Due to several factors including lack of suitable habitat, frequent large-scale fires and isolation from known populations the likelihood of the species occurring is <u>very low</u>.

A <u>low</u> likelihood of occurrence exists in small area of the western end of the access corridor, flanking the edges of the Taylor Creek floodplains. This sandplains habitat consists of Melaleuca shrubs over Spinifex grass. This habitat is considered potentially suitable due to presence of several habitat features usually observed where there is Great Desert Skink, and also the closer proximity (and better linkage) to known populations to the east of the Stuart Highway.

10.3.3 Migratory species

Two migratory species, which are listed under bilateral international conventions, occur within the project area.

Rainbow Bee-eater

The Rainbow Bee-eater (*Merops ornatus*) is a terrestrial species and occurs in the project area across red earth plains and in association with drainage features. This species is common and widespread, so habitats within the project area are unlikely to be considered 'important habitat', and the birds that occur there are unlikely to be an 'ecologically significant population' (in accordance with the EPBC Act).

Glossy Ibis

The Glossy Ibis (*Plegadis falcinellus*) is a wetland species and generally found in wetlands and flooded grasslands. One sighting in 2011 survey was recorded in close proximity to Woody's Dam. This sighting is assumed to be opportunistic use, as the dam supports neither a wetlands nor flooded grasslands habitat. The Glossy Ibis has not been recorded in subsequent surveys.

This species moves in response to rainfall. Core breeding areas are within NSW, Victoria and southern Queensland. The species often moves north in autumn, then returns south in spring and summer (Birds Australia 2010b). Neither of these habitats are located in the project site.

10.4 Other threatened species

Three additional species were identified by the DEE as requiring an assessment of likely presence and habitat within the project area. This species were not included in the targeted survey effort as their inclusion is not applicable, for the reasons described below.

10.4.1 Black-footed Rock-wallaby

The Black-footed Rock-wallaby (*Petrogale lateralis* – MacDonnell Ranges race) was not targeted during surveys as the preliminary likelihood assessment determined that there was no suitable habitat for this relatively restricted-range species within the project area. Thus it has been assessed as not occurring within the project area (refer Appendix J, Biodiversity Report).

10.4.2 Crested-tailed Mulgara

The information requested by DoE for inclusion in the Preliminary Documentation also makes reference to provision of a detailed assessment of the Crest-tailed Mulgara (*Dasycercus cristicauda*) and its habitat. However, the DoEE's expert distribution mapping does not include the project area and there are no records of the species proximate to the project area. Until recently, only one species of mulgara was recognised; there are now considered to be two – Crest-tailed Mulgara (*Dasycercus cristicauda*) and Brushtailed Mulgara (*Dasycercus blythi*). Only *D. blythi* could occur within the project area. It is listed under NT legislation, but not Commonwealth legislation, and has not been considered further in this chapter.

10.4.3 Southern Marsupial Mole

The Southern Marsupial Mole (*Notoryctes typhlops*) was previously listed as Endangered under the EPBC Act. In 2015, the Commonwealth Threatened Species Scientific Committee determined that this species was eligible for delisting due to recent information that establishes the species to be widespread and common throughout much of their known range, and with no evidence of an ongoing decline. Southern Marsupial Mole was subsequently de-listed as an EPBC-listed threatened species in November 2015.

10.5 Potential impacts

10.5.1 Project impact

This section identifies the potential direct and indirect impacts on threatened species presented by the project. These include potential impacts during construction, operation and rehabilitation, and closure. The construction period is expected to last up to 24 months, and mining and processing operations will continue for a period of at least 25 years following construction. The layout of the proposed Project site is shown in Chapter 2.

The principal activities that will have the potential to impact on threatened species are:

- Clearing of vegetation and associated direct loss of habitat.
- Fragmentation of habitat resulting in an edge effect and reduction in habitat quality in uncleared areas.
- ‘Barrier’ effect as a result of mine pit and linear infrastructure and restricting fauna movement.
- Introduction or spread of weeds resulting in habitat modification and altered fire regimes.
- Machinery use and potential impact on individual fauna species via strike.
- Alteration of hydrological regimes associated with linear infrastructure or other impediments altering surface flows.
- Groundwater drawdown from the borefield and/or changes to groundwater flows reducing environmental water.
- Noise from machinery disrupting roosting of foraging habitats and displacing fauna.
- Dust from mining and vehicle movement reducing air quality and increasing dust deposition.
- Poor waste management increasing population of feral fauna.
- Linear infrastructure facilitating the movement of feral fauna across landscape.
- Accidental chemical/hazardous material release contaminated surface.
- Inconsistent or inadequate rehabilitation reducing the quality of ecosystems in a post-closure landscape.

10.5.2 Risk assessment

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

Impact consequences have been developed specifically for threatened species to quantify impacts to populations. The consideration of impacts to populations is a key consideration to assessing the significance of impact (as detailed in Section 10.6).

Risks with an initial risk ranking of low are considered ‘tolerable’ and as such further control or mitigations is not required.

Table 10-1 Consequence ratings – threatened and migratory species

Levels of consequence		Definitions
5	Catastrophic	Moderate or substantial regional decrease in size of population(s) of listed fauna species
4	Major	Substantial local decrease in size of population(s) of listed fauna species
3	Moderate	Moderate local decrease in size of population(s) of listed fauna species
2	Minor	Minor local decrease in size of population(s) of listed fauna species
1	Insignificant	No loss of individuals of listed fauna species

Table 10-2 Risk assessment for threatened and migratory species

Source of impact	Initial risk			Mitigation	Residual risk		
	Likelihood	Consequence	Risk ranking		Likelihood	Consequence	Risk ranking
Clearing vegetation	5	1	M	• Vegetation clearing procedure • Progressive rehabilitation (commencing year 1) • Minimising clearing of vegetation deemed suitable habitat	5	1	M
Habitat fragmentation	4	2	M	• Vegetation clearing procedure • Progressive rehabilitation (commencing year 1) • Minimising clearing of vegetation deemed suitable habitat	4	2	M
Barrier effect	3	1	L	• No further action required	3	1	L
Weeds	3	2	M	• Weed management plan to outline requirements to monitor and control weeds	3	2	M
Feral fauna - - increase in resource competition and/or predation of native fauna	3	2	M	• Waste management plan to limit feral fauna access to food sources	2	2	L
Bushfire	3	3	M	• Weed management plan • Bushfire management plan including the management of potential ignition sources	2	3	M
Vehicle strike	3	1	L	• No further action required	3	1	L
Surface water contamination	2	1	L	• No further action required	2	1	L
Altered surface water hydrology	3	1	L	• No further action required	3	1	L
Groundwater drawdown	1	1	L	• No further action required	1	1	L
Noise	2	1	L	• No further action required	2	1	L
Dust	2	1	L	• No further action required	2	1	L
Rehabilitation	3	2	M	• Mine closure plan including progressive rehabilitation and performance criteria	2	2	L

1 – rare, 2 – unlikely, 3 – possible, 4 – likely, 5 – almost certain ; L – low, M – medium, H – high, E – extreme

10.5.3 Impacts to Greater Bilby

Clearing vegetation

The Greater Bilby has not recorded during any of the previous surveys within the study area. Despite not being detected, this species is mobile and could still occur in very low abundance (thus difficult to detect) in the desert sandplains situated in the western half of the access corridor. This area could be periodically utilised by the species, due to presence of suitable habitat, food plants (mainly only temporary food sources present), and closer proximity (and better linkage) to existing populations in the Tanami Desert. The small amount of clearing (416 ha) that will occur within potential Greater Bilby habitat is unlikely to have an impact on a population as the likelihood of occurrence in this area is very low.

Clearing of low quality habitat (i.e. no reliable food sources, lack of refuges, difficultly in dispersing) is almost certain to occur but will have an insignificant impact to a Greater Bilby population should it exist.

Habitat fragmentation and barriers

The construction of the gas pipeline requires only temporary disturbance with the access corridor. After construction the area of disturbance will be allowed to regenerate. The consequence of the gas pipeline is considered insignificant.

The railway line will be constructed to a 25 year ARI and will range in height from less than 0.25 to 3 m with most of the rail spur being 1 m above ground level. Sections of greater height will be associated with crossing drainage floors. Banks of culverts will be installed across the drainage floors (as described in Section 7.6.1) to facilitate surface water flow. The height of the rail spur at some crossings maybe a barrier to some fauna movement but they are able to utilise the culverts as passageways.

Weeds

The possible increase of weeds, in response to land clearing and sol disturbance could have a high impact on a Greater Bilby population should it occur, especially if combined with bushfire. The establishment or spread of weeds can alter the ecological balance of arid zone ecology.

Feral fauna

Creation of new roads and tracks and inappropriate management of waste (garbage) allows for introduction or spread of pest animal species (and potentially in some cases native predators including the dingo). Feral (and native – e.g. dingo) predators have been recently recorded within the study area.

Bushfire

Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (not patchy) would however be detrimental as the fire would remove shelter and open up bilbies to predation by exotic and native predators. Implementing mitigation measures such as fire management plan would maintain the risk at medium, however, the likelihood would reduce to unlikely. This risk will require the most intensive management.

Vehicle strike

It is possible that Greater Bilby, should they be present within the access corridor could occasionally be struck and killed by vehicles/trains moving in the area (there is a very low likelihood for this to occur). Given the Greater Bilby is primarily nocturnal, it would only be affected by vehicles travelling at night. Given that it is unlikely that vehicles would be accessing the corridor at night. The residual risk rating of death from vehicle collision for the Greater Bilby population is low.

Surface water contamination

It is unlikely that Greater Bilby would access liquid contained within tailings facility or process water turkey nests due to the location of such facilities away from their preferred sandplain habitats. The facilities occur predominantly within red earth plains and red earth sandplains – and it would highly unlikely that Greater Bilby would occupy the location for the tailings storage or disposal facilities, turkey nests or regularly access standing water within the mine site. This is rated as a low initial risk.

Altered surface water hydrology

The alteration of surface water hydrology as a result of flood mitigation or linear infrastructure would likely be limited to floodplain habitats. No potential food sources or habitat characteristics that could be suitable for Greater Bilby exist within these drainage features.

Groundwater drawdown

Impacts to the water table have the potential to impact on Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. No GDEs occur within Greater Bilby habitats, therefore water table impacts to Greater Bilby are likely to be very low. This rated as a low initial risk.

Noise

A population of Greater Bilby either does not or would not regularly occur in the vicinity of the mine site (Greater Bilby populations would most likely occur in habitats >70 km from the mine site) and hence would only ever be subjected to low noise levels, mainly from trains. A maximum of one train a day is expected to pass along the rail corridor. Noise was rated as having an initial low risk to a Greater Bilby population should it exist.

Dust

A population of Greater Bilby either does not or would not regularly occur in the vicinity of the mine site (Greater Bilby populations would most likely occur in habitats >70 km from the mine site) and hence would only ever be subjected to very low dust levels mainly from vehicles occasionally driving along rail access corridor. Dust was rated as having a low risk to a Greater Bilby population should it exist.

Rehabilitation

Rehabilitation is described in more detail in Chapter 17: Rehabilitation. The mine areas will be progressively rehabilitated. Post closure, the remaining areas of the mine (i.e. process site, camp, access corridor) will be decommissioned and then rehabilitated to reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state.

A poorly implemented rehabilitation strategy is rated as a medium initial risk and would reduce to low through the implementation of an approved Closure Plan.

10.5.4 Impacts to Great Desert Skink

Clearing vegetation

The Great Desert Skink has not been recorded during any of the previous surveys within the study area. The majority of the mine site and infrastructure corridor does not contain core habitat for the species. A small section of infrastructure corridor west of the Stuart Highway, containing desert sandplains with hummock grass was considered suitable habitat type within the project area for Great Desert Skink.

The small amount of clearing (416 ha) that will occur within potential Great Desert Skink habitat is unlikely to have an impact on a population should it exist given the large area of similar habitat in the region (well in excess of 40,000 ha). Clearing of habitat was rated as having an initial low risk to the Great Desert Skink population.

Habitat fragmentation and barriers

The construction of the gas pipeline requires temporary disturbance during construction. After construction the area of disturbance will be rehabilitated. During trenching for the gas pipeline there is a risk that skinks will become trapped. Note that the methodology for laying low pressure carbon fibre pipeline will minimise the amount of open trenching, as the trenching tool works just ahead of the pipeline roll out vehicle. The consequence this is considered insignificant due to the low likelihood of the species being present in small area of open trench.

Weeds

The possible increase of weeds in response to land disturbance, could have a significant impact on a Great Desert Skink population should it occur, especially if combined with bushfire. The establishment or spread of weeds can alter the ecological balance of arid zone ecology.

Feral fauna

Creation of new roads and tracks and inappropriate management of waste (garbage) allows for introduction or spread of pest animal species (and potentially in some cases native predators including the dingo). Feral (and native – e.g. dingo) predators have been recently recorded within the study area.

Bushfire

Large-scale, intense wildfires from a lack of patch burning can devastate or fragment local populations of Great Desert Skink (Woinarski et. al. 2007). Extensive burns (not patchy) of Great Desert Skink habitat could be detrimental as the fire would remove important shelter and food resources.

Implementing mitigation measures such as fire management plan would maintain the risk at medium, however, the likelihood would reduce to unlikely. This risk will require the most intensive management.

Vehicle strike

It is possible that Great Desert Skink could occasionally be struck and killed by vehicles moving in the area (there is a very low likelihood for this to occur). Given the Great Desert Skink is primarily nocturnal, it would only be affected by vehicles travelling at night. Mitigation would likely involve the implementation of speed limits and possibly the reduction in vehicle travel at night.

The initial risk rating that death from vehicle collision for the Great Desert Skink population was medium, with controls in place this would be reduced to low.

Surface water contamination

It is unlikely that Great Desert Skink would access liquid contained within tailings or process water due to the location of such facilities away from their preferred sandplain habitats. The facilities occur predominantly within red earth plains and red earth sandplains – and it would highly unlikely that Great Desert Skink would occupy the location for the tailings storage of disposal facilities, or regularly access standing water within the mine site. This rated as a low initial risk.

Altered surface water hydrology

The alteration of surface water hydrology as a result of flood mitigation or linear infrastructure would likely be limited to floodplain habitats. No potential food sources or habitat characteristics that could be suitable for Great Desert Skink exist within these drainage features.

Groundwater drawdown

Impacts to the water table have the potential to impact on Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. No GDEs occur within Great Desert Skink habitats, therefore water table impacts to Great Desert Skink are likely to be very low. This rated as a low initial risk.

Noise

A population of Great Desert Skink either does not or would not regularly occur in the vicinity of the mine site (Great Desert Skink populations would most likely occur in habitats >70 km from the mine site) and hence would only ever be subjected to low noise levels mainly from trains. One train a day is expected to pass along the rail corridor. Noise was rated as having an initial low risk to a Great Desert Skink population should it exist.

Dust

A population of Great Desert Skink either does not or would not regularly occur in the vicinity of the mine site (Great Desert Skink populations would most likely occur in habitats >70 km from the mine site) and hence would only ever be subjected to very low dust levels mainly from vehicles occasionally driving along access corridor. Dust was rated as having a low risk to a Great Desert Skink population should it exist.

Rehabilitation

The mine pit will be progressively rehabilitated with rehabilitation being after Year 1 of mining. Post closure of the mine the remaining areas of the mine (i.e. process site, camp, access corridor) will be decommissioned and then rehabilitated to reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state landscape.

A poorly implemented rehabilitation strategy is rated as a medium initial risk and would reduce to low through the implementation of an approved Closure Plan.

10.6 Significance of impacts

10.6.1 Threatened fauna

The significant impact criteria are listed in the *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*, developed by the former Department of Environment (2013). The criteria for threatened species include:

- Lead to a long-term decrease in the size of an important population of a species.
- Reduce the area of occupancy of an important population.

- Fragment an existing important population into two or more populations.
- Adversely affect habitat critical to the survival of a species.
- Disrupt the breeding cycle of an important population.
- Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat.
- Introduce disease that may cause the species to decline.
- Interfere substantially with the recovery of the species.

The likelihood of a significant impact to threatened species occurring has been assessed (Table 10-3).

The assessment considered the likelihood of the species occurring, the scale of the impact, effective implementation of planned mitigation and the residual risk of the impact, as discussed in Section 10.5.

The assessment addresses each significant impact criteria as either a 'yes' or 'no' response.

The assessment concluded that there are no known significant impacts to threatened fauna as a result of project activities.

Table 10-3 Significant impact assessment for threatened species

Impact criteria	Greater Bilby	Great Desert Skink
Lead to a long-term decrease in the size of an important population of a species	No	No
Reduce the area of occupancy of an important population	No	No
Fragment an existing important population into two or more populations	No	No
Adversely affect habitat critical to the survival of a species	No	No
Disrupt the breeding cycle of an important population	No	No
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No	No
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	No	No
Introduce disease that may cause the species to decline, or	No	No
Interfere substantially with the recovery of the species.	No	No

10.6.2 Migratory species

The significant impact criteria are listed in the *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*, developed by the former Department of Environment (2013).

The criteria for migratory species include:

- Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.
- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The likelihood of a significant impact to migratory species occurring has been assessed (Table 10-4). The assessment considered the likelihood of the species occurring, the scale of the impact, effective implementation of planned and committed mitigation and the residual risk of the impact (as discussed in Section 10.5).

The assessment addresses each significant impact criteria as either a 'yes' or 'no' response.

The assessment concluded that there are no known significant impacts to migratory species as a result of project activities.

Table 10-4 Significant impact assessment for migratory species

Impact criteria	Rainbow Bee-eater	Glossy Ibis
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	No	No
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species	No	No
Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	No	No

10.7 Environmental offsets

The term 'environmental offsets' refers to measures that compensate for the residual adverse impacts of an action (i.e. project activities) on the environment. The *EPBC Act Environmental Offsets Policy* states that 'offsets are not required where the impacts of a proposed action are not thought to be significant or could reasonably be avoided or mitigated'.

The assessment of the significance of impacts to threatened or migratory species has concluded that there are no known significant impacts to these species as a result of project activities. Therefore, environmental offsets under the EPBC Act are assumed to not be required.

11. Health and safety

11.1 Introduction

11.1.1 Purpose of report

The purpose of the human health and safety study is to identify and assess the potential impacts to human health and safety arising from the Ammaroo project. The study documents the controls that will be implemented by VRM to mitigate the human health and safety risks so far as is reasonably practicable as per the Northern Territory Work Health and Safety Regulations [1].

Section 5.5 of the draft EIS TOR provided the following environmental objective in relation to human health and safety:

> *The EIS should identify and assess risks and hazards to human health and safety associated with all stages and components of the Project, including pathways for development of risks and hazards.*
>
> *Sensitive receptors to risks and hazards should be identified, including their location and patterns of activity and occupation, with the potential for exposure to the risks and hazards as a consequence of the Project.*

11.1.2 Study scope

The scope of the study includes identification and assessment of the potential hazards to human health and safety associated with all stages and components of the Ammaroo project. It includes risks to health and safety of the workforce and the public for the duration of the Ammaroo project, including post-closure.

Specifically, the scope of this assessment includes the following:

- Identification of potential human health and safety hazards, including impacts from naturally occurring radioactive material (NORM).
- Qualitative risk assessment of the identified human health and safety hazards.
- Assessment of the risks against the qualitative risk criteria.
- Discussion of the management, prevention, treatment and monitoring strategies used to minimise the impacts of the Ammaroo project on human health and safety.

An assessment of radiological considerations for the Ammaroo phosphate deposit is presented in Appendix K. The report provides a technical assessment of the levels of NORM that are likely to be encountered by the project.

11.1.3 Location and surrounding land use

A summary of those closest family outstations and small communities to the site is discussed in Chapter 12: Socio-economic, section 12.2.3.

11.2 Methodology

11.2.1 Hazard analysis

The main objective of the hazard analysis is to determine the potential risks of the project to demonstrate that the residual risk levels are acceptable in relation to the health and safety of

[1] NT WHS Regulations

the workforce and the general public, and to show how the risks will be appropriately managed. The methodology covers the following steps:

- Hazard identification, in which site events and external events are identified which may lead to or contribute to human health and safety risks.
- Qualitative risk assessment to qualitatively ascertain the level of risk associated with the identified hazards.

Hazard identification

The first step in the risk analysis is the systematic identification of all possible hazardous incidents associated with the Ammaroo project.

This brainstorming activity was conducted as a desktop study based on typical hazards encountered for an open cut mining operation and associated processing facilities.

Subsequent to the desktop analysis, a risk assessment workshop was conducted in Darwin involving representatives from VRM and GHD to review the draft risk register for completeness and relevance.

The risk assessment workshop included all aspects of the Ammaroo project as part of the draft EIS risk assessment, however this chapter is limited to the human health and safety risks only. Other impacts are covered under the relevant chapters within the draft EIS.

Qualitative risk assessment

Qualitative analyses use words and descriptive scales to determine the likelihood of each identified hazard and its consequences. This provides an estimate of the likely rate of occurrence of hazardous events and their severity, from which a measure of the risk may be obtained through a simple matrix format of the equation:

Risk = Likelihood x Consequence

The risk associated with the Ammaroo project is determined by combining the likelihood of the potentially hazardous events and the magnitude of their consequences (refer Table 6-1, and Table 6-2 in Chapter 6: Risk assessment). The risk matrix is illustrated in Table 6-3, developed in consultation with VRM based on *AS/NZS ISO 31000:2009, Risk management - Principles and guidelines*.

The process of combining consequences and frequencies gives appropriate weight to the range between small consequence events (which are relatively frequent) and events of major consequence (which are very infrequent).

The risk can then be assessed against relevant criteria as shown in Table 6-4, to determine if additional actions are required to be taken or if the risk is at a tolerable level.

11.3 Results

11.3.1 Human health and safety risk management

Applicable legislation

The Northern Territory (NT) Work Health and Safety Laws are administered by NT WorkSafe and are based on the SafeWork Australia Model Work Health and Safety Act and Regulations.

The applicable NT legislation is described in Chapter 3: regulatory context. VRM will comply with the listed legislation and applicable codes of practice for all activities associated with the Ammaroo project.

Management framework

VRM will implement a health and safety management system that will be the basis for the management of all aspects of human health and safety for the Ammaroo project.

The structure of the management system will use guidance provided by WorkSafe Australia and AS/NZS 4801:2001 Occupational Health and Safety Management Systems; and will include the following elements:

- Policies
- Leadership, management, accountability and commitment
- Hazard and risk management
- Information and documentation
- Design and construction
- Incident management
- Management of change
- Contractor management
- Emergency preparedness and response
- Purchasing
- Systems of work / operations and maintenance
- Personnel
- Health and fitness for work
- Monitoring, auditing, review and improvement

As part of the management system, VRM's risk management procedures will require the maintenance of a site specific risk register to identify and assess risks to human health and safety throughout the Ammaroo project lifecycle to ensure those risks are minimised. The risk register will be a live document, formally reviewed on a regular basis to assess the operations and put in place appropriate control measures to prevent and / or mitigate the risks.

The initial revision of the site risk register is that generated for the draft EIS (Table 6-8) and discussed in this chapter. The regular review of the register will enable VRM to incorporate relevant control measures early into the design of the site and then into the operational plans and procedures.

Hierarchy of control

The hierarchy of controls is a commonly used principle applied across the industry in the management of safety hazards. It involves a prioritised order of control types from the most effective strategies to the least effective strategies.

The aim of applying the hierarchy of control is to have a combination of control strategies to manage a specific risk and to use the hierarchy to reduce the risk so far is reasonably practicable. Where applicable, a combination of controls within the hierarchy can be used.

The hierarchy of control includes:

- Elimination: Remove or avoid the hazard completely
- Substitution: Replacing with a safer alternative
- Isolation: Separating the hazard from the person, environment or process at risk by isolation, guarding, barricading, alternate duties etc.
- Engineering controls: Constructing new devices to reduce the risk
- Administrative controls: Promote awareness of hazards e.g. signage, procedures, training etc.
- Personal protective equipment (PPE): Considered only when other controls are not practical or to increase protection.

By undertaking a risk assessment of human health and safety during the early stages of the Ammaroo project, VRM have the ability to implement the hierarchy of control fully. During the design stages, control strategies higher in the hierarchy can be applied to eliminate, substitute, isolate or engineer the site, infrastructure and equipment to reduce the risks so far as is reasonably practicable.

Incident management

In the event of an unplanned health or safety incident occurring, VRM will implement an incident management system, which aims to identify the hazards and system deficiencies to prevent an incident reoccurring through an investigation and corrective action process.

VRM will implement an incident management process to enable:

- On-going identification of hazards and reporting of incidents by any site personnel
- Investigation of all reported incidents
- Follow up and close-out of identified corrective actions
- Communication of incidents across the organisation and statutory reporting if required
- Use of findings from incident investigations to improve systems, processes, and procedures.

Emergency management

An important element of the management system is emergency response. This incorporates the emergency response systems, procedures and resources. The emergency response process will be managed by the site emergency response team. All personnel within the emergency response team will undergo regular training and participate in regular mock and desktop exercises.

As part of the emergency management system, scenario specific emergency response plans will also be developed based on the potential emergencies that may arise at the operations. Examples include chemical spills, fire and explosions, traffic accident, confined space incident etc.

Reporting and audits

An effective management system includes a monitoring, auditing, review and improvement cycle.

The VRM monitoring, auditing, review and improvement process will include:

- Routine inspections of assets

- Routine monitoring of control implementation (for example, workplace observation programs)
- Routine management review of the effectiveness of all standards, procedures and work instructions / job safety analysis (JSAs)
- A document control system to enable update of all standards, procedures and work instructions / job safety analysis (JSAs) following management review
- A training management system to identify and track training requirements of all personnel, including refresher training programs
- A permit to work process to monitor and control specific higher risk activities
- A change management system to assess the impacts of changes made
- A communication strategy to notify all relevant personnel of changes made

VRM will implement a regular audit program to confirm compliance with the health and safety legislative requirements and company / operations specific processes and procedures. This will also include independent external authorities conducting audits as necessary.

11.3.2 Hazard identification and qualitative risk assessment

HAZID workshop

The team members in attendance of the human health and safety section of the workshop are provided in Table 11-1.

Table 11-1 Workshop participants

Name	Role (company)
Henry Reynolds	Facilitator (GHD)
Fiona Duncan	Co-Facilitator and Senior Risk Consultant (GHD)
David Eames	Principal Mechanical Engineer (GHD)
Nicole Conroy	Principal Environmental Scientist (GHD)
Nigel Doyle	Exploration Manager (VRM)
John Dunster	Geologist (VRM)
Jane Munday	Social impact specialist (True North)

HAZID summary

The full risk register for human health and safety risks is provided in Table 6-8.

A total of 30 hazards were identified that could result in a human health or safety risk to the workforce or the general public.

The causes that could lead each hazard to becoming a risk were identified and the associated controls / safeguards to prevent the unwanted outcome occurring were also identified. These safeguards (outlined in Table 6-8) are required to ensure the risk scenarios that were identified are contained or at least controlled to an acceptable level.

The only human health and safety hazard identified and assessed to have the potential to impact surrounding land users was associated with off-site transport activities. All other hazards were considered to be contained within the site. Off-site transport is further discussed in Chapter 13: Transport.

A summary of the hazard identification results is provided in Table 11-2 showing the hazard and maximum reasonable consequence identified.

Table 11-2 Hazard identification

Hazard	Consequences
Project personnel exposed to increased noise levels during operation of the mine site, processing plant and associated infrastructure.	Consequences of cumulative noise exposure will be an increased risk of industrial noise induced hearing loss (severe irreversible damage). The event may occur at any time during operation.
Increased mosquito breeding from new standing water locations.	Consequence will vary from increased nuisance to increased mosquito-borne disease transmission. The maximum reasonable consequence is illness. The event may occur at any time throughout the life of the project.
Mobile equipment incident on site including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.	Consequences will vary depending on severity of impact between minor injury to fatality. The maximum reasonable consequence is a single fatality event. The event may occur at any time during construction and operation.
Personnel falling from height or into depth on site including mining, processing, maintenance and administration areas.	Consequences will vary depending on the height and location of the fall from a minor injury to a fatality. Maximum reasonable consequence is a single fatality (multiple fatalities may occur e.g. failure of scaffold with multiple personnel on it, however the more reasonable outcome is assumed to be a single fatality). The event may occur at any time during construction and operation.
Personnel exposed to a confined space incident e.g. engulfment, irrespirable or noxious atmosphere.	Personnel exposed to a confined space incident e.g. engulfment, irrespirable or noxious atmosphere. Exposure in the confined space may occur because of the pre-existing environment or due to changes that occur while personnel are present. The maximum reasonable consequence is a single fatality event. The event may occur at any time during operation.
Personnel struck by ground failure or rock fall event in mining operational areas. Includes material falling from high and low walls, dumps and ramps.	Consequences will vary depending on the size of material falling and how personnel are impacted (e.g. on foot or in vehicle) and will range between injury to fatality. The maximum reasonable consequence is a single fatality. The event may occur at any time during operation.
Personnel in contact with an electrical source (low or high voltage) resulting in electrocution or arc flash burns. This includes all electrical sources on site where exposure may occur during construction or operations.	Consequences will vary depending on the type of contact and energy level associated with the equipment. This would include a range of minor injuries e.g. electric shock, through to electrocution or fatality from arc flash events. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Personnel struck by a dropped or swinging load during lifting by a lifting device or tipping a lifting device.	Consequences will vary depending on the size of the load and how personnel are impacted, ranging from an injury e.g. crushed hand or foot to a fatality. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.

Hazard	Consequences
Personnel impacted by a tyre or rim incident associated with mobile equipment.	Consequences will vary depending on the type of exposure and proximity to the event. Personnel may experience projectile / pressure impacts due to tyre pressure release, burns or pressure impacts from tyre fires and crush injuries due to dropped tyres. Consequences may range from minor injury through to fatality. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Personnel exposed to a flood event into the pit or personnel exposed to flooding within the mine lease e.g. low lying vehicle crossings	Consequences will vary depending on the extent of material released and the material being released. Ground water and flooding events may result in injury e.g. due to slips, trips & falls through to fatality e.g. due to being trapped in a submersed vehicle / drowning. Dam failures may result in injury e.g. due to exposure to tailings products through to fatality from engulfment. The maximum reasonable consequence is a major injury because of the proximity of personnel to dams the anticipated volumes of material released and flooding likely to be from a known weather system and the mine can prepare for its arrival. The event may occur at any time during operation.
Personnel struck by falling or dropped objects including structural failure.	Consequences will vary depending on the size of the item that falls and the height from which it falls, ranging from an injury to a fatality. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Personnel caught in rotating or moving equipment.	Consequences will vary depending on the equipment personnel are drawn into and how they are drawn in, potentially resulting in entanglement and entrapment. This may lead to crush injuries e.g. fingers, amputation of limbs or fatality. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Personnel impacted by a high-pressure release (stored energy).	Consequences will vary depending on the pressure at time of release, proximity of personnel to the release and the material released. This may lead to fluid injection injuries if personnel are in close proximity or they may be struck by flying debris resulting in either an injury or fatality if the object is large enough or where it strikes the person. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Personnel exposed to liquid while working in or around liquid bodies.	Consequences may include minor injuries e.g. due to trips and falls through to fatality (drowning). The maximum reasonable consequence is a single fatality. The event may occur at any time throughout the life of the project.
Personnel exposed to hazardous materials via all means e.g. ingestion, inhalation or skin contact.	Consequences will vary depending on the material personnel are exposed to, the means of exposure and the duration of exposure e.g. soda ash. The maximum reasonable consequence is a major injury. The event may occur at any time during operation.

Hazard	Consequences
Engulfment of personnel in materials while working on site on stockpiles, ROM or around bins, hoppers, chutes etc. Personnel may be engulfed while on foot or in mobile equipment.	Consequences will vary depending on the volume of material in which personnel are engulfed and the ability to self-rescue. The maximum reasonable consequence is a single fatality The event may occur at any time during operation.
Failure of backfilled pit area / poor slope stability following major rain event.	Consequences will vary depending on the instability and how personnel are impacted (e.g. on foot or in vehicle) and will range between injury to fatality. Maximum reasonable consequence is a single fatality. The event may occur at any time during operation.
Personnel exposed to hazardous flora or fauna including snakes, spiders, mosquitoes, biting insects, bees, wasps, larger animals such as dingoes / wild dogs / cats etc.	Consequences will vary depending on the flora or fauna to which personnel come into contact and whether or not they have an allergic reaction to bites / stings. The maximum reasonable consequence is a single fatality. The event may occur at any time throughout the life of the project.
Unauthorised site access / security breach during construction and operation.	Consequences will vary depending on the location of unauthorised access and the reason for access (e.g. if they are deliberately causing harm). Personnel may be exposed to many of the site hazards including mobile equipment movements, hazardous chemical etc. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Personnel exposure to whole body vibration during operation of mobile equipment in mining operations.	Consequences of whole body vibration will ultimately be muscular skeletal disorders (reversible damage / lost time injury). The event may occur at any time during construction and operation.
Personnel exposed to increased risks due to the remote location of the site and / or undertaking lone and isolated work.	Although the initial injury may not be immediately life threatening, there is potential for the situation to escalate due to the distance and time it takes for medical aid. The maximum reasonable consequence is a single fatality. The event may occur at any time during construction and operation.
Heat related illness due to desert climate.	Consequence will vary depending on the extent of heat related illness. The maximum reasonable consequence is an injury. The event may occur at any time throughout the life of the project.
Manual handing injuries during manual work conducted on site across the operations.	Manual handling injuries may include back injuries such as injuries to nerves, bones, joints and soft tissue hernias, ruptured discs and torn back muscles. Other consequences may include sprains of ligaments, strains of muscles or tendons, tendonitis, spondylolisthesis, carpel tunnel syndrome and Repetitive Strain Injury (RSI). The maximum reasonable consequence is musculoskeletal effects to bones and soft tissue structures (reversible damage / lost time injury). The event may occur at any time throughout the life of the project.

Hazard	Consequences
Radiation exposure to personnel on site.	It is not anticipated that worker exposure will reach (or exceed) the national worker dose limit of 20 millisieverts per year. In accordance with the criteria for a radioactive material outlined by the IAEA (IAEA 2004), the Ammaroo ore is not considered to be radioactive. . The combined uranium and thorium concentrations are less than 1Bq/g, averaging approximately 0.3Bq/g. Occupational doses (above natural background) are calculated to be less than 1mSv per year. At these low concentrations, it is expected there would be negligible impact on worker health.
Personnel impacted by fire or explosion. This includes equipment and substance fire and explosions. Mining operations fires would typically involve mobile equipment fires. Processing plant fires would typically involve fixed plant fires. This also includes the gas fired power generation plant and gas pipeline.	Consequences will vary depending on the size and type of fire and extent of exposure. Personnel may be impacted by smoke, heat radiation from the fire or explosion overpressure. Consequences may range from smoke inhalation, minor burns through to fatality. The maximum reasonable consequence is a multiple fatality. The event may occur at any time during construction and operation.
Bushfire from natural or human causes.	Consequences will vary depending on the size of fire and extent of exposure. Consequences may range from smoke inhalation, minor burns through to fatality. The maximum reasonable consequence is a single fatality as there is limited fuel to allow for an unexpected fire of substantial size. The event may occur at any time during operation.
Rail incident during transport of final product.	Increased trains crossing a road, negativity towards the project and delays to other road users. The maximum reasonable consequence is a vehicle crossing accident results in at least one fatality but potentially multiple fatalities. The event may occur at any time during construction and operation.
Increased industrial traffic on Stuart Highway, Sandover Highway and Murray Downs creates road safety risks e.g. through incompatible mix of industrial and local traffic accessing Ali Curung, and other Aboriginal communities and Stations ; including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.	Increased risk of road trauma, negativity towards the project. Delays to other road users. The maximum reasonable consequence is a vehicle accident with multiple fatalities (including pedestrians). The event may occur at any time during construction and operation.
Increased traffic from local workers driving to work or driving to and from home at the end of rosters increases road safety risk, particularly if workers drive home fatigued at the end of shift.	Increased risk of traffic incidents and negativity towards the project. The maximum reasonable consequence is a vehicle incident with moderate irreversible injury. The event may occur at any time during construction and operation.
Aircraft incident with FIFO from areas beyond road travelling distances.	An aircraft incident would be expected to involve multiple fatalities. The event may occur at any time during construction and operation. However, the aircraft industry is highly regulated in Australia and consequently, aircraft incidents are rare.

Risk assessment summary

Of the thirty (30) identified hazards, two (2) was assessed as having a current risk rating of 'High', twenty-two (23) rated as 'Medium' with the remaining four (5) rated as 'Low'. A summary of the risk assessment results is provided in Table 11-3.

The majority of human health and safety hazards were assessed to have a medium or above risk level. This is due to the focus of the hazard identification being on the higher consequence events to enable early identification of these events and therefore greater ability to design them out of the operations. The medium risk levels were generally due to the consequence categories of major and catastrophic, i.e. one or more fatalities, being selected as the maximum reasonable outcomes.

Table 11-3 Qualitative risk – health and safety

Potential event	Residual risk level
Noise	Medium
Mosquito breeding	Low
Vehicle incident on-site	Medium
Falling from height or into depth	Medium
Confined space incident	Medium
Ground failure or rock fall	Medium
Contact with an electrical source	Medium
Struck by a dropped or swinging load	Medium
Tyre or rim incident	Medium
Flood	Low
Falling or dropped objects	Medium
Rotating or moving equipment	Medium
High-pressure release	Medium
Exposure to liquid / liquid bodies	Medium
Exposure to hazardous materials	Low
Engulfment	Medium
Poor slope stability following major rain event	Medium
Hazardous flora or fauna	Medium
Unauthorised site access	Medium
Vibration	Medium
Remote site location and / or undertaking lone and isolated work	Medium
Extreme climate	Medium
Manual handing	Medium
Radiation exposure on-site	Low
Fire or explosion	Medium
Bushfire from natural or human causes	Medium
Railway crossing incident off-site	High
Vehicle incident off-site	High
Increased worker traffic	Low
FIFO airplane accident	Medium

11.3.3 Risk management discussion

Overview

A hazard identification and a qualitative risk assessment has been conducted for the project to identify and assess human health and safety risks to the workforce and general public as a result of the Ammaroo project.

The qualitative risk assessment identified thirty (30) hazards; two (2) was assessed as having a current risk rating of 'high', twenty-two (23) rated as 'medium' with the remaining four (5) rated as 'low'.

The highest risk identified was vehicle incidents associated with the increased industrial traffic on public roads, including vehicle-to-vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.

- Although this transport related risks has been assessed as high, a number of control strategies have been identified to be implemented within the project, including design features to be incorporated in the facilities to reduce these risks so far as is reasonably practicable.
- As the project progresses, VRM will implement a health and safety management system that will be used as the basis for the management of all aspects of human health and safety for the Ammaroo project. The project will also be developed in compliance with the relevant occupation health and safety legislation and applicable codes of practice.
- The health and safety management system will encompass an ongoing hazard identification program to identify any further hazards as the project progresses and where possible, these will be incorporated into the design of the facilities to eliminate, substitute, isolate or engineer human health and safety risks so far as is reasonably practicable. In the operational phase of the Ammaroo project, the management system will incorporate operating procedures, systems and processes to manage the identified risks. It will also include incident and emergency management systems, procedures and resources to enable the effective response to an emergency and ongoing prevention of incidents through the incident investigation process.
- As the project is in an early stage, further risk assessments will be conducted throughout the project lifecycle to enable ongoing identification and management of human health and safety risks as they arise.

Transport related risks

The highest risks identified for human health and safety were in relation to transport, specifically vehicle and rail movements and the management of traffic off-site. The top risks were:

- Vehicle incidents associated with the increased industrial traffic on public roads, including vehicle-to-vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.
- Rail incidents associated with the transport of the final product to the export port in Darwin, including railway crossings incidents.

In order to manage the vehicle related risks 'so far as reasonably practicable', the proposed control measure to be implemented for the Ammaroo project are identified as:

- Design features such as:
  – Vehicle procurement management
  – Vehicle decals and flags, flashing lights

- Railway crossing signage

- Traffic Management Plan
- Site speed restrictions
- Vehicle maintenance program including pre-start inspections and routine maintenance
- Mine site road maintenance program, including dust suppression
- Change management
- Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management etc.

In addition to the above controls, further systems and processes will be implemented to manage off site vehicle related risks. These include:

- Audit of service provider during selection process to ensure competence and professionalism
- Transport study and associated management systems
- Journey management plans (including minimising travel during dusk / dawn)
- Contractor management system
- National Heavy Vehicle Regulator Scheme accreditation
- Speed limiting on heavy vehicles
- Additional warning signage at intersections and railway crossings
- Community consultation and awareness program.

The transport of dangerous goods will be conducted in accordance with the NT *Transport of Dangerous Goods Act and Regulations*[2] and *Australian Dangerous Goods Code*[3].

Additional controls have been identified for off-site vehicle incidents. This includes in vehicle monitoring systems to track driver behaviour, proximity detection systems and alarms, accident/incident investigation protocols and quarterly road safety briefings.

The additional controls identified are not anticipated to reduce the likelihood or the consequence due to the sensitivity of the qualitative risk assessment technique.

Ground control risks

Inherent within a mining operation is the risk of ground failure or mine pit wall collapse. Within the Ammaroo project human health and safety risk assessment, ground failure or rock fall leading to a person being struck and injured was assessed as a medium risk. Although the consequence is major (potential for fatality), the likelihood is considered to be low (rare) due to the proposed controls that will be implemented. VRM has specified that blasting will not occur during the mining process, but may be required at the ballast quarry.

The planned controls are:

- Mine design (including review and sign-off processes)
- Mine modelling & mapping (hydrogeological, geological, exploration data etc.)
- Mine geological and geotechnical monitoring e.g. GPS tracking of faults, daily inspections, ground monitoring systems (prism, extensometers, radar, piezometer, survey)

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2 Transport of Dangerous Goods by Road and Rail Act (2015) & Regulations (2011)

3 Australian Dangerous Goods Code 7.3

- Geotechnical hazard maps
- Trigger action response plans
- Mine drainage design and systems
- Water management plan
- Equipment and task specific procedures / work instructions
- Equipment and task specific training and competency assessment (including ongoing refresher)
- Falling object protection systems (FOPS) on mobile equipment
- Access restrictions to pit ramps, slopes & crests
- Hazard reporting
- Operations supervision
- Emergency response procedures, including response team and equipment.

No further controls were identified for implementation other than those already planned, therefore the risk remains as medium. However, through the ongoing risk management process, if any new technologies or processes are identified that may reduce the risk, these will be considered.

Hazardous material exposure

The potential for personnel to be exposed to hazardous materials was identified as a risk associated with the Ammaroo project, particularly for the benefaction facilities. Materials identified that may cause harm to personnel include sodium silicate, sodium carbonate, polyacrylamide, fire suppression chemicals, tailings, sewage etc. Water treatment plant chemicals are also potentially hazardous. A full list of the hazardous materials that will be used at site is contained in Chapter 2: Project description, in Section 2.5.8.

Personnel may be exposed in a number of ways including during transport and storage or use of the materials. In the event of exposure, consequences will depend on the extent of exposure and the material, therefore it may range from minor consequences such as irritation to skin or the maximum consequence of a major injury, for example due to a catastrophic release of concentrated sodium carbonate.

A number of controls have been identified to reduce the risk, including a number of controls that will be taken into account within the design of the facilities. Some controls include:

- Hazardous substance storage and handling system design specifications
- Plant process control
- Storage, handling and spill management requirements as specified in the Safety Data Sheets, ChemAlert database and, where applicable, legislative requirements for the transport and storage of dangerous goods; [4, 5]
- Inspection and maintenance of hazardous substance storage systems
- Spill kits
- Procedure for transport and storage of hazardous substances
- Equipment and task specific procedures / work instructions

[4] Transport of Dangerous Goods by Road and Rail Act (2015) & Regulations (2011)

[5] Australian Dangerous Goods Code 7.3

- Equipment and task specific training and competency assessment (including ongoing refresher)
- Isolation procedure and associated training
- PPE (eye protection, breathing apparatus, gloves etc
- Signage / labelling of equipment containing hazardous substances
- Site induction.

Radiation exposure

Some phosphate deposits are known to be associated with elevated concentrations of radionuclides, including uranium and thorium. Consequently, VRM has characterised the uranium and thorium concentrations and compared these to recognised classification criteria, to determine whether the material requires additional controls for the purposes of radiation protection. This included a radiological characterization of the mined material and overburden, and an assessment of the potential radiological impacts (Appendix K).

The IAEA notes that material that averages less than 1Bq/g should not be subject to regulation (IAEA 2004) and this is based on average concentrations of radionuclides. The assessment undertaken by JRHC (2017) concluded that the mined material and overburden are not defined as “radioactive” in accordance with the International Atomic Energy Agency (IAEA) definition (IAEA 2004). Therefore, the material and project are not expected to be subject to regulation for the purposes of radiation control.

In any case, a preliminary impact assessment was conducted. The assessment showed that potential doses to workers would be very low and not exceed the national standard public dose limit of 1mSv/y (NDRP 2017).

Additionally, a broad gamma radiation baseline survey of the region was recently conducted to provide additional baseline information. Average gamma doserates were 0.07 µSv/h, with a maximum of 0.17 µSv/h. These levels are consistent with levels found elsewhere across outback Australia.

The impact assessment (Appendix K) shows that potential radiation exposure are very low, as would be expected. There are no special controls required for the purposes of radiation protection. General good practices and health and safety requirements (such as dust controls) will be more than adequate for ensuring that potential workers doses remain negligible.

However, VRM will aim to verify that the conclusions of this assessment are correct and demonstrate that potential impacts are negligible. To this end, they are committed to the establishment of a passive gamma, radon and thoron monitoring network. This will consist of 4 environmental monitoring sites (N, S, E and W of the main project area) with passive detectors that will be changed out every three months.

It is anticipated that monitored stations will be installed in a timely manner in order to gather at least one years’ worth of pre-operational baseline line radon and gamma baseline data.

Fire risks

Due to the presence of flammable and combustible materials, there is a potential for fire and explosion events. While the consequences may be catastrophic (fatalities), the likelihood is low (rare) due to the controls that will be implemented; therefore, this was assessed as a medium risk.

Scenarios may include equipment fires, e.g. mobile equipment and fixed plant, and substance fire and explosions, e.g. diesel storage, gas fired power generation plant and Amadeus Basin to Darwin high pressure gas pipeline. There is a potential for bushfires to occur which expose personnel to health and safety risks, and there is a potential for explosion from an explosives magazine during quarrying for ballast.

A number of controls will be developed during the design stage of the Ammaroo project, with additional controls developed and implemented throughout operations. Some control strategies include:

- Fixed plant and mobile equipment design specifications and associated procurement management.
- Fire resistant & anti-static equipment e.g. conveyor belts.
- Hazardous substance storage and handling system design specifications.
- Fire detection and suppression systems, fire extinguishers and firefighting training.
- Lightning arrestors.
- Fixed plant and mobile equipment maintenance program including pre-start inspections and routine maintenance.
- Gas pipeline design and SMS (AS 2884).
- Inspection and maintenance of hazardous substance storage systems.
- Electrical protection systems.
- Thermographic monitoring.
- Operational procedures including transport and storage of hazardous substances, isolation, excavation / dig permit; hot work procedure and permit.
- Signage and demarcation of gas pipeline.
- Fire breaks, cool-season controlled burns, vegetation reduction program.
- Fire management plan.

Climate extremes

The location of the Ammaroo site is in an area with relatively high ambient air temperatures, therefore personnel may be exposed to adverse effects from climatic extremes. This includes high winds, lightning, storms, hail, heat, UV radiation etc.

When working in hot conditions, heat exposure is considered one of the higher risk scenarios, which may lead to heat stress or heat stroke. Although it is considered possible, due to the controls in place there is a potential for major rather than catastrophic injury to occur as a result of climate extremes.

There are design features that will assist in reducing the risk of climatic extremes such as equipment design specifications taking into account wind loading, ventilation, lagging of hot surfaces, cooling systems, lightning arrestors etc., however there will also be a number of administrative controls used during operations to reduce the effects of climate extremes such as:

- Fitness for work management system (including hours of work, drug & alcohol policy, medicals, fatigue management etc.).
- Adverse weather procedure (including weather monitoring and stop work requirements).
- Trigger action response plans (actions to be taken if the monitored parameter is above the trigger value, with escalation processes for increasing trigger values.
- Lone and isolated workers’ procedure.

- Heat reducing PPE.
- Heat stress / hydration monitoring and provision of camel backs / electrolyte replacement drinks.
- Scheduling work to avoid hottest time of day.
- Communication protocols.

Remote area risks

Personnel may be exposed to increased risks due to the remote location of the site and / or undertaking lone and isolated work at the project site. The remoteness of the site could result in increased time for emergency response, potential communication failures and black spots, long travel distances etc. This includes personnel such as exploration crews (drillers, geologists, etc.), surveyors, pump crew, supervisors, environmental specialists and third party contractors (electrical personnel, fitters etc.).

Although the initial incident may not be immediately life threatening, there is potential for the situation to escalate due to the distance and time it takes for medical aid. Therefore, to reduce the risk associated with the remote location, VRM will implement the following controls:

- Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management, etc.).
- Adverse weather procedure (including weather monitoring and stop work requirements).
- Trigger action response plans (actions to be taken if the monitored parameter is above the trigger value, with escalation processes for increasing trigger values).
- Lone and isolated workers' procedure / protocols.
- Journey management plans.
- Communication protocols.
- Communication equipment suitable for the area and activity.
- Vehicles fitted with recovery equipment, first aid kits, water supply, etc.
- Emergency response procedures, team and equipment, specifically incorporating the limitations associated with the remote location.
- Man down alarms.

11.3.4 Ongoing risk management

The risk assessment predominantly identifies low likelihood, high consequence scenarios and as the Ammaroo project progresses, the Safety Management Systems (SMS) will be developed to manage the risks identified. This will incorporate the administrative controls mentioned within the human health and safety risk register to prevent and / or mitigate the identified risks.

The engineering controls identified within the human health and safety risk register will be built into the design of the site and associated infrastructure as the Ammaroo project progresses. Operational controls will be developed during the design and construction phases and implemented after hand over to operations.

As the Ammaroo project advances, there will potentially be further risks identified, and changes may occur to existing risks. These will be identified and recorded in the risk register and the risk assessment will be reviewed and updated regularly.

Each stage of the Ammaroo project will have specific risk assessment and risk management activities conducted. For example, safety in design assessments, hazard and operability studies and construction risk assessments. When in operations, further task based risk assessments will be developed e.g. safe work instructions (SWI) or job safety analysis (JSA).

12. Socio-economic assessment

12.1 Introduction

This chapter describes the potential social and economic impacts relating to the activities of the Ammaroo Phosphate Project.

An economic and social impact assessment report (True North Strategic Communication 2017) is provided in Appendix L of the draft EIS. An economic and social impact management plan (True North Strategic Communications 2017) is provided in Appendix E.

Section 5.6 of the draft EIS TOR provided the following environmental objective in relation to social and economic impacts:

> *To analyse, monitor and manage the intended and unintended social consequences, both positive and negative, of the Project and any social change processes.*

The level of risk associated with potential impacts to socio-economic values is described in this chapter and assessed in the risk register in Table 6-8.

12.2 Methodology

12.2.1 Approach to the assessment

The assessment considers the social impacts on people, families and communities of the region. The assessment also considered the beneficial and adverse economic impacts to the local and regional economy.

Key tasks in the preparation of the SIA included:

- Identifying a baseline social environment for the study area. This involved:
  - Identifying key areas for study spatially and socially
  - Desktop review of quantitative baseline social and economic data
  - Literature review of historical and social context of the region
  - Reviewing information gathered from the project's community engagement process.
- Predicting and analysing the consequences of change resulting from the project. This involved:
  - Preparing a risk and opportunity assessment in line with the AS/NZS 120 31000:2009 risk management –principles and guidelines
  - Grouping impacts based on International Association of Impact Assessment (IAIA), Social Impact Assessment Principles and Social Impact Assessment: Guidance for assessing and managing the social impacts of Projects
- Identifying how negative impacts will be avoided, mitigated or managed and how beneficial impacts, such as employment and economic opportunities, will be enhanced.

12.2.2 Study area

The study area and scope for the assessment covers the communities and people most likely to experience positive and negative socioeconomic impacts from the Project. The scope of the study is:

- **Temporal:** covering all stages of the project, including exploration, planning, construction, operations and closure.
- **Spatial (area of influence):** the key areas that may be directly or indirectly impacted and the people, communities, institutions and social structures close to the Project site or access routes:
  - The closest communities, such as Ampilatwatja, Arlparra / Utopia Homelands, Murray Downs (Imangara), Imperrenth, Ali Curung and other nearby outstations as well as pastoral properties, in particular Ammaroo, Murray Downs and Elkedra.
  - The broader Barkly Region, incorporating pastoral and other land uses and livelihoods (traditional, pastoral, horticultural, resource exploitation, tourism) impacted by project infrastructure, logistics, recruitment, services and supplies.
  - The Central Australian regional centres of Alice Springs and Tennant Creek and the Queensland town of Mount Isa which may be a source of labour, services and supplies beyond the immediate Project footprint.
  - The broader Northern Territory, mainly in relation to industry and economic benefits.
- **People:** people, families and communities in the Project's area of influence include Alyawarre native title holders, pastoralists and regional residents who live in the immediately impacted area, who may have connections to the land or who may experience impacts.
- **Economic:** direct and indirect economic benefits for the Barkly Region, the Northern Territory and Australia.

12.2.3 People and communities

Overview

This is remote, arid and sparsely populated country characterised by many small Aboriginal communities and homelands and large pastoral leases. Communities are serviced by local Aboriginal corporations directly or through outreach services of the Alice Springs and Tennant Creek regional offices of the Australian and Northern Territory Governments, Regional Council and non-government organisations.

The communities discussed in this chapter are shown on Figure 1-3 in Section 1.4.2 and described in detail in Table 12-1.

Table 12-1 Community information

Location	Notes
Ampilatwatja Located just off the Sandover Highway towards the project site, about 25 km south-east of the Ammaroo Project	• Population: 406. • The heart of Alyawarre, or Aherrenge country. • There are three main outstations are Irrultja (60 km south east), Atnwengerrp (40 km away) and Welere (Derry Downs) (60 km south), with considerable mobility between Ampilatwatja, Arlparra and other outstations. • Facilities / services: Council service centre and workshops, the community-owned Aherrenge store, primary and secondary schools, post office, sports facilities, aged care service, night patrol and health centre. Police services are provided from Arlparra and Atitjere (Harts Range Art centre supports the region's well-known artists).
Arlparra / Utopia 260 km from Alice Springs and 234 km south east of Tennant Creek on the southern side of the Sandover Highway	• Population: 483. • On the Utopia homelands, and acts as a service centre to Alyawarre and Eastern Anmatjere people. • Facilities / services: a community-owned store, high school, police station, aged care, recreational facilities, MyPathway, a Central Land Council office and Arid Edge (a community development program designed to engage young people). Urapuntja Aboriginal Health Corporation runs the health clinic 10 km to the north, with a large, sealed airstrip near the health clinic at Amengernternenh outstation. Municipal services are provided by the Barkly Regional Council's Arlparra Service Centre.
Ali Curung 151 km south of Tennant Creek by sealed road and 95 km north-west of the Ammaroo Project	• Population: 537. • Facilities / services: school, health clinic and police station. A dirt airstrip services flights to Alice Springs and Tennant Creek. Other facilities include the Mirnirri Store (managed by Outback Stores), Warrabri Bakery, women's centre, Arlpwe Art Centre and Gallery (established in 2008), Baptist Church, Homemakers, health centre, mechanical workshop, crèche and aged care service. An advanced water treatment plant opened in 2013 and a council water park in March 2016
Imangara (Murray Downs)	• Population: 50. • Imangara is a small community living area excised from Murray Downs Station about 205 km south of Tennant Creek • Facilities / services: school. The community accesses the store on Murray Downs Station.
Wutunugurra (Epenarra) Located on the north-eastern edge of the Davenport Ranges, about 206 km south-east of Tennant Creek	• Wutunugurra is a community living area of 99 hectares excised from the Epenarra pastoral lease in the early 1980s • It is included in this study because the population of 230 is mostly Alyawarre people who may be interested in jobs on the Project.

Location	Notes
Imperrenth (Elkedra) Outstation About 70 km from Ali Curung off the Ammaroo Road.	• Imperrenth (also known as the Dinnie Excision) is a family outstation between Imangara and Ampilatwatja, 29 km from the project site.
Tara (Neutral Junction) About 230 km south of Tennant Creek, 10 km off the Stuart Highway and 2 km past the Neutral Junction homestead.	• Population: 50. • It is the closest community to the proposed railway siding for the Project.
Other homelands	• Other smaller homelands and family outstations are Irrmarne, Indaringinya, Ngkwarlerlanem, Inkawenyerre, Atnwengerrp, Amengernterneah, Iylentye, Artekerr, Illeuwurru and Inkwelaya.
Pastoral properties	• Ammaroo Station; • Murray Downs Station; • Elkedra Station; • Neutral Junction Station; and • Ooratippra Station.
Tennant Creek	• Population: 3,636 (June 2016). • Tennant Creek is the regional service centre for government and municipal services as well as non-government services like Julalikari Aboriginal Corporation, Anyinginyi Aboriginal Health Corporation and art and music centres that serve the vast Barkly district.
Alice Springs	• Population: 24,753. • Alice Springs is a key regional service centre for Central Australia and Sandover Region and has the headquarters for many Central Region government departments, Aboriginal organisations and non-government organisations.

12.2.4 Demographic profile for key communities

Table 12-2 profiles communities near the Project site. As can be seen in Table 12-2, the localities proximal to the Project footprint are characterised by high Indigenous populations, including the regional service centre of Barkly. The Indigenous localities have very young populations, with the 0 to 14 year cohort considerably above the Territory average. The ABS Index of Relative Socio-economic Disadvantage, 2011 ranks the Barkly region as the 8th most disadvantaged in the Territory and 10th in most disadvantaged in Australia.

Table 12-2 Demographic profile - summary of key communities

ABS Indigenous locations	Indigenous		Non-Indigenous		Age profile (%)		
	M	F	M	F	0 - 14	15 - 64	65+
Ampilatwatja and outstations	192	180	12	15	34	61	5
Ali Curung	224	262	28	19	33	62	5
Imangara	42	47	3	3	40	55	5
Utopia - Arawerr - Arlparra	225	256	16	10	32	64	4
Barkly (2016)	2,342	2,359	1,212	980	26	66	8
Northern Territory (2016)	37,000	37,000	96,000	84,000	22	70	7

Source: ABS 2011.
Note – M: Male, F: Female. Appendix L details the assumptions these statistics are based on.

Community cohesion and resilience

Community cohesion is defined as the sense of harmony in a place, which can be established by the acceptance of social diversity, a shared sense of belonging across all groups, a broadly accepted vision and image of the location, reasonably similar life opportunities and access to services and positive relationships between people of different backgrounds.

The dispersion of Alyawarre people in the past century has disrupted aspects of their lifestyles, although they maintain strong links to culture and country (SIA interviews). At the time of the SIA consultation, there was evidence of considerable inter-family tension resulting in community violence in Ali Curung and Ampilatwatja.

In Tennant Creek, Aboriginal and non-Aboriginal families reportedly live in reasonable harmony, however interviewees reported a decline in community infrastructure, civic involvement and volunteering. Other interviewees said the formerly flourishing gold mining town had become a Government services town, with a growing number of transient government and NGO workers who have less attachment or loyalty to the town.

12.2.5 Regional and local governance

Central Land Council

The CLC negotiates agreements with mining companies on behalf of traditional owners to protect the interests in Aboriginal land, and in regards to the project, represents the traditional owner's interests in the land the project is expected to operate within.

Northern Territory Government

The project is in the Northern Territory electorate of Namatjira, which extends to the west of Alice Springs, and south of the Barkly electorate, centred on the service town of Tennant Creek. The focus of the government is devolving decision-making to local communities, and facilitating regional economic development including jobs in tourism, horticulture and resource developments.

Barkly Regional Council

Barkly Regional Council covers an area of 323,514 km^2 between Tennant Creek and the Queensland border. The council provides municipal services to urban living areas, outstations and 49 pastoral properties.

Australian Government

The project lies in the Federal seat of Lingiari, which covers 99.98% of the Territory's land mass, excluding only the area around Darwin.

Key issues for the Australian Government will be the project's contribution to reducing socio-economic disadvantage through jobs and training. The Government has introduced programs such as the Remote School Attendance Strategy and an Indigenous Procurement Policy to improve outcomes in remote communities.

12.2.6 Economic profile

Regional overview

The resource industry is a major contributor to the Northern Territory's economy and is seen as important for regional economic development and jobs in disadvantaged regional areas. A relatively recent focus for the Northern Territory is the contribution of horticulture to regional economies and the further development of this industry. Tourism is also key economic sector for the Northern Territory, particularly in regional areas.

Barkly region economy

Key economic features of the Barkly region are:

- The most important industries (as measured by gross value added) are the construction, mining and agriculture, forestry and fishing industries.
- Barkly accounts for about one-third of the NT pastoral production, with more than 200,000 km^2 of pastoral land over 25 leases.
- Mining activity in the Tennant Creek region has declined in recent years, but mining still accounts for a substantial contribution to the economy, although it makes less of a contribution to employment, ranking well below agriculture and construction.
- Between 2013 and 2015, tourism contributed an average expenditure of $37 million a year to the Barkly region.
- 'Public administration and safety' is the largest employer in 2011, accounting for 25% of employment (ABS 2011).
- Most businesses are based in Tennant Creek. Over the past three years, the number of businesses in the Barkly region declined from 212 in 2013 to 200 in 2015.

Income profile

Median incomes in the Barkly region have and continue to be considerably below the state average, with reflectively lower annual growth rates, as detailed in Figure 12-1.

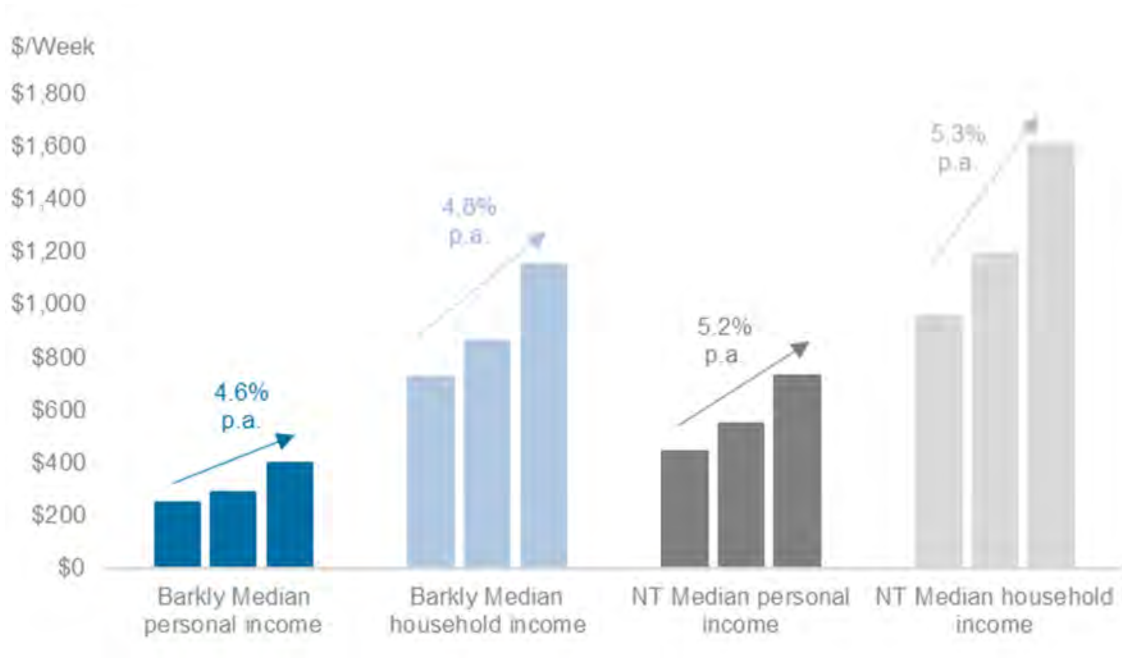


Figure 12-1 Historical median income in the Barkly region

(Source ABS 2011, GHD Analysis)

12.2.7 Labour force and education

Schools within the study area are:

- Tennant Creek - primary school (including pre-school) and high school
- Ampilatwatja - pre-school to Year 9
- Ali Curung (Alekarenge) - pre-school to middle years
- Arlparra School (Utopia) - primary school and high school includes a family learning centre for children aged 0 to 5
- Imangara (Murray Downs)
- School of the Air - pre-school to Year 9

As indicated in Table 12-3, educational outcomes for the Tennant Creek and Barkly region for Indigenous persons are well below those of their non-Indigenous counterparts, with only 31% of Indigenous persons in Tennant Creek completing year 11/12, compared to 76% of non-Indigenous persons. This is likely a reflection of wider socio-economic disadvantage and cultural barriers to education, both of which translate to poor educational attendance for Indigenous students in remote and very remote areas.

Table 12-3 Comparison of educational outcomes in 2011 for Tennant Creek (the Barkly Region)

Educational outcomes	Percentage of responses 15 - 29 year olds (%)	
	Indigenous	Non-Indigenous / not stated
Completed year 11, 12	31% (20%)	76% (85%)
Bachelor or above	2% (1%)	19% (15%)
Advanced diploma	2% (0%)	7% (9%)
Certificate	9% (4%)	20% (20%)

Labour market

Table 12-4 compares Aboriginal with non-Aboriginal participation in the labour force and education (ABS 2011). As can be seen in Table 12-4, the proportion of Indigenous persons unemployed is considerably higher than non-Indigenous persons across all areas; however non-Indigenous employment is likely representative of pastoralists (who are always employed) and the government employees posted to these areas (who leave if they are not employed).

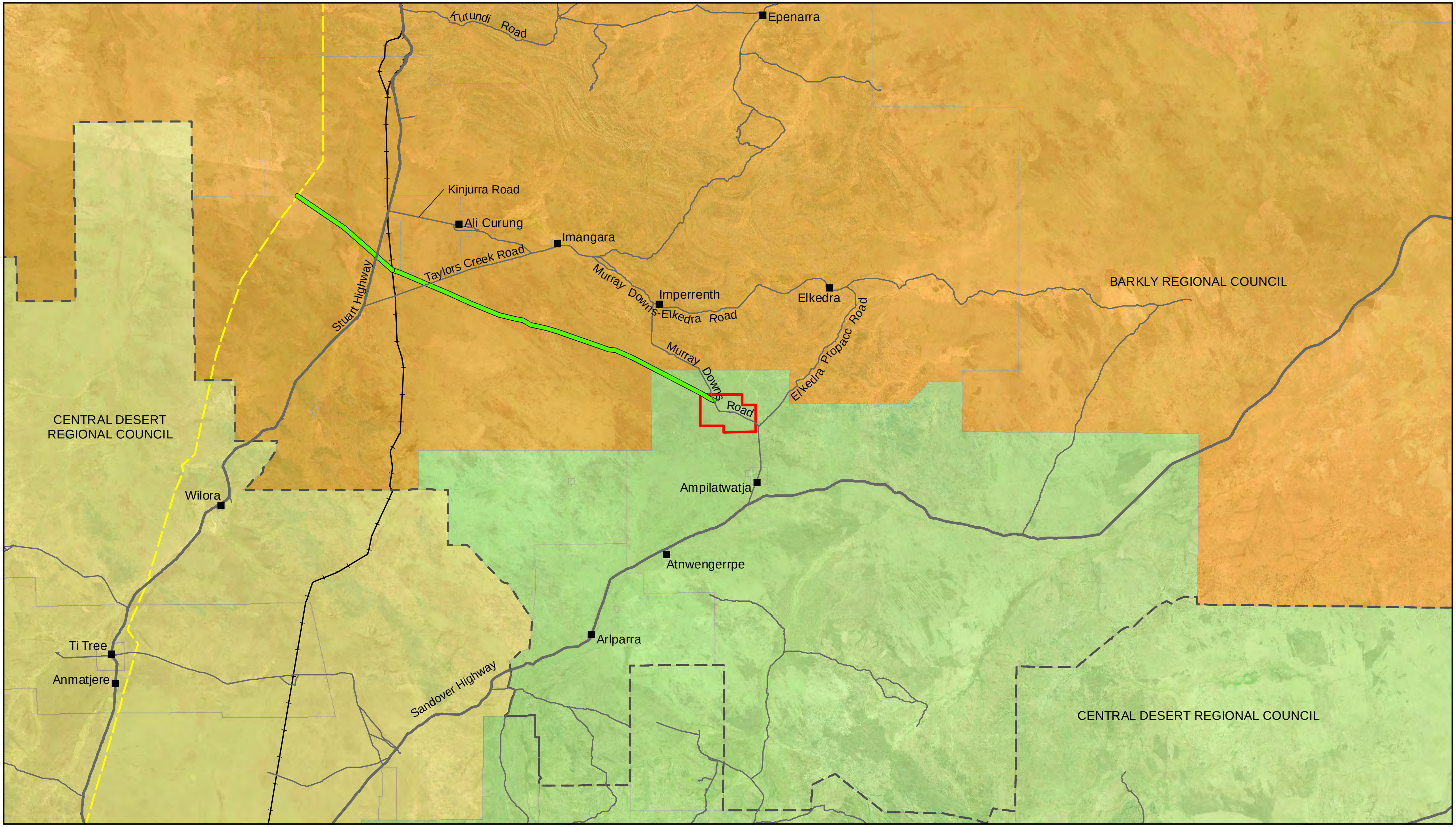
Regardless, Aboriginal unemployment rates for the communities in the study area are highest in Ampilatwatja (45.6%) and lowest in Imangara (15.8%), which also has the highest participation in the labour force (38%). A general correlation can be made between non-school qualifications and workforce participation, whereby those areas that have a greater number of post school qualifications have a higher level of workforce participation.

Employment services are provided by a number of programs in and around the project site. This includes Community Development Program services provided by MyPathway. In Tennant Creek employment services are provided by Julalikari Aboriginal Corporation.

Table 12-4 describes key ABS labour force, population and education statistics. Administrative areas described in the table below are depicted in Figure 12-2.

Table 12-4 Key labour force, population and education statistics (ABS 2011)

A: Aboriginal Non-A: Non-Aboriginal	Population aged 15+ (Total no.) A	Non-A	All	Unemployed (Total no. and %) A	Non-A	Total	Participation rates (%) A	Non-A	Non-school qualifications (Total no.) A	Non-A
Barkly SA2 Region (minus Tennant Creek)	1368	440	1886	81 21.3%	3 0.8%	84 11.2%	27.9%	83.4%	56	222
Tennant Creek SA2 (town)	1106	1028	2332	73 18.6%	17 2%	90 7.1%	35.5%	84.2%	121	218
Sandover Plenty SA2 129,514.9 km	2381	325	2769	150 25.9%	4 1.7%	157 19.3%	24.3%	70.6%	130	157
Ampilatwatja and outstations 15,113.3 km	239	21	267	26 45.6%	0 0%	33.8%	23.9%	73.9%	6	15
Utopia, Arawerr, Arlparra 2627.2 km	318	27	352	22 26.8%	0 0%	22 21.6%	25.9%	76.9%	18	16
Ali Curung 443.2 km	313	42	358	13 18.6%	0 0%	13 12.3%	22.4%	83.7%	6	30
Imangara (Murray Downs) 6.2 km	50	6	56	3 15.8%	0 0%	3 12%	38%	100%	0	6
Wutungurra (Epenarra)	114	7	121	3 16.7%	0 0%	3 7.7%	30.7%	57.1%	3	3
Arlpurrurulam 10 km	287	30	317	22 31.4%	3 10%	25 25%	24.3%	100%	10	19



1:1,500,000 @ A4

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns and Communities
- Major Road
- Local Road
- Proposed Corridor
- Local Government Boundaries
- Project Site

SA2 Name (SA3 Name)

- Barkly (Barkly)
- Sandover - Plenty (Alice Springs)
- Yuendumu - Anmatjere (Alice Springs)

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	18 Sep 2017

Administrative Areas

Figure 12-2

G:\43\22544\GIS\Maps\4322544_113.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Boundaries, Towns, Rail, Pipeline, Imagery (2015). Created by: CM

12.2.8 Infrastructure and social services

Road infrastructure

The project site is reached by travelling north or south on the sealed Stuart Highway and then along the Sandover Highway from the south, or the Murray downs Road from the north, towards site. All local roads are unsealed and of varying conditions. The Murray Downs Road is a key route for local pastoralists moving cattle north for export from Darwin. The level of tourism traffic is unknown. A detailed discussion on transport infrastructure is provided in Chapter 13: Transport.

Health and emergency services

Health services provide to the local community include the following:

- Tennant Creek - Royal Flying Doctor Services, Tennant Creek Hospital Anyinginyi Health Aboriginal Corporation, St John Ambulance
- Ampilatwatja - Health Centre Aboriginal Corporation
- Arlparra - Urapuntja Health Centre Aboriginal Corporation
- Ali Curung - Centre Clinic
- Alice Springs - Royal Flying Doctor Services.

Emergency services comprise the following:

- Tennant Creek - Tennant Creek Police, NT Fire and Rescue Services, NT Emergency Services, St John Ambulance
- Ampilatwatja - Police from Arlparra and Harts Range
- Arlparra - Police Station
- Ali Curung - Police Station.

Housing

The level of home ownership in Tennant Creek is lower than for the Northern Territory and half the rate for Australia. The rates for Aboriginal people are lower still with 18.5% owning or in the process of buying and 70.2% of Aboriginal people renting, compared with 57% of Tennant Creek residents overall. Public housing in the study area is generally overcrowded, which has flow on impacts on health, social cohesion, workforce participation and educational attendance and outcomes.

12.2.9 Health and wellbeing

The World Health Organisation (2008) outlines ten key determinants of health comprising:

- Social gradient: a person's social and economic circumstances.
- Stressful economic and social circumstances mean people are less likely to be healthy and have a long life.
- Early years of life: babies born with low birth weight have a much greater likelihood of developing coronary health disease in adulthood.
- Social exclusion.
- Stress at work: having little control over jobs, limited opportunities to use their skills or in high demand jobs with few rewards.
- Unemployment, job and income insecurity can lead to chronic stress.

- Social support.
- Addiction: misuse of alcohol, drugs and tobacco is harmful to health but is often a response to stressful situations and social breakdown.
- Food security, including good quality and affordable food.
- Transport is vitally important to accessing health and other services and, for Aboriginal people, a means to find traditional bush foods and hunting.

Remote Aboriginal Northern Territory communities continue to reflect poorly against these measures, which impacts on school attendance, employment outcomes and individual health and well-being (Appendix L). There is a gap between the health status of Aboriginal and non-Aboriginal Territorians, including chronic diseases and mental health. Smoking rates, and alcohol consumption and admissions to hospital for circulatory disease, cancer and injury are higher amongst Aboriginal people than non-Aboriginal people. Child mortality rates for Aboriginal children aged 0-4 are 333 deaths per 100,000 population compared with just 93 for non-Aboriginal residents.

Alcohol-related crime rates in Tennant Creek remain high, although progress has been made with a Tennant Creek Alcohol Management Plan and Alcohol Accord.

Police crime statistics for Tennant Creek for the calendar years of 2015 and 2016 show:

- 12.4% increase in assaults (including a 13.4% increase in domestic violence).
- 28.6% increase in reported sexual assaults.
- 60% increase in house break ins.
- 107% increase in motor vehicle thefts and 34.7% increase in property damage.

Police reported generally lower crime rates in Ampilatwatja and the Utopia Homelands, with their main workload resulting from alcohol, domestic violence and road safety. There is a higher workload in Ali Curung, where there have been issues with alcohol and conflict between families.

12.2.10 Culture

Indigenous heritage

The region is known for its strong cultural and environmental values, particularly in the Iytwelepenty/Davenport Ranges National Park, which forms the boundary of both the traditional lands of the Warumungu, Alyawarre and Kaytetye people, and also of the pastoral leases of Elkedra, Kurundi, Murray Downs, Singleton and the Anurrete Aboriginal Land Trust. Ceremonial activities are still practised and there is a strong art movement in all communities within the study area.

European heritage

European heritage is linked to early pastoral settlement and mining activities. Conservation and heritage sites around the Davenport National Park, include the Old Police Station Waterhole that served as an outstation for the Heavitree Gap Police Station in Alice Springs.

Natural resources and the environment

Water is a key constraint to population and industrial growth in Central Australia. There is no permanent surface water in the region but there are ephemeral creeks that run after rain, and a substantial aquifer in the Georgina Basin.

Human rights

The United Nations Declaration on the Rights of Indigenous Peoples includes the right for Indigenous peoples to be included in impact assessment processes, with a stipulation of 'free, prior and informed consent'. A consequence of this stipulation is the importance of meaningful engagement to ensure Aboriginal people receive information that helps them understand the Project, that they are not inhibited from providing feedback and that this is received before any rights are disturbed.

Native Title gives traditional owners the right to negotiate a Land Use Agreement and compensation through the CLC, as well as the right to protect sacred and important sites, the right to access for traditional activities such as hunting and the right to have a say on the management or development of land once the mining is finished.

12.3 Assessment of potential impacts

This section examines the potential opportunities and threats that the project will have on key social and economic features of the existing environment. The level of risk posed to socio-economic values by each source of impact was assessed using standard qualitative risk assessment procedures, which have been described in Chapter 6: Risk assessment. The risk associated with each potential impact is detailed in the risk register in Table 6-8. The full risk assessment is provided

12.3.1 Population and communities

Job creation as a result of the project could result in an influx of new people moving to the area. The Project is unlikely to bring substantial numbers of new residents or families to Tennant Creek; but downstream beneficial impacts from the project (e.g. a stronger business sector providing services to the mine) may result in a small increase in families in the wider region. However, the overall impact is expected to be low.

Negative impacts on community cohesion and community resilience could potentially come from the following:

- The influx of workers and their families to smaller communities such as Ampilatwatja, and the local region, creating tensions with existing communities, relating to employment opportunities.
- Community tensions if jobs are seen as not going to all families.
- Expectations being unrealistic with barriers to realising the potential economic benefits such as a lack of relevant skills and capabilities.
- Tension that can arise from the distribution of benefits, including wages and royalty payments, particularly management of cash payments.

Pastoralists in the Sandover region have strong connections to their properties, with generations of families living and working in the region and a cohesive pastoral industry. Potential negative impacts for them would be on their amenity, with noise, dust and additional traffic damaging roads.

The availability of people to take part in community events, including sports, and availability of community volunteers, such emergency services, can be impacted if a significant proportion of residents work long hours, shift work or live away from home as a result of the mine operations.

These risks relate to the construction and operational phases of the project. There are high levels of uncertainty about these risks and there may be potential cumulative impacts as a result of other changes in the region, such as other large resources Projects.

12.3.2 Economic impact

Local business

The Barkly business community has substantial experience of working with the mining industry and in remote locations, with a relatively strong trades and civil sector. Small Aboriginal enterprises may tender for civil works packages, building their capacity for other work with pastoralists and communities. The economic impact on the region, should this occur in reasonable numbers, is anticipated to be an opportunity.

On the other hand, the use of local contractors and businesses by the Project may result in some short-term reduction in business capacity in the local area. This impact is anticipated to be highest during the Project's construction period when there will be short term demand for a range of contractor services.

Local businesses that cannot meet the company's prequalification requirements may not win work on the Project, resulting in unmet expectations. Or local businesses may over-extend and invest unsustainably in staff and equipment, particularly during the construction period. This is a risk that will need to be managed by the local business community.

There is potential for the project to impact directly on grazing, mustering and the movement of cattle (i.e. project traffic, dust, noise and/or weeds) particularly during construction, resulting in reduced pastoral productivity resulting from traffic, dust, noise and weeds.

Inflationary pressures

The presence of a mine can lead to inflationary pressures in a small economy, by creating scarcity and higher costs of goods and services, increasing the cost of housing and pushing up wages and conditions. This can create impacts for disadvantaged or marginalised people either on welfare or low wages.

Apart from potential pressure on wages, these impacts are considered unlikely due to the Project's distance from towns, and the lack of commercial accommodation in nearby centres such as Ampilatwatja. A focus on recruiting from local communities and the scale or change from local procurement is unlikely to be sufficient to cause inflationary pressures.

Tourism

Large-scale resource development can take up flights and accommodation that support other sectors, in particular tourism. The tourism sector in Tennant Creek would welcome a small increase in occupancy rates, but not saturation of the existing capacity of only 277 tourist beds in the Barkly. Opportunities for expansion of the Outback Caravan Park to accommodate any certain increase in demand may be available.

The significance of this risk was assessed as low, given the distance from regional centres such as Tennant Creek, and plans to FIFO workers to the mine site. It is likely that the project would have a small positive effect on short-term accommodation in Tennant Creek and Alice Springs as management and contractors transit through the region.

Workforce participation

The advent of a mining project may prompt good workers to leave their current jobs for better paid work at the mine and cause lost productivity for other employers as a result.

This risk is considered likely, but short-term. Given that mining requires either low-skilled labour or specific professional skills, it may also be unattractive to many existing local workers. Local Government considers the risk as likely, but also as an opportunity to train additional workers to backfill positions.

Indirect employment opportunities

Indirect employment (i.e. the number of workers employed as a result of the additional expenditure in the economy from the project, which generates additional jobs) is expected over the life of the Project. Most of the job creation would occur in the rest of Australia. This is because the redistribution of profits and taxes from the project are expected to be spread proportionately based on population size in each region of Australia.

Associated indirect impacts may have a positive effect to other sectors, such as retail, goods, services and hospitality due to increased wealth in the community and increase the capacity of local businesses. This may result in long-term growth in business capacity in the region. Employment opportunities from the project may also lead to a general upskilling of the workforce, increasing long-term employability of the workforce.

12.3.3 Labour force and education

The project will create a maximum 300 direct jobs in the 12 month peak construction phase, but an average of 150 over the whole 2-year construction period. In steady state operation, the project will employ approximately 165 workers.

The relatively small scale of the project is likely to suit the capabilities of Barkly or Central Australian businesses. Pastoralists and Tennant Creek businesses have provided the majority of services to the project to date, including clearing and civil works.

The construction workforce is likely to be a combination of local Aboriginal workers, complemented by FIFO workers from Alice Springs, Tennant Creek and Mount Isa. There is no capacity for an external workforce to live anywhere but the accommodation camp on site.

Opportunities for local jobs

The regional manager of MyPathway estimates that perhaps 25% of VRM’s 300 construction jobs could be filled by Aboriginal people from all Alyawarre communities, including Arlpurrurulam. The types of job available are likely to suit local workers (truck and grader drivers) and some Aboriginal people may move back to their land for jobs and business opportunities with the project.

Given the project’s minimum 25-year lifespan, longer-term opportunities could be enhanced by working with employment providers and schools to transition promising students into jobs and by providing the appropriate mentoring and support.

Aboriginal recruitment will be enhanced by awarding contacts to companies with a good track record of Aboriginal employment and training, using labour hire as a means of accommodating cultural obligations, focussing on work that Aboriginal people aspire to such as land management and human resource practices.

However, the project is more likely to recruit workers already in jobs than currently unemployed workers and there will be difficulties in meeting aspirations for Aboriginal employment. due to cultural obligations, poor skills and a lack of experience in the workforce (particularly with long shifts), poor English and an unwillingness to travel away from traditional country and family.

12.3.4 Infrastructure and social services

Subject to consultation with the Northern Territory Government, substantial legacy benefits from the project would include upgrading of roads used by pastoralists and the community, improved telecommunications and access to common user infrastructure such as the railway spur line.

The Sandover Highway, which services communities and pastoral properties to the Queensland border, and the Murray Downs Road past Ali Curung and Imangara, are in poor condition.

Upgrading of the Murray Downs Road would have particular social and economic benefits for pastoralists and communities because these roads are used to deliver fuel, cattle, food supplies to the store and by growing numbers of four-wheel drive tourists on the Binns track.

Corporate sponsorship of community infrastructure or events by VRM would contribute to the distribution of benefits to local communities.

Social infrastructure, such as health and education services, will be unlikely to experience negative impacts as FIFO workers would use mine supplied health services, but there could be some increased demand for services at the Ampilatwatja Health Centre during construction, and due to the increased presence of local families. Tennant Creek hospital would bear the burden, potentially, of medical evacuations or disaster response. However, these are identified as a low risk.

The project is unlikely to impact on public or private housing availability or affordability in regional centres such as Tennant Creek due to FIFO nature of workforce, but an influx of families to Ampilatwatja would strain already overcrowded public housing, should Aboriginal workers move to the local area seeking work and bring their families. However, the 'honey pot' effect of people arriving in the community in expectation of work, is expected to be short-lived.

The project is not expected to substantially increase workloads or require an increased police presence in Ampilatwatja, as issues can be managed by a Code of Behaviour. Increased availability of alcohol or drugs, either through wages and benefits payments could impact local communities through increased crime, antisocial behaviour and decreased road safety.

12.3.5 Health and wellbeing

There may be improved health outcomes for local workers through higher incomes, healthier living conditions while in the workers' camp and taking part in health promotion programs (such as healthy diets and anti-smoking campaigns).

Road safety is an existing issue which could be compounded by increased project traffic contributing to the deterioration of road quality, especially after heavy rain and increased road dust during dry periods. VRM will reduce road safety risks to employees by flying workers from home towns to air strips and bussing them to site, and by implementing strict workplace health and safety procedures.

Mental health problems arising when FIFO workers become lonely or distressed by long periods away from families, may be even more applicable to Aboriginal workers living in the accommodation village, due to the cultural importance of families and the unfamiliarity of a mining lifestyle. However with good human resource management and the relatively low workforce numbers, the likelihood of this risk is low, however the consequence of any loss of life or attempted self-harm result in an overall medium risk.

The Department of Health has expressed concern about the increasing prevalence of sexually transmitted diseases in remote parts of the Territory. VRM will implement a Code of Behaviour for its workers, including restrictions on leaving the workers' village or worksite for non-work purposes. Consequently, the risk is negligible.

Mining projects can lead to fears and negative perceptions of potential impacts, such as pollution or chemical spills. Given the nature of this project and apparent level of community support, the likelihood is considered low. Further, the appointment of a community liaison officer should help identify any emerging issues, resulting an overall low risk.

There is a risk of increased crime and anti-social behaviour if royalties or wages are spent on alcohol by local workers or residents from nearby ‘dry’ communities. This will be addressed by strict controls on alcohol consumption at the mine site and bans on taking alcohol from site. Consequently, the risk is assessed to be low.

Police report low-level crime in the region, such as vandalism and thefts and suggest good security measures for both company and workers’ property. Crime prevention methods such as secure compounds and padlocks will help reduce the incidence of crime. The opportunistic nature of this sort of crime leads to an assigned risk of medium.

12.3.6 Culture and heritage

Potential impacts to culture could occur from the destruction or damage of sacred or culturally significant sites by project activities or unauthorised behaviour by workers trespassing or accidentally wandering into cultural exclusion zones. Further details are provided in Chapter 14: Aboriginal and historic cultural heritage. This issue could impact local cultural identity and existing ceremonial activities.

The project could have a minor contribution to cultural maintenance through sponsorship, cultural staff inductions and purchases by project staff of art from the art centres in each major community.

12.3.7 Natural resources and the environment

Apart from short-lived dam water after rain, pastoralists and communities in the Sandover and Barkly regions are reliant on bore water for irrigation, domestic and pastoral use. Water is a sensitive issue and there may be community concerns about the use of water by the project.

Modelling suggests project water drawn from the Georgina Basin carbonate aquifer will have no impact on pastoral bores, community drinking water or horticultural activities (the closest of which are near Ali Curung and on the west of the Stuart Highway). Details are provided in Chapter 8: Groundwater

The project will monitor groundwater drawdown to provide early warning signals of any impact, allowing corrective action

12.3.8 Human rights

Human rights breaches for this project are likely to be unintended and would be avoided with appropriate human resource management and a Code of Behaviour for workers. Potential breaches include labour issues such as inequitable access to jobs by women, paying under the award rates to workers or work experience students, racism in the workforce and discriminatory work practices. These will be managed with cross-cultural training, appropriate human resource management and strict codes of conduct for all workers. While it is important to put in place measures to avoid breaches of human rights, with appropriate management the likelihood of them occurring is rated as low.

VRM will liaise with the CLC, for issues relating to native title holders. The CLC is responsible for ensuring that native title holders have provided free, prior and informed consent in relation to this project.

12.4 Mitigation and monitoring

12.4.1 Pre-construction and planning controls

An Economic and Social Impact Management Plan (Appendix E) will be implemented prior to construction commencing. This plan will include the following measures to avoid or reduce likely impacts on communities. A community strategy will be developed to work with the local community to:

- Employ a community liaison officer to interface with the community.
- Plan for any influx of people to local communities relating to the Project construction or operation.
- Identify ways the community, local businesses and pastoralists can benefit from common user or shared infrastructure. This will include regular liaison with the three levels of Government to take a regional approach to infrastructure development and on shared planning to optimise the potential for the project to supply local communities.
- Manage the impacts on local services, e.g. by providing additional temporary accommodation demand and supply for goods and services expected for the project.
- Prepare a sponsorship policy covering small local investments in the communities in which it operates. Priority will be sponsorships that foster community pride and work skills, such as sport, scholarships and community activities. VRM currently sponsors the Ampilatwatja men's AFL and women's softball teams.
- Work with the CLC who will identify native title holders with a right to negotiate and manage negotiations on their behalf.
- Ensure good communication to traditional owners about all aspects of the project timing, scale, likely disruption and implications.

A workforce plan will be prepared to manage breaches in human rights and labour law, equitable opportunities, and women in the workforce. This will include:

- Performance criteria mandated in contracts to ensure adherence to human rights and labour requirements.
- Codes of behaviour that address any issues that could lead to breaches.
- Cross-cultural training for all workers, including management.
- Appropriate grievance procedures and remedies for workers to raise any concerns.
- Collaboration with relevant recruitment providers to increase the available local labour pool, e.g. through shared planning and training programs.
- The workforce plan would contain a program for work-readiness and training. This will include:
- Establishing a training committee, with all relevant parties once the timing of construction is known to maximise training and work-readiness.
- Engaging with Community Reference Groups and local education providers to develop strategies to get members of the local community work-ready.
- Collaboration with the CLC to manage expectations and with the intention of achieving equitable treatment of employees from local communities.

- Employment training programs will include life skill training including money management topics. Look at joint training opportunities with other local businesses. Include driving courses to help local people get jobs driving buses or heavy equipment.
- Consider recruitment providing incentives for FIFO workers to relocate to Alice Springs or Tennant Creek.
- Encourage local workers to live at the accommodation village while on shift, particularly single workers.
- Identify opportunities for involvement in land management and caring for country programs for local Aboriginal communities including potential commercial opportunities for seed gathering, nurseries and revegetation.
- Ensuring contractors have a commitment to Aboriginal participation services.

A pre-construction business management program will be established for engagement and training of local businesses to identify potential demand for goods and services. This will include:

- Preparation of a Local Industry Participation Plan as part of its obligations under the Project Development Agreement with the NT Government (as a result of being awarded major Project status).
- Collaborating with the Northern Territory Government, Industry Capability Network (ICN) and Chamber of Commerce and Regional Infrastructure Development Committees to prepare local businesses for opportunities and to package and promote tenders to suit local capacity.
- Work with the Northern Territory Government to seek funding for upgraded local roads and regular maintenance.
- Providing information about company expectations and the types and range of jobs available, including opportunities for women.
- Providing advice on planning and timeframes of contracts available to ensure companies tendering for work don't over-extend.

12.4.2 Operation

All distribution of community benefit payments will be managed either via the CLC or through an agreed trustee arrangement with the aim of an equitable distribution of benefits. VRM will sign a land use agreement with Traditional Owners, through a negotiated benefit agreement with the CLC, and will work with local education and employment providers to maximise opportunities and the capacity of local people to realise the opportunities.

VRM will prepare a Code of Behaviour covering the behaviour of both its staff and all contractors and sub-contractors to address all issues raised in this ESIMP. This includes:

- Issues such as bans on private vehicles, firearms and pets, not leaving the worksite except for authorised work purposes, respecting all sacred and cultural sites, drug and alcohol tests, limits on alcohol consumption, not taking alcohol offsite and general standards of behaviour.
- Cultural inductions and mentoring to provide a safe and welcoming workplace for Aboriginal men and women.
- VRM will liaise with the Department of Housing and Community Development to forecast any predicted increase in the population of Ampilatwatja as a result of the project to provide forward planning of the need for increased public housing.

- An accommodation and transport strategy will be prepared to manage the capacity of local hotels and flights and likely project demand. This strategy will include monitoring of potential displacement, matching rosters and transport from site to flight schedules, and providing temporary accommodation if necessary.

Onsite facilities will include medical facilities for staff to reduce pressure on local health clinics. Other health support initiatives will include health promotion programs at the worksite.

VRM will maintain good communication and engagement with the community during operation of the Project through the following:

- Community updates on the project, distributed by email to key stakeholders and placed on community noticeboards.
- Posting regular updates and community reports on a project page of the VRM website.
- Transparent monitoring and availability of results, including regular publishing of baseline data and operational data will be provided to regulators and the community.
- Holding annual site visits/open days for the community, particularly for the families of staff.
- Conducting annual satisfaction surveys with key stakeholders.
- Maintaining a well-publicised inquiry line and email.
- Maintaining a recruitment presence in Ampilatwatja, with regular attendance by the community liaison officer to answer queries.
- Encouraging school visits and work experience by students from nearby schools.
- Liaison with pastoralists, particularly during mustering periods.
- Open and honest communication of any incidents in breach of these commitments.

The Culture and Heritage Management Plan (Appendix E) will include cross-cultural awareness programs and a cultural induction programme will be mandatory for all employees and contractors.

Mitigation relating to ground water resource management and biodiversity and are addressed in Chapters 8 and 9 respectively. Mitigation relating to traffic management, including road safety, noise and air quality are addressed in chapters 13: Transport, 15: Air and 16: Noise.

13. Transport

13.1 Introduction

This chapter describes the potential traffic and transport (road) impacts relating to the activities of the Ammaroo Phosphate Project.

A traffic impact assessment report (GHD 2017) is provided in Appendix M of the draft EIS.

Section 5.7 of the draft EIS TOR provided the following environmental objective in relation to transport:

> *Key transport risks will be effectively identified and avoided / mitigated / minimised to the greatest practicable extent.*

This chapter addresses the transport impact assessment, as required in the TOR for the project. The level of risk associated with potential impacts to traffic and transport is described in this chapter and assessed in the risk register in Table 6-8.

13.2 Methodology

The assessment considers the construction and operational impacts of the project on the public road network and identifies appropriate treatments to mitigate significant traffic or road safety impacts and includes:

- An overview of the existing road conditions and traffic volumes on affected roads.
- An assessment of the project case for each relevant phase with regard to traffic impacts, focusing on traffic generation of light and heavy vehicles and vehicle haulage rates.
- An analysis of the construction phase, as the critical phase, with regard to road capacity, turn treatment warrants and other potential road impacts.
- Recommendations for mitigating treatments to manage the impacts of the works and details on future traffic related assessments.

The life of the project covers the three distinct stages of construction, operation and decommissioning. Each of these stages will have markedly different traffic impacts on the public road network, and hence have been assessed separately in this traffic impact assessment.

13.3 Existing environment

As is typical for remote mining projects, transport and logistics is a key issue. The Ammaroo site is reached by travelling north or south on the sealed Stuart Highway then along unsealed roads, most in poor condition. While there are plans to rail freight and concentrate along a spur line in the transport corridor, during the construction phase the site will be accessed by local roads, with a substantial increase in industrial traffic, mostly along the Murray Downs Road.

The Murray Downs Road is a key route for local communities and local pastoralists moving cattle north for export from Darwin (Munday, 2017).

13.3.1 Key roads

The key roads within the area impacted by the project (Figure 13-1) are Stuart Highway, Murray Downs Road (and Kinjurra Road) and Sandover Highway.

Stuart Highway

Stuart Highway (National Route 1/National Route 87) is a national highway connecting Darwin, in Northern Territory, and Port Augusta, in South Australia, and linking the key rural population centres of Katherine, Daly Waters, Tennant Creek and Alice Springs. Within the vicinity of the project site, it is generally a sealed two-lane, single carriageway road with one lane in each direction. The width of seal is approximately 7 m wide with unsealed shoulders and the posted speed limit is 130 km/h.

Murray Downs Road (and Kinjurra Road)

Murray Downs Road is a two-way, single carriageway road that connects from Ali Curung in the north-west to the Sandover Highway in the south east. Murray Downs Road is used predominantly by road trains transporting cattle, tourism traffic associated with the Binns Track, and locals. The road consist of both unsealed formed road sections and gravel sealed sections. Near the project site, the road is approximately eight metres wide and a default speed limit of 110 km/h applies.

Kinjurra Road is a sealed two way single carriageway road with 8 km of two lane seal and 14 km of single lane seal (formation varies from 7–9 m). The road connects with Murray Downs Road at Ali Curung (in the east) and connects with Stuart Highway in the west. A default speed limit of 110 km/h applies.

Sandover Highway

The Sandover Highway is an unsealed two-way, single carriageway road connecting the Queensland Border in the north-east to Plenty Highway in the south-west. Plenty Highway then connects to the Stuart Highway, approximately 70 km north of Alice Springs. A default speed limit of 110 km/h applies.

13.3.2 Traffic volumes

Traffic volumes were sourced from the Department of Infrastructure, Planning and Logistics' (DIPL) 2015 Annual Traffic Report. Annual average daily traffic (AADT) volumes at permanent counter locations (Figure 13-2) have been collated for the key roads. The AADT volumes include both light and heavy vehicles.

The DIPL does not currently maintain any permanent counting stations along Murray Downs Road or Kinjurra Road. Traffic volumes (vehicles per day (AADT)) were estimated based on:

- A review of counting stations on adjacent roads (refer Figure 13-2).
- Advice from Tenant Creek Regional DIPL office.
- Qualitative data concerning use of Murray Downs Road from the *Verdant Minerals Economic and Social Impact assessment July 2017* (Appendix L) (Munday, 2017).

The Munday report states anecdotally that there are about 45 road trains and 200 tourist vehicles (4WD off-roading on Binns Track) on Murray Downs Road per year. It is also understood local trips are made to and from local communities on Murray Downs Road. Table 13-1 summarises the available data.

Based on the data, a conservative estimate of 40 vehicles a day (AADT) has been adopted on Murray Downs Road and 60 vehicles a day (AADT) on Kinjurra Road for the purpose of this assessment.

For Murray Downs Road, a 40 vehicle estimate is considered conservative and this figure would be more likely for the southern end from the Ampilatwatja turn off, back to Atnwengerrpe. To the north of the Ampilatwatja turn off, the traffic volume is likely to be less.

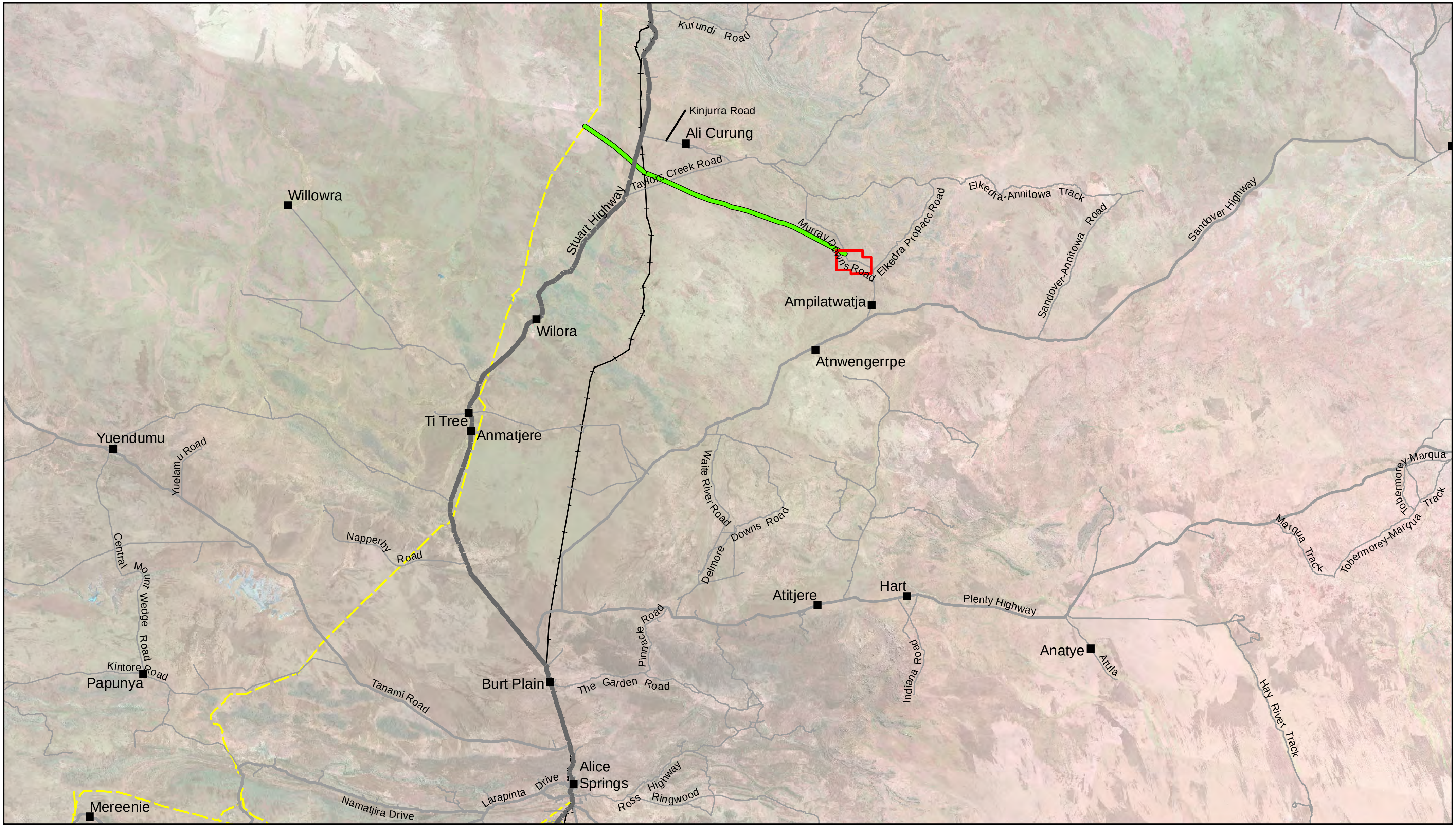
For Kinjurra Road, the traffic volume is likely to be slightly higher, compared to the Murray Downs Road volume, due to access to the Ali Curung community and the Centrefarm developments. Hence, a conservative estimate of 60 vehicles a day has been made for this road section.

The directional split for all roads was approximately 50:50, i.e. 50% northbound and 50% southbound.

Table 13-1 2015 AADT volumes from count station data

Survey location	Two way AADT Volumes (vpd) (2015)
Stuart Highway (RTVDC021 – North of Murray Downs Road)	353
Stuart Highway (RTVDC022 – South of Murray Downs Road)	305
Stuart Highway (RAVDP014 – South of Sandover Highway)	634
Sandover Highway (RAVDC024 – North of Murray Downs Road)	7
Sandover Highway (RAVDC022 – South of Murray Downs Road)	37
Murray Downs Road	40*
Kinjurra Road	60*

*Estimated figure



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0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns
- Stuart Highway
- Major Road
- Local Road
- Access corridor
- Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	11 Oct 2017

Public road network

Figure 13-1

G:\43\22544\GIS\Maps\4322544_188.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Boundaries, Towns, Rail, Pipeline, Imagery (2015). GHD - Survey Locations (2017). Created by: CM

1:2,500,000 @ A4

0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND
- Towns
- Count station - two way AADT volumes (2015)
- Stuart Highway
- Major Road
- Local Road
- Proposed Corridor
- Project Site

* estimated values

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	11 Oct 2017

Traffic count stations

Figure 13-2

G:\43\22544\GIS\Maps\4322544_189.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Boundaries, Towns, Rail, Pipeline, Imagery (2015). GHD - Survey Locations (2017). Created by: CM

13.4 Proposed development

13.4.1 Construction phase

The total construction period of the mine site, process plant, rail spur and other infrastructure and facilities is expected to be up to 24 months, however the peak construction period will be over a 12-month period. The majority of the heavy vehicle movement associated with construction will be contained within this 12-month period. Murray Downs Road passes directly through the project site, and so during construction it is proposed to realign Murray Downs Road to bypass the site Figure 2-5 in section 2.2 shows the potential realignment of Murray Downs Road.

As indicated in Figure 2-5, most of the site infrastructure and facilities will be contained within the area bypassed by the new alignment of Murray Downs Road, with the exception of the accommodation camp and the landfill. This will minimise the impact associated with the mine on the public road network. Local trips within the mine between facilities such as the mine site, process plant and borrow pits will not occur on public roads. Local trips between the mine site and the accommodation camp will need to do so via a new intersection with the realigned Murray Downs Road.

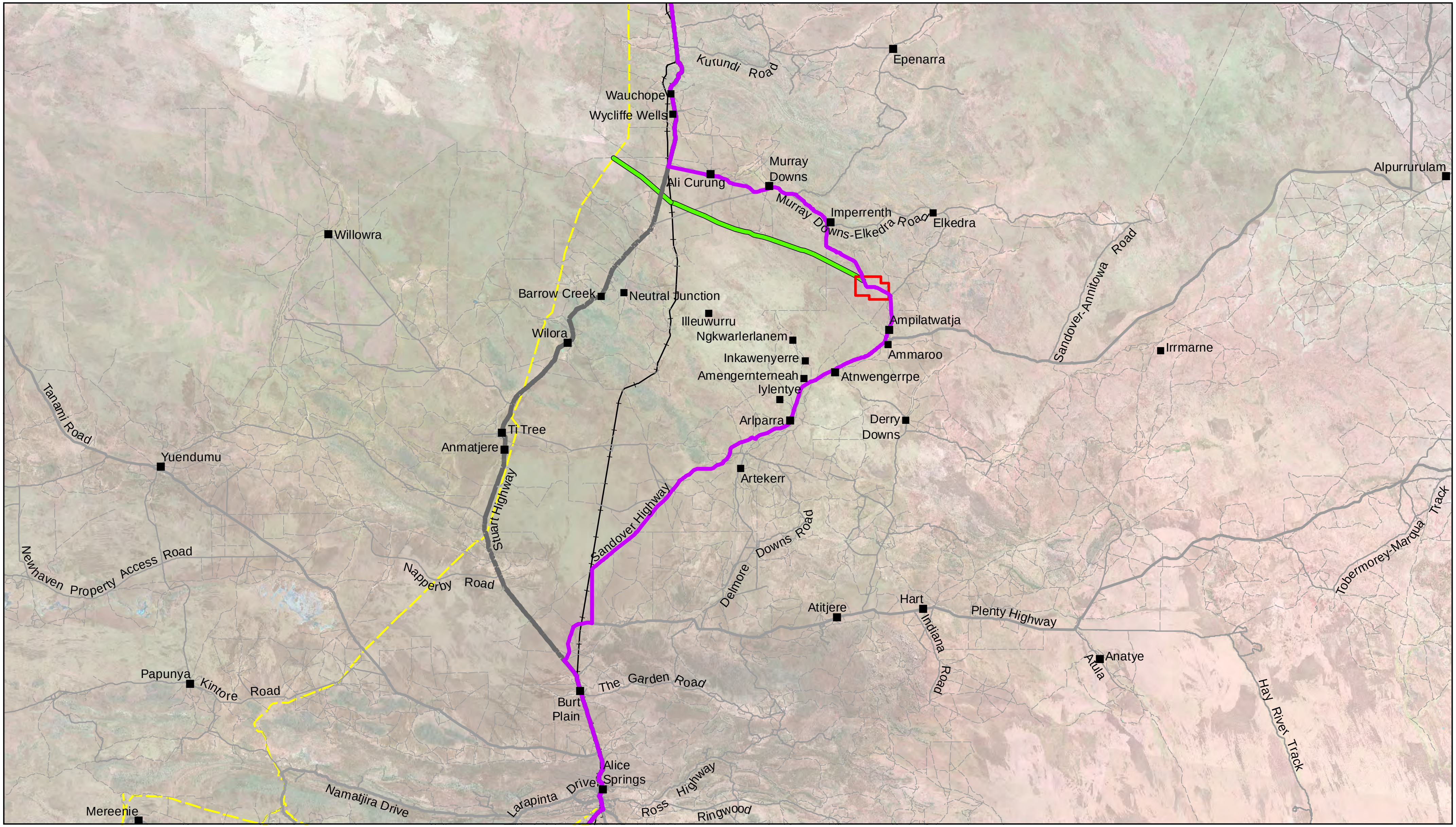
13.4.2 Haulage routes

It is anticipated that all traffic originating from Darwin will travel to the site via the Stuart Highway, turning onto Kinjurra Road / Murray Downs Road. For traffic originating from Adelaide and Alice Springs, it is anticipated traffic will travel along the Stuart Highway before turning onto Plenty Highway, Sandover Highway and then onto Murray Downs Road. These routes from north/south will vary if one road or the other deteriorates, or a load is deemed too wide to safely travel e.g. via the Murray Downs road route from the north.

These routes are shown below in Figure 13-3.

The following intersections occur along the expected haulage routes and will be affected by developmental traffic generation:

- Stuart Highway/Kinjurra Road
- Kinjurra Road/Murray Downs Road
- Stuart Highway/Plenty Highway
- Plenty Highway/Sandover Highway
- Sandover Highway/Murray Downs Road
- Murray Downs Road/ plant site and accommodation camp access road.



1:2,500,000 @ A4

0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Towns	Local Road
Haulage Route	Tracks
Stuart Highway	Proposed Corridor
Major Road	Project Site

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	11 Oct 2017

Haulage route

Figure 13-3

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Boundaries, Towns, Rail, Pipeline, Imagery (2015). GHD - Survey Locations (2017). Created by: CM

13.4.3 Construction stage trip generation

Light vehicles

The WorleyParsons "*Traffic Assessment – Construction and Operations*" memorandum indicates the construction workforce at the site is expected to peak at around 300 personnel

Due to the locality of the project site, a permanent camp will be constructed to accommodate workers for the operating life of the project. During the peak construction period, additional temporary accommodation will also be provided for the expanded workforce.

It is understood the majority of the construction workforce will be engaged on a fly-in/fly-out (FIFO) basis, flown to Alice Springs, and then transported to the accommodation camp by bus, or alternately flown into nearby regional airstrips. It is assumed 90% of construction personnel will be transported to the site by bus (30 seater buses) from the camp accommodation and the remaining 10 per cent will utilise site vehicles.

The primary impact on the public road network due to construction workers based on site will be a result of travel (by bus) between the accommodation camp and the airport at Alice Springs.

For the purposes of this assessment, it is assumed a typical FIFO roster would apply, i.e. two weeks on and one week off. This would mean the total workforce would consist of 480 workers with two thirds at the camp at any one time.

As such, the average turnover would be 23 workers per day over a three week period (two bus trips on average each day). However, to simplify worker management, the contractor may choose to have worker changeover occur only once a week. As such, 14 bus trips would then occur on the same day.

To provide a robust analysis, it is assumed for this impact assessment the latter FIFO scenario occurs, where all FIFO bus movements will occur on the same day. It is assumed only 10 per cent of these bus movements will occur in the peak hour as in reality, bus movements will be timed to coincide with aircraft arrivals and departures at Alice Springs Airport (which may or may not occur during peak hour).

In addition to the workers based on site, it is understood additional specialist contractors and other miscellaneous trips by light vehicles will be made. The WorleyParsons "*Traffic Assessment – Construction and Operations*" memorandum indicates up to 20 additional light vehicle trips will occur and this has been adopted with a conservative estimate of 50 per cent of these trips being undertaken during peak times.

A summary of workforce trip generation is provided in Table 13-2.

Table 13-2 Summary of construction workforce trip generation

Vehicle type	AM Peak Trips	PM Peak Trips	Total Daily Trips
FIFO shuttle buses	2 (once a week)	2 (once a week)	14 (once a week)
Miscellaneous other light vehicle traffic	5	5	20
Total	**7**	**7**	**34 (once a week)**

The distribution of light vehicle traffic will be dependent on the trip purpose; however it is assumed all FIFO shuttle buses, and the majority of miscellaneous light vehicle traffic, will originate in Alice Springs.

The following traffic distribution for light vehicles has been assumed.

- North (Darwin) 15 per cent
- South (Alice Springs) 85 per cent

Heavy Vehicles

The WorleyParsons *Ammaroo Construction Truck Movements preliminary for EIS 15 Sept 2017* spreadsheet indicates the majority of equipment and materials required for construction will originate from the north (Darwin), with the remainder originating from the south (Adelaide). In addition, gravel and concrete material will be extracted from borrow pits on site.

Within the 12 month peak construction period, 850 truck movements (1,700 trips) transporting equipment and material will be required on public roads. It is expected the majority of heavy vehicles used to transport materials will be standard B-doubles, however overmass vehicles will be used to transport large equipment such as the crusher and mill (100 tonnes and 360 tonnes respectively). WorleyParsons have advised the figures have been developed assuming rail will be used to transport the majority of the rail line and sleepers.

A further 18,750 truck movements are expected within the project site, primarily to and from borrow pits within the 12-month peak construction period. These trips are expected to be fully contained within the project site and will not affect the public road network.

Table 13-3 summarises the heavy vehicle estimates, as indicated in the WorleyParsons *Ammaroo Construction Truck Movements preliminary for EIS 15 Sept 2017* spreadsheet.

Table 13-3 Anticipated heavy vehicle trips

Description	Quantity	Type of package	Truck journeys -from Darwin	Truck journeys from South	Trucks – from borrow pits
Railway above ground equipment	18,000	Rail line & components	10		
Buildings/Camp	80	Bed units	40		
	20	Kitchen units	0	20	
	10	Laundry units	0	10	
	10	Offices units	5		
	20	Misc. containers	20		
Box culverts	2800		10		
	100		5		
	100		5		
Fencing gates	4,000	120 m rolls	5		
Gravel	1,200,000				15,000
Mass excavations	1,400,000				3,500
Concrete	11,000		30		250
Structural steel, stairs, sheeting	2,000	Sub-assemblies and loose	40		
Piping	20,000		30	15	
Sub stations	5	Large loads - escorted	5		
Electrical equipment	Varies	Non packaged equipment, fittings and bulks	20		
Process equipment	800	Large equipment not in modules; mill 360 t, crusher 100 t,	50		
escorted loads	50	Pre-assembled units	50		
	50	Heavy construction equipment, cranes etc.	50	10	
	50	Mining Fleet	30	10	
Diesel, oils & chemicals		Tankers and Iso packs	50	50	
Camp consumables		Containers - refrig + Misc	50	50	
Construction equipment		Misc. construction tools and equipment	50	50	
Contingency		Nominal	45	35	

Description	Quantity	Type of package	Truck journeys -from Darwin	Truck journeys from South	Trucks – from borrow pits
Total		**Combined loads of different types**	**600**	**250**	**18,750**

Source: WorleyParsons "Ammaroo Construction Truck Movements preliminary for EIS 15 Sept 2017" spreadsheet

Heavy vehicle movements are anticipated to be approximately evenly spread across the work day. As such, a conservative assumption that only 10 per cent of daily trips will occur in the peak hour has been adopted.

A summary of heavy vehicle trip generation is provided in below. The calculated values have been rounded up to the nearest whole number to provide a conservative estimate of heavy vehicle impacts.

Table 13-4 Summary of heavy vehicle trip generation

Vehicle type	AM Peak Trips	PM Peak Trips	Total Daily Trips
Equipment and material	1	1	3
Consumables, miscellaneous heavy vehicle trips and contingency	1	1	3
Total / day	**2**	**2**	**6**

Based on the data in Table 13-3 the following traffic distribution for heavy vehicles has been adopted.

- North (Darwin) 70 per cent
- South (Alice Springs) 30 per cent

13.5 Potential impacts

This section identifies the potential direct and indirect impacts the transport network presented by the project. Transport-related impacts on health and safety are discussed in in Section 11: Health and safety.

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

A summary of the risk assessment results is provided in Table 13-5. Multiple hazards may exist as a result of a one potential event. Refer to the full risk assessment in the Environmental Risk Register (Table 6-8) for further detail.

Table 13-5 Qualitative risk – transport

Potential event	Residual risk level
Additional traffic reducing the operational performance of the road network	Low
Structural road capacity reduced as a result of project vehicular use.	Medium

13.5.1 Construction traffic impacts

Background traffic growth

The volume of traffic on key roads is assumed to have increased in line with historical growth rates relative to the survey year (2015). Forecast traffic volumes have been estimated for the construction year (2019) based on survey volumes and historic growth rates.

The AADT volumes counted in 2015 along each road section in Table 13-1 have been extrapolated to 2019 in order to estimate the background traffic volumes (i.e. traffic volumes independent of the project). The annual growth rate used is the average historical increase observed between 2007 and 2015, according to the *DIPL 2015 Annual Traffic Report*.

For Murray Downs Road, a 2.0% growth rate was assumed, which is consistent with the calculated growth rates on Stuart Highway and Sandover Highway in the project vicinity. It is noted there have been no other major changes in land use or new developments occurring in the area that would suggest a significantly higher growth rate.

Where multiple counters were available in the adjacent area, the counter which recorded higher volumes was chosen to provide a more conservative assessment.

The results are presented in Table 13-6.

Table 13-6 Background traffic volume growth

Survey location	Annualised AADT growth (2007 – 2015)	Two way AADT volumes (vpd) (2015)	Two way AADT volumes (vpd) (2019)
Stuart Highway (RTVDC021 – North of Murray Downs Road)	1.53%	353	375
Stuart Highway (RAVDP014 – South of Sandover Highway)	3.59%*	634	730
Sandover Highway (RAVDC022 – South of Murray Downs Road)	2.36%	37	41
Murray Downs Road	2.0%**	40**	44**
Kinjurra Road	2.0%**	60**	65**

**Based on 2010 to 2015 volumes*
***Estimated figures*

Road capacity – operational performance

Austroads *Guide to Traffic Management Part 3* (2013) provides guidance on the capacity of roads and traffic lanes. In uninterrupted flow conditions (such as those usually found on rural highways) a traffic lane can typically carry between 1,500 to 2,400 passenger cars per hour depending on site-specific conditions. A nominal capacity of 1,800 vehicles per hour, per lane is generally adopted for sealed highways.

The *Unsealed Roads Manual Guidelines to good practice* (ARRB, 2009) provides guidance on capacity standards for unsealed roads. Given the width and function of the unsealed section of Murray Downs Road, it would be classified as a Main Road (Class 4A), capable of carrying relatively high traffic volumes of nominally between 150 and 1000 vehicles per day.

The peak hour traffic volumes for the road are assumed to be 10 per cent of the AADT volume. This is considered to be a conservative estimate for peak volume traffic, as rural roads often have less “peaking” compared to urban roads. As such, the two-way peak hour volumes of roads within the study area are presented below in Table 13-7.

Table 13-7 Peak hour traffic volumes

Survey location	Forecast two way AADT Volumes (vpd) (2019)	Estimated two way peak hour volume (vph) (2019)
Stuart Highway (RTVDC021 – North of Murray Downs Road)	375	38
Stuart Highway (RAVDP014 – South of Sandover Highway)	730	73
Sandover Highway (RAVDC022 – South of Murray Downs Road)	41	5
Murray Downs Road	44*	5*

**Estimated figure based on anecdotal evidence and provided information*

Based on trip generation numbers presented in previous sections, all affected roads will have capacity to handle the increased traffic volumes from the project. Consequently, the impact is considered to be low.

Structural road capacity

Both Murray Downs Road and Sandover Highway are currently unsealed roads with unknown pavement construction. As such, it is not known whether the pavement is able to accommodate the increased traffic associated with the project, particularly with regard to oversized vehicles transporting project components. It is also understood current conditions along Murray Downs Road are poor, particularly in low-lying areas, and the road is subject to flooding.

To ensure the safety of the road for public use, an assessment of the road surface condition should be made to understand whether a gravel seal should be implemented on sections affected by the project. This will also improve the access of the road in all weather conditions.

Table 13-8 below shows the current formation of both Kinjurra Road and Murray Downs Road, as supplied by DIPL. Of particular focus should be the formed sections of Murray Downs Road, where an assessment will need to be made on whether a gravel seal should be implemented.

Consideration should also be given to upgrading the sections of road within major floodways. However, it is noted travel along these sections of road instead may be managed during construction.

Table 13-8 Road formation information

Road name	Start of section	End of section	Segment length (km)	Surface type
	Chainage from	Chainage to		
Kinjurra Road	0	22.47	22.47	2 - SEALED
Murray Downs Road	0	17	17	4 - FORMED
	17	25.92	8.92	5 - FLAT BLADED
	25.92	49.84	23.92	4 - FORMED
	49.84	51.34	1.5	3 - GRAVEL
	51.34	87.02	35.68	4 - FORMED
	87.02	90.52	3.5	3 - GRAVEL
	90.52	122.49	31.97	4 - FORMED

Turn treatment warrants

To assess the turn treatment warrants, a worst case scenario was assumed. This assumes all vehicles arriving at the site would occur in a peak period and all vehicles leaving the site will also occur in the peak. This is considered conservative, as the mine operates from 6:00 am to 6:00 pm, with vehicle trips expected to be spread throughout the day.

With reference to the Austroads *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections, 2010*, the turn warrants for a road with a design speed of equal to or greater than 100 km/h is shown in Figure 13-4.

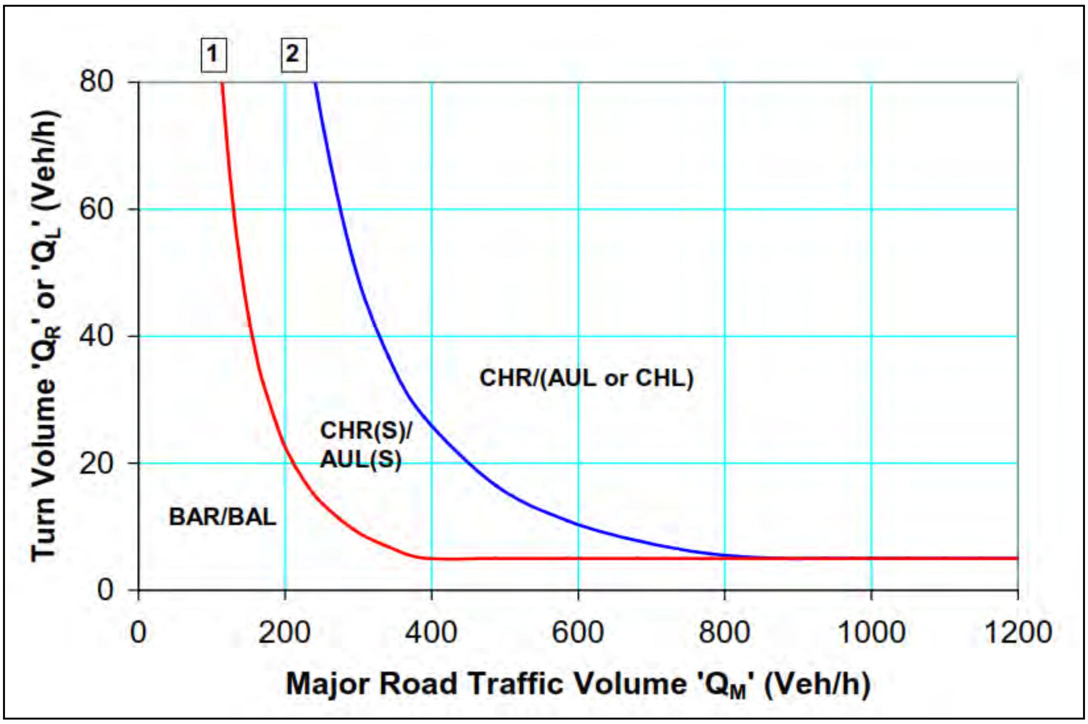

Figure 13-4 Austroads turn warrants

As noted in Table 13-7, the highest conservative estimates of two-way peak hour volumes is 73 vph on Stuart Highway south of Sandover Highway. Referring to Figure 13-4, for a design speed equal to or greater than 100 km/h, the Austroads warrants specify a basic left/right treatment is suitable if there are less than 100 vehicles per hour travelling along the major road.

A basic left/right treatment ("BAL" or "BAR") is a localised shoulder widening treatment, as shown in Figure 13-5. For this project, such treatment would be appropriate to all previously identified intersections on the haulage routes to the site including Stuart Highway/Kinjurra Road, Stuart Highway/Plenty Highway, Plenty Highway/Sandover Highway and Sandover Highway/Murray Downs Road.

There will be no impact to the operation of Murray Downs Road from the accommodation camp and mine site access road given the low traffic volumes along that road, and given Murray Downs Road is the major road. Issues such as queueing vehicles will be contained within the private access roads.

Haulage route assessment

The haulage contractor will complete an assessment of the full haulage route from origin (ports) to destination (the project) for overmass vehicles. It is understood overmass vehicles will be used to transport large equipment such as the crusher and mill (100 tonnes and 360 tonnes respectively).

13.5.2 Operation traffic impacts

During the operation phase of the mine, there will be a significant decrease in traffic generation on public roads compared to the construction phase.

The primary transport method for the ore produced by the project will be via the constructed private railway spur line, where the Worley Parsons PFS report indicates two trains each of 126 wagons / 252 containers will operate on a 67 hour cycle.

The mine workforce is expected to reduce to around 110 at any given period. It is assumed mine operations will be 24 hour, split across two shifts (6:00 am to 6:00 pm and 6:00 pm to 6:00 am). The traffic generated by the mining operations on public roads will therefore primarily consist of FIFO workers accessing the site. It is envisaged that bulk fuels and consumables will be delivered by train via the rail spur.

As such, the construction phase of the project is considered to be the critical traffic impacting phase of the project. Any impacts assessed during the construction phase will be the peak impacts of the project and any impact mitigation recommended for the construction phase will also adequately address impacts during the operation phase.

13.6 Mitigation

13.6.1 Works

Section above shows the turn movement assessments, which indicates a BAR/BAL treatment would be sufficient in terms of intersection capacity, as shown below in Figure 13-5. However, the type of turning treatment provided should also consider other elements of the actual intersection location, such as steepness of grades, sight distances and speed limit. In particular, Austroads suggests a BAL treatment would not be appropriate where numerous heavy vehicles travel quickly down a steep grade, and a channelised left turn is a more suitable treatment in such instances.

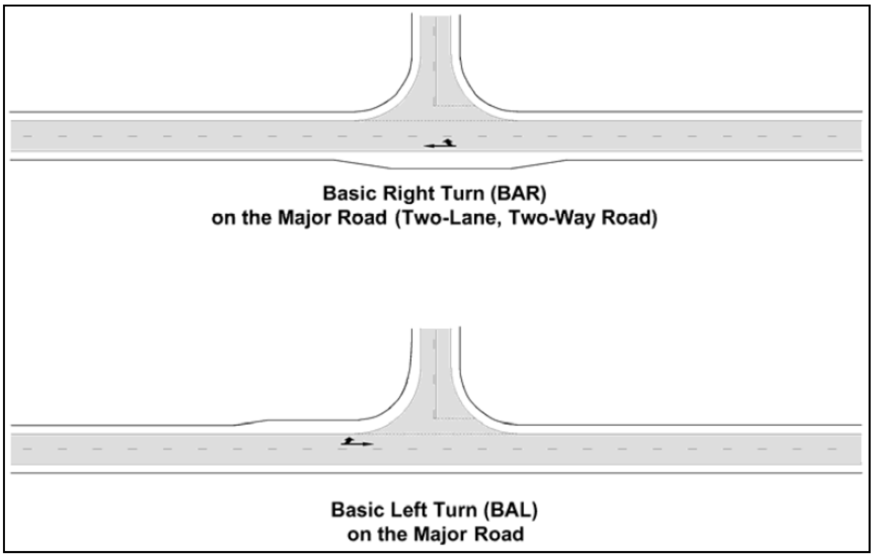

Figure 13-5 BAR and BAL treatments (from Austroads Guide to Road Design Part 4A, 2010)

As such, a review assessing sight distances, grade and any other associated road safety issues should be completed on identified intersections on the haulage route. If any safety deficiencies are identified, the BAR/BAL treatments identified may not be appropriate and a higher order treatment may be required.

The new mine site/accommodation camp intersection with Murray Downs Road should be designed and constructed so to maintain a safe environment for all road users. A road safety audit should be completed on the design of the intersection to confirm this.

13.6.2 Traffic management

The development of a Traffic Management Plan (TMP) will address the following issues:

- A road inspection and maintenance agreement in consultation with the NT Government to address pavement wear issues associated with the project
- A road safety review assessing sight distances, grade and any other associated road safety issues on identified intersections on the haulage route to ensure a BAR/BAL treatment is appropriate.
- Swept path analysis on affected intersections to ensure heavy vehicles are able to make required turning movements at those intersections.

The ongoing condition of the road will be impacted due to the increased numbers of heavy vehicles associated with the project, particularly in the construction phase.

An inspection and maintenance agreement will outline the responsibilities and liabilities of each party in relation to remediating works required on the road due to the project.

14. Aboriginal and historic cultural heritage

14.1 Introduction

This chapter describes the Aboriginal and historic (non-Aboriginal) cultural heritage values of the study area, and discusses previously recorded or newly identified Aboriginal and historic heritage sites. This chapter also addresses the potential impacts on Aboriginal and historic heritage arising from project activities, and the mitigation measures to avoid or reduce the direct or indirect impact of proposed mine construction and operation.

A detailed Aboriginal and Historic Cultural Heritage Assessment was completed for the project site and is provided in Appendix N for review by the NT EPA. The complete report is not however, included in any public release of the draft EIS, based on cultural sensitivity following consultation with Traditional Owners.

A Cultural Heritage Management Plan (CHMP) is included as a sub-plan in the EMP, provided in Appendix E.

Section 5.8 of the Project TOR provided the following environmental objective in relation to cultural heritage:

> *Places and items with historic and/or cultural heritage values protected under the Heritage Act, the Northern Territory Aboriginal Sacred Sites Act or any other relevant Territory or Commonwealth legislation, will be identified and those values protected.*

The term ‘cultural heritage’ includes, very broadly, all places and values of archaeological, traditional, historical or contemporary significance. Cultural heritage assessment investigates the value or significance of particular items, sites and places to the whole or particular sections of society. The cultural heritage assessment process operates on the basis that Aboriginal and non-Aboriginal cultural heritage should be conserved and protected and that project proponents have a statutory responsibility to protect such values.

14.2 Methodology

14.2.1 Review of background data

A review of previous reports and assessments was undertaken to identify registered sacred, natural and historic sites, places or objects including:

- Review abstract of records from Aboriginal Areas Protection Authority (AAPA) Authority Certificate(s).
- Central Land Council (CLC) cultural exclusion zone coordinates.
- Review of databases in October 2016 to identify known Indigenous and non-Indigenous historic sites, places or objects of heritage value including:
  - Northern Territory Heritage Branch Archaeological Site Register
  - National Native Title Tribunal Register
  - EPBC Act Australian Heritage Database.

14.2.2 Environmental, ethnographic and archaeological context

A review of the environmental, ethnographic and archaeological context of the subject land was undertaken to identify the potential for any unknown objects and/or places of potential significance. The following was reviewed:

- Environmental characteristics - such as drainage lines, topography and geology provide insight into how people used land in the past, and establish a context for identifying the archaeological potential of the area. It also assists to explain why certain historical events may have occurred and why certain historical themes may apply or dominate in a particular area.
- Ethnographic and historical literature - to provide insight into history of use and occupation of the study area based on documentary evidence and early ethnographic records. It also identified factors that may have affected archaeological site survival and any historical archaeological relics that may survive in the study area.
- Archaeological context - including the previously documented known places and objects, locally and regionally, that have been recorded by other archaeologists.

14.2.3 Indigenous stakeholder consultation

Verdant has an ongoing and established relationship with Traditional Owners and was responsible for organising Indigenous stakeholder consultation for the purposes of cultural heritage surveys. Extent Heritage Advisors met with Traditional Owners at Ampilatwatja on 26 October 2016 and 29 October 2016 to discuss the purpose and scope of the cultural heritage survey. Hard copies of maps showing the location of proposed infrastructure was provided to Traditional Owners to be discussed within the community. Four Ampilatwatja community representatives were involved in the cultural heritage survey, as discussed below.

14.2.4 Field investigation

Cultural heritage surveys were undertaken from 29 October to 6 November 2016 and 31 March to 2 April 2017 by Extent Heritage Advisors and Aboriginal custodians to:

- Confirm the location of previously recorded sites.
- Record any additional Aboriginal and historic sites, places or objects identified within the study area.
- Identify any additional areas of archaeological potential.

The survey comprised sampling within the footprint of proposed key infrastructure including borefield, borefield access track and pipeline corridor, accommodation camp, mine site area, processing plant and TSF, and infrastructure corridor.

The project footprint did change to some extent after the archaeological survey was complete, included the following infrastructure location changes:

- The accommodation camp site moved to the east
- The borefield access track and pipeline corridor moved to the west.

These changes have been noted in the results of field investigations outlined in section 14.5 below.

Due to the size of the Project area, the survey included a combination of pedestrian and vehicular transects. Areas of ground exposure were examined for archaeological evidence such as stone artefacts, mature trees were examined for Aboriginal cultural scarring, and rock outcrops were examined for the presence of rock shelters and evidence of quarrying and rock art (petroglyphs). Creek lines were also examined to document soil profiles, soil disturbance, erosion and potential for sub-surface archaeological deposits.

The sampling program considered the various land system units of the study area as well as available access. The combined length of the pedestrian and vehicular archaeological survey transects totalled 164.7 km. Vehicular transects consisted of 110.8 km of survey, with pedestrian survey transects covering 53.9 km. The archaeological survey effectively sampled is approximately 16.3 km^2 or approximately 30% of the project area. Survey transects are shown on Figure 14-1.

Ground surface visibility during the October 2016 survey was generally high across the project area owing to the high levels of pastoral land use and grazing, vegetation clearance along pre-existing access tracks and relatively sparse vegetation across the sand plain that underlies much of the project area. However, ground surface visibility during the March 2017 survey was generally low across the transport corridor to the west of the highway owing to relative sparse but well established vegetation. The average ground surface visibility was 40%, with some areas as high as 90%.

Aboriginal archaeological sites identified during the survey were documented, photographed and locations recorded using a handheld GPS unit.

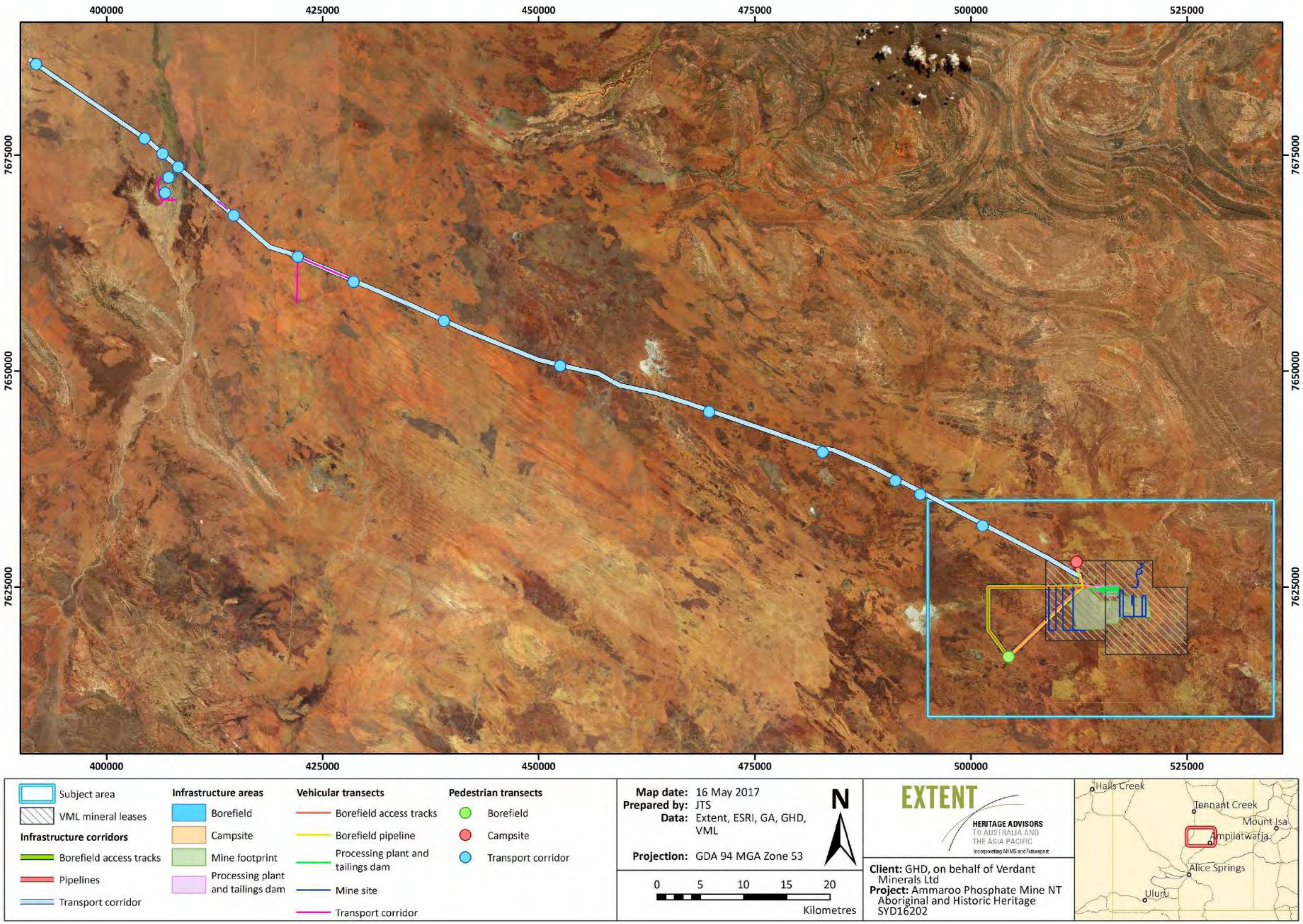

Figure 14-1 Survey transects. Note that parts of the mine footprint include Restricted Works Areas and were not included in the survey coverage.

14.3 The environmental, ethnographic and archaeological context

The following information is sourced from the cultural context described in the Aboriginal and historic cultural heritage assessment report (Extent 2107). Primary references have been cited in that document.

14.3.1 Environmental context

Raw stone material including chalcedony, chert (re-crystallised in calcretes), silcrete and quartz occur within the region and are suitable for the production of knapped tools. Quartz was an important raw material used for stone tool production by Aboriginal people. Sandstone is also known to be utilised for grinding tool and is associated with landscapes to the north of the Project site.

In arid regions water is the most critical resource, and early ethnographers and ethno-archaeologists working in arid Australia noted the role played by water availability in determining activities, especially settlement patterns for Indigenous groups. The major source of water in the region is the Sandover River, an ephemeral watercourse approximately 30 km south of the mine site. The channel of the Sandover River is wide and shallow, and when the river is flowing nearby areas are prone to flooding. At Ammaroo Station, the Sandover floodout zone spans approximately 200 km^2. There are very few drainage lines in the vicinity of the subject area, and those that exist are small, unnamed ephemeral streams, mostly in the northeast.

There are no permanent water sources and almost no ephemeral water sources along the entirety of the transport corridor. This lack of permanent water likely restricted the use of the region by Aboriginal people in the past. It is likely that the area was only visited and/or occupied intermittently when significant rainfall had occurred – such behaviour will constrain the type and nature of archaeological deposits that may be present.

14.3.2 Ethnographic and historical context

Aboriginal history

The subject area is located within country where the Alyawarre are identified as the Traditional Owners. The greater region is the location where three main Aboriginal language groups converge, including Anmatyerre, Alyawarre and Kaytetye. To the south is the major language group of the western, central and eastern Arrente. To the north-west is the major language group of the Warlpiri.

European history

The first Europeans to traverse the region were associated with John McDouall Stuart's expedition in 1860 and notes from this expedition describe tracks and fires, suggesting a large Aboriginal population

European use of the region commenced with the construction of the Overland Telegraph Line (OTL) in 1870-72, approximately 90 km west of the subject area, followed by gold mining in the Tanami region (north-west of the study area); and the development of the pastoral industry between Alice Springs and Tennant Creek. A 1920 chart of the pastoral leases in the region shows both Elkedra Station and Murray Downs Station, and a 1922 map shows a pastoral lease at Ammaroo.

Aboriginal-European colonial relations and frontier violence

The Anmatyerre and Kaytetye have had a lengthy period of culture contact after 1870, following the influx of cattle graziers after the construction of the OTL.

The regional pastoral industry took possession of scarce water supplies, and developed herds that depleted native vegetation and drove away native game. Wells, important for stock routes, were generally constructed on natural soakages, which were connected to local people as sacred places. This fuelled animosities between pastoralists and the Aboriginal traditional owners during drought.

14.3.3 Archaeological context

Regional archaeological context

Pleistocene dates of 36,500 to 42,500 BP have been found from Puritjarra. It is generally accepted that the current arid zones of Australia were significantly different during the Pleistocene, and Indigenous people occupied these areas early on after colonisation of the Australian continent.

Three themes of particular relevance for interpreting the archaeological record within the study area are:

- Pleistocene and Holocene climate change.
- The distribution, abundance and permanency of water sources and climate seasonality.
- The species composition, distribution and abundance of economic plant species.

Owing to the close interdependency between desert ecology, climatic variation, and topography, these conditions would significantly influence the economic and social systems of the people that inhabited the arid zone. Early ethnographers and ethno-archaeologists working in arid Australia noted the role played by water availability in determining activities, especially settlement patterns for Indigenous groups.

Local archaeological context

No previous archaeological investigations have been undertaken within the subject area; and only three in the surrounding region, all of which were associated with the Darwin to Alice Springs railway. As a result, the locations of previously identified Aboriginal archaeological sites generally cluster along the rail corridor, rather than reflecting past Aboriginal occupation and use of the broader landscape.

Heritage Surveys (1997)

Heritage Surveys undertook an archaeological survey of the proposed Alice Springs to Darwin railway between Alice Springs and the Buchanan Highway. The Tennant Creek to Bond Springs Station section of the railway easement is adjacent to the western end of the Project’s proposed infrastructure corridor.

Twenty-four Aboriginal archaeological sites and 150 isolated artefacts were identified, including 17 artefact scatters, 4 quarries, 2 rock shelters with artefacts and paintings, and 1 knapping floor.

Isolated artefacts recorded along the railway easement were manufactured predominantly from chalcedony (34.9%), followed by quartz (19.3%), chert (16.0%), and quartzite (14.7%). Smaller quantities of silcrete, siltstone, sandstone and igneous material were also present. The artefacts were generally located in areas adjacent to ephemeral creek lines, gravel lags or rock outcrops.

Heritage Surveys (1998)

A second survey was undertaken for an alternate alignment of the proposed Alice Springs to Darwin railway, focused on an area near the Devils Marbles Conservation Reserve, at the far west of the Davenport Ranges (approximately 60 km north of the project's proposed infrastructure corridor).

Two Aboriginal archaeological sites (both quartzite quarries) and three isolated artefacts (quartzite flakes) were recorded during this survey. The quartzite quarries were identified on alluvial flats to the north of a line of low, rocky hills and slopes that form part of the Davenport Range. Locally occurring quartzite outcrops in the vicinity of both quarries in the form of cobbles and small boulders.

ADrail Design & Construction Joint Venture (2003)

ADrail undertook a series of archaeological clearance surveys of six ancillary construction areas and ten railway realignments associated with the proposed Alice Springs to Darwin railway. Eighteen Aboriginal archaeological sites were identified, consisting of 9 quarries, 6 artefact scatters, 2 quarries with knapping floors, and 1 background scatter. The site closest to the subject area is an artefact scatter at Bonney Well (Bonney Well Artefact Scatter), approximately 126 km north east of the subject area.

14.4 Existing values

14.4.1 Archaeology

No Aboriginal archaeological sites or objects have previously been recorded within the project site. Searches of the NT Heritage Branch Archaeological Site Register in October 2016 identified a total of 19 Aboriginal sites recorded in the Davenport Ranges area and NT Portions 3,375, 1,290 and 2,286.

14.4.2 Sacred sites and cultural exclusion zones

There are five sacred sites, recorded by the AAPA (and derived from an abstract of record) within the broader project area.

There are 25 cultural exclusion zones previously identified by the CLC within, and partially within, the project site area. There has been no additional information provided regarding the nature of the sites or features within these sites. Any CLC exclusion zones that could possibly be impacted will be fenced off. Native title

A search of the National Native Title Tribunal Registers in October 2016, identified three native title determinations covering part of the project site, and three registered Indigenous Land Use Agreements (ILUAs). There are no registered native title claims or unregistered claimant applications. The native title determinations and registered ILUAs include:

- National Native Title Register – DCD2011/014 Neutral Junction, DCD2014/010 Sandover River and DCD2016/001 Stirling/Neutral Junction Pastoral Lease.
- Register of ILUAs – DI2007/002 NT Oil Ltd EP 127 and 128 ILUA, DI2014/003 Ammaroo ILUA and DI2016/001 Neutral Junction Locality ILUA.

14.4.3 Historic sites

No historic sites, places or objects with cultural heritage significance were identified during the desktop assessment or surveys. The nearest registered historic heritage items are Barrow Creek Hotel, Barrow Creek Telegraph Station and Neutral Junction Homestead (Old), which are approximately 50 km south of the infrastructure corridor, and 110 km west of the mine site.

There has been very little early historic development within the subject area, and those parts within Project site have been predominantly used for pastoral purposes in the twentieth century. There is one item of potential heritage significance relating to past land use. This is the Ilbumric Bore, an abandoned government bore in the north east of the project site that contains objects such as remnants of a water pump, discharge pipe and storage tank, and Mark BD-C Southern Cross diesel engine.

14.5 Results of field investigation

During the field investigations, 110 Aboriginal archaeological sites were recorded. These sites include:

- 29 artefact scatters
- 2 artefact scatters/quarries
- 3 artefact scatter/knapping floors
- 76 isolated artefacts

These sites are identified in Table 14-1 and

Table 14-2.

The sites in the Project area range in size from 1 m^2 to an estimated 15,000 m^2. The sites with quarries were all found near surface rock outcrops associated with the Chabalowe Formation, confirming that local stone outcrops were used for sourcing raw materials. The main artefact types identified during the current study include flakes, cores, broken flakes, tulas, and pounding and grinding stones. Raw material types present in the overall artefact assemblage within artefacts scatters include chert, silcrete, quartz and quartzite.

The archaeological site and artefact assemblage distribution is typical of arid Australia, and suggest sporadic and short term visits to the region following rainfall events. The findings show that Aboriginal people living south of the Davenport Ranges were adapting to the arid landscape with toolkits similar to those recorded elsewhere in this region.

Almost every site was affected by water-based soil erosion and deposition. The combination of inclined slopes, water pooling on the ground surface, and inundation from sudden rainstorms means sheet wash has occurred across nearly the entire area, and the presence of livestock has compounded the erosional and depositional effects of the sheet wash. Pastoral landuse in the Project site has affected the structural integrity of the soils. Livestock trampling has caused soil disturbance to depths between 10 and 20 cm. Bushfire and vehicle impacts also affected some sites.

The heritage significance of Aboriginal archaeological sites has been assessed using the four criteria outlined in the Australia ICOMOS Burra Charter, 2013 (the Burra Charter); aesthetic, historic, scientific, and social or spiritual significance (Australia ICOMOS 2013). Aboriginal sites recorded during the field survey were ranked from low to high archaeological significance. The ranking of significance is as follows:

- **Low archaeological significance**: The site or object is common in the local area and/or the Northern Territory. The site has low excavation/research potential.

- **Moderate archaeological significance**: The site or object is rare in the local area, and/or has a high artefact density. The site has the potential to answer research questions that can add to our understanding of pre- or post-contact Aboriginal land use and occupation of the local area.
- **High archaeological significance**: The site or object is rare in the Northern Territory, or the site is a representative (and intact) example of a type of site that may be common elsewhere. The site has the potential to answer research questions that can add to our understanding of pre- or post-contact Aboriginal land use and occupation of central Australia or the Northern Territory.

The location of each archaeological site in relation to the proposed infrastructure is described in Table 14-1. All archaeological sites identified during the field investigation are mapped in Figure 14-2 to Figure 14-8.

No Aboriginal sites of high archaeological significance were identified during the field surveys.

Table 14-1 Aboriginal sites identified during the survey

Site features	Site name	Archaeological significance
Artefact scatter	APP-02, APP-09, APP-15, APP-20, APP-21, APP-22, APP-26, APP-30, APP-34	Moderate
	APP-01, APP-05, APP-07, APP-11, APP-12, APP-13, APP-14, APP-16, APP-17, APP-18, APP-19, APP-23, APP-24, APP-25, APP-27, APP-28, APP-29, APP-31, APP-32, APP-33	Low
Artefact scatter; quarry	APP-03	Moderate
	APP-04	Low
Artefact scatter; knapping floor	APP-06	Moderate
	APP-08, APP-10	Low

Table 14-2 Isolated artefacts recorded during the survey

Artefact type	Site name	Archaeological significance
Flake	APP-ISO-50	Moderate
	APP-ISO-01, APP-ISO-02, APP-ISO-03, APP-ISO-04, APP-ISO-05, APP-ISO-06, APP-ISO-07, APP-ISO-09, APP-ISO-10, APP-ISO-13, APP-ISO-14, APP-ISO-16, APP-ISO-20, APP-ISO-22, APP-ISO-24, APP-ISO-26, APP-ISO-27, APP-ISO-28A, APP-ISO-30, APP-ISO-32, APP-ISO-34, APP-ISO-35, APP-ISO-36, APP-ISO-37, APP-ISO-39, APP-ISO-41, APP-ISO-42, APP-ISO-43, APP-ISO-44B, APP-ISO-45, APP-ISO-46, APP-ISO-52, APP-ISO-53, APP-ISO-54, APP-ISO-58, APP-ISO-59, APP-ISO-62, APP-ISO-63, APP-ISO-64, APP-ISO-69, APP-ISO-70, APP-ISO-71, APP-ISO-74	Low
Broken flake	APP-ISO-28B	Low

Artefact type	Site name	Archaeological significance
Proximal broken flake	APP-ISO-11, APP-ISO-15, APP-ISO-25, APP-ISO-44A, APP-ISO-48, APP-ISO-57, APP-ISO-61	Low
Medial broken flake	APP-ISO-73	Low
Core	APP-ISO-08, APP-ISO-12, APP-ISO-17, APP-ISO-18, APP-ISO-19, APP-ISO-21, APP-ISO-29, APP-ISO-31, APP-ISO-33, APP-ISO-40, APP-ISO-47, APP-ISO-60, APP-ISO-65, APP-ISO-66, APP-ISO-72	Low
Tula slug	APP-ISO-23, APP-ISO-67, APP-ISO-68	Low
Grindstone	APP-ISO-38, APP-ISO-49, APP-ISO-51, APP-ISO-56	Moderate
Muller	APP-ISO-55,	Moderate

These figures has been removed to respect and protect the cultural sensitivities of the area following consultation with the Central Land Council and Traditional Owners.

14.6 Potential impacts

The project may have direct or indirect impacts on identified cultural heritage sites.

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

A summary of the risk assessment results is provided in Table 14-3. Multiple hazards may exist as a result of a one potential event. Refer to the full risk assessment in the Environmental Risk Register (Table 6-8) for further detail.

Table 14-3 Qualitative risk – Aboriginal and historic cultural heritage

Potential event	Residual risk level
Site establishment result in physical disturbance of known cultural heritage sites.	Medium
Unexpected find of cultural heritage site results in physical disturbance.	Low

14.6.1 Direct impacts

There is potential for direct impacts on 6 archaeological sites and 14 isolated artefacts that are located within the project footprint, as outlined in Table 14-4.

Table 14-4 Archaeological sites and artefacts within the project footprint

Location	Archaeological site			Isolated artefacts			Total
Value	Low	Moderate	Total	Low	Moderate	Total	
Borefield	1	1	2	1	-	1	3
Mine site	1	1	2	5	-	5	7
Processing plant and tailings storage facility	1	-	1	4	-	4	5
Transport corridor	1	-	1	3	1	4	5
Total	4	2	6	13	1	14	20

The expected impact causing likely partial or complete destruction of archaeological sites is considered to include excavation, earthworks, grading, and establishment of structures. In total, 20 archaeological sites and isolated artefacts would be subject to direct impact.

There are no archaeological sites or isolated artefacts of high scientific significance.

Sites with moderate scientific significance within the footprint of proposed infrastructure include artefact scatter/quarry, and artefact scatter/knapping floor. Isolated artefacts of moderate include artefacts such as grindstone and flake. Permits will be sought from the regulatory authorities prior to site disturbance and in conjunction with consultation with Traditional Owners and their representatives.

In addition, there is the potential for inadvertent damage, destruction or removal of previously unidentified sites to occur during earthworks and clearance.

14.6.2 Indirect impacts

There is potential for indirect impact to 20 archaeological sites and 41 isolated artefacts, which are located outside the project footprint, as outlined in Table 14-5.

Table 14-5 Archaeological sites and artefacts outside the project footprint

Location	Archaeological site			Isolated artefacts			Total
Value	Low	Moderate	Total	Low	Moderate	Total	
Outside proposed infrastructure footprint	15	5	20	34	7	41	61

In total, 61 archaeological sites and isolated artefacts located outside the proposed infrastructure footprint have potential to be indirectly or inadvertently impacted by the project's construction or operations.

There are no archaeological sites or isolated artefacts of high scientific significance.

Indirect impacts are likely to occur during activities associated with pipeline construction, vegetation clearing, vehicle movement and construction of access roads. Disturbance or partial destruction of archaeological sites may result from impacts such as dust, minor construction and fencing, storage of materials, sediment build up from run-off from rainfall events in disturbed areas carrying sediment or creating erosion, and pedestrian or light vehicles passing through areas outside the construction zone.

Cultural exclusion zones

There is also the potential for a mobilised workforce during construction to inadvertently damage, or trespass across CLC cultural exclusion zones.

14.6.3 Mitigation measures

The management and mitigation measures identified for cultural heritage within the Project area are based on:

- Assessed scientific significance
- Legislative requirements and the planning approval framework
- Heritage best practice in accordance with the principles of *The Australia ICOMOS Charter for Places of Cultural Significance, 2013* (The Burra Charter).

The surveyed archaeological sites have been identified as having either low or moderate archaeological significance. There are no sites of high archaeological significance within the Project site and within the broader project area.

A significant proportion of the archaeological sites are located in association with specific landscape features, in particular cobbles/pebbles and chert-bearing rock outcrops in the south west of the Project area associated with the Chabalowe Formation. Avoiding these types of landscape features, where possible, will reduce the risk of impacting unknown archaeological resources.

Where possible, options to avoid adversely impacting identified heritage items will be considered. However, the construction phase of the Project cannot completely avoid harm to heritage items.

Whilst all Aboriginal archaeological places and objects are protected under NT legislation, the Heritage Act recognises that the destruction of sites may be necessary to allow other activities or developments to proceed. In order for the Director of the Heritage Branch to make informed decisions on such matters, a consideration of the significance of cultural heritage places and objects is an important element of the cultural heritage assessment process.

Of the 110 archaeological sites recorded during field survey, 20 sites are located within the footprint of proposed infrastructure and will be directly impacted by the Project. An additional 61 sites have the potential to be indirectly impacted by the project. In addition, given that the field survey covered approximately 30% of the project site, it is also likely that additional, as yet unknown archaeological material is present.

A Cultural Heritage Management Plan (CHMP, Appendix E) will be implemented during project construction and operation and include the following mitigation measures:

- Consultation and engagement with Traditional Owners and custodians
- Measures to enable the Proponent to meet its duty of care to protect the cultural and heritage values of any places or items of significance, including, where necessary,
  - approval to carry out work on heritage place or object will be sourced from NT Heritage Branch prior to construction
  - planning for an appropriate recording and salvage program if requested
- Procedures to avoid sites and areas incl. appropriate signage, or sites clearly marked
- Code of behaviour.
- Cross-cultural training as part of induction.
- Procedures for the discovery of surface or sub-surface items during the course of the Project.

The impact assessment found that the residual impacts of the Project are expected to be low to medium.

The provision of a CHMP to Indigenous stakeholders and Traditional Owners will occur for review purposes prior to implementation, and following any significant revision or modification. Approval will be sought prior to submitting a work approval application for archaeological mitigation or permission to disturb Aboriginal archaeological places and objects within the Project site.

15. Air

15.1 Introduction

This chapter summarises the baseline and potential air quality impacts arising from the project on the surrounding environment and sensitive receptors. Mitigation measures that will be implemented to reduce and manage air emissions impacts to sensitive receptors within and surrounding the study are documented.

Section 5.9 of the EIS TOR provided the following environmental objective in relation to air:

> *Sensitive receptors to Project generated emissions to air, including dust, will be identified and protected from significant impacts.*

This chapter addresses the air impact assessment, as required in the TOR for the project. A detailed air quality impact assessment report (GHD 2017) is provided in Appendix O of this EIS. The level of risk associated with potential impacts to air values is described in this chapter and assessed in the risk register in Table 6-8.

15.2 Existing environment

15.2.1 Sensitive receptors

The assessed sensitive receptors are shown in Figure 15-1. The proposed accommodation village (mine camp) is the nearest human receiver within the project site (3.5 km from the mining lease). External to the project site, there are a number of homelands and outstations. The approximate distance between the sensitive receptors and mining lease boundary are listed in Table 15-1. A description of these communities is provided in Section 12.2.3: People and communities

Table 15-1 Sensitive receptors external to the project site

Code	Sensitive receptor	Distance to the mining lease (km)
R1	Mine camp	3.5
R2	Ampilatwatja	12
R3	Imperrenth	29
R4	Ngkwarlerlanem	37
R5	Indaringinya	41

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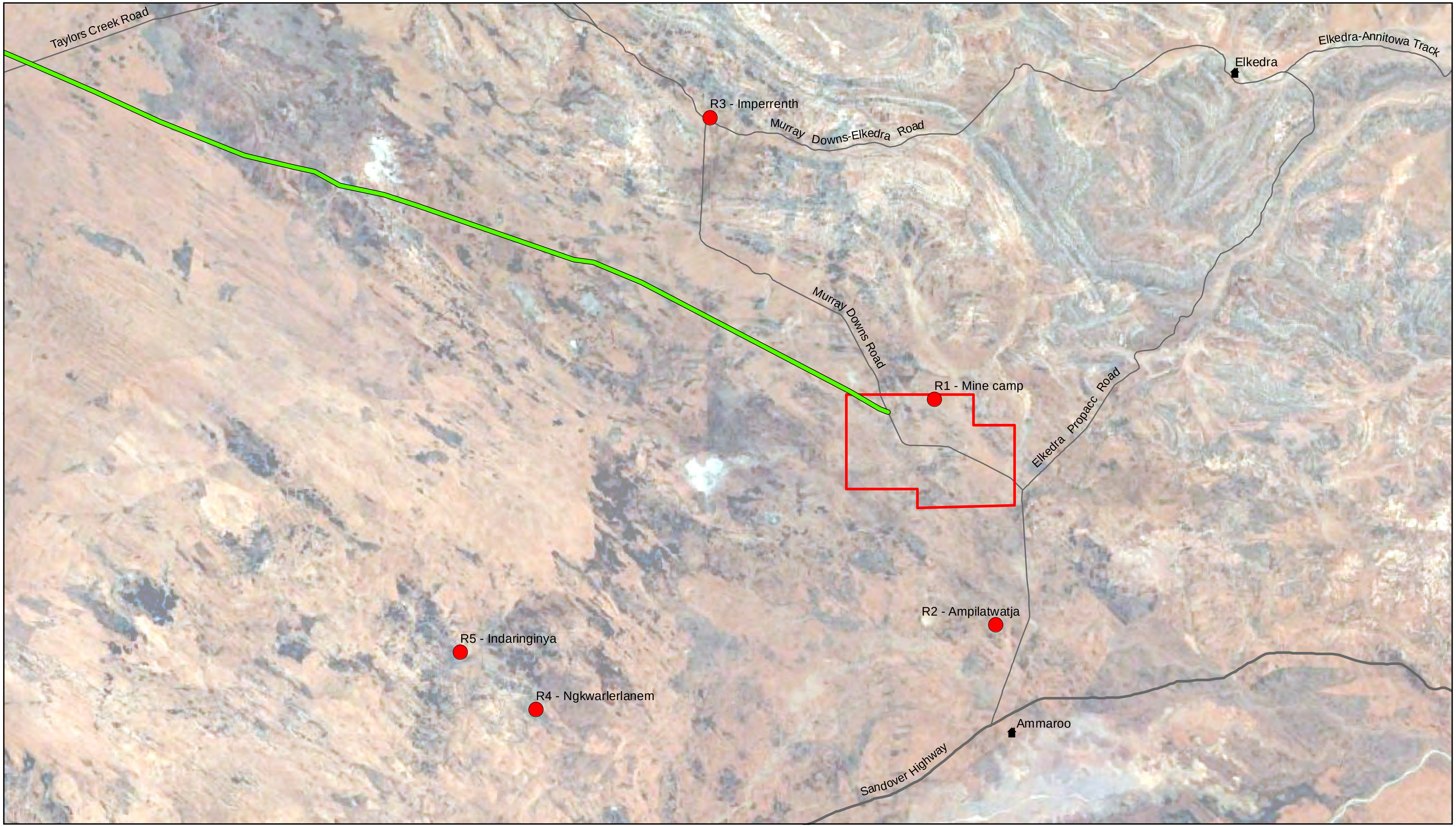


1:500,000 @ A4

0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Assessed sensitive receptors
- Homesteads
- Major Road
- Local Road
- Access corridor
- Mineral lease

GHD

VERDANT MINERALS

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number 43-22544
Revision 0
Date 11 Oct 2017

Assessed sensitive receptor locations

Figure 15-1

G:\43\22544\GIS\Maps\4322544_149.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). GHD - Assessed Sensitive Receptors (2017). Created by: CM

15.2.2 Climate

The climate conditions used in this EIS and for the air quality assessment are detailed in Chapter 4: Environmental context.

15.2.3 Air quality

Existing conditions relating to 'background' air quality relate to particulate matter (PM) and gaseous emissions. Due to the remote location, background sources of gaseous products of combustion (such as oxides of nitrogen (NOx), carbon monoxide (CO), sulphur dioxide (SO_2) etc. will be negligible to non-existent. Background information relating to dust (particulate matter and deposition) is not available and so baseline monitoring derived from another project site in the same region (GHD 2016) has been used to provide a baseline for ambient conditions.

The existing air pollutant levels are presented in Table 15-2, and are discussed below.

Table 15-2 Existing air quality

Parameter	Value	Unit	Justification
Dust deposition	0.5	g/m²/month	Site representative measurement
PM_{10}	20	µg/m³	Site representative measurement
TSP	40	µg/m³	[1]Scaled from PM_{10}
It is expected that due to the remote, rural nature of the existing environment, that the majority of suspended particulates are suspended due to wind erosion from the environment. The NPI manual for mining (Australian Government, 2012) states a TSP:PM_{10} ratio of 2, which has been applied to this situation.			

Monthly dust deposition rates gathered at the other project site (GHD, 2016) are presented in Figure 15-2. During the monitoring program high monthly values did occur; however, all sites satisfied the 12-month rolling average criterion. A regional background level of dust deposition close to 0.5 g/m²/month can be assumed as the ambient background.

During monitoring of PM_{10} at the other site, daily averages were generally less than 20 µg/m³. Levels increased during the summer months and it was suggested that the seasonal variation was likely due to localised sources associated with dry and hotter conditions found in summer during a period when little or no rain occurs. A conservative value for background dust concentrations is approximately 20 µg/m³. The annual average of TSP can reasonably be estimated to have a value of twice the PM_{10} value at 40 µg/m³ (just less than 50% of the assessment criterion).

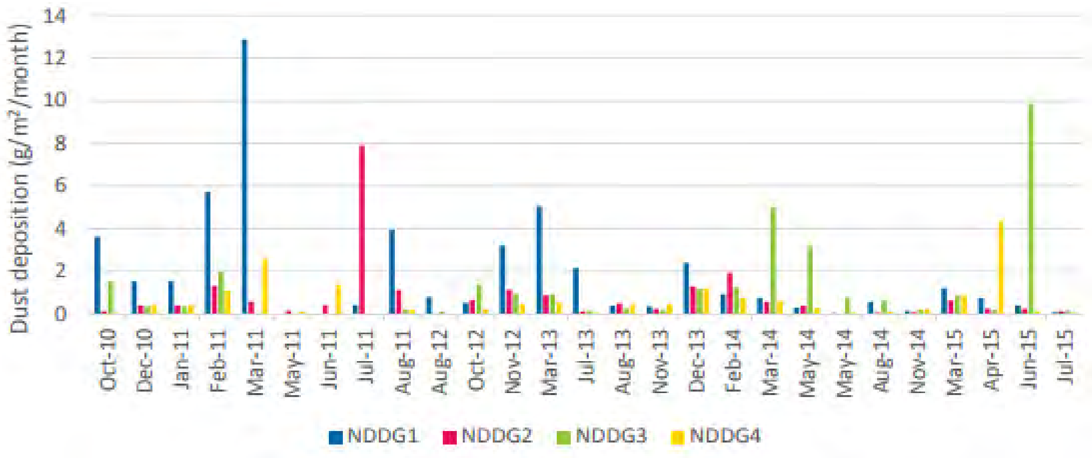


Figure 15-2 Dust deposition from another project site in the same region

15.3 Methodology

15.3.1 Approach to the assessment

A summary of the approach to the air quality impact assessment is described below and detail is provided in Appendix O.

The air quality impact assessment was completed using the AERMOD dispersion model.

In order to ensure the assessment protects the air quality values in the study area, air quality emissions (particulate, dust, and gaseous) were estimated for a worst case scenario in which the mining operations occur at the maximum rate and nearest to the sensitive receptors.

The following general settings were used in the model:

- Site topography and three-dimensional terrain has been used in the model, with 30 m resolution.
- The effect of building wakes on stack sources were not considered.
- The non-default option of "Adjust Surface Friction Velocity (ADJ_U*)" was applied. This was applied to be consistent with the Environment Protection Authority Victoria (EPAV) approved the use of the LOWWIND3 option in AERMOD to better resolve the dispersion associated with light wind conditions, in line with current US EPA AERMOD usage guidance advice.
- A surface roughness length of 0.3 m was selected to represent the modelling domain.
- All discrete and gridded receptors were modelled at ground level.

15.3.2 Assessment criteria

Assessment criteria for dust emissions resulting from the project are summarised in Table 15-3.

Table 15-3 Assessment criteria for dusts

Pollutant	Averaging period	Return interval (design GLC)	Criterion
Total suspended particulates (State of NSW and Environment Protection Agency, 2016)	Annual	Maximum	90 µg/m^3
Particulates as PM_{10} (EPA Victoria, 2007)	24-hours	Maximum	60 µg/m^3 (for area sources)
Particulates as $PM_{2.5}$ (Department of the Environment, 2016)	24-hours	Maximum	25 µg/m^3
Dust deposition (State of NSW and Environment Protection Agency, 2016)	Annual	Rolling 12-month average	2.0 g/m^2/month (increment) 4.0 g/m^2/month (maximum)

Table 15-4 provides assessment criteria for the gaseous constituents from the gas fired power plant. If the plant achieve these compliance limits then other gaseous constituent pollutants will also be within limits.

Table 15-4 Assessment criteria for gaseous emissions

Pollutant	Averaging period	Return interval (design GLC)	Criterion
Carbon monoxide – CO (Victoria Government, 2001)	1-hour	99.9%ile	29,000 µg/m^3
Nitrogen dioxide – NO_2 (Victoria Government, 2001)	1-hour	99.9%ile	190 µg/m^3
Nitrogen dioxide – NO_2 (State of NSW and Environment Protection Agency, 2016)	Annual	Maximum	62 µg/m^3
Sulphur dioxide – SO_2 (Victoria Government, 2001)	1-hour	99.9%ile	450 µg/m^3

15.3.3 Emissions inventory

The emissions inventory for the project includes dust generating sources located at the mine site and gaseous generating sources, primarily from power generation at the plant.

The modelled scenario represents the worst case scenario for air quality impacts at the nearest sensitive receptor – the mine camp. This scenario occurs during pit operations during years 11-15, where the active pit is both proximate to the mine camp and aligned with processing plant emission sources. The modelled scenario incorporates the controls that would be active at the mine site.

Dust generating sources

The following areas are identified as having the potential to emit dust:

- Pit and mining: material handling activities such as excavation, dumping and loading, and grading will lead to emissions of dust.
- Hauling: ore hauling will lead to wheel generated dust emissions from haul trucks.
- Stockpiles: wind erosion from stockpiles will lead to dust emissions to air.
- Open areas: wind erosion from disturbed areas will lead to dust emissions to air.
- Processing: material processing activities prior to and within the beneficiation plant will lead to dust emissions.

Gaseous generating sources

The following processes are identified as having the potential to emit combustion emissions:

- Diesel generators
- Natural gas generators
- Rotary drier

Dust control

Control techniques have been assumed and modelled for each of the sources identified at each stage of the mine operations. Some processes have no controls, while other dust sources can be reduced through the application of various measures.

A summary of the controls applied for the air emissions modelling are provided in Table 15-5.

Table 15-5 Summary of applied controls

Control type	Control factor (% reduction)	Applicable to which emission sources types
Level 2 watering e.g. (>2L/m^2/hr)	TSP – 75% PM_{10} – 75%	Haul roads
Water sprays	TSP – 50% PM_{10} – 50%	Material processing sources (primary and secondary crushing, screening, conveying, stockpile loading, train load-out)
Pit retention	TSP – 50% PM_{10} – 5%	All in pit sources
Fabric filter	TSP – 99% PM_{10} – 99%	Rotary drier (dust emissions only)
Primary rehabilitation	TSP – 30% PM_{10} – 30%	Rehab pit 1
Secondary rehabilitation	TSP – 60% PM_{10} – 60%	Rehab pit 2
Vegetation	TSP – 90% PM_{10} – 90%	Rehab pit 3

Summary of modelled emissions at each source

Summaries of the modelled emission rates for each source is provided in Table 15-6 and Table 15-7. All emissions are 'as modelled', and as such include all control measures and pit retention factors, e.g. TSP emissions from pit sources have been halved as 50% of emissions do not escape the pit. Therefore, the emissions inventory is a summary of the emissions which will impact on the predicted GLC's and dust deposition.

A total of 45 individual sources were inputs to the AERMOD dispersion model to represent the emissions from the mine.

Table 15-6 Summary of dust emissions

Description	Activity data		Control method	Emission rate (g/s)	
	Value	Unit		TSP	PM_{10}
Excavators or front-end-loaders on overburden in pit	2109	t/hour	Pit retention	7.3	6.7
Loading overburden to trucks in pit	2109	t/hour	Pit retention	7.3	5.0
Dumping overburden in pit	2109	t/hour	Pit retention	3.5	2.4
Excavators or front-end-loaders on ore in pit	816	t/hour	Pit retention	2.8	2.6
Loading ore to trucks in pit	816	t/hour	Pit retention	2.8	1.9
Dumping ore on ROM stockpile	816	t/hour	None	2.7	1.0
Front-end-loaders on ore on ROM stockpile	816	t/hour	None	5.7	2.7
Dozer in pit	1	hours/hour	Pit retention	2.4	1.1
Graders in pit	11.4	vkt/hour	Pit retention	0.30	0.26
Hauling ore to ROM stockpile	5.5	vkt/hour	Level 2 watering	3.6	1.1
Haul trucks returning to pit	5.5	vkt/hour	Level 2 watering	2.5	0.73
Screen	582	t/hour	Water sprays	6.5	4.9
Conveyor	582	t/hour	Water sprays	0.026	0.012
Primary crusher	582	t/hour	Water sprays	16	1.6
Secondary crusher	582	t/hour	Water sprays	49	4.9
Loading stockpiles	582	t/hour	Water sprays	0.32	0.14
Rotary drier	320	t/hour	Fabric filter	2.6	2.1
Train load-out	320	t/hour	Water sprays	0.018	0.008
ROM stockpile	2.25	ha	None	0.25	0.13
Beneficiation stockpile	0.5	ha	None	0.056	0.028
Topsoil stockpile	26.6	ha	None	3.0	1.5
Active pit	10	ha	Pit retention	0.56	0.53
Previous pit	10	ha	None	1.1	0.56
Rehab pit 1	10	ha	Primary rehabilitation	0.78	0.39
Rehab pit 2	10	ha	Secondary rehabilitation	0.44	0.22
Rehab pit 3	10	ha	Revegetation	0.11	0.056

1 AUSPLUME accepts emission rate for area sources as $g/s/m^2$

Table 15-7 Summary of combustion emissions

Emission source ID	Description	Activity data		Control method	Emission factor (g/s)				
		Value	Unit		CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$
C1,C2	2.5 MW Diesel generators	2	MWh/hour	Uncontrolled	1.8	8.3	0.0000027	0.24	0.23
C3-C10	2.5 MW Natural gas generators	2	MWh/hour	Uncontrolled	0.072	0.28	0.00044	0.0016	0.0016
C11	Natural gas fired rotary drier	2	MWh/hour	Uncontrolled	1.7	5.6	0.022	0.15	0.15

15.4 Potential impacts

This section identifies the potential direct and indirect impacts on air quality presented by the project.

An assessment of the risk associated with project impacts has been completed as discussed in Chapter 6: Risk assessment.

A summary of the risk assessment results is provided in Table 15-8. Multiple hazards may exist as a result of a one potential event. Refer to the full risk assessment in the Environmental Risk Register (Table 6-8) for further detail.

Table 15-8 Qualitative risk – air

Potential event	Residual risk level
Dust generating sources in the mining and processing areas impacting on air quality at sensitive receptors.	Low
Combustion generating sources in the mining and processing areas.	Low

15.4.1 Air quality assessment

- The pollutants of interest in this assessment are:
  - Particulate pollutants
  - Gaseous pollutants.

In terms of human health, the pollutants of major concern for this assessment are primarily particulate pollutants related to dust generated by mining activity, specifically, $PM_{10.}$

The modelling is a conservative worst case scenario that demonstrates emissions dispersion at the highest levels likely to be achieved based on the mine's activities and the dispersion environment (i.e. wind and other climate conditions that will carry the pollutants from the pit to beyond the site boundaries).

Table 15-9 shows the dispersion modelling results for particulate pollutants. shows the dispersion modelling results for gaseous pollutants.

Air quality impacts are predicted to be compliant with all relevant air quality criterion for all sensitive receptors with the mine camp being the closest (geographically and) with worst-case concentrations compared to the assessment criteria.

- A breakdown of dust emissions from each area suggests that mining activities (all in pit activities) and hauling of material and material processing are individually and cumulatively the highest risk sources. Wind erosion from stockpiles and open areas as well as particulate matter emissions associated with combustion are not considered high risk sources. The highest risks to air quality occur where both mining and material processing emission sources are aligned with the wind direction.
- The contour plot for PM_{10} (Figure 15-4) shows that although Table 15-6 suggests that the mine is compliant with the 60 µg/m³ criterion (as a peak 24-hour average for the period) it is marginally so, suggesting that there remains some risk of non-compliance. An investigation in to the frequency of elevated PM_{10} concentrations, through analysis of the daily averages, shows that of 365 modelled 24-hour periods only 4 periods fall within 30% of the criterion. A time series of 24-hour PM_{10} concentrations is presented in Figure 15-3.
- The selected 70th percentile PM_{10} background concentration of 20 µg/m³ is also presented in Figure 15-3. The background concentration selected is conservative and contributes to one third of the PM_{10} criterion for every period in the model. In reality, background

particulate concentrations due to natural sources are highly variable, and the probability of peaks in background concentration and impact due to mining operations occurring simultaneously is low.

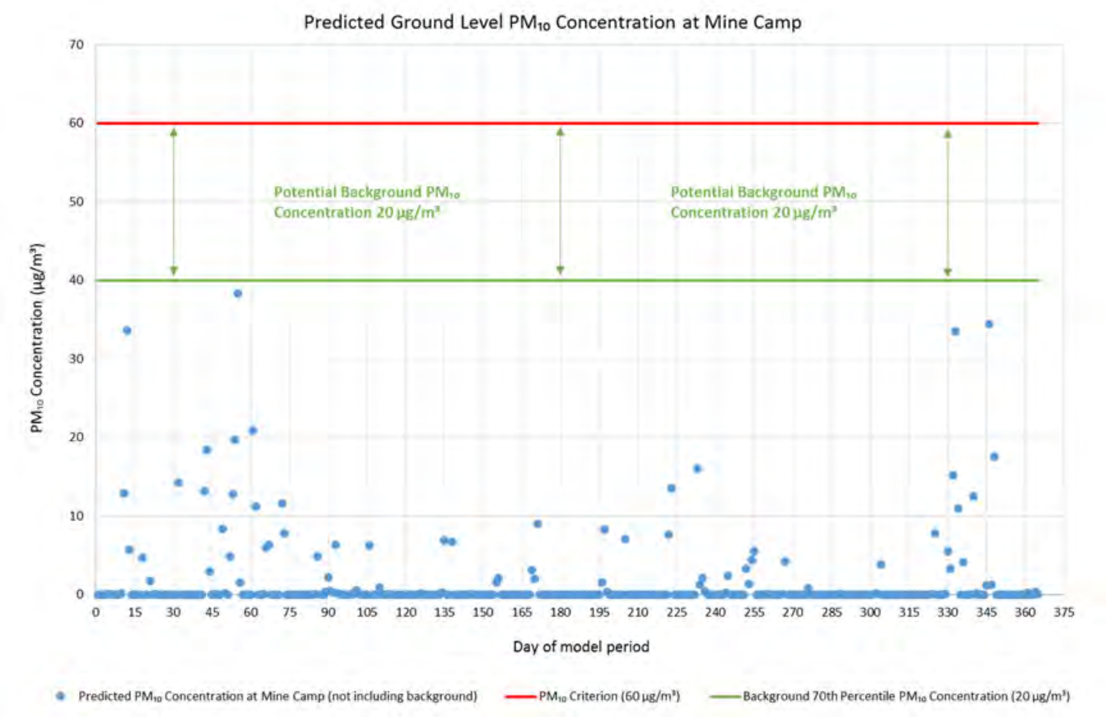
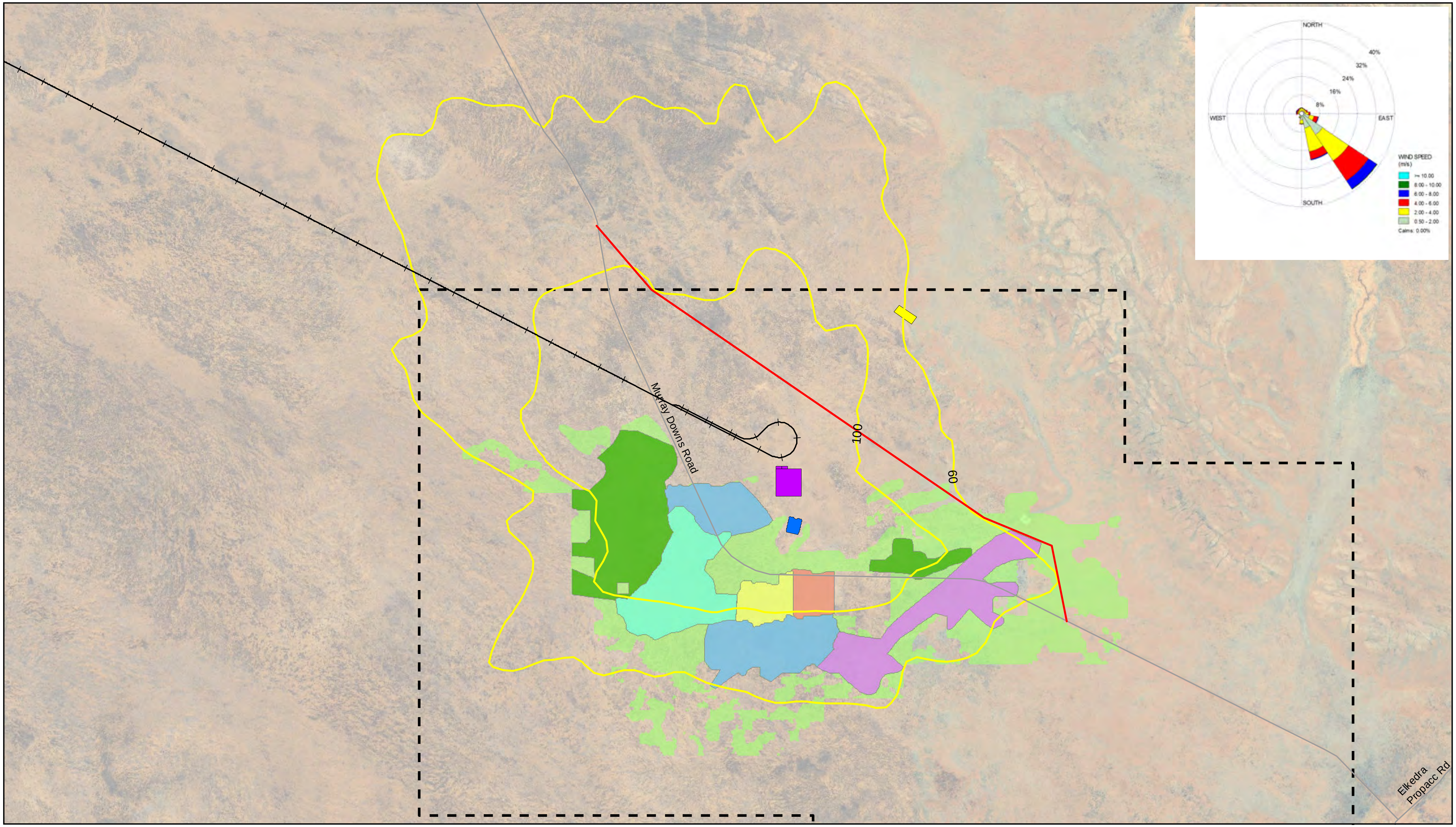


Figure 15-3 Time series of 24-hour PM_{10} concentrations

At present, the only formal assessment criteria for flora and fauna environmental values relate to agriculture and health and biodiversity of ecosystems that are particularly sensitive. For example, this concerns ozone levels affecting vineyards or fluoride (especially from aluminium smelters) affecting vulnerable crops (vineyards again) or native heathland in coastal regions. There are no formal criteria for assessing air quality impacts to environmentally sensitive receptors, including flora and fauna values such as those present within the Davenport and Murchison ranges site of conservation significance. The flora in particular will be adapted to a harsh semi-arid climate (where the stomata will restrict during daylight hours).

Instead, impacts on environmentally sensitive receptors are most often considered in terms of human health criteria. Nonetheless, in terms of flora and fauna values, the pollutant of major concern for this assessment is dust deposition.

The average annual dust deposition rate for the south-eastern edge of the ranges will be less than what is experienced at the accommodation camp. This worst-case dust deposition rate is below the amenity criterion of 2 g/m^2/month (up to 12 grams of dust deposited over every square metre across an entire annual cycle) (Figure 15-5), which is of the same order of magnitude that deposits naturally.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Road Realignment
- Rail Connection
- Existing Roads
- Maximum 24-hour Average PM10 GLC - µg/m³
- Mine camp
- ROM stockpile
- Beneficiation plant
- Mineral Lease
- 40 yr pit shape

Mine staging

- 0 - 2 yrs
- 3 - 5 yrs
- 6 - 10 yrs
- 11 - 15 yrs
- 16 - 20 yrs
- 21 - 25 yrs

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PM10 GLC's
Maximum 24-hour Average

Figure 15-4

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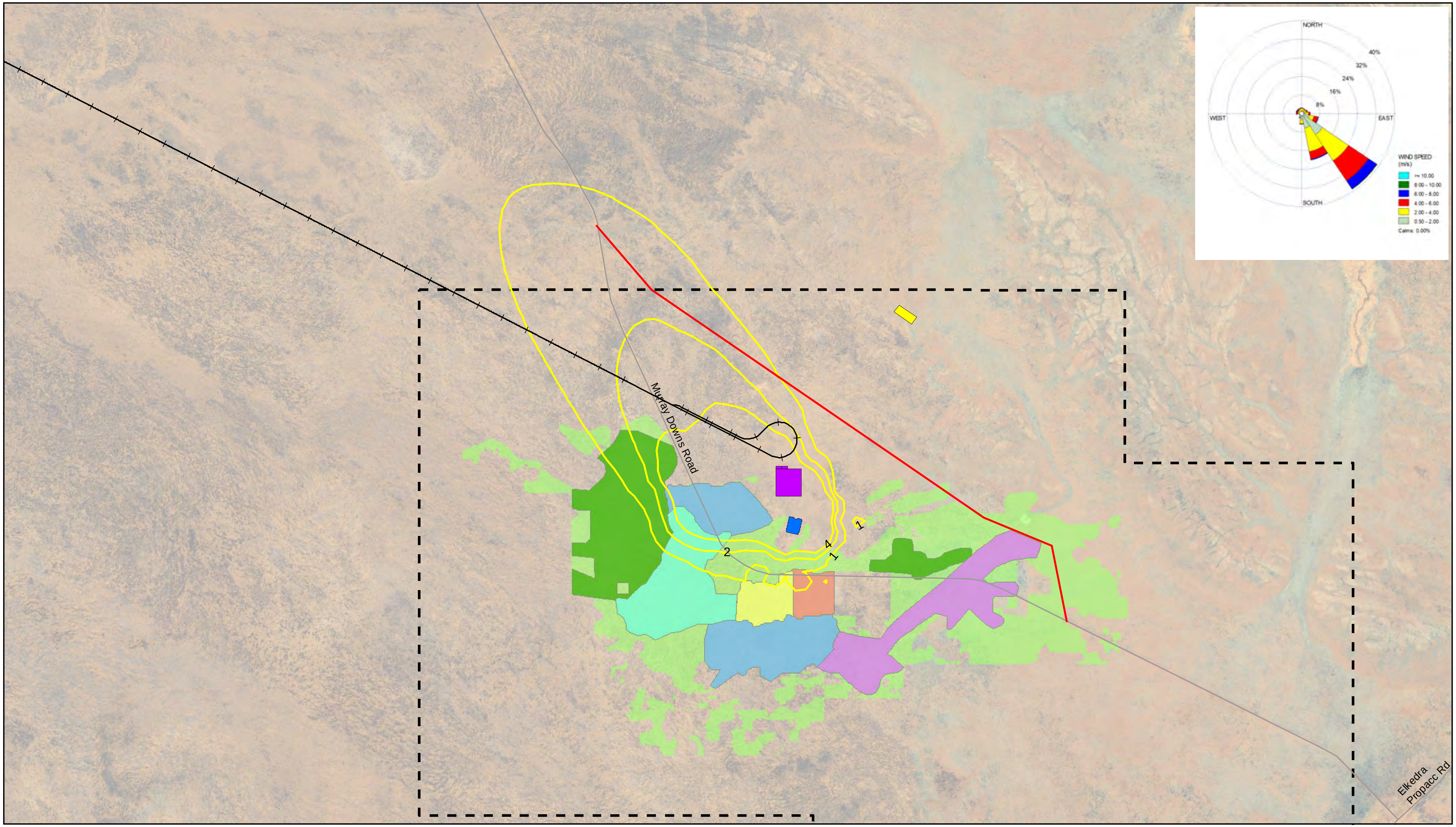
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 30/08/2017). VML - Pit Footprint (2017). Created by: CM



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Road Realignment
- Rail Connection
- Existing Roads
- Annual Average Dust Deposition Rate - g/m²/month
- Mine camp
- ROM stockpile
- Beneficiation plant
- Mineral Lease
- 40 yr pit shape

Mine staging

- 0 - 2 yrs
- 3 - 5 yrs
- 6 - 10 yrs
- 11 - 15 yrs
- 16 - 20 yrs
- 21 - 25 yrs

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Dust Depositon Rate Annual Average

Figure 15-5

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Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 30/08/2017). VML - Pit Footprint (2017). Created by: CM

Table 15-9 Results of impact assessment for particulates

Pollutant	Averaging period	Return interval (design GLC)	Background value (µg/m³)	Predicted ground level concentrations (µg/m³)					Criterion
				R1	**R2**	**R3**	**R4**	**R5**	
Total suspended particulates (NSW Approved Methods)	Annual	Maximum	40	42	40	41	40	40	90 µg/m³
Particulates as PM_{10} (VIC Mining PEM)	24-hours	Maximum	20	58	23	25	23	21	60 µg/m³ (for area sources)
Particulates as $PM_{2.5}$ (NEPM)	24-hours	Maximum	0	0.85	0.047	0.063	0.028	0.018	25 µg/m³
Dust deposition (NSW Approved Methods)	Annual	Rolling 12-month average	0.5	0.54	0.50	0.52	0.51	0.51	2.0 g/m²/month (increment) 4.0 g/m²/month (maximum)

Table 15-10 Results of impact assessment for gaseous pollutants

Pollutant	Averaging period	Return interval (design GLC)	Predicted ground level concentrations (µg/m³)					Criterion
			R1	R2	R3	R4	R5	
Carbon monoxide – CO (VIC SEPP (AQM))	1-hour	99.9%ile	40	2.5	2.7	1.2	1.2	29,000 µg/m³
Nitrogen dioxide – NO_2 (VIC SEPP (AQM))	1-hour	99.9%ile	170	11	11	4.9	4.8	190 µg/m³
Nitrogen dioxide – NO_2 (NSW Approved Methods)	Annual	Maximum	1.2	0.086	0.42	0.020	0.022	62 µg/m³
Sulphur dioxide – SO_2 (VIC SEPP (AQM))	1-hour	99.9%ile	0.17	0.011	0.012	0.0051	0.0051	450 µg/m³

15.5 Mitigation and monitoring

A Dust Management Plan (DMP) will be developed in order to avoid, minimise and control impacts on air quality. The DMP will incorporate the controls used in the modelling, including:

- Water trucks will water the primary emission sources (including the haul road) at a rate greater than 2 litre/m^2/hr.
- Crushing and conveying equipment for dry material shall have dust controls.
- Pit retention controls, by default, will be applied to all dust sources within any operational pits.
- Disturbed open areas will be progressively rehabilitated.

As modelling for this assessment is conservative and provides general guidance of potential impacts, post construction monitoring will be conducted to provide an evaluation of local air quality and the contribution of the mine against dust assessment criteria. Air quality performance will be reported in the annual mine management plan.

In addition, a monitoring site is established at the accommodation camp to audit the dust management plan. This would include PM_{10} in-air concentration and a dust deposition gauge (as part of a wider gauge network). If dusts level are found to approach the criterion level, to further mitigate the risk of PM_{10} exceedances at the camp, meteorology specific control measures will considered. Where a meteorological forecast indicates that winds will be blowing towards the mine camp or a reactive monitor reaches a predefined trigger level, measures such as reducing site activity or significantly increasing the intensity of dust controls (such as water sprays or chemical dust suppressants on major haul road links) should be carried out.

16. Noise

16.1 Introduction

This chapter describes the potential noise and vibration impacts relating to the activities of the projects. This includes an assessment of the potential for project activities from construction to operations at the mine site and the rail corridor to exceed noise and vibration criteria for sensitive receptors within and surrounding the study area. Mitigation measures that will be implemented to minimise the noise and vibration impacts of projection construction and operations on sensitive receptors are documented.

Section 5.11.2 of the draft EIS TOR provided the following objective in relation to noise:

> *The potential sensitivity of human and biological receptors to noise and vibration and mitigation measures should be discussed. The Proponent should address the impact of noise and vibration resulting from the Project on residents and the community.*

This chapter addresses the noise impact assessment, as required in the TOR for the project. A noise and vibration assessment (GHD 2017) is provided in Appendix P of this draft EIS. The level of risk associated with potential impacts to noise values is described in this chapter and assessed in the risk register in Table 6-8.

16.2 Existing environment

The project is located in a rural area. The existing noise environment within the vicinity of the project site is anticipated to be a typical rural noise environment setting, with potential local noise sources such as:

- Natural noise from wind, thunder, animals and insects
- Local neighbourhood activities at the nearby receivers
- Occasional local traffic noise

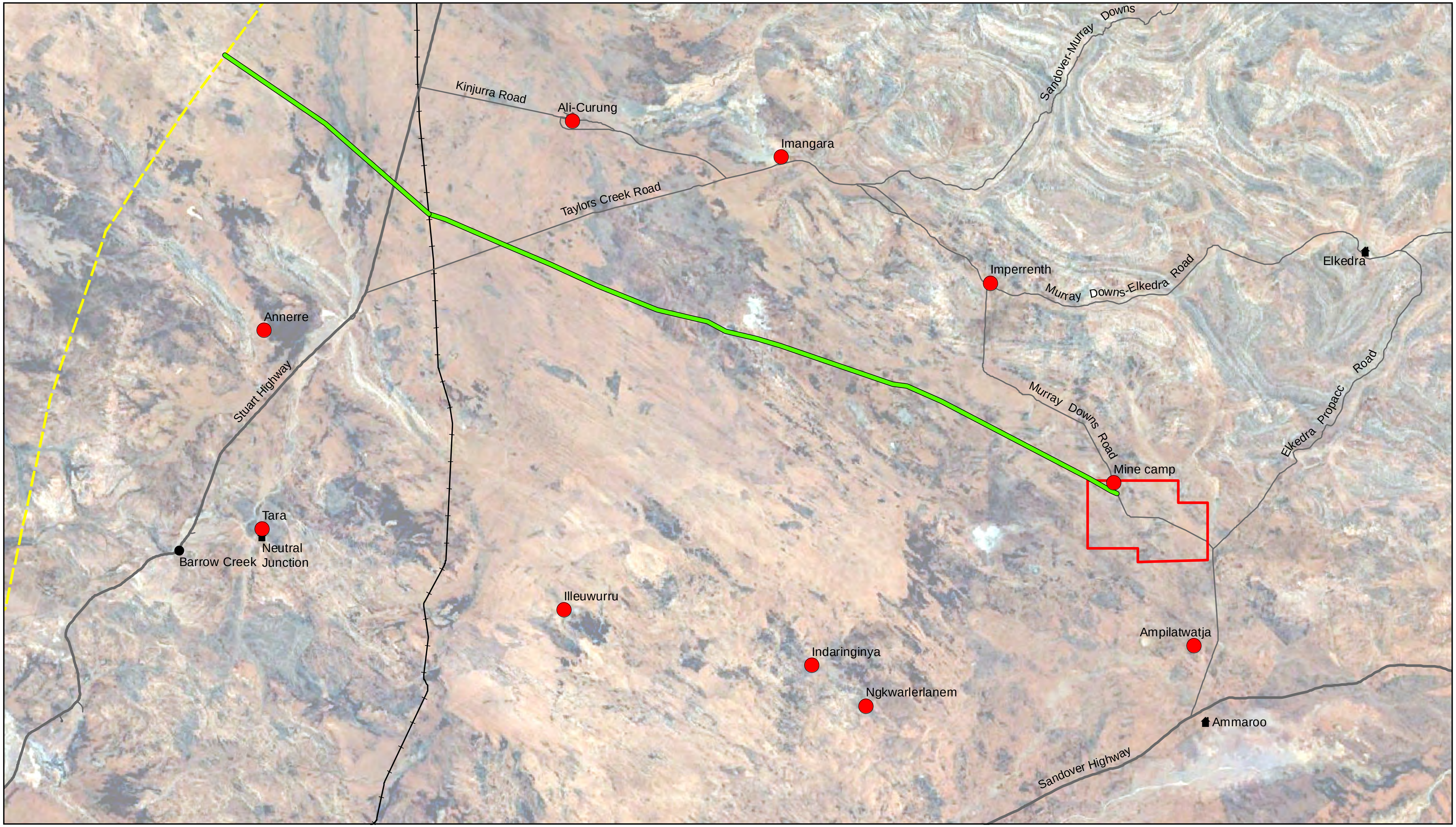
16.2.1 Sensitive receptors

The assessed sensitive receptors are shown in Figure 16-1. The proposed accommodation village (mine camp) is considered as the nearest human receiver within the project site. External to the project site, there are a number of homelands and outstations. The approximate distance between the sensitive receptors and mining lease boundary are listed in Table 16-1.

No threatened species are present within the mine site or the area surrounding. As a consequence, no assessment of noise and vibration impacts on biological receptors has been undertaken.

Table 16-1 Sensitive receivers external to the Project site

Sensitive receiver	Distance to the mining lease (km)
Mine camp	-
Ampilatwatja	12
Imperrenth	29
Imangara	61
Ali-Curung	86
Ngkwarlerlanem	37
Indaringinya	41
Illeuwurru	72
Tara	112
Annerre	114



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0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Assessed sensitive receptors
- Homesteads
- Roadhouses
- Major road
- Local road
- Rail
- Amadeus gas pipeline
- Access corridor
- Mineral lease

GHD

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Assessed sensitive receptor locations

Job Number	43-22544
Revision	0
Date	11 Oct 2017

Figure 16-1

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Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Access corridor, Mineral lease (2017). GHD - Assessed Sensitive Receptors (2017). Created by: CM

16.3 Methodology

16.3.1 Approach to the assessment

Construction noise assessment

The project is assumed to use standard construction equipment, general trade equipment and specialised equipment as required for the construction of the processing plant infrastructures. Typical construction equipment noise levels have been obtained from AS 2436 – 2010: *Guide to noise and vibration control on construction, demolition and maintenance sites* and GHD's noise database.

Propagation calculations take into account sound intensity losses due to hemispherical spreading, with additional minor losses such as atmospheric absorption, directivity and ground absorption ignored in the calculations. As a result, predicted received noise levels are expected to slightly overstate actual received levels and provide a measure of conservatism.

Construction blasting assessment

Blasting will be carried out at the nominated ballast quarry. Blast effects were predicted based on the equations provided in AS 2187:2006 *Part 2 Explosives - Storage and Use - Use of Explosives*. It is very likely that ground conditions including rock structure and strata type can vary significantly in and surrounding a mine site. As such, typical site constants have been adopted. No details of the blast configuration and design have been are available at this stage of project planning. Generally, rail ballast construction should not require a maximum instantaneous charge (MIC) of greater than 100 kg and a charge of 50 kg; as a consequence these are the maximum MIC and charge weights adopted in the assessment.

Operational noise modelling

Noise modelling was undertaken using Computer Aided Noise Abatement (CadnaA) version 2017 noise modelling software to predict the effects of airborne operational noise from the mine. CadnaA takes into account a moderate ground based temperature inversion, which increases noise impacts. As a result, modelled received noise levels generally represent a worst case scenario.

The assessment has been modelled based on available data, the proposed layouts for the mine and processing sites and noise generating equipment information provided at the time of the assessment. The following general settings were used in the model:

- A general ground absorption coefficient of 0.5 was used to represent the surrounding ground type comprising of mixed vegetated, soil and hard stand areas.
- All sensitive receptors were modelled at 1.5 m height above ground.
- Site topography and three-dimensional terrain has been used in the model, with 5 m resolution for the mine site as well as the project vicinity.

Rail noise modelling

Railway noise prediction was undertaken using CadnaA software version 2017 and the Nordic prediction method for Train Noise (NMT) ThemaNord 1996:524 algorithm. Operational rail (L_{Aeq} and L_{AFmax}) noise was modelled for the project; however, this draft EIS has only assessed the L_{Aeq} levels, which provide indicative information on the likelihood of potential rail operational noise impact.

Rail source noise level input data for the noise model input was adapted using the NMT method for adding new trains from a combination of existing NMT train data within CadnaA, data contained in the NSW Asset Standards Authority (ASA) *2015 Rail Noise Database* (RNDB) and data from past project measurements conducted by GHD.

The following atmospheric conditions were implemented in the model configuration:

- Atmospheric conditions of 15 °C and 70% humidity were used
- Neutral weather conditions

Vibration

The vibration assessment was undertaken based on a literature review of indicative vibration levels provided in the NSW RTA *Environmental Noise Management Manual* (ENMM) 2001 (RTA NSW, 2001). Specifically, the ENMM provides typical construction equipment ground vibration levels at 10 m. The vibration attenuation at separation distances was calculated through regression analysis, based on the formula provided by ENMM.

Modelling assumptions

The modelling conditions and assumptions were based on a worst case scenario whereby the project will create the largest noise impact possible based on the expected activities and equipment. The assumptions are detailed in Section 6.1.2 of Appendix P: Nosie and vibration assessment.

16.3.2 Assessment criteria

The noise criteria applicable for the sensitive receptors identified are summarised in Table 16-2. All sensitive receptors have been classified as 'residential' when applying assessment criteria. This allows for the highest level of protection for nearby communities.

Table 16-2 Adopted noise criteria

Impact and phase	Guideline
Construction noise	Northern Territory Environmental Protection Authority (NT EPA)
Construction and rail vibration	*BS 5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration.*
Construction blasting	Appendix J of *Standard AS 2187:2006 Part 2 Explosives - Storage and Use - Use of Explosives*
Mine operational noise	The NSW Industrial Noise Policy (NSW EPA, 2000)
Road traffic noise	NT DPi Road Traffic Noise on NT Government Controlled Roads Policy.
Rail noise	*NSW EPA Rail Infrastructure Noise Guideline* (RING
Rail vibration	BS 6472, *Guide to Evaluation of Human Exposure to Vibration in Buildings*
Sleep disturbance	World Health Organisation (WHO) *Guideline for Community Noise* (WHO, 1999)

16.4 Potential impacts

As there are no sensitive receptors within proximity of project site, no noise criteria will be exceeded. Consequently, no risk assessment was undertaken for noise. Health and safety related impacts of noise and their management for the workforce are discussed in Section 11: Health and safety.

16.4.1 Noise criterion assessment

The permanent mine accommodation camp will be constructed as part of the construction works; therefore, impacts to sensitive receptors at this location are only assessed during operations.

16.4.2 Construction noise

Received noise during the construction phase is shown in Table 16-3, with no noise barriers in place and with each plant item operating at full power. Based on the modelled results, the noise criteria of 47 dB(A) $L_{Aeq15mins}$ for the closest sensitive receptor (8 km) will be achieved. Similarly, the criteria for night-time sleep disturbance of 40 dB(A) L_{eq} and 55 dB(A)L_{max} will be achieved.

Table 16-3 Predicted construction plant item noise levels (dB(A)L_{max})

Plant item	dB(A) L_w	Distance of source to receiver (m)							
		50	250	500	750	1,000	2,000	3,500	8,000
Scraper	116	74	60	54	50	48	42	37	34
Crane	105	63	49	43	39	37	31	26	19
Backhoe	104	62	48	42	38	36	30	25	18
Compressor	101	59	45	39	35	33	27	22	15
Concrete pump	108	66	52	46	42	40	34	29	22
Dump truck	117	75	61	55	51	49	43	38	31
Water truck	107	65	51	45	41	39	33	28	21
Compactor	113	71	57	51	47	45	39	34	27
Concrete batch plant	113	71	57	51	47	45	39	34	3
Dozer	108	66	52	46	42	40	34	29	2
Grader	110	68	54	48	44	42	36	31	2
Loader	113	71	57	51	47	45	39	34	3
Excavator	107	65	51	45	41	39	33	28	2

16.4.3 Construction vibration

The predicted ground vibrations at various distances are shown in Table 16-4 for typical construction equipment. As the closest sensitive receptor is 8 km from the construction site, construction vibration is highly unlikely to exceed the human perception criteria.

Table 16-4 Predicted construction equipment vibration levels (mm/s PPV)

Plant item[6]	Human perception preferred criteria *(maximum criteria)*		Predicted ground vibration				
	Day	Night	10 m	50 m	100 m	200 m	500 m
15 t roller	0.28 *(0.56)*	0.2 *(0.4)*	7.5	0.7	0.2	0.1	<0.1
Dozer	0.28 *(0.56)*	0.2 *(0.4)*	3.3	0.3	0.1	<0.1	<0.1
7 t compactor	0.28 *(0.56)*	0.2 *(0.4)*	6.0	0.5	0.2	0.1	<0.1
Rock breaking	0.28 *(0.56)*	0.2 *(0.4)*	7.0	0.6	0.2	0.1	<0.1
Backhoe	0.28 *(0.56)*	0.2 *(0.4)*	1.0	0.1	<0.1	<0.1	<0.1
Excavator[7]	0.28 *(0.56)*	0.2 *(0.4)*	3.6	0.3	0.1	<0.1	<0.1
Grader[8]	0.28 *(0.56)*	0.2 *(0.4)*	2.0	0.2	0.1	<0.1	<0.1

16.4.4 Construction blasting

Blasting overpressure and ground vibration

Blasting may be required for the construction of rail ballast construction. The closest sensitive receptor (Imperrenth) is 20 km from the proposed construction site.

Charge mass estimates to achieve the maximum operation airblast overpressure criteria of 115 dB(L) and ground vibration criteria of 5 mm/s PPV are shown in Table 16-5. Based on these results and the distance to the closest sensitive receptor being 20 km, ground vibration from blasting will not exceed the criteria.

Ground vibration generally diminishes faster than airblast overpressure; consequently, airblast overpressure is generally the controlling factor for establishing the distance at which blasting can occur without exceeding human perception criteria. Blasting at distances to receivers of less than 500 m would be restricted by the MIC.

As shown in Figure 16-2 and Figure 16-3, the blast overpressure and vibration levels for the assessed charge masses are expected to be well under the criteria at the nearest sensitive receiver located approximately 20 km away.

Table 16-5 Charge mass estimates

Distance to receptor (m)	MIC (kg) to meet 115 dB(Lin)	MIC (kg) to meet 5 mm/s PPV
150	0.1	25
200	0.2	45
250	0.4	71
300	0.8	101
350	1.2	>100

[6] NSW RTA Environment noise management manual
[7] The predicted ground vibration values were based on data stipulated in:Cenek.P.D, et al. *Ground vibration from road construction* (May 2012) Research paper.
[8] Tynan, A.E. Ground Vibrations. Damaging effects to Buildings. Australian Road Research Board 1973

Distance to receptor (m)	MIC (kg) to meet 115 dB(Lin)	MIC (kg) to meet 5 mm/s PPV
400	1.8	>100
450	2.6	>100
500	3.5	>100
600	6.1	>100
700	9.8	>100
1,000	28.6	>100
2,000	>100	>100

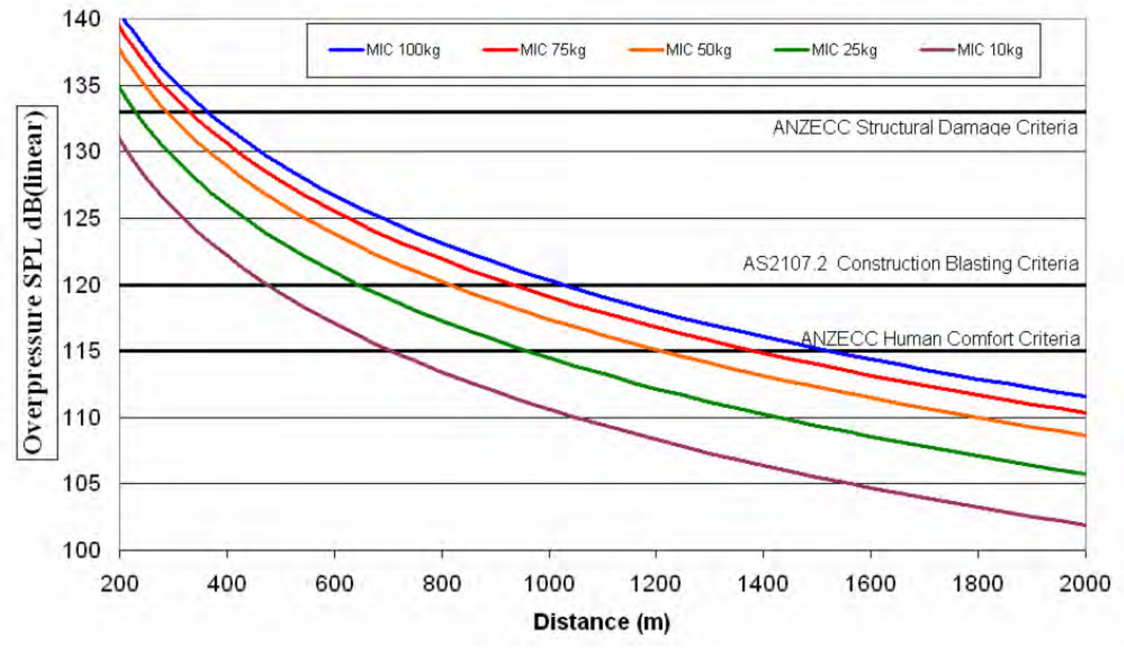

Figure 16-2 Airblast overpressure predictions for different charge masses and distances

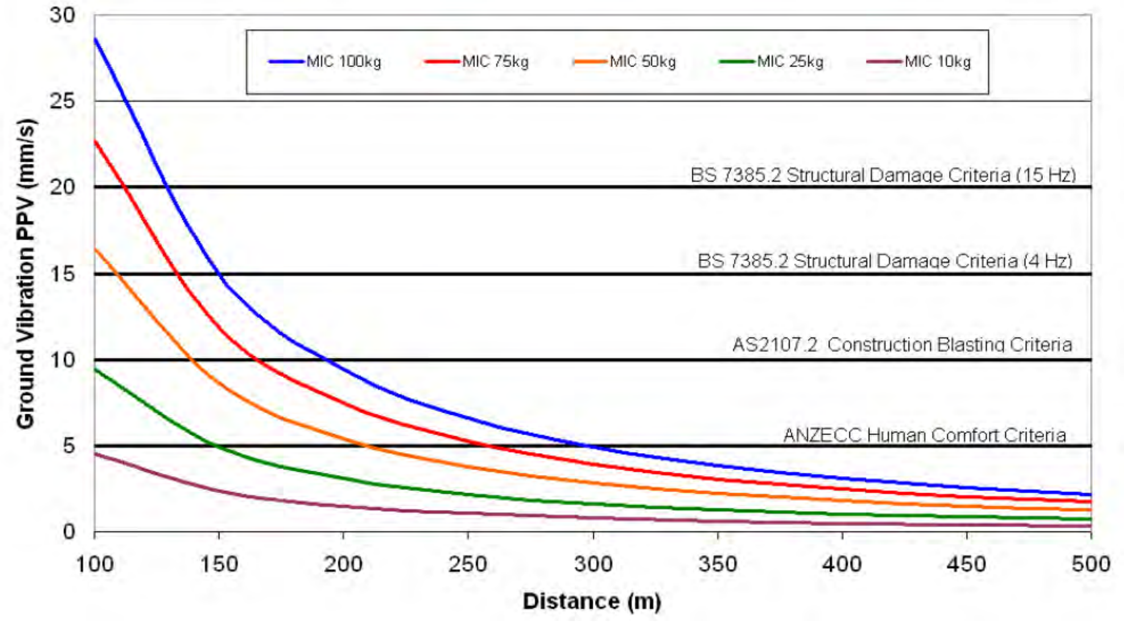

Figure 16-3 Ground vibration predictions for different charge masses and distances

16.4.5 Operational noise

Noise impacts will vary over the life of the mine, depending on where machinery is operating within the mine pit. A worst possible case scenario has been modelled, which includes machinery operating within the area located, as much as practicable, nearest to the direction of the sensitive receivers.

The predicted sound pressure levels due to the mine operation activity at the nearby noise sensitive receivers are summarised in Table 16-6 including the quantity of equipment and source height scenarios. Based on noise model results, the predicted sound pressure levels at the sensitive receptors are all expected to be under the specified noise criteria (Table 16-6).

Table 16-6 Predicted mine operation sound pressure levels at the assessed receivers, dB(A)

Nearest sensitive receiver locations	Industrial noise criteria dB(A)$L_{eq(15\ mins)}$	Predicted noise levels dB(A)$L_{eq(15\ mins)}$	Complies
Mine accommodation camp	35	35	Yes
Ampilatwatja	35	9	Yes
Imperrenth	35	<5	Yes
Imangara	35	<5	Yes
Ali-Curung	35	<5	Yes
Ngkwarlerlanem	35	10	Yes
Indaringinya	35	<5	Yes
Illeuwurru	35	<5	Yes
Tara	35	<5	Yes
Annerre	35	<5	Yes

16.4.6 Mine operational vibration

Based on the equipment requirements during operations (Appendix P) and the construction vibration assessment in Section 16.4.3, it is expected that ground borne vibration impacts associated with the operation of the project would be insignificant at identified nearby sensitive receivers.

It is the responsible of the Proponent to ensure that the operation of the equipment during mine activities does not cause vibration impact to heritage sites surrounding the mine site.

16.4.7 Predicted rail noise impact

- The predicted average airborne rail noise levels at the nearest sensitive are detailed in Table 16-7. There are no nearby noise sensitive receivers that are anticipated to exceed the RING airborne noise trigger levels. The predicted noise levels include a +2.5 dB(A) facade correction.

Table 16-7 Predicted airborne rail noise levels at nearby sensitive receivers, dB(A)

Sensitive receptor	Period	Predicted noise levels dB(A)	RING rail noise criteria dB(A)	Complies
Mine accommodation camp	Day (07.00 am to 10.00 pm)	38 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	40 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Ampilatwatja	Day (07.00 am to 10.00 pm)	5 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	7 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Imperrenth	Day (07.00 am to 10.00 pm)	9 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	12 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Imangara	Day (07.00 am to 10.00 pm)	7 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	9 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Ali-Curung	Day (07.00 am to 10.00 pm)	9 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	11 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Ngkwarlerlanem	Day (07.00 am to 10.00 pm)	4 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	7 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Indaringinya	Day (07.00 am to 10.00 pm)	5 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	7 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Illeuwurru	Day (07.00 am to 10.00 pm)	4 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	7 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Tara	Day (07.00 am to 10.00 pm)	3 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	4 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes
Annerre	Day (07.00 am to 10.00 pm)	4 dB(A)$L_{eq(15\ hrs)}$	60 dB(A)$L_{eq(15\ hrs)}$	Yes
	Night (10.00 pm to 07.00 am)	7 dB(A)$L_{eq(9\ hrs)}$	55 dB(A)$L_{eq(9\ hrs)}$	Yes

L_{Amax} noise modelling results indicate that the 80 dB(A)L_{max} criterion is predicted to occur at approximately 250 m from the rail track, taking into consideration the train horn and crossing bell noise. As the noise sensitive receptors are all located far greater than 250 m from the rail alignment, the maximum rail operation noise levels are not expected to have significant impacts on these receivers.

16.4.8 Other operational rail noise impacts

Wheel curve squeal

There is the potential that wheel curve squeal can occur on curved tracks at levels of up to L_{Amax} 100 dB(A) at 15 m and is considered more annoying due to its high pitch. Wheel squeal may occur at the balloon loop rail track located within the mine site lease boundary. However, as the nearest sensitive receptor is greater than 2 km away, the L_{Amax} noise levels due to wheel squeal are not expected to exceed the RING criteria.

Braking

Braking can result in brake squeal, which can produce similar noise emissions to wheel curve squeal. Brake squeal can be controlled through rolling stock wheel maintenance or low squeal brake blocks. The L_{Amax} criterion refers to the maximum noise level not exceeded for 95% of rail pass by events. Accordingly, with appropriate maintenance, brake squeal may not occur for more than 5% of the time and has therefore not been included in the predicted L_{Amax} noise levels for the proposal.

Rail vibration impact

Recent vibration testing of coal trains in the Hunter Valley have indicated there is low probability of adverse impact upon human comfort for receptors located more than 50 m from the rail line (Hunter8 Alliance, May 2010). Given the nearest sensitive receptor is over 1 km from the rail corridor, it is highly unlikely there would be adverse operational rail vibration impacts.

16.4.9 Sleep disturbance impacts

The project's outdoor sleep disturbance criteria are:

- 40 dB(A)L_{eq} (steady noise)
- 55 dB(A)L_{max} (intermittent noise).

The mine operational noise has been assessed to comply with the INP noise criteria, which are more stringent than the sleep disturbance noise criteria. Therefore the mine operational noise is not expected to have significant sleep disturbance.

The predicted average operation rail noise indicates a level of not more than 40 dB(A)L_{eq} at the nearest sensitive receptor(mine accommodation camp). Hence, the average operation rail noise is not expected to have significant sleep disturbance impact on the Project.

Train horn noise and noise from brake air release impacts (L_{Amax}) are predicted to be 12 dB(A) at the mine accommodation camp, which is well below the sleep disturbance criterion of 55 dB(A)L_{max}. Hence, the train horn noise and noise from brake air release noise emissions are considerably below the sleep disturbance criteria.

16.5 Mitigation and monitoring

The noise and vibration assessment found that the project's activities during construction and operation should not exceed noise criteria. Therefore, no mitigation measures are required.

17. Rehabilitation

17.1 Introduction

This chapter addresses the approach to rehabilitation, decommissioning and mine closure, as required in the TOR for the project and is based on the Closure Report (GHD 2017) provided in Appendix Q of the EIS and the Flora and Fauna Report (EcOz Environmental Consultants 2017) provided in Appendix J of the EIS. The level of risk associated with rehabilitation and closure is described in this chapter and assessed in the risk register in Table 6-8.

Section 5.10 of the EIS TOR provided the following environmental objective in relation to rehabilitation, decommissioning and closure:

> *Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.*

17.1.1 Landscape condition

The project is within the pastoral stations of Ammaroo, Murray Downs and Neutral Junction, which have a moderate level of habitat degradation typical of that associated with cattle grazing in central Australia (i.e. increased weeds, erosion development, and changes to soil surface structure/infiltration, water source degradation and altered fire regimes).

17.1.2 Habitat areas

Mine site and water supply infrastructure

The mine site and water supply infrastructure areas constitute red earth plains and shallow sandplains, which support a mixture of low woodlands and low open woodlands (Mulga, Gidgee, Coolabah and Bloodwood) over short-lived tussock grass.

There is a moderate level of pastoral activity within the mine site area and water supply infrastructure corridor, with the highest activity occurring in red earth plain (due to the presence of palatable species).

Weed occurrences are typically associated with station tracks and watering points such as Woody's Dam. Overall, a low weed presence was observed during surveys, with only a few isolated Rubber Bush (*Calotropis procera*, Class B weed) plants observed, and several other non-declared grass species.

Access corridor and gas pipeline

The access corridor is 137 km in length, and spans a variety of different landforms and associated vegetation communities. Broadly, the access corridor can be discussed in terms of the eastern half and western half, as these areas support distinctly different landform types.

The eastern half of the corridor supports a mixture of red earth plains, shallow red earth sandplains, low rocky rises, alluvial plains and several seasonal swamps and claypans. Vegetation varies from Mulga woodlands (over tussock grasses) on the red earths, *Acacia* spp. and Mallee (*Eucalyptus* spp.) shrublands (over Spinifex) on the shallow sandplains, and Mulga and Smooth-barked Coolabah (*Eucalyptus victrix*) woodlands (with tussocks and sedges) in drainage floors and swamps.

The western half of the corridor supports extensive areas of desert (aeolian, windblown) sandplains, small pockets of Mulga dominated red earth plains, and one floodplain associated with the Taylor Creek drainage system (which originates from ranges situated to the south). Vegetation within the sandplains is predominantly Acacia shrublands over Spinifex with the western areas supporting moderate densities of Bigfruited Bloodwood (*Corymbia sphaerica*). The floodplains support variable densities of Smooth-barked Coolabah (*Eucalyptus victrix*), Bean Tree (*Erythrina vespertilio*), Bloodwood (*Corymbia opaca*), and Sandhill Teatree (*Melaleuca lasiandra*) over a diverse range of tussocks, sedges, and forbs.

Drainage features also occur within the western half of the access corridor – drainage floors, alluvial plains, clay pans and seasonal swamps; however, no watercourses have been identified.

In general, pastoral impacts are noted as low to absent within the sandplains due to the dominance of Spinifex understory (i.e. hummock grassland) which has very little grazing value. The red earth plains have moderate levels of pastoral activity, especially in areas close to water points or cattle yards.

Taylor Creek floodplain has been noted as having a moderate to high level of pastoral impact, due to the presence of several water points, yards, station tracks and bores. Buffel Grass (introduced grass species of benefit to the pastoral industry) was widespread in these floodplains, and several other weed species (including patches of Rubber Bush, *Calotropis procera*, a Class B species under the *Weeds Management Act*) were also noted.

17.1.3 Environmental objectives

As part of the Flora and Fauna assessment (EcOz Environmental Consultants 2017), habitat mapping was undertaken to describe and map the landforms, major soil types and vegetation communities within the project area. This habitat mapping data will be used to inform the weed and erosion potential and provide baseline flora lists (and condition) for rehabilitation purposes.

17.1.4 Rehabilitation objectives

This report provides the rehabilitated landform objective and post-mining landform design for each of the project key areas.

The rehabilitated landform objective is to:

- Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use.
- Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values, and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.

The intended post-mining land use for the rehabilitated site is natural habitat compatible with pastoral use, and applies to the key project features described below.

17.1.5 Closure Domains

The site layout for the Ammaroo Phosphate Project is provided in Figure 2-2 and Figure 2-3. The site is divided into the following key areas:

- Administration and plant area (including a beneficiation plant and power plant).
- Permanent camp (including a waste management facility/ landfill, and sewage/septic facilities).
- Rail loop.
- Open pits (including in-pit tailings / waste backfill).

- Starter TSF (or surface TSF).
- Production borefield.
- Access corridor including rail spur and gas pipeline.
- Borrow pits and their access roads.
- Temporary waste and soil stockpiles #.
- Murray Downs Road realignment area.

Those areas assigned a # prefix (i.e. temporary waste and soil stockpiles) are not designated closure domains. They are dynamic areas, opportunistically close to their source and/or ultimate end-use location; and they will be utilised opportunistically in progressive rehabilitation throughout the mining cycle. When individual stockpile locations are completely consumed, they will be rehabilitated on an ongoing basis. These dynamic features are discussed further throughout the document.

- Note that, although the rail loop is physically contained within the construction/plant area, it is discussed collectively with the rest of the access corridor in this document.
- Appendix Q describes the proposed closure tasks based on the current understanding of the project, and provides the key content of a draft Mine Closure Plan (MCP).

17.1.6 Progressive project rehabilitation activities

Clearance of native vegetation for the project totals 3,600 Ha over 25 years and will include the broad vegetation types of Mulga woodlands and shrublands, and hummock grasslands. Although these vegetation types are common within the region, the clearing will result in a loss of fauna habitat, and has the potential to impact on weed cover and fire regimes in the area

Progressive rehabilitation will commence in the early years and continue over the life of the mine, thus reducing the risk that unforeseen closure results in a failure to meet rehabilitation objectives.

Progressive rehabilitation will also allow the project to refine and improve the rehabilitation process as lessons are learnt. A Rehabilitation Plan will be developed that describes how topsoil and vegetation will be stored, species selection, and weed management, how land is to be reinstated and active rehabilitation success criteria. A Weed Management Plan will be used to minimise the impact of weeds on rehabilitation success.

Temporary waste rock and soil stockpiles will be dynamic areas and not designated as closure domains. The changing areas they occupy (away from drainage features) will be opportunistically close to their source and/or ultimate end-use location throughout the mining cycle. When individual stockpiles are completely consumed, those areas will be remediated on an ongoing basis.

17.1.7 The closure register

The Closure Report (Appendix Q) documents key closure tasks for closure domains within closure registers that apply to key project areas. All project features will be closed, with the exception of the Murray Downs Road realignment area, and bores or access tracks that may be left open following consultation with pastoralists. Project areas will be rehabilitated to reflect the current predominantly flat area geometry. Areas will be covered with stockpiled material and stabilised and revegetated to enable natural habitat compatible with pastoral use.

For each closure domain, a closure register has been developed in Appendix Q that describes:

- Closure work tasks

- Schedule of work for research
- Investigation and trials tasks
- Schedule of work for progressive rehabilitation
- Availability and management of closure material sources
- Key tasks for unexpected (early) closure and/or temporary closure
- Information gaps
- Performance monitoring and maintenance schedule.

Key risks associated with rehabilitation and closure, and the measures that will be implemented to minimise those risks are described in Table 17-1.

Table 17-1 Key closure risks

Hazard / event - end of life	Consequence	Mitigation measures
Failure of post-closure surface TSF batters leading to erosion or seepage and loss of material to the environment. Or failure of in-pit TSF concept, excessive settlement or contaminated seepage discharge.	Erosion and dispersion of particulate matter via air, surface, or groundwater flows, with resultant downstream effects on dependant ecosystems.	• Reporting of spills • Contaminated sites register • Contaminated sites report • Contaminated sites rehabilitation designs • Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria • Undertake further sampling/monitoring to accurately define level and extent of any ground contamination during operations and improve volumetric estimates.
Poor management of waste materials during operations leads to closure plans being unachievable or costly.	Delays to effective rehabilitation by project proponent, including erosion, or seepage resulting in non-sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years.	• Conceptual closure plan developed for the project at start-up • Increase level of detail in closure designs during operations (detailed design level 5 yrs. prior to closure) • Prepare decommissioning and rehabilitation plan • Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. • Regular monitoring of identified key environmental aspects of operation that are potentially most problematic during operation and at closure i.e. surface/in-pit tailings, waste rock seepage to ensure these aspects are fully understood and accounted for in all closure designs and proposals. • Strip mining methodology allows for progressive rehabilitation and review, include in mine plan showing open areas, replacement and order of fill etc.

Hazard / event - end of life	Consequence	Mitigation measures
		• Employ closure project manager • Undertake inspections & monitoring • Performance monitoring of progressive rehabilitation and correction of designs/execution if required
Contaminated sites not adequately remediated, including process plant, workshops, and fuel farm or storage areas.	Delays to effective rehabilitation by Project proponent, including erosion, or contaminated seepage resulting in non-sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years. Inability to relinquish, leading to damage to reputation, not able to get bond, ongoing environmental damage.	• Long term offtake arrangements for clients • Strategic long term investors • Concept closure plan • Commit to developing/refining closure designs through operations • Closure materials topsoils etc. stockpiles at start-up of operations • Surface TSF design conservative and in-pit tailings/waste limited impact should they enter early closure as closure concept does not significantly change • Progressive rehabilitation • Bonds held by NT Government requires 110% of estimated closure cost reviewed and provided annually.
Closure designs not developed in detail to enable appropriate closure execution, including ineffective implementation of design, poor rehabilitation execution or design failure, resulting in significantly higher closure cost above closure provisioning.	Insufficient closure cost provision resulting in inability to execute closure plan. Delays or inability to achieve effective rehabilitation by project proponent. Delays in achieving rehabilitation criterion and or relinquishment and could be a period of years, with un-remediated project site potentially acting as source of ongoing environmental hazard.	• Reporting of spills • Contaminated sites register • Contaminated sites report • Contaminated sites rehabilitation designs • Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria • Undertake further sampling/monitoring to accurately define level and extent of any ground contamination

Hazard / event - end of life	Consequence	Mitigation measures
		during operations and improve volumetric estimates.
Reduction in the quality of ecosystems due to inconsistent / inadequate rehabilitation	A decrease in the abundance of flora and fauna ecosystem.	• Conceptual closure plan developed for the project at start-up. • Increase level of detail in closure designs during operations (detailed design level 5 yrs. prior to closure) • Prepare decommissioning and rehabilitation plan • Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. • Regular monitoring of identified key environmental aspects of operation that are potentially most problematic during operation and at closure i.e. surface/in-pit tailings, waste rock seepage to ensure these aspects are fully understood and accounted for in all closure designs and proposals. • Strip mining methodology allows for progressive rehabilitation and review, include in mine plan showing open areas, replacement and order of fill etc. • Employ closure project manager • Undertake inspections & monitoring • Performance monitoring of progressive rehabilitation and correction of designs/execution if required
Unexpected early closure of the project, due to delays or falling commodity prices.	Delays to effective rehabilitation by project proponent, including through erosion or seepage resulting in non-sustainable ecosystems and groundwater effects. Potentially exacerbated by closure designs not yet developed in detail at time of early closure.	• Long term offtake arrangements for clients • Strategic long term investors • Concept closure plan • Commit to developing/refining closure designs through operations

Hazard / event - end of life	Consequence	Mitigation measures
		• Closure materials topsoils etc. stockpiles at start-up of operations • Surface TSF design conservative and in-pit tailings/waste limited impact should they enter early closure as closure concept does not significantly change • Progressive rehabilitation • Bonds held by NT Government requires 110% of estimated closure cost reviewed and provided annually.
Insufficient funds / bonds for project closure activities, due to inadequate closure plan designs, poor assumptions or failure to recognise impact of changes to operations on closure plans	Delays to effective rehabilitation, with un-remediated Project site potentially acting as source of ongoing environmental hazard. Worst credible consequence is involuntary administration, with NT Government to complete remediation with bonds shortfall and consequential budgetary impact.	• Reporting of spills • Contaminated sites register • Contaminated sites report • Contaminated sites rehabilitation designs • Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria • Undertake further sampling/monitoring to accurately define level and extent of any ground contamination during operations and improve volumetric estimates.

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