01

Introduction

1. Introduction

1.1 Overview

Arafura Resources Limited (Arafura) is proposing to develop Nolans Project (the project) located approximately 135 kilometres (km) north west of Alice Springs, Northern Territory (NT) (Figure 1-1). The project is construction, mining, processing, rehabilitation and decommissioning of a rare earth (RE) mine and associated infrastructure.

The project is targeting a fluorapatite mineral deposit containing REs at Nolans Bore. The Nolans site comprises the mine site, a processing site, a borefield area and accommodation village site, and interconnecting access roads and utility service corridors (Figure 1-2).

Mining operations will be undertaken using conventional open pit methods (drill, blast, load and haul) at a maximum overall mining rate of ten million tonnes per annum (tpa), to produce an average one million tonnes of concentrator feed each year.

Excavated ore will be fed to beneficiation circuits at the mine site. The circuits will include staged crushing, grinding, wet magnetic separation and flotation. A concentrator will produce phosphate-bearing and RE-bearing concentrate in a slurry form. The slurry will be pumped via a high density polyethylene (HDPE) pipeline to the processing site approximately eight kilometres to the south of the mine site.

The processing site contains RE extraction processing units, a sulfuric acid plant, process residue storage facilities (RSFs), evaporation ponds, a power station and other infrastructure to support the operation. From the processing site, RE concentrate will be transported to Port of Darwin, NT and subsequently, to an offshore RE separation plant. The RE separation plant will be in an established chemical precinct capable of meeting the reagent demands of the refining process; and subject to a separate approvals process. The offshore component is excluded from the scope of this Draft Environmental Impact Statement (EIS).

The project triggers assessment under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act), controlling provisions 18 and 18 A (listed threatened species and communities) and 21 and 22A (nuclear actions) and NT *Environmental Assessment Act 1982* (EA Act), at the level of an EIS (refer to Appendix A and Appendix B).

This EIS is submitted to the NT EPA and DoE for assessment in accordance with relevant legislation.

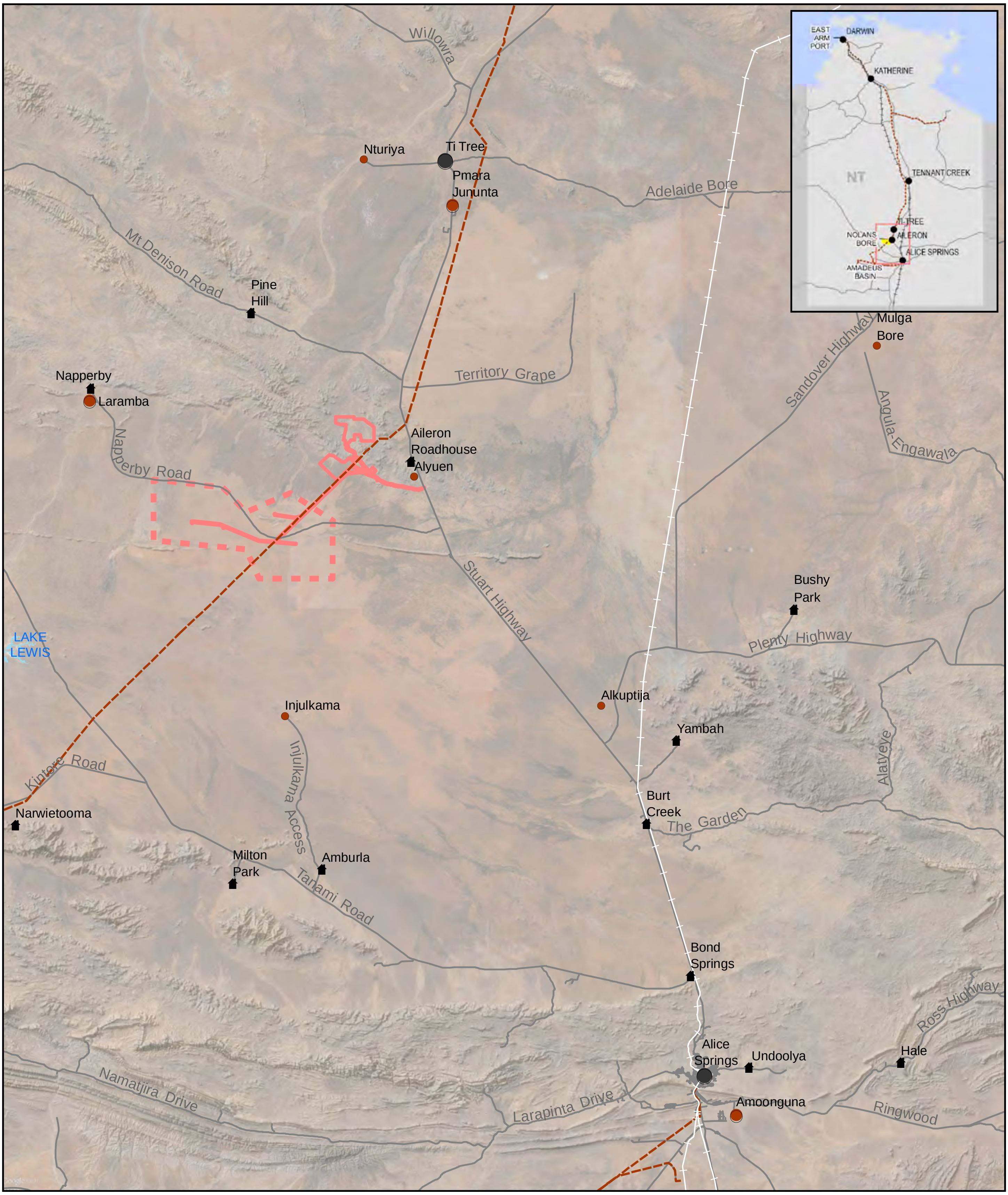
1.2 Proponent details

The project proponent is Arafura Resources Limited (Arafura or the Company or the Proponent). Arafura has a registered office in Perth, Western Australia, and an office in Darwin, NT.

The Proponent's contact for the project is:

Mr Brian Fowler
Arafura Resources Limited
General Manager Northern Territory and Sustainability
PO Box 37220, Winnellie, NT 0821
Phone: +61 8 8947 5588
Email: eis@arultd.com

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



LEGEND

- Town
- Community
- Station
- Outstation
- Gas Pipeline
- Roads
- Project Areas
- Borefield Area
- Waterbodies

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0 10 20 30 40

Kilometres

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

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ARAFURA RESOURCES LIMITED

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Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number 43-22301
Revision 0
Date 13 Apr 2016

Project location

Figure 1-1

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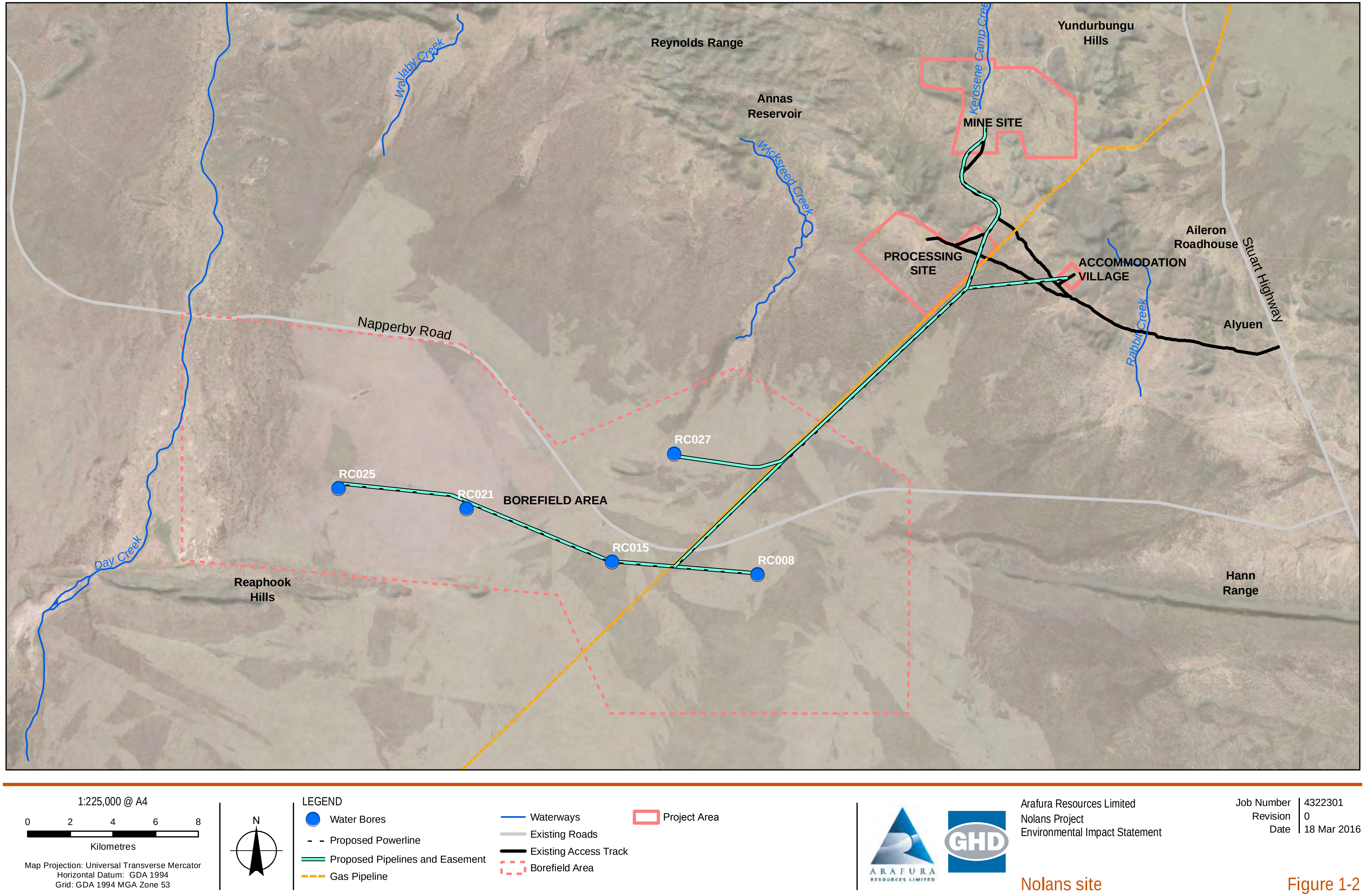
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Gas Pipeline, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 09/11/2015). ARL - Project Areas (2015). Created by: CM



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Job Number	4322301
Revision	0
Date	18 Mar 2016

Nolans site

Figure 1-2

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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 - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM

1.2.1 Ownership and commodity information

Arafura is an emerging RE producer. The project will be the company's first mining and chemical processing operation. The Nolans Project is 100% owned by Arafura, an Australian stock exchange listed company.

Arafura is positioning itself to produce high quality RE products, and to target customers in key growth areas such as the automotive, clean energy technology and electronics sectors. In 2014 the global demand for RE products reached 126,000 tonnes, and this demand is forecast to grow at 5% per annum over next ten years; driven by technology innovation, particularly in industrial and clean energy sectors.

The project has the potential to supply 10% of the world's magnet feed demand through its production of NdPr (neodymium-praseodymium, or didymium) oxide. The use of REs in the permanent magnet sector is expected to grow by approximately 10% per annum.

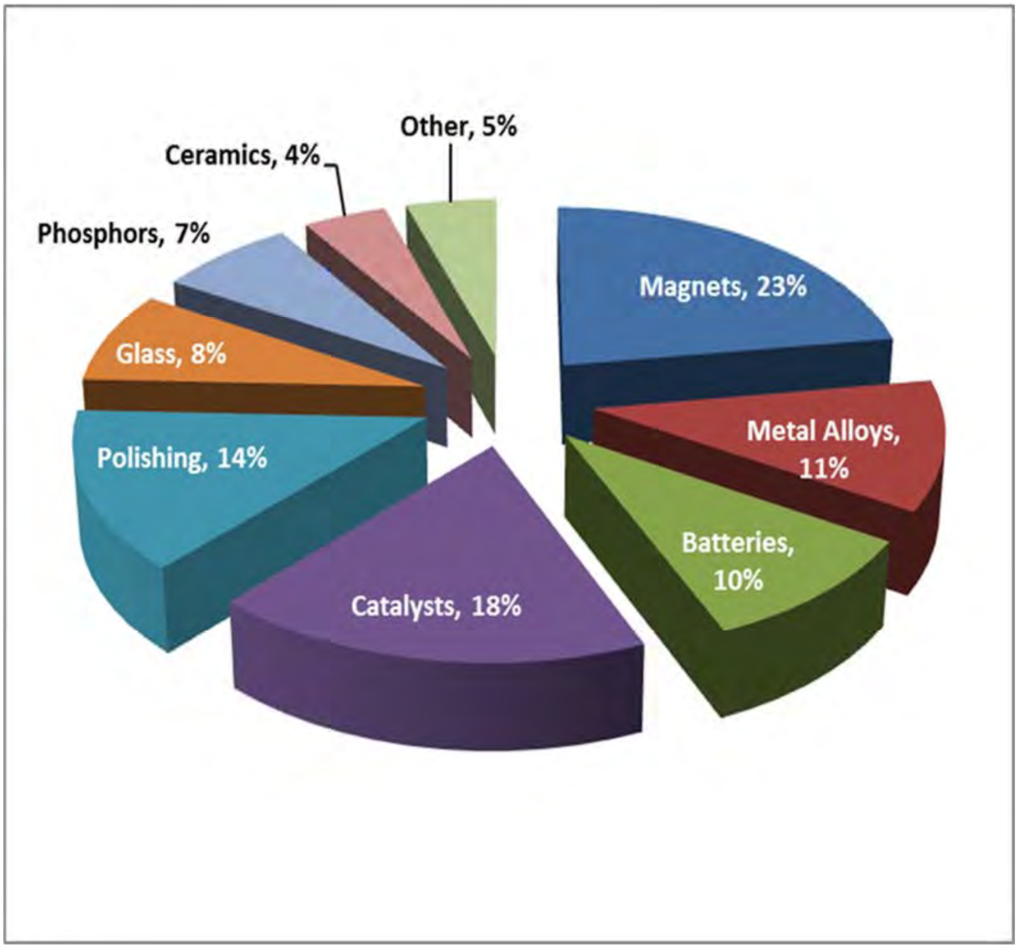


Figure 1-3 End uses of rare earth products (Arafura 2014)

1.2.2 Market position

Arafura's sales plan targets customers across the entire RE supply chain where visibility, security and stability of supply are becoming increasingly important. To position Arafura strongly in the regional markets of Europe, Japan, South Korea and North America, a combination of direct sales to end users and partnering with strategic distributors is important. Arafura has forged long-term relationships with key end users and strategic trading partners involved in key markets.

1.2.3 Key business dealings

Expertise in processing and marketing of REs resides in China. Arafura has recognised the need for strategic Chinese partnerships to enhance their access to RE expertise.

The East China Mineral Exploration and Development Bureau is a major state-owned enterprise and an important long-term strategic partner for, and shareholder in, Arafura. East China Mineral Exploration and Development Bureau has been the conduit through which Arafura has developed relationships with a number of Chinese RE producers, research institutes and investment groups, to help accelerate the development of the project.

Planning and project feasibility has progressed over a number of years as new information about the mineral deposit, processing technologies, project economics, RE markets and site conditions has developed.

1.3 Development context including project background

1.3.1 Project title

The recent and current name is the Nolans Project which is herein referred to as “the project”. The project has previously been referred to as the Nolans Bore Project, Nolans Rare Earth Project, and Nolans Bore Rare Earth Mine.

1.3.2 Status of the project

The project is in the Definitive Feasibility Study (DFS) phase and Arafura is seeking environmental approval for the project.

In September 2014, Arafura released the Nolans Development Report (Arafura 2014). In December 2014 Arafura lodged a variation notification to the NT Environment Protection Authority (NT EPA) in accordance with the Section 14A “Procedure where proposed action altered” under the NT Environmental Assessment and Administrative Procedures under the EA Act. Pursuant to Section 14A of the Environmental Assessment Administrative Procedures, the NT EPA considered the alteration and determined that an EIS is necessary with respect to the project. Final Terms of Reference (TOR) for the preparation of an EIS (Appendix B) were issued in May 2015.

In February 2015, the Proponent also submitted a revised referral (EPBC 2015/7436) describing the changes to the proposed action to the Federal Minister for the Environment. In March 2015, the delegate of the Minister determined the project to be a controlled action (Appendix A) and that assessment and approval is required at a federal level. Triggers for assessment under Commonwealth legislation include the potential to have a significant impact on the following matters of national environmental significance that are protected under Part 3 of the EPBC Act:

- Listed threatened species and communities (sections 18 & 18A) and
- Protection of the environment from nuclear actions (sections 21 and 22A).

The project is being assessed under a bilateral agreement between the Australian and NT Governments made under section 45 of the EPBC Act. Arafura is seeking approval under the EPBC Act and EA Act.

1.3.3 Project schedule

Arafura developed a detailed project execution plan for the Nolans Project in 2014, including planned commencement of construction in the second half of 2016 through to planned commencement of project operations in the first half of 2019 (Arafura 2014).

Construction of the mine, processing plant and associated infrastructure may take up to 30 months to complete. Pre-stripping will commence in Year 1 and provide construction materials for all proposed infrastructure.

1.3.4 Background

The Nolans Bore RE-phosphorus-uranium deposit was discovered in 1995 by PNC Exploration. The first exploration drilling was carried out at Nolans Bore in 2001 on Exploration Licence (EL) 9672, a predecessor tenement to Arafura's current EL 28473.

Systematic drilling of the site has been undertaken by Arafura since 2000. Nearly all of the exploration and resource definition activity has been confined to an area measuring 1.5 x 1.2 km, centred approximately on the-now decommissioned Nolan stock bore. This work indicates the widespread presence of RE-rich fluorapatite mineralisation at or near surface, within steeply dipping veins up to tens of metres in thickness and hundreds of metres in length extending below 250 metres drilled depth across large parts of the deposit. The full extent of the deposit is yet to be outlined, but deeper drilling in one part of the deposit has encountered mineralisation and alteration down to at least 430 metres (m) below surface (Arafura 2014).

In February 2008 Arafura applied for a Mineral Lease (ML) over the deposit and immediate surrounds (ML 26659; 1,404 hectares). In March 2008 a Notice of Intent (Arafura and GHD 2008) was submitted to the former NT Department of Natural Resources, Environment and the Arts (NRETA) for consideration under the EA Act. NRETA referred the project for assessment under the EA Act at the level of an EIS, and issued EIS guidelines for the project.

In August 2008, a referral (EPBC 2008/4371) under the Commonwealth EPBC Act was submitted to the former Department of Environment, Water Heritage and Arts. The Minister declared the project a "controlled action" under controlling provisions section 21 and 22A of the EPBC Act relating to a "nuclear action".

Planning of the project continued throughout 2010 and 2012, and extensions to the timeframe of the EIS guidelines were sought and granted by the NT environmental regulator.

Since 2008, the Nolans Bore mineral resource has approximately doubled and project requirements have altered, resulting in an expanded footprint that now includes a borefield, a downstream chemical processing operation at the processing site, and an accommodation village. As a result, additional ML applications were lodged with the NT Department of Mines and Energy (DME) to accommodate the expanded footprint of the project on ELs 28473, 28498 and 29509.

The project's 2008 post-beneficiation flow sheet has changed from a single complex, intended to be located at Whyalla in South Australia, to a split configuration comprising a processing plant at the Nolans site and an offshore RE separation plant in an established chemical precinct capable of meeting the reagent demands of the refining process.

A summary of the project's development in a global context is provided in Table 1-1.

Table 1-1 Summary of Nolans Project development context

Year	Project development context
1995	Discovery of Nolans Bore rare earths-phosphorus-uranium prospect by PNC Exploration
2001	Arafura acquires Nolans Bore exploration licence. First drill hole into Nolans Bore and maiden Joint Ore Reserves Committee (JORC) mineral resource (4 million tonnes).
2003	Arafura lists on the Australian Stock Exchange
2005	First metallurgical test program
2006	Australian Government grant ($3.3 million) for process development
2007	Pre-feasibility study: REs, phosphoric acid, uranium processing in the NT. China imposes RE export and production quotas.
2008	First environmental studies at Nolans site. Mine site mineral lease lodged. Global financial crisis.
2009	Chinese investment (24.86%) into Arafura. Process and configuration changes: REs, phosphate, uranium, gypsum processing in South Australia.
2011	Rare earth price bubble
2012	Major process breakthrough: first separated RE products. Major JORC mineral resource upgrade (47 million tonnes). Maiden JORC ore reserve (24 million tonnes).
2013	Rare earth prices collapse. Process and configuration changes: RE processing in the NT and offshore.
2014	Increased Chinese technical involvement in process development. Life-of-operation water supply secured. Processing site mineral leases lodged.
2015	EIS recommences on expanded project footprint. China removes RE export duties and quotas. Increase in JORC mineral resource (56 million tonnes).

1.3.5 Hydrogeological investigations

A hydrogeological investigation at the proposed Nolans mine site was completed in 2011 to estimate dewatering requirements during mining operations (Environmental Earth Sciences 2011).

In 2010-11 hydrological investigations to identify a sustainable water supply for the life of project initially focussed on potential groundwater supplies in the Cainozoic basins within about 40 km of Nolans Bore, and in particular, in the Ti Tree Basin aquifer to the northeast of the Nolans mine site.

In 2012 Arafura shifted its attention towards exploring the groundwater potential in the concealed and poorly constrained northern Burt and eastern Whitcherry basins (herein referred to as the “Southern Basins”) to the southwest of the mine site.

Arafura completed an exploratory water drilling program in the Southern Basins in late 2012 that successfully encountered groundwater in all exploration bores, including two bores in a high yielding thick sandstone aquifer.

A follow-up drilling campaign during mid-2014 included drilling through the entire Cainozoic sequence into the underlying basement units, and undertaking controlled pump testing of production bores sited in the best aquifers and dispersed across the entire area.

The Southern Basins area provides a sizeable, high-yielding, slightly brackish groundwater system that has the capacity to service the life of the operation, and therefore a viable sustainable alternative and preferred supply to the Ti Tree Water Control District.

1.4 Project location and regional context

1.4.1 Location and land tenure

The Nolans mine site is located 10 km west of the Stuart Highway, 65 km west of the Darwin-Adelaide railway, and 150 km by road from the major Central Australian town of Alice Springs (Figure 1-1). The Stuart Highway is the main highway from Adelaide to Darwin. The access road to the Nolans site is a proposed new sealed road.

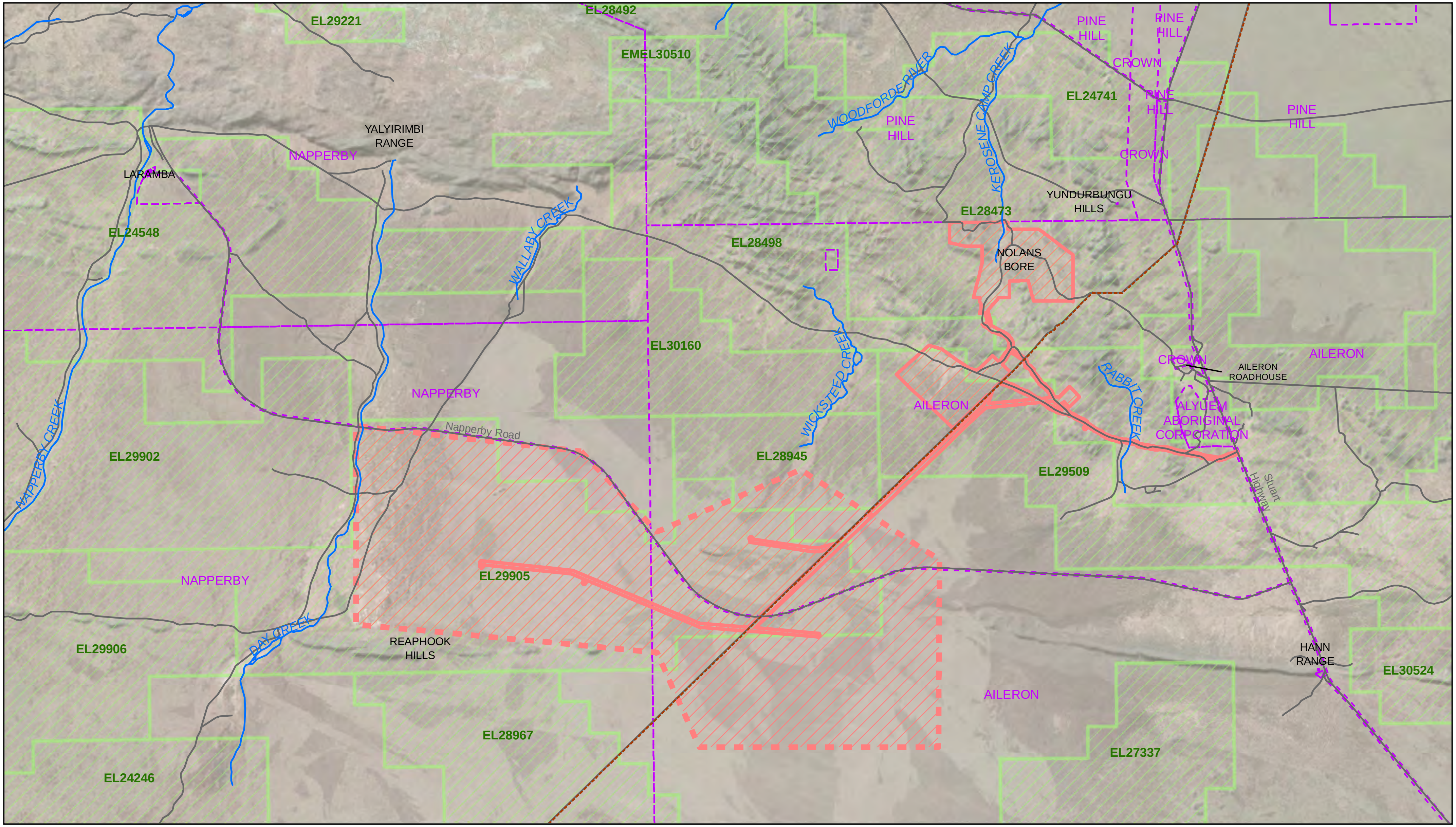
The Nolans site is located at latitude 22.565˚ south and longitude 133.239˚ east, within three granted ELs 28473, 28498 and 29509 (Figure 1-4).

Arafura has lodged applications for the following mining and ancillary tenements with the DME:

- ML 26659 over the mine site and
- MLs 30702, 30703 and 30704 over the processing site and accommodation village.

Aileron Pastoral Holdings Pty Ltd also hold background land tenure to the mine site and processing site under Aileron Perpetual Pastoral Lease (PPL 1097). The predominant land use on the pastoral lease is cattle grazing.

There may be a requirement for a separate Indigenous Land Use Agreement (ILUA) covering access to the borefield, which is situated some 35 km southwest of the mine site.



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Kilometres

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

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LEGEND

Gas Pipeline
Waterways
Roads
Project Areas
Borefield Area
Pastoral Leases
Exploration Licence

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Land tenure

Figure 1-4

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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, Waterways, Gas Pipelines, Imagery (2015). DME - Mineral Titles (2015), DPLE - Tenure, Cadastre (2015). ESRI - SRTM (2006). GHD - Project Areas (2015). Created by: CM

The Adelaide to Darwin railway runs through Alice Springs. The rail corridor is located approximately 40 km east of Nolans site and the closest point. Arafura proposes to utilise the railway, accessing it at Alice Springs.

Daily flights between Alice Springs and most Australian capital cities eliminate the requirement for a dedicated airstrip at Nolans. The nearest paved and gravel airstrip to the Nolans site is at Ti Tree and Aileron Station respectively. The latter may be suitable for use by emergency aircraft following some upgrade.

The Amadeus Basin to Darwin natural gas pipeline passes directly adjacent to the Nolans processing site and within five kilometres of the mine site (Figure 1-1). The project will utilise gas during operation. A gas take-off line will be required to tap into the gas pipeline to service the site.

1.4.2 Major communications and community centres

The town of Alice Springs (population of about 26,000), south-southeast of the Nolans site along the Stuart Highway, is served by modern road, rail and telecommunications infrastructure. Traditional owners of the land on which Arafura will operate are Anmatjere people, with senior traditional owners living in the Alyuen, Ti Tree, Pmara Jutunta and Laramba communities and further afield in places such as Alice Springs (Figure 1-5). (Note that Anmatjere is also written Anmatyerr. Both spelling variations are utilised throughout this EIS).

Small communities and family outstations in the surrounding area include:

- Aileron Roadhouse - an important stop-over for travellers on the Stuart Highway, 12 km east of the Nolans site.
- Aileron Station – a 4,078 km^2 cattle station within which nearly the entire footprint of the Nolans Project is contained (with the exception of the western extent of the borefield and the Woodforde carbonate quarry). The property was acquired in July 2015 by Melbourne-based Aileron Pastoral Holdings Pty Ltd.
- Alyuen (Aileron) – a family outstation 130 km north of Alice Springs and two km west of the Stuart Highway (population about 20). It is located about 15 km south east of the Nolans site.
- Alkuptija (Gillians Bore) - a family outstation three kilometres west of Stuart Highway and 70 km south east of Nolans mine site (population about 20).
- Burt Creek (Rice's Camp) – a family outstation close to Stuart Highway and 93 km south east of Nolans mine site (population about 15).
- Injulkama (Amburla) – a family outstation 56 km south of Nolans mine site and 100 km to the north west of Alice Springs (population about 10).
- Laramba - a key community due to its relative proximity to the Nolans site and borefield. Access to the community is by the Napperby station road, which runs west from the Stuart Highway. The community is located approximately 50 km west of the Nolans site. Laramba is a large community of mostly Aboriginal people (population approximately 300) including some of the traditional owners of the Nolans site. It has a school, community health centre and other facilities.
- Napperby Station – a 5,356 km^2 cattle station, 50 km to the west which has been owned and operated by the Chisholm family since 1948. This includes a shared borefield area and Laramba community living area.

- Pine Hill Station – 2,686 km^2 cattle station bordering Aileron Station to the north. It hosts the proposed Woodforde carbonate quarry (not the subject of this EIS) and until recently was owned and operated by the Braitling family.
- Pine Hill (Anyumgyumba) – a small family outstation located near the Pine Hill Station homestead, 35 km west of the Stuart Highway and approximately 29 km north of the Nolans mine site. It has a small transient population.
- Pmara Jutunta (Six Mile) – a major community of about 190 people 46 km to the north east of Nolans mine site and close to the Stuart Highway and Ti Tree community.
- Ti Tree – a community located 170 km north of Alice Springs and 53 km north of the mine site, along the Stuart Highway. It is a large community with facilities including a school, health centre, library, police station and airstrip. Population is approximately 280 persons. Ti Tree serves as the operational centre for the Anmatjere Community Government Council.
- Nturiya (Ti Tree Station) is 17 km to the west of Ti Tree and has a population of about 100.

1.4.3 Landmarks

The Nolans mine site is at the head of the Kerosene Camp Creek valley on the north facing slopes of a northeast – southwest trending ridge of the Reynolds Range, whilst the processing site is situated on the southern slopes of the same ridge. Topographic elevation is 886 m above sea level (m ASL) at Mt Boothby to the east of the mine site, and 1,006 m ASL at Mt Freeling to the west. Most of the Kerosene Camp Creek valley floor at the mine site is typically between 650 and 700 m ASL whilst the processing site is at an elevation of about 670 m ASL (Figure 1-5).

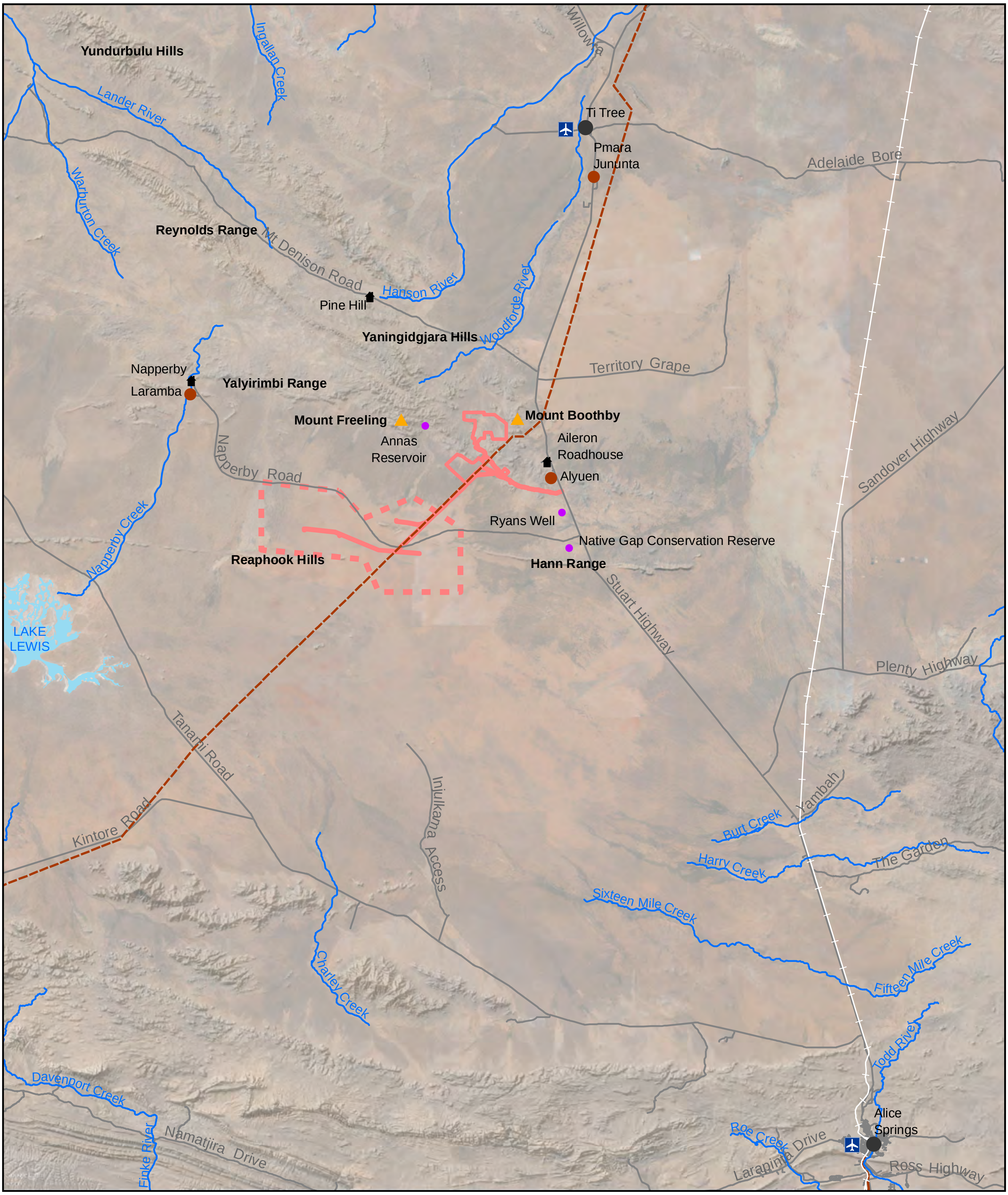
1.4.4 Water features

The important surface water drainage features within the Nolans site flow only immediately following rainfall events. Surface water flows originate in the catchments of the Reynolds Range and Yalyirimbi Range. These flows typically result in terminal creeks (i.e. their flow does not make it to a secondary water feature), including Gidyea Creek, Day Creek, Wallaby Creek, Wicksteed Creek, Kerosene Camp Creek, Rabbit Creek and Allungra Creek. Napperby Creek is the exception in that it discharges to the ephemeral Lake Lewis, following periodic high rainfall events. Likewise, the Woodforde River also discharges to the Hanson River downstream (north) of the study area. No significant surface water drainage features originate from the Hann Range, Reaphook Hills or in the low-lying dune country of the relatively flat plains of the Ti Tree Basin and Southern Basins.

The Nolans mine site is in the headwaters of the Woodforde River drainage system that flows across the south western fringe of the Ti Tree Basin. Kerosene Camp Creek is an ephemeral creek that flows through the centre of the mine site before joining the Woodforde River 10 km to the north. Nolans Creek is a major tributary of Kerosene Camp Creek that drains an area of 26 km^2 and flows adjacent to the eastern boundary of the proposed flotation tailings storage facility (TSF) and between two waste rock dumps (refer Chapter 3).

The processing site occupies a small part of the headwaters of several poorly defined creeks draining southwards into the Lake Lewis catchment. Distinct channels have not formed within these headwaters and runoff from the processing site is dispersed in minor rills.

The access road from the Stuart Highway to the Nolans site will cross the headwaters of numerous creeks draining southwards into the Lake Lewis catchment.



LEGEND

●	Town	☗	Station	—	Roads	▭	Project Areas
●	Community	●	Site of Interest	- - -	Gas Pipeline	⬚	Borefield Area
▲	Mountain	✈	Airport	—	Waterways	■	Waterbodies

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Kilometres

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

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Land marks and water features

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, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 15/12/2015). ARL - Project Areas (2015). Created by: CM

Water sampling in the Woodforde River indicates fresh but very turbid water, neutral in pH and with sufficient dissolved oxygen to support aquatic life. Conditions at the mine site may exhibit higher salinity and turbidity due to the lower volume of flow and dilution capacity. Baseline groundwater data indicates that aquifer discharge is not suitable for human consumption but is considered suitable as stock water.

Further details on surface water are contained in Chapter 7 and Appendix I. Further details on hydrogeology are contained in Chapter 8 and Appendix K.

1.4.5 Sites of cultural and/or social significance

A number of sites in the vicinity of the Nolans site have historical and/ or cultural interest. Sites on the National Reserve System closest to the project site (and the approximate distance at the closest point to the project site) include Annas Reservoir (7.5 km), Ryan Well (18.5 km) and Native Gap (28.5 km).

Annas Reservoir Conservation Reserve (Figure 1-5) played an important part in the overland journeys of nineteenth century explorers and settlers including John McDouall Stuart in 1860 and Alfred Giles in 1879. It was also a strategic water supply to the Overland Telegraph Construction team. In 1884 Annas Reservoir became the station homestead for the Barrow Creek Pastoral Company station (51,800 km^2) which was later abandoned.

Aileron Roadhouse is situated along the Stuart Highway about an hour and a half's drive north of Alice Springs and three and a half hours' drive south of Tennant Creek (Figure 1-5). The roadhouse hotel was established in 1936 to provide a stopover for travellers heading up and down the 'track'. Today the roadhouse continues to be an important stop-over providing various amenities tor travellers along the Stuart Highway.

Ryan Well Historical Reserve is close by (Figure 1-5) and contains a hand dug well from 1889 that was part of a pastoral settlement in the early twentieth century. Later in the 1930's, it became an important supply point for miners heading north-west to the 'Granites' gold rush.

Native Gap Conservation Reserve is a small roadside reserve located alongside the Stuart Highway between Alice Springs and Tennant Creek. The Reserve is of great importance to Arrernte and Anmatjere Aboriginal people (Figure 1-5), is a registered sacred site, is at the intersection of several creation-time stories and its name probably derives from the profile of a 30 m high sandstone ridge which dominates the site. It is also associated with the Overland Telegraph Line which was constructed through the area in the late nineteenth century.

Archaeological surveys carried out in 2006, 2010, 2012 and 2015 are described in detail in Chapter 16. Survey and assessment has identified a number of historic and cultural heritage items within, and in the vicinity of, the project area (within 100 m of proposed infrastructure), including 63 Aboriginal archaeological sites, 76 isolated artefacts and one potential historic site. Aboriginal site features include artefacts, quarries, scarred trees, grinding surfaces, reduction areas, a rockshelter, potential habitation structure, and engraving.

The potential historic site, Old Albs Bore and Yard, is associated with the pastoral history of Aileron Station, and consists of a water tank, stock yards, and a windmill.

1.4.6 Features of ecological significance

The Nolans site and part of the access road are within the Burt Plain bioregion (sub-region BRT1) (refer Chapter 9). The Burt Plain bioregion is a national priority bioregion for conservation planning and covers an area of about 73,800 km^2. The bioregion is very poorly reserved, and most ecosystems are not well represented, particularly mulga woodlands. The region contains five small conservation or historical reserves and one national park (Dulcie Ranges National Park) totalling 0.26% of the area of the bioregion.

The Department of Land Resource Management (DLRM) mapping shows no significant flora but indicates the presence of significant fauna in the immediate vicinity of the Nolans site and its access road including Rainbow Bee-eater (*Merops ornatus*), Glossy Ibis (*Plegadis falcinellus*), Bush Stone-curlew (*Burhinus grallarius*) and Redthroat (*Pyrrholaemus brunneus*).

Further details of the flora and fauna at the Nolans site are in Chapters 9 and 10 and Appendices M and N.

1.4.7 Other proposals or actions associated with this project

Carbonate material is required for acid neutralisation and pH control on the project. Arafura has secured exploration title (EMEL 30510) over a sizeable carbonate deposit located on Pine Hill Station north of the Woodforde River (Figure 1-4).

The deposit comprises fine to medium-grained marble and marly limestone. The carbonate unit dips moderately to the north and northeast and is assumed to continue with depth. Sampling has indicated that this material has suitable acid neutralisation capacity for use at the processing site.

The annual requirement of carbonate material will be nominally 125,000 tpa delivered to the processing plant, some 35 km to the south west.

It is anticipated that the carbonate will be mined by conventional quarrying methods using suitable bench heights to a maximum depth of around 50 m (although this can be extended if necessary). The quarry width at the natural surface will be around 100 m.

Arafura will seek a contractor to undertake the following scope of work:

- Drill and blast 125,000 tonnes of carbonate material at the Woodforde quarry each year.
- Crush and screen the blasted material.
- Load and haul the crushed carbonate product to the processing site, a distance of approximately 35 km.
- Construct a haul road of a standard suitable for the size and type of haulage units proposed by the contractor.
- Maintain two stockpiles of 20,000 tonnes of carbonate at the processing site and a similar stockpile at the Woodforde quarry.
- Provide site power, all water, fuel, lubricants, ground engaging tools and spares for the nominated equipment.
- Provide all necessary personal protection equipment, safety equipment, safe working procedures and licensing for the proposed operation.
- Provide adequate meals and accommodation for the contractor’s nominated workforce.

The proposed Woodforde quarry and haul road from the quarry to the Nolans processing site are not included in the scope of this EIS, but are described with reference to other exploration activities and/or areas that may be mined in the future, or other potential future actions planned. A separate regulatory approval will be sought for the quarrying operation in the future.

1.4.8 Other proposals and actions in the region

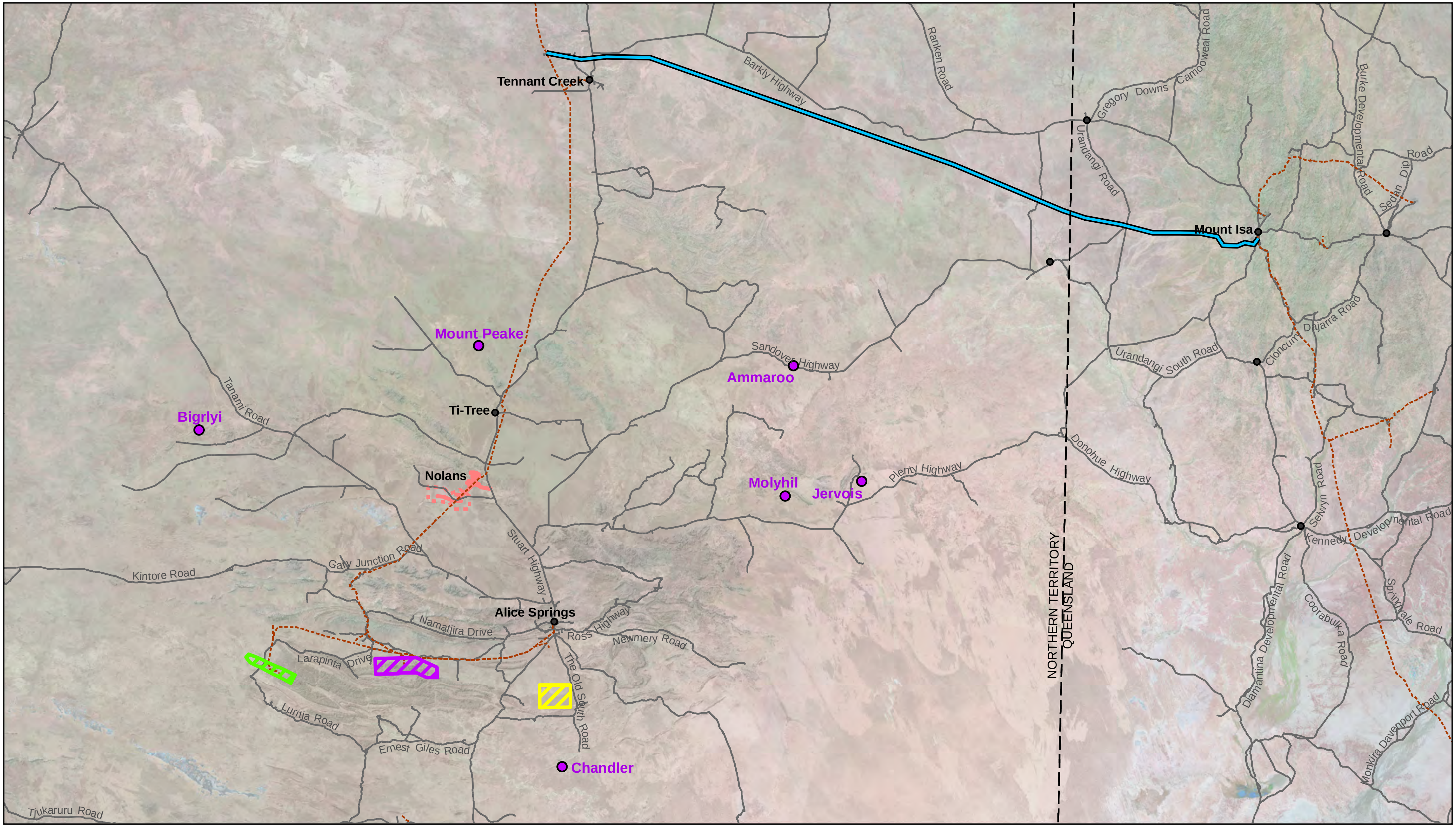
There are a number of potential mining, mineral processing operations, gas fields and gas pipeline opportunities that are proposed for the Central Australian region (Figure 1-6). The proposed operations lie within 400 km of Nolans site. Table 1-2 is reproduced from the Northern Territory Government’s March 2016 publication “Mining Developments in the Northern Territory”.

Some of these projects/ potential projects have a similar development timeline to the Nolans Project and have the potential to compete with Arafura for infrastructure investment and skilled human capital.

In addition to the above listed proposed resource developments, Central Petroleum Limited has in recent years 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 provides established customers with gas via the Amadeus Basin to Darwin natural gas pipeline.

Jemena Northern Gas Pipeline Pty Ltd proposes to construct and operate a high pressure underground gas pipeline between the Amadeus Gas Pipeline commencing at Warrego approximately 45 km north-west of Tennant Creek, and the Carpentaria Gas Pipeline near Mount Isa. The pipeline would be 622 km in length; with approximately 457 km in the NT.

Chapter 4 provides discussion on potential cumulative impacts in the region.



1:4,250,000 @ 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 and communities
- Other Projects within 400 km of Nolans Project
- Northern Pipeline Project
- Gas Pipeline
- Roads
- Project Area
- Palm Valley Gas Field
- Dingo Gas Field
- Mereenie Oil Gas Field

ARAFURA RESOURCES LIMITED

GHD

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	13 Apr 2016

Other Projects within 400 km of Nolans Project

Figure 1-6

G:\43\22301\GIS\Maps\4322301_036_OtherProjects.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, Placenames, Imagery (2015). DME - Other Projects (2016), ESRI - SRTM (2006). GHD - Project Areas (2015). Created by: CM

Table 1-2 Mining and mineral resource actions and proposals in the region (NTG 2016)

Mine	Information
Ammaroo	
Company	Rum Jungle Resources Limited
Location	200 km south east of Tennant Creek
Description	New mine including open cut strip mining operations with crushing and screening to produce Phosphate Rock Concentrate for export or conversion to phosphoric acid for export or further conversion to ammonium phosphate fertilisers.
Product	Rock phosphate, phosphoric acid or ammonium phosphate fertilisers
Resource	Global Resource of 1.145 billion tonnes @ 14% P_2O_5 (10% cut-off) or 338 Mt @ 18% P_2O_5 (15% cut-off) Measured Resource of 138 Mt @ 15.7% P_2O_5 (10% cut-off)
Mine Life	25 years plus (potentially as much as 100 years)
Approvals	Environmental – in progress Mining – pending environmental approvals
Proposed Schedule	Pre-Feasibility completed in September 2014. Securing strategic industry investor. Construction – 2017/18 and Production – 2018/19
Jobs	Construction – TBC Production – 110-300
Capex	A$500M to A$1.8B depending on product and associated deployment
BIGRLY	
Company	Energy Metals Limited
Location	Approximately 340 km NW of Alice Springs
Description	Potential open pit and underground mining with on-site processing through simple acid leach circuit.
Product	Uranium
Resource	7.5 Mt @ 0.13% U_3O_8 for 21.1 M lbs U_3O_8 & 19.7M lbs V_2O_5 3.63 Mt @ 0.14% U_3O_8 for 11.2 Mlbs U_3O_8 & 15.7 Mlbs V_2O_5
Mine Life	Pre-Feasibility Study (PFS) based on 8 years
Approvals	Development proposals yet to be submitted.
Proposed Schedule	Results of Pre-Feasibility Study released in June 2011. Feasibility and environmental studies continue. Construction and Production – TBA

Mine	Information
Jobs	Construction – TBA Production – TBA
Capex	A$181M (from Pre-Feasibility Study).
Chandler	
Location	Approximately 120 km south of Alice Springs
Description	New Underground multi-mineral salt mine utilising standard mining technology, access via decline, room and pillar using a continuous miner. Voids left from mining used for storage. Surface facilities include salt processing plant (wet & dry), offices, camp and airstrip.
Product	Industrial and edible salts, associated minerals (fertilizer) & storage/disposal
Resource	309 Mt Halite (NaCl) JORC Measured Resource = 525 year mine life
Mine Life	25 years extendable
Approvals	Environmental – in progress Mining – Pending environmental
Proposed Schedule	DFS stage 1 (FEL2) completed in June 2014. DFS (FEL3) due in 2016. Construction (Darwin East Arm) – Q2 2016 Storage – Q4 2016 Construction (Chandler siding) – Q4 2016 Storage – Q3 2017 Construction (Mine) – Q2 2017 and Production – Q4 2021
Jobs	Construction – 280-350 Production – 180
Capex	A$648.7M
Jervois	
Company	KGL Resources Limited
Location	Approximately 270 km north-east of Alice Springs
Description	Reopen old mine based on open cut for first 4 years and underground operation from years 4 to 8. Sulphide ore processed via a conventional flotation processing facility to produce a copper concentrate. A second product of lead zinc concentrate will also be produced in certain ore zones.
Product	Copper concentrate with bismuth, silver & gold credits plus a separate lead and zinc concentrate with bismuth, silver & gold credits.

Resource	30.5 Mt @ 1.1% Cu & 23 g/t Ag (includes 113,000 oz gold & 190 kt Pb/Zn)
Mine Life	8 years+
Approvals	Terms of Reference for EIS issued May 2014. EIS being prepared.
Proposed Schedule	Pre-Feasibility Optimisation Study released October 2015. Construction – Q3 2017 and Production – Q4 2018
Jobs	Construction – Peaking at about 360 Production – Peaking at about 300
Capex	Initial CAPEX A$189.5M
Molyhil	
Company	Thor Mining PLC
Location	220 km northeast of Alice Springs
Description	Proposed open pit mining operation with on-site processing by flotation to produce W and Mo concentrate. Definitive Feasibility Study completed in July 2012 with upgrade in January 2015. Letter of Intent signed for tungsten offtake.
Product	Tungsten and Molybdenum concentrates.
Resource Reserve	4.71Mt at 0.4% combined WO_3 and Mo 3.0 Mt at 0.31% WO_3 and 0.12% Mo
Mine Life	Initially 6 year
Approvals	Environmental – November 2011 Mining – pending assessment of MMP
Proposed Schedule	Development subject to obtaining project finance
Jobs	Construction – 60 Production – 70
Capex	A$70M
Mount Peake	
Company	TNG Limited
Location	235 km north of Alice Springs

Description	Open pit mining and onsite processing to produce a magnetite concentrate. Concentrate railed to processing site near Darwin to produce high purity iron, vanadium and titanium products. New processing technology developed.
Product	High purity Vanadium (99% V_2O_5), Titanium Pigment & Pig Iron
Resource	160Mt @ 0.3% V_2O_5, 5% TiO_2, 23% Fe (120Mt Measured JORC)
Mine Life	Approximately 20 years
Approvals	EIS submitted February 2016 and available for public review through March 2016. MMP yet to be submitted. Separate development proposal and approval process for proposed Darwin Refinery.
Proposed Schedule	Definitive Feasibility Study completed July 2015. Construction (Mine) – Q3 2016 Production (Mine) – Q2 2018
Jobs	Construction (Mine) – up to 350 Production (Mine) – 175 to 250
Capex	A$970M for Stage 1 A$792M for Stage 2 (from DFS)

1.5 Structure of the EIS

The structure of the EIS is based on a combination of:

- Addressing and following the order of the NT EPA TOR where relevant
- Addressing potential environmental project risks identified in the NT EPA TOR and the environment project risk assessment (Chapter 5 of this EIS and Appendix F and G) and
- Presenting information in an order that aims to set the context for the reader and provide a logical sequence of information.

A summary overview of the structure of the EIS is below.

Chapter 1 - Introduction
Chapter 1 provides an overview and background to the project, proponent details, and context and setting of the project location.
Chapter 2 – Regulatory context
Chapter 2 summaries legislation and key guidelines that apply to the project and Arafura's approach to environmental management.
Chapter 3 – Project description
Chapter 3 provides a detailed description of the proposed action assessed in the EIS and for which Arafura is seeking environmental approval.
Chapter 4 – Project alternatives and cumulative impacts

Chapter 4 provides a high level summary of alternatives to various aspects of the project considered by Arafura throughout the development of the project. Cumulative impacts that may arise from projects being undertaken by other companies is summarised.
Chapter 5 – Risk assessment
Chapter 5 includes a description of the risk assessment method undertaken for the environmental and human health aspects of Nolans Project. A summary of the risk assessment is included. The content of the EIS is largely based around addressing the identified higher risks.
Chapter 6 – Community consultation
A summary of community and stakeholder consultation is included in this chapter. Key themes and matters raised during consultation are summarised. The content of the EIS is also aimed at addressed key themes raised by the community.
Chapter 7 – Surface water
The surface water chapter provides a description of key surface water features and functions in vicinity of the project and how the project may impact the existing environment. Potential mitigation measures are recommended.
Chapter 8 - Groundwater
The groundwater chapter provides a “water story” to understand the groundwater resources of the area and their users, potential impacts to groundwater from the project and relevant mitigation measures.
Chapter 9 – Biodiversity
The Biodiversity chapter includes a description of existing flora and fauna of the project area, threatened species listed in the NT only, context for threatened species listed under the EPBC Act, discussion about potential impacts in the project life of mine (LOM) envelope and mitigation measures.
Chapter 10 - Protected Matters under the EPBC Act
This chapter focuses on matters protected under the EPBC Act including matters of national environmental significance (MNES), particularly certain threatened species that triggered assessment under the EPBC Act. The intention of this chapter is to assist the Department of the Environment in assessing information relevant to their jurisdiction (combined with Chapter 12 Radiation).
Chapter 11 – Human health and safety
This chapter addresses the potential impacts to human health and safety associated with all stages and components of the Nolans Project. It includes risks to the workforce and the general public for the duration of the project, including post-closure, as required in the TOR for the project.
Chapter 12 – Radiation
Chapter 12 provides an overview of the radiological environment of the Nolans Project including a summary of the natural levels of background radiation in the region and impacts from operating the project on workers, the public and the environment. This chapter also address potential impacts on environmental air quality resulting from radon gas and other radioactive emissions.
Chapter 13 – Air
This chapter addresses potential impacts on air quality resulting from dust and processing plant emissions for all stages of the project.

Chapter 14 – Noise and vibration
A study of key noise and vibration generating activities of the project, and how they may impact nearest human sensitive receptors, is summarised in Chapter 14.
Chapter 15 – Socioeconomic
This chapter provides a summary of the project's social impact assessment and economic assessment describing potential benefits and consequences to the socioeconomic environment.
Chapter 16 – Historic and cultural heritage
Chapter 16 includes a summary of known indigenous and cultural heritage sites and items/objects, their potential significance and potential impacts and mitigation. At the request of the Central Land Council, sacred site mapping is not included in the public record due to cultural sensitivities.
Chapter 17 – Transport
In this chapter, key transport movements to and from Nolans site, and the contribution of the project to the transport network is assessed.
Chapter 18 – Rehabilitation, decommissioning and closure
A conceptual framework, objectives and risks for/of rehabilitation, decommissioning and closure are discussed in Chapter 18.
Appendices
Key supporting documents and/or technical reports that are the foundation of the EIS chapters are included as appendices. They include more detail about methods, guidelines, assumptions, calibration, monitoring considerations and concept management plans. The management plans are live documents and will be updated throughout various phases of the project as required by regulators (and Arafura management), in the event the project is approved and Arafura proceeds.

02

Regulatory context

2. Regulatory context

2.1 Commonwealth legislation

2.1.1 Aboriginal Land Rights (Northern Territory) Act 1976 (Cth)

The *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) (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.

Subject to Commonwealth powers, an estate or interest in Aboriginal land, or an exploration licence / permit affecting Aboriginal land, may only be granted with the consent of the relevant traditional Aboriginal owners of that Aboriginal land (Sections 19 and 40). The Land Rights Act also mandates the protection of sacred sites.

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 in land

– ascertaining and expressing the wishes and the opinion of Aboriginals living in the area of the Land Council with respect to land (Section 23).

The subject area is within the administrative boundary of the Central Land Council (CLC). The CLC has recorded sacred sites in the subject area.

The subject area is not located on Aboriginal land.

2.1.2 Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)

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

ATSIHP empowers the Federal Minister administering the Act 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 subject area are currently subject to a declaration under ATSIHP.

2.1.3 Atomic Energy Act 1953 (Cth)

The *Atomic Energy Act 1953* (Cth) (AE Act) vests ownership in the Commonwealth of prescribed substances located in the Northern Territory (Section 35). Prescribed substances are uranium, thorium, *and* similar radioactive substances including associated derivatives or compounds, *or* otherwise as prescribed by regulation *(Section* 5).

The AE Act also regulates the discovery of prescribed substances in the Northern Territory including making it an offence not to provide notification of such discoveries to the relevant Federal Minister (Section 36).

The Federal Minister has powers under the AE Act to require a person to report on prescribed substances within a person's control, on a person's land or in relation to work carried out in connection with the production or use of prescribed substances (Section 37).

2.1.4 Australian Jobs Act 2013 (Cth)

The *Australian Jobs Act 2013* (Cth) requires major projects, both private and public, with a capital expenditure of $500 million or more to develop an Australian Industry Participation (AIP) plan and provide it to the Australian Industry Participation Authority (AIPA). There are also requirements to notify the AIPA about the project, project proponents and certain events. The definition of eligible facility (section 6) may apply to the project.

An AIP is required to be lodged at least 90 days before the trigger date, defined to mean the earliest trigger event (Section 13). Trigger events include developing diagrams, developing flow diagrams, contracting/procurement, preparing an equipment list, sourcing or scoping goods and services, or making an environmental submission in relation to a project (Section 13(4)).

2.1.5 Australian Radiation Protection and Nuclear Safety Act 1998 (Cth)

The *Australian Radiation Protection and Nuclear Safety Act 1998* (Cth) establishes the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to regulate Commonwealth activities that raise radiation protection or nuclear safety concerns. ARPANSA develops standards, codes or practice and guidelines for radiation protection and management. These issues are addressed in Chapter 12 and Appendix P.

2.1.6 Environment Protection and Biodiversity Conservation Act 1999 (Cth)

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).

This project will not affect any of the following MNES (Chapter 2, Part 3):

- 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
- a water resource in relation to coal seam gas development.

The project (proposed action) was referred to the Commonwealth Department of the Environment (DotE) on 18 February 2015. On 16 March 2015 the Commonwealth Minister for the Environment determined that the action was a "controlled action" and required formal assessment and approval under the EPBC Act. Reasons included:

- the proposed action may affect listed threatened species and communities (sections 18 and 18A) including the listed vulnerable Black-Footed Rock-Wallaby (*Petrogale lateralis*) – MacDonnell Ranges Population, Greater Bilby (*Macrotis lagotis*) and Great Desert Skink (*Liopholis kintorei*)
- the proposed action is a nuclear action (sections 22 (1) (a) and (e)) due to the presence of certain minerals.

The bilateral agreement between the Commonwealth and the Northern Territory allows a single environmental impact statement process to be undertaken under the *Environmental Assessment Act* (NT) and the *Environmental Assessment Administrative Procedures* (NT) and for each jurisdiction (the Territory and the Commonwealth) to consider the results from such assessment and suggest conditions (in the case of the Territory) or impose conditions (in the case of the Commonwealth).

This EIS is submitted to the NT EPA and DoE for assessment in accordance with relevant legislation.

Listed threatened species and communities (sections 18 & 18A)

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 impact and proposed mitigation measures proposed for the listed threatened species and communities are separately addressed in Chapter 9 of this EIS.

Nuclear Actions (sections 21 & 22A)

The impact of the project as a nuclear action is considered to impact the environment in a more holistic manner, and as such, has been addressed throughout the EIS. Refer to Chapters 9 and 12 for more information.

2.1.7 National Greenhouse and Energy Reporting Act 2007 (Cth)

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* (Cth) (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).

2.1.8 Native Title Act 1993 (Cth)

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

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). In some circumstances, there may be more than one native title party.

If agreement is reached, the negotiation parties are 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).

If more than 6 months have passed since notice of the future act was made under the NTA (Section 29), and no agreement has been reached following good faith negotiations, any party may apply to the NNTT for a determination that the future act may be done, done with conditions, or may not be done (Section 38). In the event that the NNTT is required to make such a determination, the NNTT is obliged to consider the criteria listed in Section 39 of the NTA, which include:

- The effect of the act on the native title party, their rights, their sites, land and waters, access to their lands and waters, way of life, culture, traditions and the development of the native title party
- The interests, opinions, and wishes of the native title party in relation to the management, use or control of land and waters affected by the future act
- The economic or other significance of the future act to the State / Territory or Australia
- The public interest in the doing of the act and
- Any other matter the NNTT considers relevant.

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).NT 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 and access authorities.

A search of the National Native Title Tribunal Registers was undertaken on 12 May 2015. There is one native title determination covering part of the subject area, and two registered claimant applications.

2.2 Northern Territory legislation

2.2.1 Bushfires Act

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

2.2.2 Control of Roads Act

The *Control of Roads Act* provides for the processes of opening and closing roads in the Northern Territory. Any public or gazetted 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.

2.2.3 Dangerous Goods Act

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

This legislation applies to the project as dangerous goods will be handled during construction and operation of the project. Arafura will obtain licences for storage or transportation of any dangerous goods, and project blasting permits if required.

2.2.4 Environmental Assessment Act and Environmental Assessment Administrative Procedures

In March 2008, the Proponent submitted a Notice of Intent to the former NT Department of Natural Resources, Environment and the Arts for consideration under the *Environmental Assessment Act* (EA Act). The then Minister 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 EIS were issued by Northern Territory Environment Protection Authority (NT EPA) in May 2015. In summary, these detailed the scope and limitations of the proposed project in specific relation to regulatory context, existing environment, risk assessment and environmental management. This EIS addresses the TOR. This EIS is submitted to the NT EPA and DoE for assessment in accordance with relevant legislation and the requirements of the EA Act and the associated EA *Administrative Procedures*.

2.2.5 Heritage Act

The *Heritage Act* provides a system for the identification, assessment, protection and conservation of the Northern Territory's natural and cultural heritage. Under the *Heritage 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.

GHD contracted Archaeological & Heritage Management Solutions to undertake an impact assessment of any historic and cultural heritage items within the vicinity of the project (see Appendix U). Four archaeological surveys were conducted between 2006 and 2015 and have been referred to in preparation of the heritage section of the EIS. A Cultural Heritage Management Plan (CHMP) has been prepared and included in Appendix U.

A search of the NT Heritage Register was undertaken on 21 May 2015. Three places in the vicinity of the subject area are declared heritage places. Of these, Aileron Homestead and Ryan Well Historical Reserve are the closest, being located within 10 kilometres of the subject area.

Arafura intends to where necessary:

- Establish exclusion zones prior to commencement of the construction phase of the project
- Ensure any necessary archival recording and artefact collection takes place in accordance with legislation
- Consult with traditional owners (see Appendix U).

2.2.6 Liquor Act

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

2.2.7 Mineral Royalty Act

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

2.2.8 Mineral Titles Act and Mineral Titles Regulations

The *Mineral Titles Act* (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.

Arafura requires a mineral lease for the proposed project under the MT Act. In February 2008, Arafura applied for a mineral lease under sections 41 and 66 of the MT Act, covering the Nolans Bore area and immediate surrounds (ML 26659; 1,404 hectares). Title will not be granted to ML 26659 until compliance with the aforementioned NTA processes have been completed.

Since 2008, the Nolans Bore mineral resource has approximately doubled and project requirements have altered, resulting in an expanded footprint to include a borefield, a downstream chemical processing operation and an accommodation village. As a result, additional mineral lease applications have been lodged with the NT Department of Mines and Energy (DME) to accommodate the expanded footprint. Land tenure details are described and illustrated in Chapter 1 of this EIS.

Arafura 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.

2.2.9 Mining Management Act and Mining Management Regulations

The *Mining Management Act* (MM Act) and the Mining Management Regulations regulate mining activities and the management of mining sites. The legislation is administered by the DME.

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) has been submitted as part of this EIS in Appendix X. An approved MMP will be required prior to commencement of proposed works if the project is approved.

A draft Rehabilitation, Decommissioning and 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 Mine Rehabilitation Closure Plan and are set out in Chapter 18. A Certificate of Closure would be required based on achievement of closure criteria.

2.2.10 Northern Territory Aboriginal Sacred Sites Act

The *Northern Territory Aboriginal Sacred Sites Act* (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 Sacred Sites 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 conditions imposed are followed. AAPA administers authority certificates in consultation with the relevant custodians under the Sacred Sites Act.

Arafura has undertaken sacred site clearances with AAPA, and authority certificates were issued in 2008 (C2008/205) and 2013 (C2013/205). Copies of the authority certificates are attached to the historic and cultural heritage report in Appendix U of the confidential report issued to the NT EPA.

2.2.11 Northern Territory Environment Protection Authority Act

The *Northern Territory Environment Protection Authority Act* establishes the Northern Territory Environment Protection Authority (NT EPA) as an independent regulatory authority with duties and functions under the *Waste Management* and *Pollution Control Act* and the EA Act.

2.2.12 Planning Act

The *Planning Act* (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* and the related Planning Scheme 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 logistical support infrastructure in Darwin and/or Alice Springs may fall under the *Planning Act* and will be subject to a separate approvals process.

2.2.13 Public and Environmental Health Act and Public and Environmental Health Regulations

The *Public and Environmental Health* Act (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 of this EIS.

2.2.14 Radiation Protection Act

Under the *Radiation Protection Act* (RPA), a person must not manufacture, sell, acquire, possess, use, store, transport, dispose of or otherwise deal with a radiation source other than in accordance with a licence authorising the person to do so.

Part 3 of the RPA stipulates that the operator of the mine site must monitor exposure to radiation and report to the CEO of ARPANSA and the Chief Health Officer.

Arafura will submit an application for a licence and will monitor the radiation, details of which are described in Chapter 12 of this EIS. The operation of the project will be regulated as a radiation practices under the RPA and under the requirements of the MM Act and *Work Health and Safety Act 2011* (refer Chapter 12).

2.2.15 Soil Conservation and Land Utilisation Act

The main purpose of this Act is to prevent soil erosion and conserve and reclaim the soil. To minimise impacts on soil erosion, an erosion and sediment control plan and mine closure plan have been prepared (see Appendix W) to meet the objectives of this Act.

2.2.16 Territory Parks and Wildlife Conservation Act

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

The TPWC Act defines wildlife as that being in a park, reserve, sanctuary, wilderness zone or area of essential habitat, or is a vertebrate that is indigenous to Australia (other than fish), or is specifically prescribed as being protected by the TPWC Regulations. The TPWC 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”.

The TPWC Act lists those species of plants and animals that are protected within the Northern Territory. 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 chapters 9 and 10 of this EIS and Appendix M and N.

2.2.17 Traffic Act

The *Traffic Act* 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.

2.2.18 Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act & Regulation

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.

2.2.19 Waste Management and Pollution Control Act & Waste Management and Pollution Control (Administration) Regulations

The *Waste Management and Pollution Control Act* (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 EIS addresses waste in Appendix X.

2.2.20 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.

2.2.21 Weeds Management Act

The *Weeds Management Act* (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.

Noxious Weeds

Declared noxious weeds in the NT are plants proclaimed under the WM Act. The legislation requires that reasonable attempts be made to control or eradicate these species. Categories of noxious weeds include the following:

- Schedule Class A/C Weeds: These plants do not occur in the NT but pose a significant threat if they invade or if present, pose a serious threat. Reasonable effort must be made to eradicate these weeds
- Schedule Class B/C Weeds: These weeds often occur widely in the NT. They are capable of spreading further and should be prevented from doing so. Continuing control measures are required to prevent their spread. Reasonable attempts must be made to contain the growth and prevent the movement of these plants
- Schedule Class C Weeds: This category includes plants that pose an unacceptable risk of spreading in the Territory or to other parts of Australia if they were to be sold or traded in the NT and are a serious threat to another State or Territory of Australia. All schedule Class A and B weeds are considered to be Class C weeds.

The manager of the project site will be responsible for the management of weeds in accordance with the WM Act.

One noxious weed (*Tribulus terrestris*) was recorded within the study area. This plant will be controlled in accordance with the WM Act, as detailed in Chapter 9 and the Weed Management Plan contained in Appendix X of this EIS.

2.2.22 Work Health and Safety (National Uniform Legislation) Act 2011 & Work Health and Safety (National Uniform Legislation) Regulation 2011

The Work Health and Safety (National Uniform Legislation) Act 2011 (WHS Act) and Work Health and Safety (National Uniform Legislation) Regulations (WHS Regulations) regulates 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, Arafura will when necessary maintain a Hazardous Materials chemical register and use material safety data sheets.

2.3 Local government requirements

The project area is within the jurisdiction of the Central Desert 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). Arafura will adhere to relevant Regional Council bylaws or requirements.

2.4 Policies and guidelines and standards

2.4.1 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.

An Economic Impact Assessment (Appendix T), Social Impact Assessment (SIA) (Appendix S) and EMP (Appendix X) have all been prepared in accordance with the above guidelines and are included as part of this EIS.

2.4.2 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.
- **Code of Practice and Safety Guide -Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA 2005)** - Provides guidance on the safe management of radioactive materials during the operation and closure of mining and mineral processing activities.
- **Strategic Framework for Mine Closure (ANZMEC 2000)** - Presents a high level framework for the development of mine closure planning. The Nolans 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 Appendix W). This is informed by the requirements and advice in this guidance note.
- **TEAM NT: Technologies for the Environmental Advancement of Mining in the Northern Territory Toolkit (NTMC and DMPM, 2004)** - Guidance and discussion of challenges specific to mining and mine closure in the Northern Territory.
- **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. (refer Appendix W and X)

2.4.3 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)
- International Atomic Energy Agency (IAEA) *Management of Radioactive Waste from the Mining and Milling of Ores Safety Guide WS-G-1.2*
- Mineral Council of Australia 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*
- Threat Abatement Plans, Recovery Plans and Survey Guidelines
- Department of Health *Guidelines for Preventing Mosquito Breeding Sites Associated with Mining Sites*
- Managing Acid and Metalliferous Drainage (DITR, 2007) and
- The Global Acid Rock Drainage Guide (INAP, 2011).

2.4.4 Australian Standards

The Australian Standards which 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 4360:2004 Risk Management
- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines;
- AS2885 design, construction, testing, operations and maintenance of gas and petroleum pipelines that operate at pressures in excess of 1050kpa
- HB 436:2004 Risk Management Guidelines.

2.5 Environmental history

2.5.1 Proceedings

Arafura 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. Similarly, there are no proceedings relating to the exploration activities to date (February 2016).

2.5.2 Association with the Mining Management Act

Arafura has MLs and ELs (as described in Chapter 1 of this EIS) under the MT Act which are associated with the MM Act.

2.5.3 Accreditations

Arafura has been operating in the Northern Territory since the late 1990s and has established and maintained good professional working relationships with NT regulators. Arafura 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 Arafura transitions to the construction and operational phase of the project, it intends to design and roll out its final operating management system.

Arafura's activities and systems are based on the management of risk. Arafura has developed risk management, safety and environmental management plans, and all safety, environmental and community related incidents are routinely recorded. Meetings are convened on a regular basis with all key stakeholder groups to report on current and planned activities. Audits are also completed when operational activities occur at the Nolans site.

2.6 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 Ecologically Sustainable Development (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 ecologically sustainable 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.

The main challenge to ESD in relation to the proposal is the management of the renewable and non-renewable resources on which the mining industry depends. The main objectives listed in the strategy include:

- to ensure mine sites are rehabilitated to sound environmental and safety standards, and to a level at least consistent with the condition of surrounding land
- to provide appropriate community returns for using mineral resources and achieve better environmental protection and management in the mining sector
- to improve community consultation and information, improve performance in occupational health and safety and achieve social equity objectives.

As per the Arafura's 2014-2015 Sustainability Report (Arafura 2015):

- Arafura endeavours to minimise the production of waste products during its exploration activities. Contractors are required to recycle or dispose of waste products through licenced waste recyclers wherever possible.
- Water will be an integral requirement for the Nolans Project and Arafura has demonstrated a commitment to minimising impacts on groundwater resources in Central Australia. Extensive exploration has been undertaken aimed at locating a sustainable groundwater supply for the LOM.
- The project will leverage off Amadeus Natural Gas Pipeline lower cost and emissions-producing natural gas for power generation using high efficiency gas turbine generation. The Nolans processing circuit will provide 25-30% of the project's energy needs by recycling waste heat.
- Social sustainability is implemented in Arafura through Workplace Health and Safety (WHS), Human Capital Management, Stakeholder Engagement and an established Corporate Conduct. Arafura has adopted Corporate Governance charters, codes, policies and procedures including Continuous Disclosure, Code of Conduct, Trading in Company Securities, Whistleblower and Shareholder Communication. These are live documents available on the Arafura website www.arultd.com.
- Conservation of biological diversity and ecological integrity will be implemented throughout the project LOM through implementation of a biodiversity management plan and other operational controls (e.g. clearing permits etc.).

Implementation of ongoing sustainability practices assist in application and achievement of ESD guiding principles.

Rehabilitation, decommissioning and closure during and after mining operations have ceased are detailed in Chapter 18 of this EIS. The overriding intent of mine closure and rehabilitation is to return the land to, as close as is reasonably practical, its pre-disturbance condition.

The proposed closure and rehabilitation objectives for the Nolans Project will reflect the post-closure land uses and landforms agreed with stakeholders. As with the final land-uses, the closure objectives may be amended in later versions of the MRCP. Each objective will be applied, as relevant, to each domain of the project as detailed plans and protocols are devised. Where practicable and feasible, ESD will be considered during development and implementation of the MRCP.

03

Project description

3. Project description

3.1 Introduction

A detailed description of the proposed project / proposed action is provided in this chapter. The project detail is preliminary/concept design only at this stage, for the purposes of assessment in the EIS. Detailed design of project components and site surveys will be undertaken where relevant at a later stage, post environmental approval and Arafura's decision to proceed with the project.

Information in this chapter has been provided by Arafura. Other key sources of information include studies undertaken by specialist companies engaged by Arafura.

The chapter addresses a majority of Section 3 of the TOR.

3.2 Key project components

Arafura plans to mine, concentrate and chemically process REs at the Nolans site (Figure 3-1) then transport a RE intermediate product to an offshore refinery (separation plant) for final processing into high-value RE products.

Life of mine (LOM) production scheduling has been developed for a period of 43 years (Table 3-1). The project is being designed to produce 20,000 tonnes per annum of RE products.

Table 3-1 Nolans Project

Description	Unit	M&I Case[1]	LOM Case[2]
Pit Stages	Number	6	7
Total Mine Life	Years	25	43
Pre-production Period	Years	2	2
Effective Mine Production Period	Years	23	41

Note 1: M&I refers to the higher-confidence Measured and Indicated classifications of the project's total inventory of Mineral Resources that, under certain assumptions, could be converted to economic Ore Reserves in accordance with the 2012 JORC Code.

Note 2: LOM refers to the project's total inventory of Mineral Resources, represented by Measured, Indicated and Inferred classifications in accordance with the 2012 JORC Code.

The general arrangement of the proposed operation includes the three key sites, the mine site, the processing site and the borefield. In addition, the workers' accommodation village, utilities corridors and access roads comprise Nolans site. A more detailed inventory of key project infrastructure is provided below.

3.2.1 Mine site

An open pit will be excavated to a depth of 225 m with a surface area of up to 135 ha. Associated infrastructure includes the following:

- Six waste rock dumps will receive a LOM waste quantity of 158 million loose cubic metres (mlcm) constructed to a height of about 50 m in 10 m lifts interspersed with 5 m wide berms
- Topsoil storage with a footprint of 95 ha and height of about three metres
- Stockpile areas
- Run-of-mine (ROM) pad to provide a facility for selective mining and ore blending (up to three months' ore supply)

- Concentrator comprising a comminution circuit to crush and grind the ore, and beneficiation circuits to reject gangue (valueless rock or mineral aggregates in an ore) and produce a mineral concentrate
- Flotation tailings storage facility (TSF) comprising LOM envelope of 245 ha and an embankment height of around 25 m
- Heavy and light vehicle workshop and administration offices and facilities comprising wash down area, tyre change facility, lube storage facility, etc.
- Haul roads
- Kerosene Camp Creek diversion and
- A single pumping stage slurry pipeline between the concentrator and processing plant.

The open pit is designed to a depth of 225 m below ground level and is expected to require dewatering to on-site turkey's nest dam. Overburden and waste material will be deposited in purpose constructed waste rock dumps (WRDs) with a stand-off distance from the pit of 50 m. Ore will be processed through the concentrator to produce a mineral concentrate and tailings.

Mining operations will deliver broken ore to various stockpiles on the ROM pad from which a front end loader will feed the crushing circuit. A single stage jaw crusher, with dust suppression, will crush the rock to around 50 mm. This crushed material will then be fed to a ball mill for grinding before it is pumped to a beneficiation circuit comprising high intensity magnetic separation and flotation cells to produce a mineral concentrate.

The concentrate is then pumped via a bunded HDPE slurry pipeline to the processing site located eight kilometres south of the mine site.

Figure 3-1 illustrates the general arrangement of the central mining and haul road network.

3.2.2 Processing site

The processing plant will require construction of the following infrastructure to produce RE intermediate products:

- Extraction processing units
- Sulfuric acid plant
- Process residue storage facilities (RSFs) to store phosphate, impurity and water leach residues in cells, with a combined potential footprint area of 160 ha and embankment heights of up to 24 m
- Evaporation ponds consisting of six cells x 10 ha each and an embankment height of 2.5 m
- 18.5 MW gas fired power station.

The processing plant will produce a number of waste streams and two RE intermediate products. Waste streams will be confined to onsite engineered storage facilities.

Figure 3-2 depicts the processing site general arrangement.

3.2.3 Borefield

Groundwater will be supplied from multiple bores located northeast of Reaphook Hills and pumped to a centrally located transfer water pond for onward pumping to a reverse osmosis (RO) plant for use in the processing plant.

Infrastructure in support of the borefields will comprise:

- Well heads, pumping stations and above ground water transfer pipelines
- Minor service roads and power supply.

Figure 3-3 depicts the borefield general arrangement.

3.2.4 Access and haul roads

Access roads/tracks and service corridors will be established for the following:

- From the Stuart Highway (intersection with Stuart Highway approximately five kilometres south of the Aileron Roadhouse access road) to the processing site
- Between the processing site and the mine site
- From the processing site to the accommodation village
- From the processing site to the borefield area via an access track and services corridor.

The main access road from the Stuart Highway to the processing site will be built to a public road standard with a pavement width suitable for the safe passing and overtaking of heavy vehicles (i.e. road trains). This will be a sealed road with signage, road markings, etc. also suitable for anticipated occasional public use.

The internal road between the processing site and the mine site will be gravel because traffic volumes will be relatively low. The road will be engineered and maintained by internal road maintenance crews.

Other project roads, including those to the borefield, will likely be of a lesser quality but all will be constructed to ensure user safety as a guiding principle.

Road construction will adopt methods aimed at avoiding changes to surface water flow, through construction of floodways and/or culverts and/or installation of side drains where necessary. Baseline biodiversity data will be used during the road design to avoid impact to sensitive areas (e.g. creek crossings) where possible.

Wherever practicable, services including power, water, sewerage and communication will run within the access road corridors. This will enable regular inspection of infrastructure by site personnel. It is intended that wherever practical, natural drainage will be allowed to flow under or across roads with minimal impediment to ensure the natural flow of surface water.

Flora, fauna and heritage surveys of the proposed corridors for all internal roads (and utility corridors) have been undertaken. An allowance of a 100 m wide corridor for the sealed access road between the Stuart Highway and the processing site, and 30 m wide for all other access roads, was made. The wide corridor assessment allows flexibility in alignment of the road and temporary construction laydown areas. The final road alignment will be significantly less than the surveyed corridor.

The road corridors have been selected to avoid heritage sites and sensitive vegetation.

3.2.5 Other infrastructure

Other infrastructure proposed to be constructed for the project includes:

- Accommodation village (Figure 3-4)
- Water treatment plant - a small packaged unit located within the processing site
- Sewerage treatment plants – small package treatment units at each of the processing site, mine site and accommodation village
- Site wide drainage and sediment basins
- Gas supply offtake pipeline (to connect to the existing Amadeus Basin to Darwin, high pressure gas pipeline)
  - Above ground pipelines that will be generally aligned with road access corridors, to enable regular inspection and access when required. Pipelines include:Potable water supply pipeline (from the borefield area to the mine site, processing site and accommodation village)
  - Process water supply pipeline (from the borefield area to the processing site and mine site)
  - Slurry transfer pipeline (HDPE pipeline earth bunded along the pipeline corridor with deflection shield on welded joints to minimise impact of welding failures) from the concentrator at the mine site to the processing site as mentioned above in Section 3.2.1).
- Overhead power lines (from the power station at the processing site to the mine site and accommodation village)
- Fuel and materials storage facilities at the mine site, processing site and accommodation village. It is likely there will be three fuel storages, the largest of which will be at the mine to provide fuel for the mining fleet. Smaller storages will be built at the processing site and at the accommodation village for backup power.

Additionally, the project will include offsite components as detailed below.

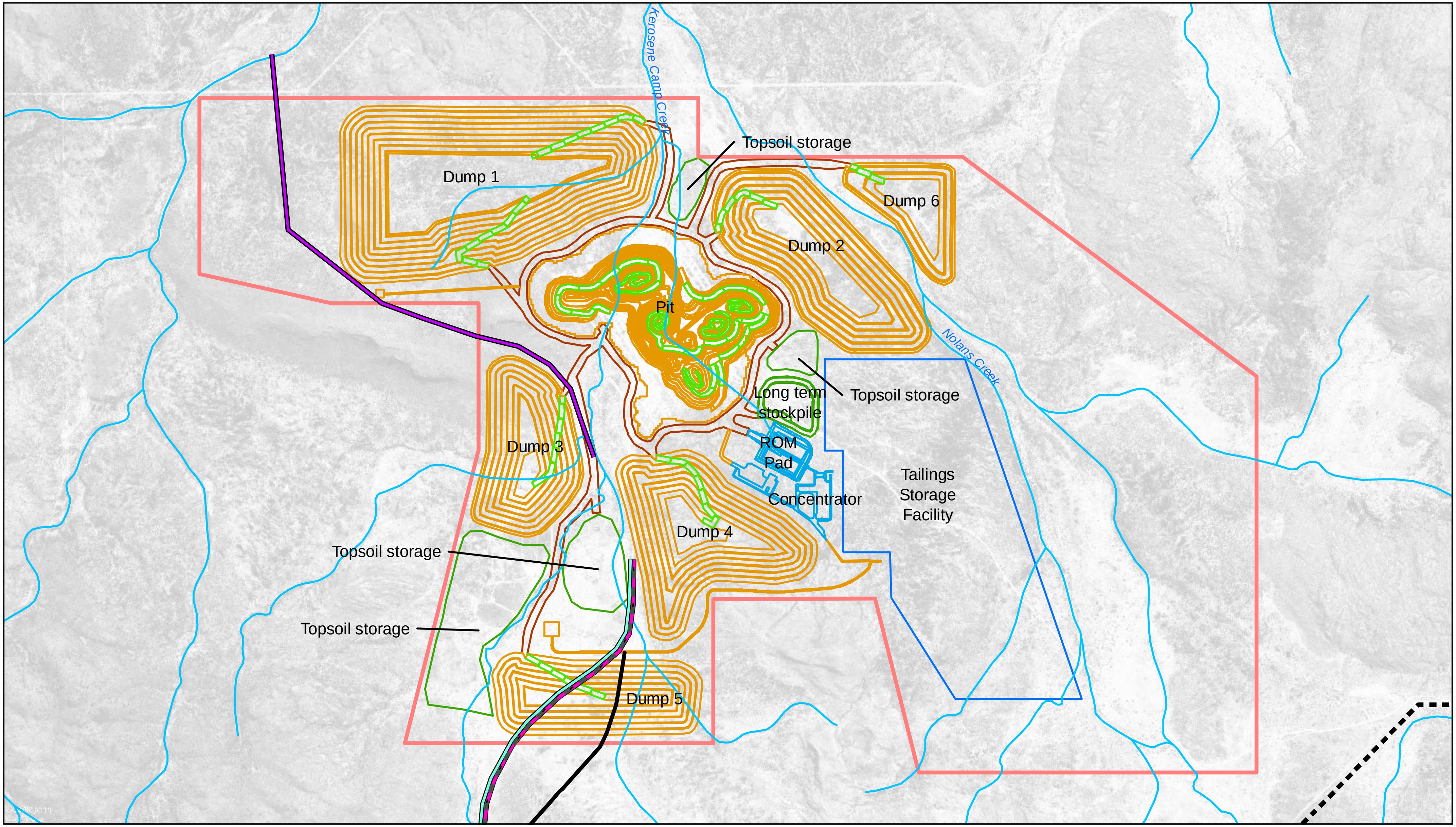
3.2.6 Logistics

Arafura is intending to work with the owners and operators of existing freight facilities in Alice Springs and Darwin to ensure those facilities meet the logistics requirements of in and outbound reagents, materials and product volumes. The main material storage facility at the processing site will be sized to store and manage in and outbound shipping and tank containers that meet the International Organisation for Standardisation (ISO) requirements.

3.2.7 Separation plant

A separation plant will be constructed within an established chemical precinct at an offshore location (at this stage assumed to be the USA Gulf Coast although other locations with similar logistical advantages, such as South Korea, are under consideration). The RE intermediate feed to the separation plant will be separated into three final RE products using solvent extraction followed by precipitation and calcination.

The separation plant will be subject to a separate approvals process and is excluded from the scope of this EIS.



1:35,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

Powerline	Waterways
Potable Water Pipeline	Access Road
Diversion Channel	Existing Gas Pipeline
Water Supply Pipeline	Mine Site Boundary

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	18 May 2016

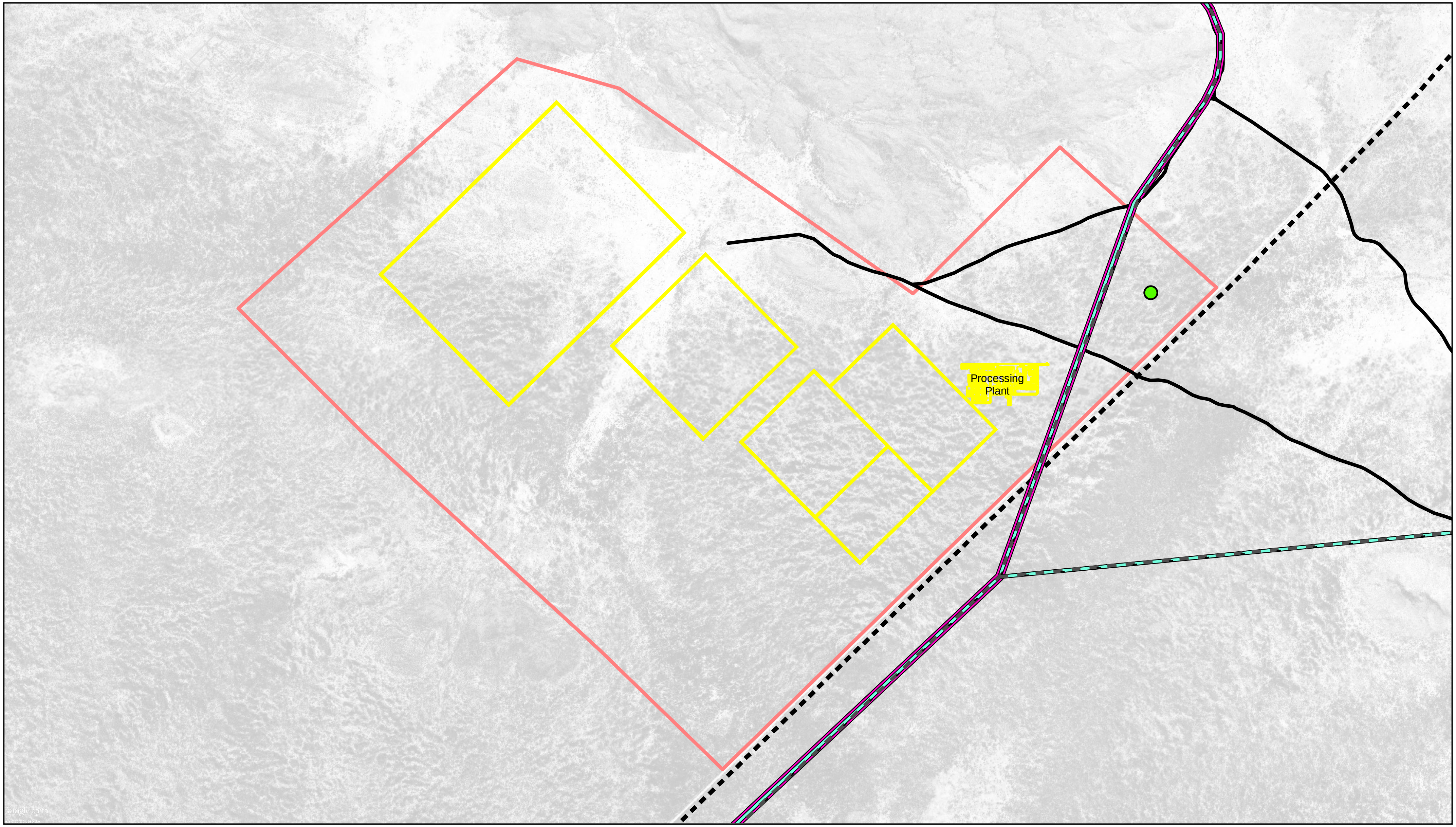
Mine site general arrangement

Figure 3-1

G:\43\22301\GIS\Maps\4322301_011_ProjectInfrastructureMineSite.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM



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0 250 500 750 1,000

Metres

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

N

LEGEND

- Power Station
- Residue storage facilities (RSFs) and evaporation ponds
- Powerline
- Potable Water Pipeline
- Water Supply Pipeline
- Existing Gas Pipeline
- Access Road
- Processing Site Boundary

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	13 Apr 2016

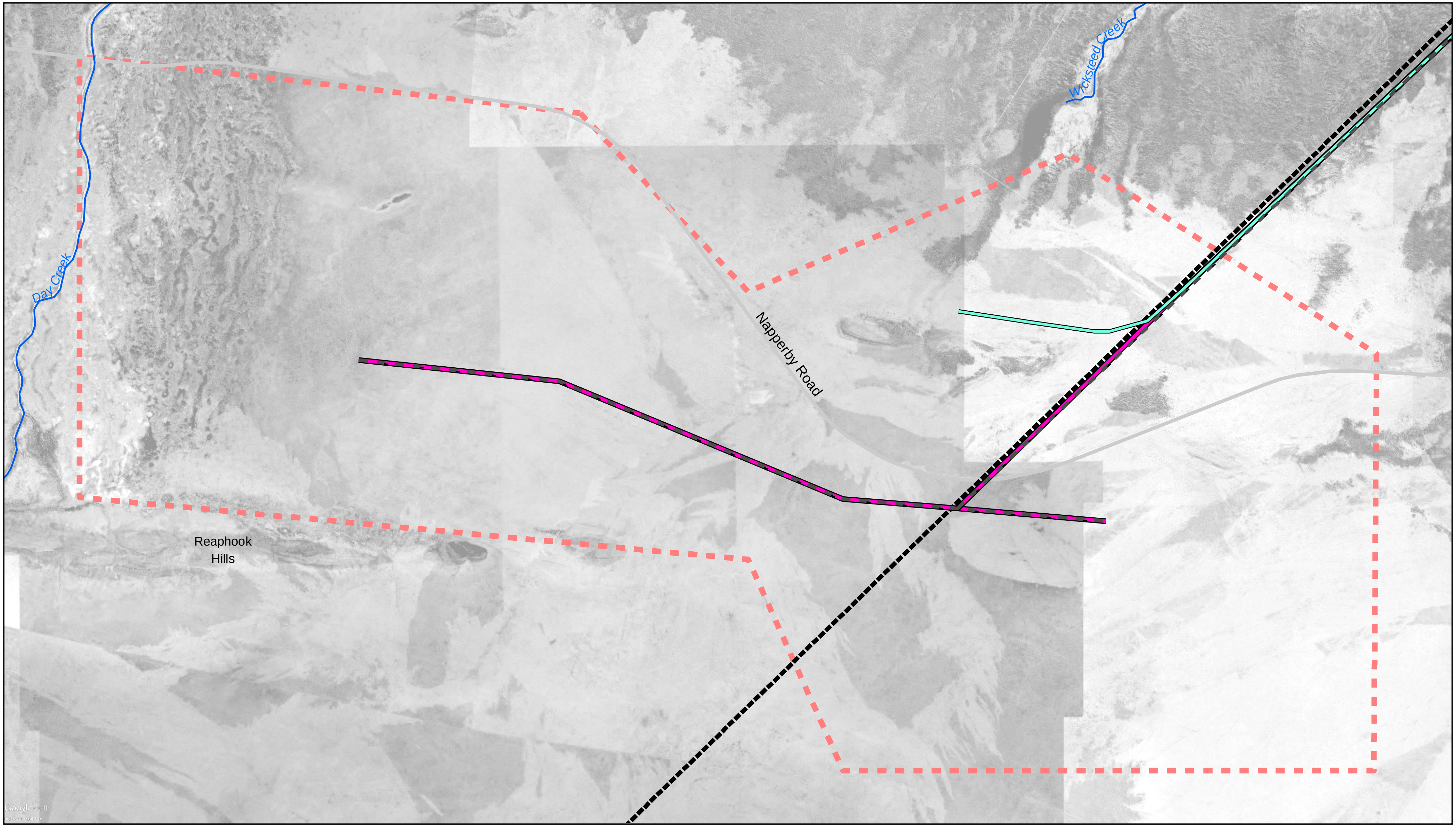
Processing site general arrangement

Figure 3-2

G:\43\22301\GIS\Maps\4322301_012_ProjectInfrastructureProcessingSite.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). 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

- Powerline
- Potable Water Pipeline
- Water Supply Pipeline
- Existing Gas Pipeline
- Waterways
- Roads
- Borefield Area Boundary

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Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	13 Apr 2016

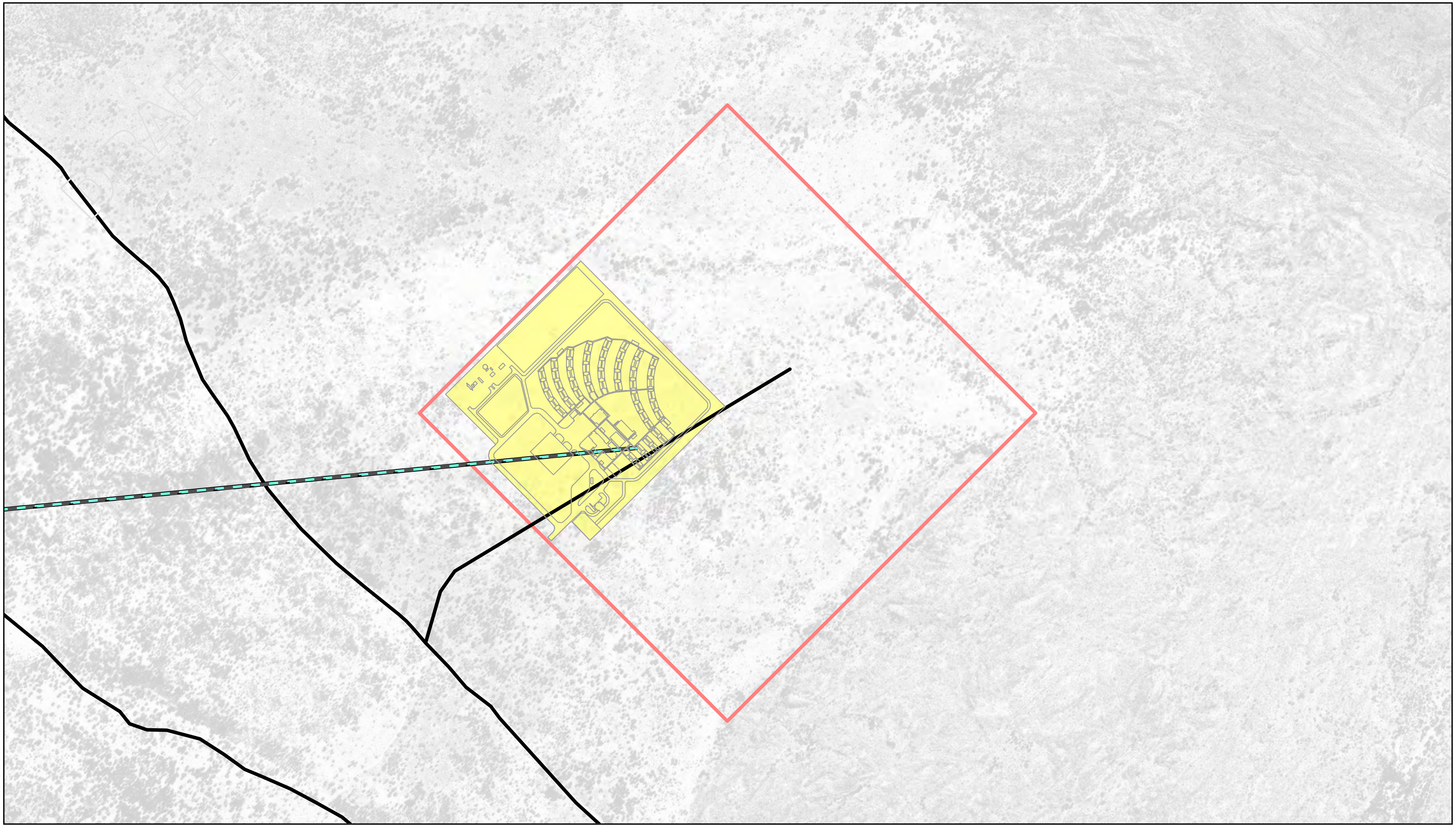
Borefield general arrangement

Figure 3-3

G:\43\22301\GIS\Maps\4322301_014_ProjectInfrastructureBorefield.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Powerlines, Borefield Area (2015). Created by: CM



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0 100 200 300 400

Metres

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

N

LEGEND

- Powerline
- Potable Water Pipeline
- Access Road
- Accommodation Village Boundary
- Accommodation Village

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	18 Mar 2016

Accommodation village general arrangement

Figure 3-4

G:\43\22301\GIS\Maps\4322301_013_ProjectInfrastructureAccommodationVillage.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM

3.3 Buildings and facilities

All site buildings and facilities will be constructed in accordance with the relevant NT building regulations and codes applicable to the Nolans site.

The concentrator and processing plant areas will comprise a mix of site erected steel framed and clad buildings and transportable modular buildings. Where practicable, the buildings will be of a modular type construction that can be manufactured off site and transported to the site. Some of the larger buildings may be formed by multiples of these transportable modules or constructed on site as required.

3.3.1 Concentrator

The concentrator is a mid-sized facility (relative to other site infrastructure) located within the mine site (Figure 3-1) featuring conventional comminution and processing technology buildings which include:

- Plant control room - including an operations area, control stations and space for computer servers a small staff amenities area.
- Crusher control room - a small prefabricated transportable building located adjacent to the crusher with working space for crusher operator.
- Plant workshop - bays open at the front with wide aprons. An overhead crane will service the bays. There will be an air conditioned room for electrical and instrument maintenance and services.
- A warehouse – to house small to medium components and provide secure storage for spare parts and consumables in high racking designed to be accessed from a personnel access platform.
- Plant crib room, change room and first aid facility - including a serving bench and wash up facilities. The clinic and first aid facility will be a single transportable building and include treatment room, office, store room and ablution.
- Reagents storage warehouse - a steel framed building with roof cover only. The concrete floor will be bunded and graded towards sumps to prevent contamination of the surrounding environment should reagents spill accidentally.

3.3.2 Processing plant

The processing plant area (Figure 3-2) buildings will include:

- A prefabricated administration building providing individual offices for senior staff and open plan partitioned work stations.
- A prefabricated amenity / crib room attached to the administration building with ablution block.
- A prefabricated emergency services facility comprising a small office and storage area for rescue equipment. There will be an undercover area for an ambulance, fire truck /rescue vehicle and emergency response trailer.
- A prefabricated operations centre complex will be a series of buildings including a control room, training room, crib room, change room, plant ablutions and laundry.
- The shower and change facility will have capacity for the entire plant workforce to change and shower each shift. The change room will contain dirty and clean change areas, showers, toilets and lockers as well as cleaner and plant rooms. Adjacent to the change room facilities will be a small commercial laundry. To control the unintended dispersion of

radioactive material, all operations personnel from the plant and mine will be required to change potentially contaminated work clothing before leaving site. Grey water from the laundry will be pumped to the RSFs.

- A laboratory will be used for sample preparation and storage and will comprise a well-equipped prefabricated laboratory building. The drainage system will include provision for handling contaminated liquids and strong acids and bases.
- A maintenance workshop will have open access and will include service bays for mobile equipment, fixed plant, electrical equipment and welding.
- A warehouse will form an extension of the workshop building. It will provide secure storage for spare parts and consumables in high racking designed to be accessed from a personnel access platform. The warehouse will house small to medium components and larger items susceptible to weather damage and stores. A secure compound will adjoin the warehouse for containerised reagent storage. This area may also contain an undercover area for ultraviolet sensitive product. The concrete floor will be bunded and graded towards sumps to prevent contamination of the surrounding environment should reagents spill accidentally.
- A product warehouse will be sized to store bulk bags of product and will include a concrete loading area external to the building.
- Wash down area and a wheel wash facility for equipment and vehicles that have come into contact with radioactive materials.

3.4 Construction

3.4.1 Project implementation strategy

Arafura will be the operations manager and contract suitably qualified companies to carry out various construction and operational roles during the project. Arafura will obtain all necessary approvals and permits and ensure that any contracting companies are aware of, and comply with, all regulatory requirements and requirements imposed by Arafura to ensure its internal standards are adhered to. Arafura will award two primary contracts:

- An engineering, procurement and construction management (EPCM) contract to carry out all necessary design, engineering, procurement, construction and commissioning works for the processing plant and infrastructure
- A separate contract with a specialist mining consultant to finalise any outstanding details of the mine design and to manage the tendering process for the award of the mining contract.

3.4.2 Construction method

Construction will generally follow four steps, as outlined below:

- **Site preparation** including staged vegetation clearing and topsoil stripping of the project site, initial WRD footprints, haul roads and access roads, TSF/RSFs and other dams, plant site and ancillary buildings and facilities. Topsoil will be stockpiled for later re-use in rehabilitation or landscaping. Graders, front-end loaders and bulldozers will level the ground to the required gradients. Cleared vegetation will be stored for later application as mulch to the rehabilitated landforms. A construction laydown area will be located at or near the processing site, with a smaller laydown area at the mine site.

- **Building platforms and hardstand areas** will be established and site drainage constructed. Foundations of major plant items and buildings will be established using concrete mixed in a temporary on-site batching plant.
- **Services corridors** will be designed and constructed to an appropriate engineered standard.
- **Equipment installation and construction of the plant** will involve assembling and installing equipment items fabricated or manufactured off-site using a range of cranes.
- **Plant commissioning** will involve testing and commissioning equipment in preparation for operations. Pre-commissioning is generally carried out using air or water. Once pre-commissioning is complete, commissioning takes place with ore, reagents and other process materials. When the pre-determined levels of output and quality are achieved, the plant will be handed over to operations personnel for optimisation and routine operation.

3.4.3 Sources of construction materials

A preliminary geotechnical site investigation was carried out by Knight Piésold Pty Ltd (2014) to evaluate foundation conditions and identify potential material borrow sources for the Nolans site infrastructure. This survey investigated a number of locations with 30 km of the Nolans site to assess construction material. Some of the sites investigated are sites used previously for highway construction or road construction on Aileron Station. Prior to project construction further geotechnical investigation will be undertaken and construction materials investigation completed. Any required regulatory approvals to source these materials for construction purposes (i.e. associated with extractive minerals title processes) will be sought prior to construction. Wherever possible the company intends using material from the pit pre-strip as construction material.

Interpretation of site conditions is based on the sub surface lithology revealed during the investigation program which included visual assessment of the in situ materials, the results of in situ field tests, and the results of laboratory testing carried out on selected representative samples collected during the fieldwork.

The geotechnical site investigation identified borrow material for earthworks construction within 30 km of the mine site, and these are summarised in Table 3-2.

Table 3-2 Summary of borrow materials

Material Type	Description	Location
Zone A	Low permeability material, generally greater than 30% fines and a PI of 8 or more.	Two possible source areas, within the pit area and to the south east of the TSF.
Zone C	Granular material (sandy gravel) with a fines content typically of 15 % to 20 %.	This material will be won from the overburden in the pit or by selective excavation from the WRD.
Zone F	Sand with less than 5% fines.	Two possible source areas, within creeks and imported from a local quarry.
Base Course	Granular material (sandy gravel) with a fines content typically of 15% to 20%	Two possible source areas, Native Gap road quarry and imported from a local quarry.
Road Aggregate	14 mm high strength stone.	One possible source area, imported from a quarry in Alice Springs.
Concrete	Variable properties but generally 40 N/mm^2	Proposed onsite batching plant during construction.

The region is known for localised, elevated concentrations of naturally occurring radioelements uranium and thorium. The aim is to ensure that all construction materials are not acid generating, and are benign with respect to activity concentrations.

3.5 Mining

3.5.1 Mineral resources

Systematic exploration of the Nolans Bore site has been undertaken by Arafura since 2001, with most of the exploration and resource definition activity confined to an area measuring 1.5 x 1.2 kilometres within the mine site boundary.

There is limited outcrop of fluorapatite at Nolans Bore, with most of the deposit covered by a thin veneer of soil and alluvium up to around one and a half metres thick. Systematic drilling indicates the widespread presence of RE mineralisation, with steeply dipping veins up to tens of metres in thickness and hundreds of metres in length, extending below 250 metres drilled depth, across large parts of the deposit. The full extent of the deposit is yet to be outlined but deeper drilling has demonstrated that mineralisation extends down to at least 430 metres below surface in the deposit's North Zone.

A total of 628 reverse circulation and diamond core holes have been drilled into the Nolans Bore deposit (Figure 3-5). The amount and overall proportion of diamond core drilling is considered sufficiently high (31%) to provide good geological control and support the estimation of higher confidence Measured and Indicated (M&I) Mineral Resources.

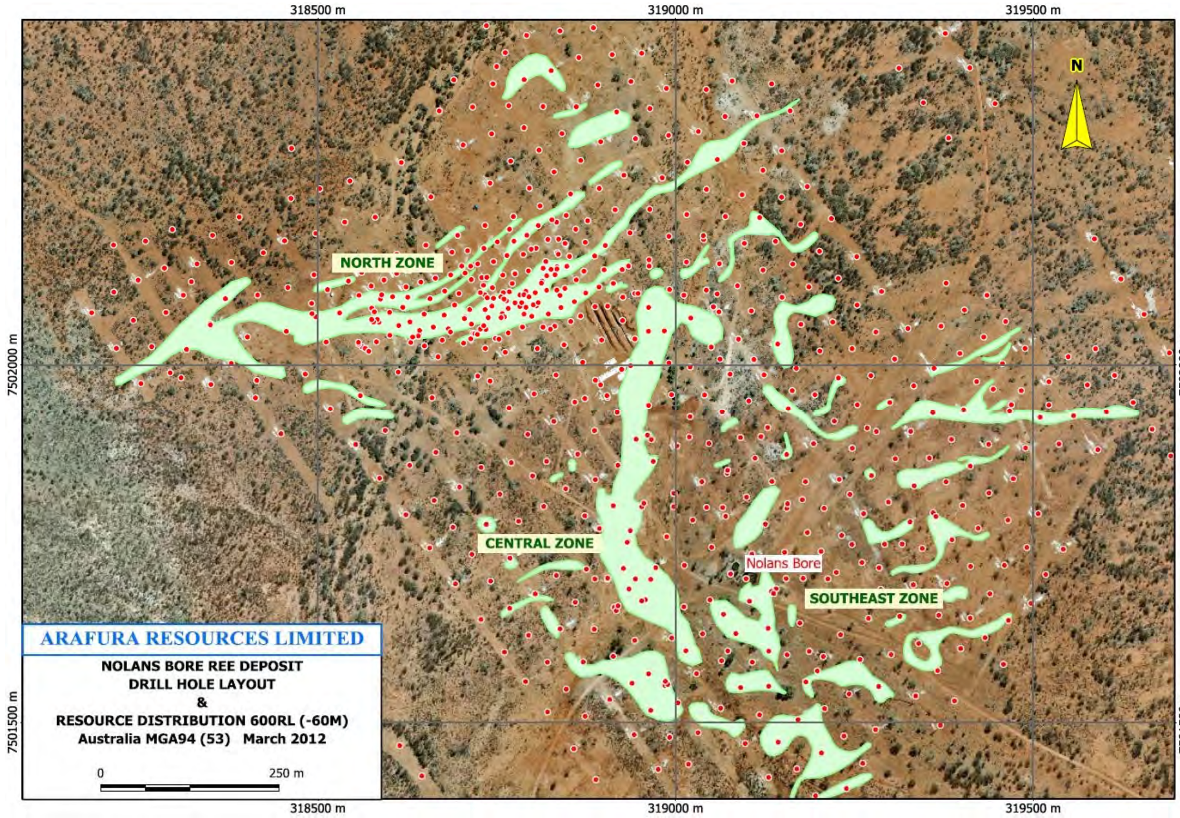


Figure 3-5 Distribution of drilling and mineral resources – plan view

An estimate of mineral resources for Nolans Bore, as at December 2014, reported above a 1% total RE oxide (TREO) cut-off grade and compliant with the 2012 JORC Code, is shown in Table 3-3, and the distribution of these resources both laterally and with depth is shown in Figure 3-6.

Resource model estimates support a 23-year production life mining the Measured and Indicated Resources only (M&I Case). Adding Inferred Resources supports a potential 43-year LOM case.

These production scenarios do have the potential to change due to an upgrade in the project's estimate of Mineral Resources reported by Arafura in October 2015, adding a further 20 per cent to the total inventory that underpins the LOM Case.

The deposit contains elevated concentrations of phosphate, uranium and thorium, averaging 11% P_2O_5, 190 ppm U_3O_8 and 2,900 ppm ThO_2 respectively, although Arafura does not initially intend to commercially recover these elements. All three elements and the radioactive decay chain daughter products of uranium and thorium will report to tailings or process residues.

Table 3-3 Mineral resources

Category	Mineral (million tonnes)	Rare Earth (TREO %)	Rare Earth (tonnes)	Phosphate (P_2O_5 %)	Uranium (U_3O_8 lb/t)
Measured	4.3	3.3	144,000	13	0.57
Indicated	21	2.6	563,000	12	0.42
Inferred	22	2.4	511,000	10	0.37
Total	47	2.6	1,217,000	11	0.41

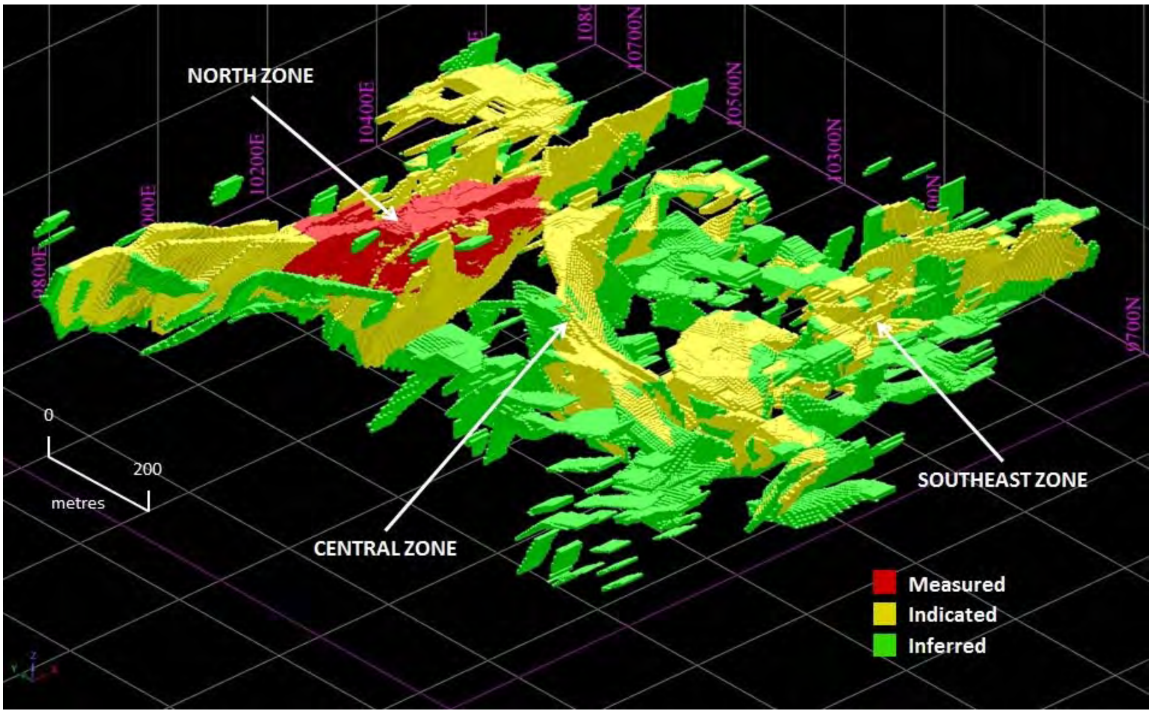


Figure 3-6 Distribution of mineral resource categories – oblique view

3.5.2 Mineralisation

The project's Mineral Resources are comprised of two broad styles of RE-bearing mineralisation:

- **Apatite mineralisation** comprises up to about 95% fluorapatite and typically contains abundant mineral inclusions of RE-bearing minerals such as monazite group minerals, allanite, thorite and numerous other RE phosphates, silicates and carbonates. The apatite itself contains variable amounts of REs but a higher proportion of REs are hosted in the mineral inclusions.
- **Calcsilicate mineralisation** tends to be lower grade than the apatite mineralisation, and is typically dominated by apatite, allanite, epidote, amphibole and pyroxene. In addition to REs, the mineralisation has elevated concentrations of calcium, phosphorous, thorium, uranium, strontium and fluorine.

The two broad styles of mineralisation described above are further subdivided into six material type categories based on geological and mineralogical characteristics, and metallurgical performance. These are listed in Table 3-4 and illustrated in Figure 3-7.

Apatite material types 1, 2 and 3 (MT123) comprise a higher grade material relative to calcsilicate material types 4, 5 and 6 (MT456). This subdivision provides the means to selectively mine and preferentially process the best performing material (MT123) early in the life of the operation, while deferring the lesser performing material types (MT456) in mine scheduling.

Table 3-4 Material types

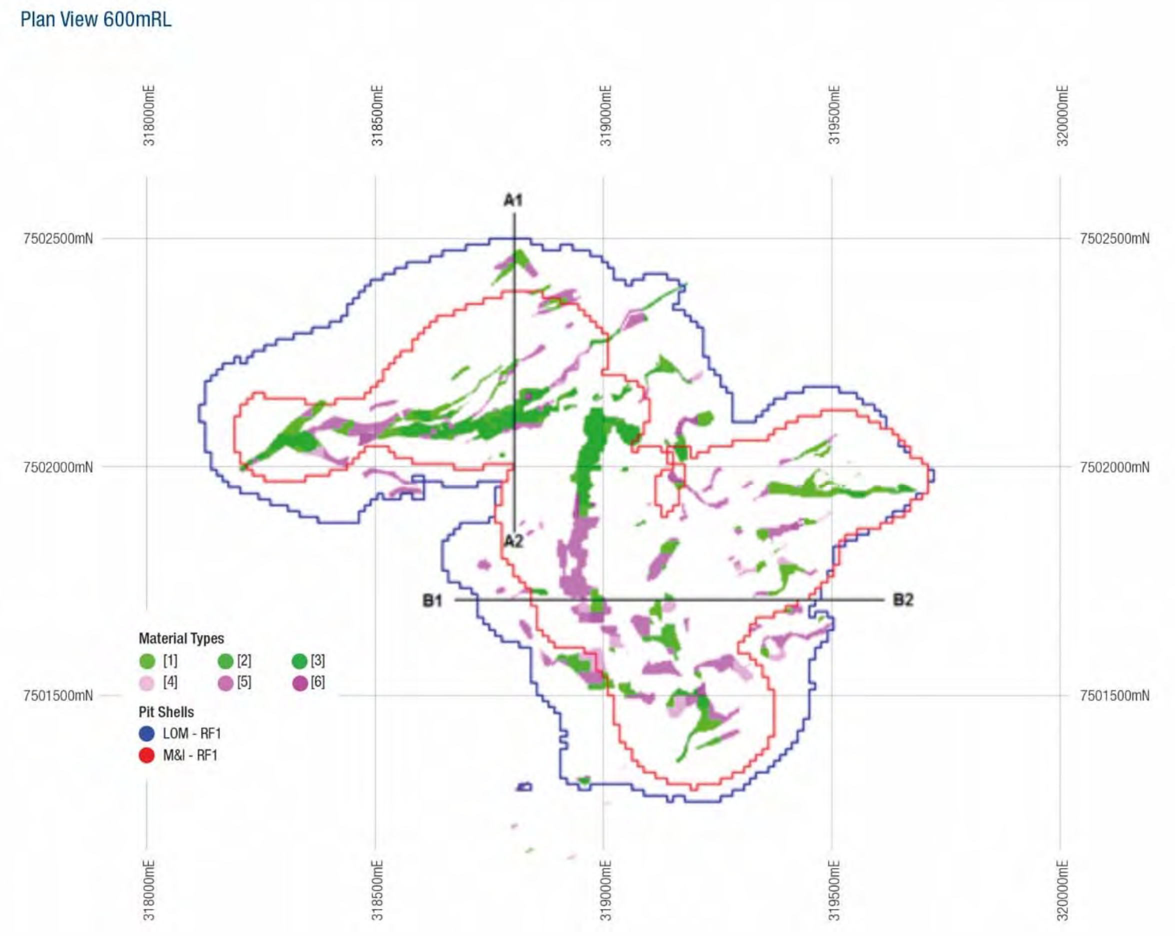
Style	Type	Description	Proportion
Apatite (MT123)	1	Cream/green apatite	17%
	2	Brown apatite	7%
	3	Brown apatite with kaolin and/or clay	21%
Calcsilicate (MT456)	4	Apatite and allanite	9%
	5	Apatite, allanite and calcsilicate	44%
	6	Apatite, allanite, calcsilicate with kaolin and/or clay	2%

3.5.3 Future exploration

Arafura has been exploring the region around the project site for REs and other mineral commodities since 1999. In that time, it has held exploration rights over approximately 6,300 km^2 of land, including the current EL that hosts the Nolans Bore deposit (EL 28473), either in its own right on in joint venture with other companies.

Arafura's exploration methodology involves flying airborne geophysical surveys to provide a focus for detailed on-ground geological, geochemical or biogeochemical investigation (as appropriate) in advance of drilling. Often, a target area fails to deliver encouraging results at an early stage of its assessment, leading to relatively rapid turnover of ELs.

There are currently no areas, apart from the Nolans Bore deposit itself and the carbonate deposit in the north-western part of Arafura's exploration footprint (see Section 1.4.7), where potentially mineable resources have been identified. Nonetheless, Arafura maintains a modest exploration presence in the region, and is currently acquiring exploration tenure targeting alternative models for RE deposits that have the potential to delivery complementary feed to the Nolans processing plant.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Pit Shells
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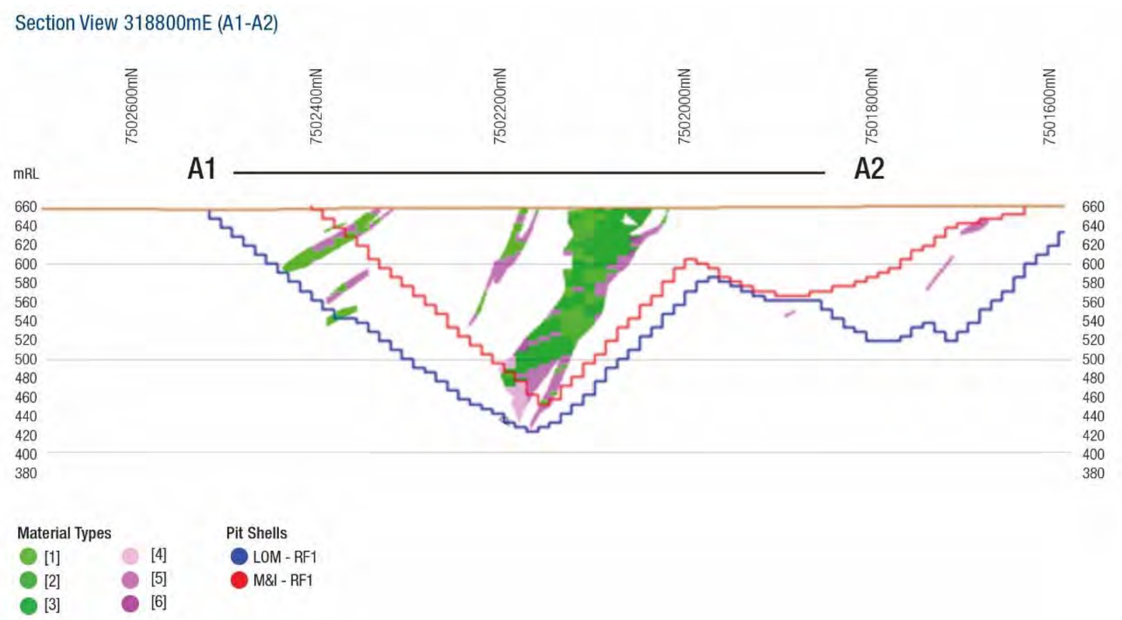
M&I - RF1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M&I - RF1

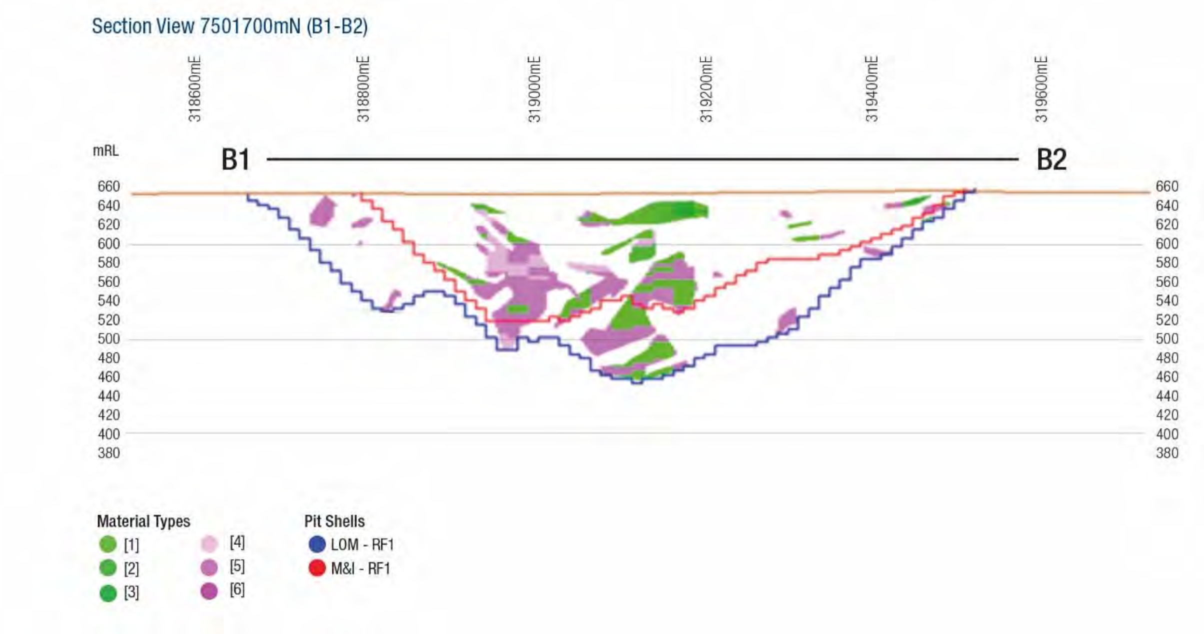


Figure 3-7 Distribution of material types

3.5.4 Mine scheduling and pit development sequence

The overall aim of the mine schedule is to ensure that sufficient ore is mined at a grade to produce an annual target of 20,000 tonnes of TREO equivalent. This will be achieved using selective mining methods from the pit, and the use of stockpiles, to optimise the required ore feed to the concentrator.

The open pit mining operation will use conventional drill, blast, truck and excavator mining methods. The truck and excavator mining method was selected because:

- A high degree of ore selectivity and blending can be achieved
- Studies have shown this method to be cost effective and often the lowest cost option and
- A high degree of operational flexibility is possible, particularly for multiple pit stages and the bench geometry associated with nested pit stages at the mine site.

3.5.5 Mining methodology

Drill and blast will be required for both ore and waste with design powder factors ranging from around 0.40 kg/BCM for oxide mineralisation and waste to around 0.60 kg/BCM for fresh mineralisation and waste. Blasthole drilling will be carried out by 89mm blasthole drills. All blasting will be undertaken using emulsion explosives selected mainly for its water resistance and resultant reduced drilling cost. The bulk emulsion explosives are delivered by a sub-contractor as a down-the-hole service which is the supply of bulk explosives on the bench.

All final design batters and interim walls will be pre-split drilled and blasted with specialised packaged explosives.

The sub-contractor's explosives plant will be located south of WRD 3 and north of WRD 5 as shown in Figure 3-1. An explosives magazine will be located near the south west corner of WRD 1.

In and adjacent to zones of mineralisation, blasthole cuttings will be sampled, radiometrically and geologically logged, and analysed to determine the type of mineralisation and TREO, P_2O_5, U and Th grade as well as other indicator elements as required. Zones of mineralisation will then be identified by the geologists as plant feed, material to be stockpiled and waste. After blasting and prior to excavation, the various material types will be marked out by the geological and grade controllers. The excavator operators will then proceed to selectively mine the various material types sending each truck to the designated destination (ROM pad, stockpile or WRD).

As an additional grade control aid, two Radiation Discriminators will be installed. The discriminators use gamma detection units to determine the average radioactivity of the material within a truck's tray and therefore provide the truck operator and grade controllers guidance regarding the destination of the truck (to the ROM pad, stockpile or WRD). This equipment will help to prevent ore being sent in error to the WRD and conversely waste being sent to the ROM pad.

The extraction sequence for the LOM case is shown in Figure 3-8. The extraction sequence provides for seven pit stages. Extraction quantities are summarised in Table 3-5.

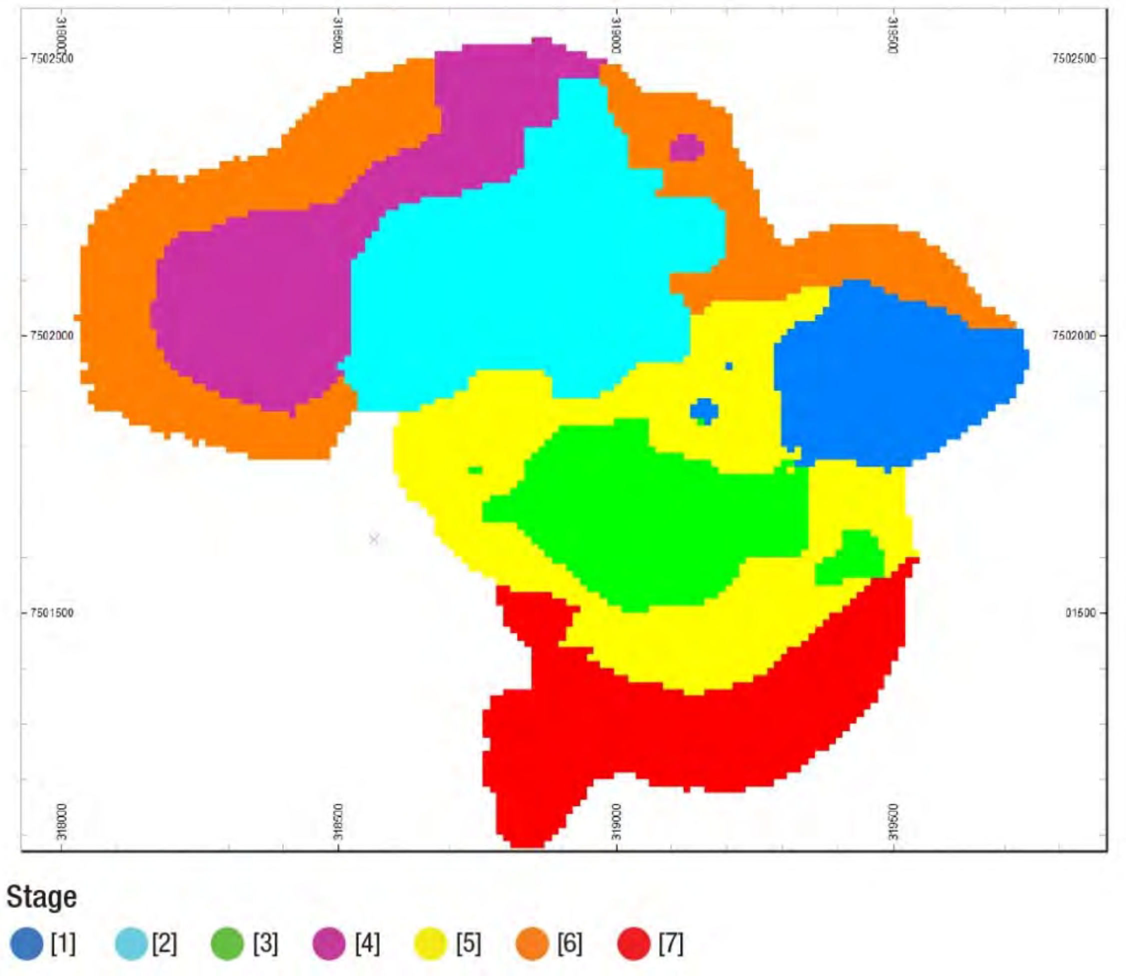


Figure 3-8 LOM pit stages

Table 3-5 LOM extraction quantities

Item	Total over LOM (tonnes)
Mined (MT123)	
Ore (ROM)	20,676,580
Ore (Long Term Stockpile)	4,791,310
Ore (Low Grade)	98,886
Mined (MT456)	
Ore (ROM)	9,763,313
Ore (Long Term Stockpile)	9,284,059
Ore (Low Grade)	9,712,754
Mined (Combined Material Types)	
Ore (ROM)	30,439,893
Ore (Long Term Stockpile)	14,075,369
Ore (Low Grade)	9,811,640
Ore - Total	54,326,902
Waste	304,092,777
Total Mined	358,419,679

The mining schedule for the LOM scenario is based on a maximum overall mining rate of 10 Mtpa ore and waste (Figure 3-9) to produce an average of 900,000 tonnes per annum of plant feed, and 358.4 Mt of ore and waste over the 43-year LOM scenario.

Mine production schedules have been generated from the pit optimisation shells based on selectively mining and processing higher grade material (MT123) in the early years of the project, and deferring the processing of lower grade material (MT456) until later years (Figure 3-9).

Plant feed (MT123 and MT456) is mined from the open pit mine and stockpiled on the ROM pad adjacent to the primary crusher. The ROM plant feed is then rehandled by a front end loader into the primary crusher. To optimise grade control, lower grade mined material is stockpiled off the ROM pad and is rehandled twice; once from the long term stockpile to the ROM, and again from the ROM to the primary crusher.

The target is to produce 20,000 tonnes of TREO equivalent per annum (Figure 3-10).

The annual material movement in tonnes for each pit stage is shown in Figure 3-11.

In any one year, a number of pit stages may be mined simultaneously. That is, when a pit stage has been developed sufficiently to expose the ore in that stage, waste development of the next stage or stages commences. Generally, one excavator fleet will remain mining ore and associated waste while the other excavator fleet(s) commences mining waste in the subsequent stage(s). For example, in Year 13, one excavator and associated trucks is mining ore in Stage 3 while the other excavators are mining waste in the upper levels of Stages 4 and 5.

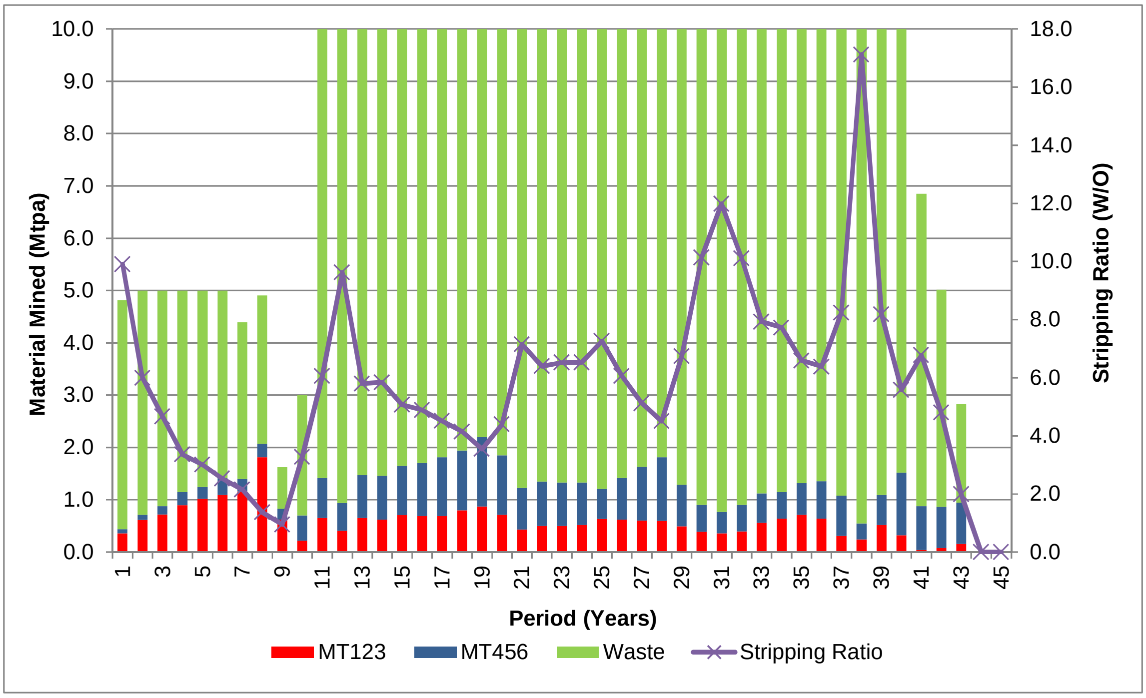


Figure 3-9 LOM production profile – material mined

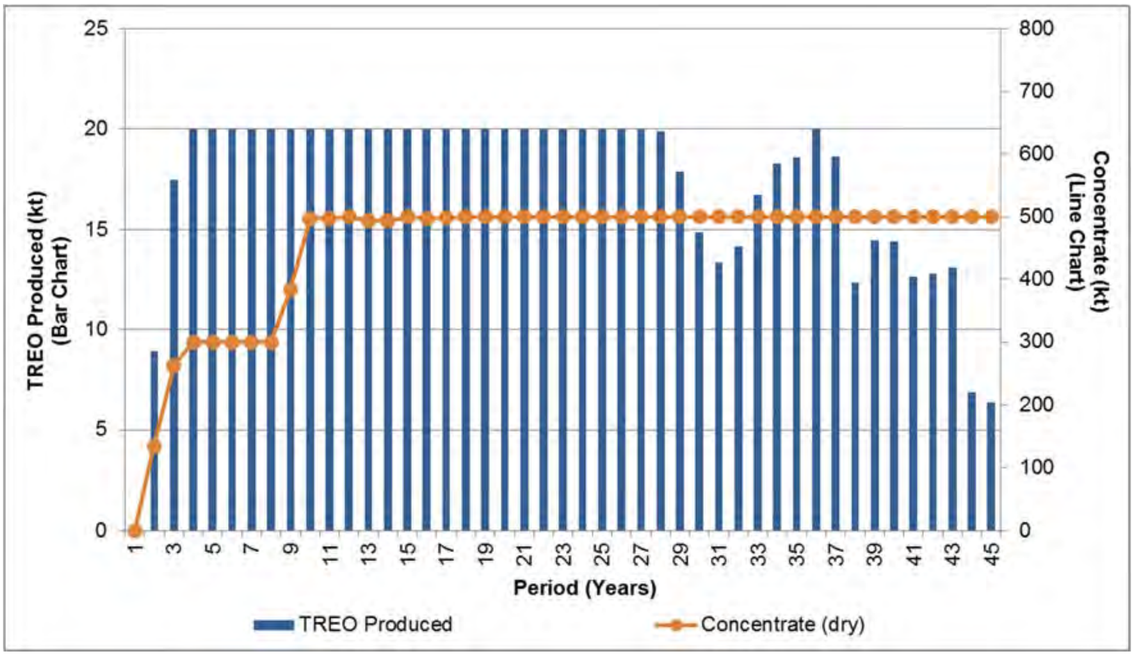


Figure 3-10 LOM production profile – concentrate and REO output

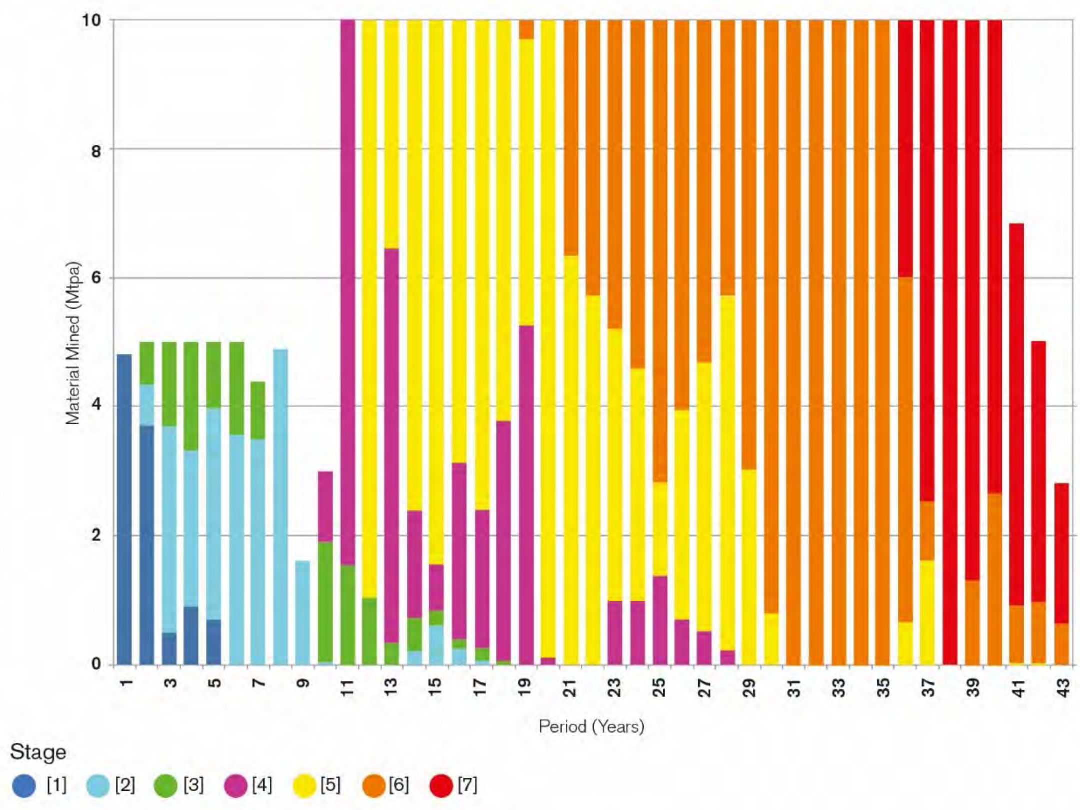


Figure 3-11 LOM production profile – pit stages

3.5.6 Mining fleet

Mining consists of some/limited blasting of waste rock and ore and use of dozers (49t CAT D9T), graders (CAT 16M) and excavators (108t Hitachi EXI 200). The ore and waste rock are loaded in the pit by excavators, into haul trucks (90t CAT 777F). The haul trucks are used to transport material out of pit to either:

- The concentrator ROM pad or Long Term Stockpile (LTS) or
- One of six WRDs (variable locations).

The primary and auxiliary mining fleets are shown in Table 3-6 below. Truck allocation to each of the excavators is dynamic, will depend on the ore and grade requirements, and ore exposures at any point in time i.e. as the ore haulage is from deeper parts of the pit and on a longer haul lead to the ROM pad, the ore excavator will require more trucks than the waste excavator(s).

On average, when the excavator fleet is at its peak, truck allocation will be four trucks allocated to the ore excavator and three trucks each to the waste excavators with a single truck under maintenance or being serviced.

Table 3-6 Mining Equipment

Type	Make and Model	Class	Activity	Peak Number
Excavators	Hitachi EXI 200	108 tonne	Load-and-Haul	3
Trucks	Caterpillar 777F	90 tonne	Load-and-Haul	11
Dozers	Caterpillar D9T	49 tonne	Auxiliary	3
Graders	Caterpillar 16M	16' blade	Auxiliary	2
Service Truck	Man 6 x 6	-	Auxiliary	1
Water Trucks	Man 6 x 6	-	Auxiliary	2
Rock breaker	Caterpillar 336DL	-	Auxiliary	1
Lighting Plant	Allight	-	Auxiliary	12
Front End Loaders	Caterpillar 990H	-	Auxiliary	2
Light vehicles	Various	-	Auxiliary	22
Surface Crawler Drill	Sandvik DP1100	89 mm dia. hole	Blast Drilling	6
RC Drill	Atlas Copco RC 127	127 mm dia. hole	Grade Control	1
Dewatering Pump	Chesterton	-	Dewatering	3

3.6 Processing

3.6.1 Overview

The Nolans process configuration falls into three geographical and processing categories (Figure 3-12):

- Comminution and beneficiation
- Rare earth extraction
- Rare earth separation.

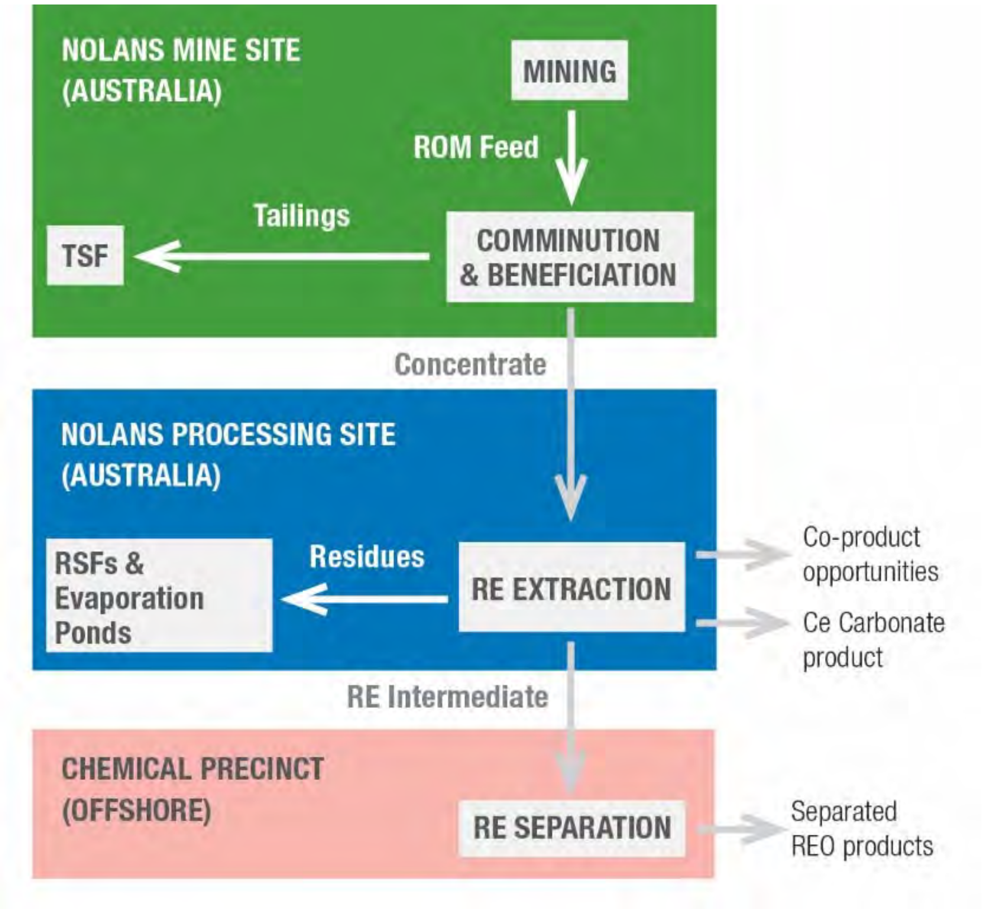


Figure 3-12 Process configuration

3.6.2 Mine site processing

Mining operations will deliver broken ore to a ROM pad (from which a front end loader will feed the crushing circuit) as well as to the LTS. Plant feed (MT123 and MT456) is mined from the open pit mine and stockpiled on the ROM pad adjacent to the primary crusher. The ROM plant feed is rehandled once and is processed soon after being mined.

Lower grade material mined during the early years of the Project is stockpiled off the ROM pad and is rehandled twice; once from the Long Term Stockpile to the ROM, and again from the ROM to primary crusher.

Waste rock will be hauled from the pit to the nearest WRD.

The concentrator comprises comminution and beneficiation circuits (Figure 3-13). Comminution includes a crushing circuit fed by front end loader, and ore is then conveyed to a single ball mill for grinding.

In the beneficiation circuit, ground material is passed through a wet high intensity magnetic separation (WHIMS) circuit to isolate RE-bearing magnetic minerals into a concentrate. This concentrate is then reground and upgraded using flotation cells to produce a RE-rich concentrate.

The reject from this magnetic process (i.e. the magnetic tails) are further processed through a flotation circuit to produce a phosphate-rich concentrate. The RE and phosphate concentrates are then combined as the feed material and pumped in a slurry to the processing plant at the processing site. All rejected magnetic and flotation tailings are then combined and pumped to a flotation TSF at the mine site.

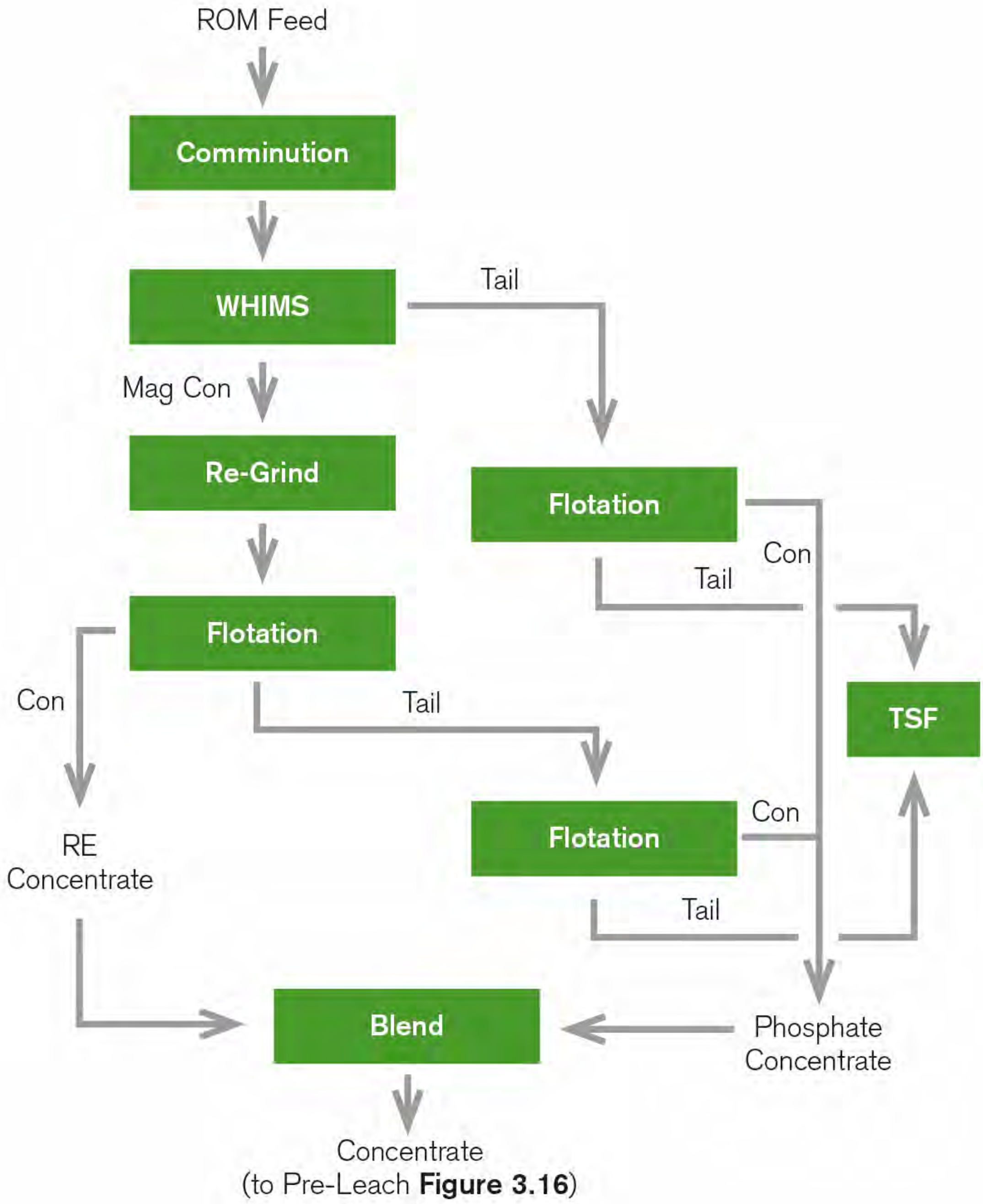


Figure 3-13 Concentrator circuit (Source: Arafura 2014)

3.7 Processing site

The processing site is located eight kilometres south of the mine site and hosts RE extraction processing units, a sulfuric acid plant, RSFs, evaporation ponds and other infrastructure to support the operation (Figure 3-2).

Concentrate will be pumped through a HDPE slurry pipeline from the concentrator to the processing site. The slurry pipeline will run above ground within a compacted earth bunded corridor, with event ponds located at low points along the alignment. Centrifugal pumps, arranged in series will be utilised to pump the concentrate slurry along the pipeline. The pump arrangement has been specified for a head of 198 m, the primarily component of which is friction losses within the pipe.

The processing plant comprises the following major processing facilities (Figure 3-14):

- Sulfuric acid pre-leach (SAPL)
- Sulfation and water leach
- Double sulfate precipitation (DSP) and purification and
- RE chloride intermediate and cerium (Ce) carbonate production.

The processing plant has several ancillary plants associated with it, such as a sulfuric acid plant, steam and gas power generation and water treatment as well as other infrastructure and services.

3.7.1 Sulfuric acid pre-leach

Mineral concentrate is received from the concentrator as a slurry at the processing plant and following dewatering, is fed to the SAPL process stage. The SAPL process produces a solid feed, containing the majority of the REs, for the sulfation process. It also produces a pre-leach liquor containing the remaining REs, for use in the water leach process. The solid feed material from SAPL is dewatered prior to being transferred to the sulfation process.

Solid sulfur will be sourced internationally and containerised at Darwin Port before being transported to site. It is anticipated that around 20,000 tonnes of solid sulfur will be transported to site quarterly for stockpiling and subsequent use (see also Section 3.10.4). It will remain in shipping containers whilst on site, prior to use.

3.7.2 Sulfation (acid bake)

A relatively low temperature acid bake process using concentrated sulfuric acid is used to sulfate the solid feed material, and liberates the REs for subsequent processing and extraction. This lower temperature process minimises the energy requirement for the sulfation process and offers a broader range of processing technologies.

3.7.3 Water leach

The sulfated material is leached with a mixture of pre-leach liquor, filtration wash filtrates and water. The water leach liquor is processed to recover REs and the solid residues are neutralised in the acid neutralisation section prior to final on-site disposal in the water leach RSF.

3.7.4 Double sulfate precipitation

Water leach liquor produced in the water leach section passes to the double sulfate precipitation stage. The addition of sodium sulfate in the double sulfate precipitation stage selectively precipitates the REs as a double sulfate salt. This is subsequently filtered and washed for further processing.

Liquor streams containing elevated levels of sodium sulfate are collected and evaporated for re-use in the double sulfate precipitation stage. Evaporation ponds are used to evaporate excess process fluids.

The RE-depleted double sulfate precipitation filtrate is neutralised with carbonate and lime in a two stage impurity removal process to produce a residue containing thorium and a phosphate residue that contains most of the uranium present in the Nolans ore. These residues will be stored and managed on-site in dedicated RSFs.

3.7.5 Conversion to hydroxide

The double sulfate precipitation solid salt is mixed with sodium hydroxide to convert it to a RE hydroxide solid. This solid is washed and dried prior to further processing. During the drying operation, in the presence of air, most of the cerium which is present as Ce^{3+} is oxidised to Ce^{4+}. This assists subsequent separation from the other REs to produce a cerium carbonate product during intermediate-stage processing.

3.7.6 Hydroxide dissolution

The dried RE hydroxide undergoes a selective re-leach with dilute hydrochloric acid to produce a mixed RE chloride liquor containing low levels of cerium. As the cerium is predominantly in the oxidised Ce^{4+} state it remains relatively insoluble in the solid phase during this selective re-leach process.

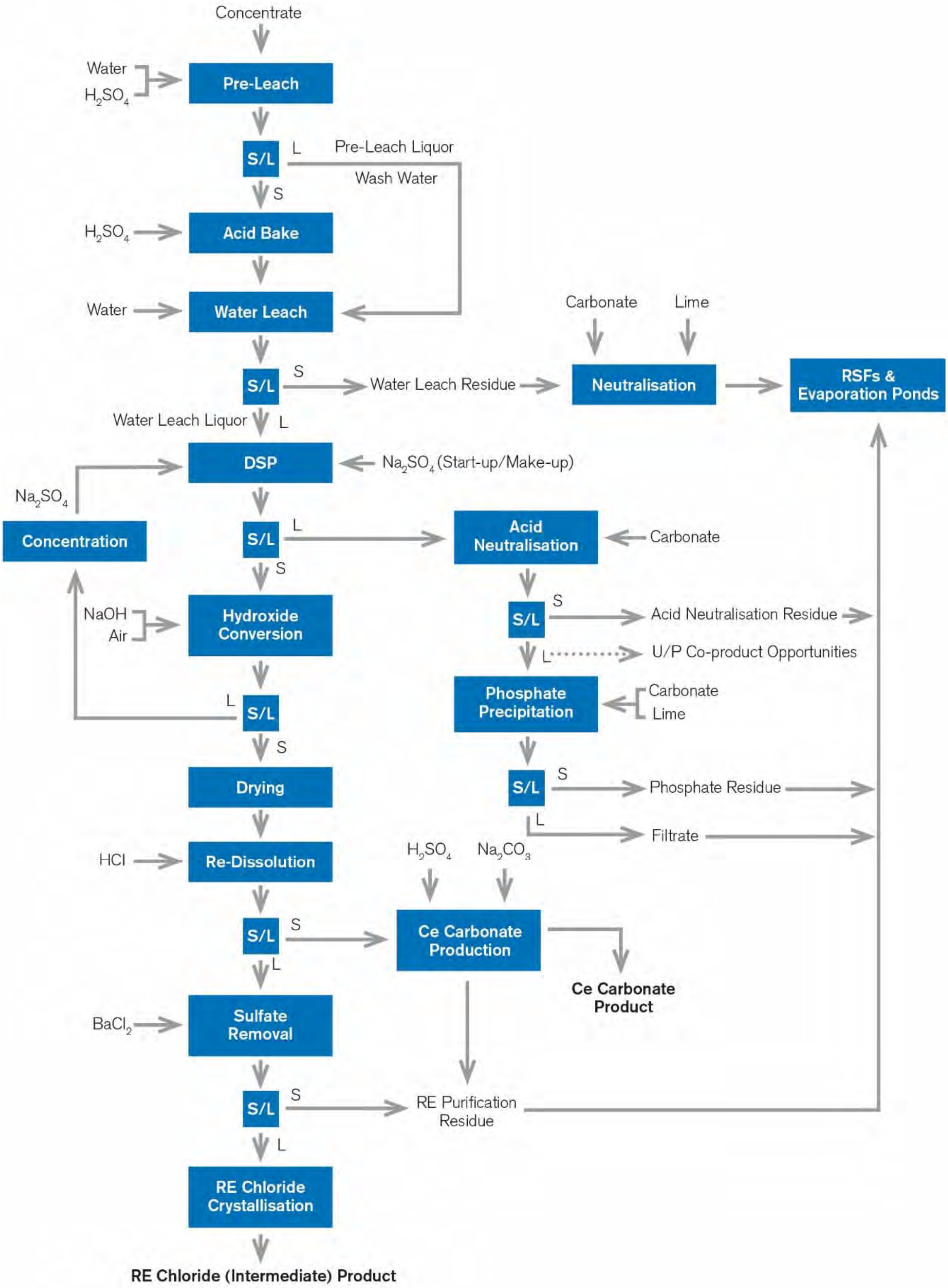


Figure 3-14 RE extraction circuit (Source: Arafura 2014)

3.7.7 Intermediate processing products

The RE chloride liquor from hydroxide dissolution is treated with barium chloride to remove residual excess sulfates and subsequently crystallised as an RE intermediate feed for transport and further processing at an offshore separation plant.

The cerium-rich solid from the hydroxide dissolution is treated to remove the residual thorium as a chemically stable precipitate and this precipitate is sent to the on-site neutralisation RSF. The cerium-rich liquor is precipitated by the addition of sodium carbonate to produce a cerium carbonate product.

The RE chloride intermediate and cerium carbonate products will leave the facility in bulk bags stored within standard shipping containers for transport to Alice Springs by road and then to Darwin via rail to the port for export. The former product will be shipped to the separation plant for refining. The latter product is targeted for direct sale to international customers.

3.7.8 Chemical precinct

Rare earths will be separated into final refined products at an offshore separation plant.

The separation plant will be subject to a separate approvals process and is excluded from the scope of this EIS.

3.8 Power demand

The power demand for the Nolans site has been estimated from detailed load lists for the mine and concentrator, processing plant and infrastructure assets including the accommodation village and water supply (Table 3-7).

Table 3-7 Power demand summary

Area	Power Demand (kW)
Mine and concentrator	9,000
Processing plant	8,000
Accommodation village, bores, water transfer, potable water, sewerage	1,500
Total	**18,500**

3.8.1 Power supply

There is no local grid supply opportunity in the region. Power demand will be serviced by cogeneration from a sulfuric acid plant and gas fired on-site generation located at the processing site.

The sulfuric acid plant associated with the processing plant will generate power via a steam turbine from the steam arising from burning sulfur. This is a common feature of sulfuric acid plant design.

Acid plant vendor supplied information indicates that the sulfuric acid plant should deliver a net power output of approximately 6 MW over and above its internal consumption requirements.

The project will require additional power over and above that available from the sulfuric acid plant and it is planned that this will be generated by a gas turbine facility located at the processing site. The facility will also maintain site-operating capability during acid plant or steam turbine/generator outages, i.e. maximum power output of 18.5 MW.

The load and generating capacity from the waste heat of the sulfuric acid plant leaves a normal operating natural gas fired generation requirement of approximately 12.5 MW. This is expected to provide the optimum steam/power demand flexibility for the site.

The Amadeus Basin to Darwin high pressure gas pipeline is adjacent to the Nolans site. Arafura has engaged in discussions with the pipeline operator and a number of existing and prospective gas producers regarding a long-term gas supply opportunity for the project. The close proximity of the Nolans site to the gas pipeline eliminates the need for a significant offtake connection pipeline. The supply capacity and capability easily exceed the project's process gas demands.

In addition, emergency diesel generators will be located at three of the principal Nolans site areas (mine site, processing plant and the accommodation village) to maintain safe emergency power requirements for personnel, and safety critical drives and personnel safety in the event of a major power outage. Processing plant emergency generators will also provide black start capability.

While the processing plant is under construction, power will be generated at the accommodation village using diesel or gas generator sets which will also provide it with longer term emergency power.

3.8.2 Power distribution

The power plant will be located at the processing site adjacent to the sulfuric acid plant. The site layout requires overhead power lines to distribute power to infrastructure at the processing site, the mine site (approximately eight kilometres north of the proposed generation facility), the raw water collection pond and borefield area (approximately 13 km south west of the proposed generation facility), and the accommodation village (approximately five kilometres south east of the proposed generation facility).

High voltage (HV) overhead lines from the processing plant will transmit the power to the site users via kiosk substations. In total, there will be approximately 30 km of overhead lines.

The borefield service corridor (Figure 3-3) to the raw water collection pond will include a high voltage overhead power line. The pipeline bore field pump stations will be fed from a pole-mounted transformer, while the pumps in the borefield pump stations will be powered by diesel generators. If a decision to distribute power to individual bores within the borefield is made, the length of power lines required will increase significantly but will result in minor additional disturbance.

Power will be transmitted to the accommodation village by overhead high voltage (11 kV) conductors. At the village there will be a kiosk substation from where power will be distributed below ground at low voltage (415 V).

3.9 Tailings and residue management

3.9.1 Configuration

The Nolans site requires tailings and residues storage facilities which include:

- A flotation TSF adjacent to the concentrator at the mine site (Figure 3-1) and
- Separate water leach, neutralisation and phosphate RSFs, and evaporation ponds adjacent to the processing plant (Figure 3-2).

The LOM storage capacity and footprint of these facilities are summarised in Table 3-8 and Table 3-9 below.

The envelopes shown in Figure 3-1 to Figure 3-4 are larger than the LOM footprint areas represented in the tables below, to allow for future expansion of these facilities and extensions to the LOM should this be required.

Table 3-8 Tailings and residues storage

Facility	Embankment height (m)	Number of cells	Total footprint (ha)	Water storage capacity (Ml)	Tailings/ residue storage (Mt)
TSF	25.1	2 or more	~100	-	~45
Phosphate residue	24.0	2	~60	-	~13
Impurity removal residue	24.1	2	~150	-	~54
Water leach residue	20.9	2	~114	-	~33

Table 3-9 Quantities of tailings and residues

Facility	Slurry throughput (wet Mtpa)	Slurry throughput (dry Mtpa)	Slurry input (percentage solids)	Salinity (specific gravity)
TSF	1.17	0.450	38.6	1.000
Phosphate removal	0.4	0.141	34.9	1.068
Impurity removal	1.48	0.592	40.0	1.025
Water leach	1.07	0.357	33.5	1.007

Table 3-10 Other ponds

Facility	Embankment height (m)	Number of cells	Total footprint (ha)	Water storage capacity (Ml)	Tailings/ residue storage (Mt)
Evaporation pond	2.5	6	60	1,500	0
Sodium sulfate pond	2.5	3	10	250	0

3.9.2 Design and operation

The TSF and RSFs will collect leachate and minimise seepage, whilst also maximising tailings and residue densities.

Knight Piésold (2014) assessed the facilities as having an ANCOLD High C consequence category classification, based on an assessment of all criteria (see Table 3-11) and a conservative estimate of “population at risk”. The resultant consequence category was a conservative assessment in the absence of a detailed “population at risk assessment” at the time of preparation of the report (2014).

Table 3-11 Severity level impact assessment

Criterion	Impact Category
Damage to infrastructure	Medium
Business importance	Medium
Public health	Minor
Social dislocation	Minor
Impact area	Medium
Impact duration	Medium
Impact on natural environment	Minor

In 2016, ATC Williams undertook a Flotation TSF Failure Impact Assessment (Appendix J), including a detailed population at risk assessment (excluding site personnel). The ANCOLD consequence category classification was assessed as low, thus the average recurrence interval (ARI) and possible maximum flood (PMF) indicative storage facilities designs (i.e. freeboard storage for 1 in 100,000 ARI or PMF 72-hour event are conservative.

The TSF will have a low permeability soil liner and the embankments will be constructed from suitable mine waste material. This waste will be non-mineralised country rock. Decant water will be recycled to the processing plant. Any additional construction materials will be sourced locally from areas identified previously. These volumes will be subject to additional regulatory approval for extractive purposes. A more detailed geotechnical evaluation will be completed prior to construction.

The current RSF design incorporates a HDPE/low permeability soil liner system, combined with basin drainage and a leakage collection and recovery system.

The purpose of the drainage system is to reduce the water head on the underlying liner and thus reduce seepage rates. The water from the drainage system will be collected and discharged into the pond within the same facility. Ponded water will evaporate and water will not be recycled to the processing plant due to the quality of the water and its detrimental impact on the operation of the plant.

Detailed chemical characterisation of these process residues is in progress. Following receipt of this work an alternate design for the RSFs may be contemplated which removes the HDPE liner. The life of a HDPE liner is around twenty years and the project currently contemplates 43 years LOM. Any new design concept will place greater emphasis on recovery of entrained water or seepage rather than containment.

The evaporation and sodium sulfate ponds will be lined with an HDPE liner. Excess process liquor plus RO plant reject and treated sewage effluent will be directed to one of the evaporation ponds after which the flow will be directed to the next pond in sequence. Over time the liquor will concentrate through evaporation and the remaining brine in the cell will be pumped to the impurity removal RSF to reduce the accumulation of precipitate in the evaporation ponds. The cell will then be available to receive excess process liquor for the next cycle.

Waste storage facility design drawings are presented in Appendix E. The size and configuration of waste storage facilities may change, but typical design features will remain the same.

Tailings and residue management plans will be developed following finalisation of engineering design. Waste facility operations will also comply with procedures outlined in the radiation and water management plans within the Environmental Management Plan.

3.9.3 Monitoring and closure

During operation a monitoring program for the TSF and RSFs will be developed to monitor their performance and integrity during operation, and to assist management of these facilities post closure. This will include groundwater monitoring stations to ensure early detection of groundwater level and/or quality changes. Embankment piezometers and survey pins will be installed to monitor stability and other parameters. It is proposed that the TSF and RSFs will be progressively covered with a layer of benign stable rock during operations if practicable to limit the area of exposed residues.

Closure of the TSF and RSFs will be in accordance with the approved mine closure and rehabilitation plan. At closure the TSF and RSFs will have a layer of around two metres of benign waste rock placed over them to limit natural erosion and ensure long term security of the contained tailings and residues. Following closure of the facilities a modified monitoring program will be developed and agreed with regulators to monitor and manage the performance of these storage structures.

3.10 Wastes and hazardous material

3.10.1 Waste rock dumps

Six waste rock dumps (WRDs) will receive a LOM waste quantity of around 158 million loose cubic metres constructed to a height of about 50 m above the land surface built in ten metre lifts interspersed with five metre wide berms. WRD capacities are shown in Table 3-12 and the locations are shown in Figure 3-1. The design criteria are summarised in Table 3-13

Waste rock will be hauled to the nearest waste rock dump from the pit stage being mined in the pit at that time. For example, in Year 13 waste from Stage 3 is sent to Dump 2, waste from Stage 4 to Dump 1, and waste from Stage 5 to Dump 2, 3 or 4, depending which is nearer to that part of Stage 5 being mined.

A swell factor of 30% has been applied to designs, but with traffic compaction and consolidation over time, this may actually be closer to 25% in operations. Therefore, a swell factor of 30% is expected to be an upper limit and to provide a safety margin in WRD design capacities.

A total storage area of 95 ha has also been set aside for topsoil storage (Figure 3-1). Top soil storage will progressively be increased as WRD footprints increase during mining. To ensure that topsoil remains viable, storage will be kept to a minimum and top soil will also be used progressively as WRDs are rehabilitated and closed.

Table 3-12 Waste Rock Dumps

Waste Rock Dump Number	Volume (Mlcm)	Footprint (ha)
1	77.14	212.61
2	26.87	101.64
3	14.30	68.22
4	22.60	99.19
5	14.57	70.36
6	4.11	38.04
Total	**159.59**	590.06

Table 3-13 WRD design criteria

WRD design parameter	Quantity	Unit
Lift	10	m
Overall face angle	16	Degrees
Berm width	5	m
Road gradient	10	%
Road width	35	m
Stand off from pit crest	50	m
Maximum dump height (to maximum RL)	50 (~730)	M (mRL)
Stand off from infrastructure	35-50	m
Swell factor	30	%

3.10.1 Naturally occurring radioactivity

The area of the Nolans Bore deposit, including both the surface layers and the mineralised layers, contains elevated concentrations of naturally occurring uranium and thorium. Higher uranium and thorium concentrations are naturally associated with the RE mineralisation.

Arafura has conducted radiological monitoring since commencement of systematic exploration work in the mid-2000s. This has enabled Arafura to characterise the natural background radiation levels, including elevated levels of uranium and thorium associated with the project and to develop appropriate management practices (details of the existing background levels are provided in Chapter 12 of this EIS).

The project does not intend to extract and commercially recover the uranium and thorium, and consequently any uranium, thorium or radioactive decay products (known as radionuclides) in the ore are considered impurities, requiring removal. The rejected radionuclides will be part of the waste streams that report to the TSF and RSFs.

During operations, some waste rock will be mined that has a radionuclide concentration exceeding 1 Bq/g. This concentration is recognised as the level at which a material is defined as radioactive and therefore subject to control (ARPANSA 2015). The waste rock that exceeds 1 Bq/g will be encapsulated during operations and progressively covered with inert waste rock material. This rock coming from the mining operation will be quickly classified into its respective category (radioactive or benign) by the truck passing under a sensor. The sensor will direct the driver to the appropriate dumping location within the mine site area.

The radionuclide concentrations through the operation's processing circuits and in the tailings have been determined through test work undertaken by ANSTO (Australian Nuclear Science and Technology Organisation) in Sydney, and this is described in Chapter 12 and Appendix P of this EIS. JRHC Enterprises and Radiation Advice & Solutions, who are regarded as technical specialists in the radiation field, have completed additional calculations and estimations.

At closure, the TSF and RSFs will be covered with sufficient inert waste rock material to ensure that the underlying tailings material is secured from erosion and that radiation levels are less than 1 Bq/g at surface.

As part of the environmental impact assessment, the radiological impact of the operations on workers, the public and the environment has been assessed and is addressed in Chapter 12.

3.10.2 Potential acid forming material

Acid forming material risk assessment and management is addressed in Chapter 8 and Appendix L. Acid and metalliferous drainage (AMD) assessment has revealed low sulfur content and significant apparent neutralising capacity in most lithologies and waste streams. The static and kinetic AMD and geochemical testing indicates that the proposed waste rock, ore and pit wall material has a low risk of generating acidic, metalliferous or saline leachate.

Conceptually, potential acid forming (PAF) material will be contained and encapsulated within benign waste in designated areas of the contaminated WRD. Based on the waste rock characterisation assessment completed for the project there is a low risk of acid metalliferous drainage resulting from the waste rock associated with the project.

Additional information relating to the characterisation of the expected waste rock properties is contained in Chapter 8.

3.10.3 Process waste streams

The following waste streams will be generated by the project with each waste stream reporting to an individual storage facility (see Section 3.9):

- Flotation tailings from the concentrator
- Phosphate residue from the processing plant
- Impurity removal residue from the processing plant and
- Water leach residue from the processing plant

Sodium sulfate is not considered a waste stream as it will be recovered for re use in the processing plant.

Expected slurry volumes are summarised in Table 3-9 and the location of the TSF and RSFs is shown in Figure 3-1 and Figure 3-2.

The project's process flowsheet has phosphate, uranium and thorium reporting to waste streams.

Hazardous process materials

Detailed logistics modelling indicates that the project will have annual movements of approximately 190,000 tonnes of in-bound raw materials to the Nolans site, and these will predominantly be in the form of standard intermodal cargo. Arafura has engaged with the major operators and service providers to assess and ensure access to the required infrastructure and to incorporate the most efficient solutions for cargo movements. The transport impact assessment is described in Chapter 17 and Appendix V.

Sulfur and sulfuric acid

Sulfuric acid will be required both for the start-up of the acid plant and during the initial stages of ramp-up until consumption rates justify the commencement of on-site acid production. Arafura is working with the owners and the operators of the bulk tank facility at the Port of Darwin to facilitate handling of internationally sourced concentrated sulfuric acid via existing infrastructure. Where transport volumes justify the investment, the company will work with the owners and operators of existing bulk handling installations to facilitate investment in additional capacity.

Caustic soda and hydrochloric acid

It is expected that hydrochloric acid will be sourced from a regionally based supplier and delivered in ISO tank containers. Alternatively, internationally sourced hydrochloric acid will be delivered in bulk to Darwin for subsequent transfer to ISO tank containers.

Caustic soda will be procured on the international market and delivered in bulk to Darwin for subsequent transfer to ISO tank containers.

This dedicated fleet of ISO tank containers will be transported on standard rail and road intermodal services between Darwin and Alice Springs and the Nolans site (see Section 3.12).

3.10.4 Other raw materials and reagents

All other inbound raw materials and reagents such as soda ash will be containerised and transported using intermodal services. This maximises the use of standard services while maintaining flexibility and minimising cost. Sourcing of other critical raw materials will include a matrix of local, regional, national and international suppliers in order to manage the supply related risk. Diesel for the Nolans operation will be delivered by road tankers directly from Alice Springs (refer Chapter 17 and Appendix V.)

Additionally, Arafura has identified several potential carbonate (marble and calcrete) sources at surface within 30 km of the mine site on land over which it maintains exploration rights. Any approvals regarding development of a small quarrying operation to produce carbonate product, and the road transport of this product on Pine Hill and Aileron stations between the quarrying operation and the processing site, will be subject to a separate process.

3.10.5 Rare earth products

Out-bound RE product from the Nolans site will utilise existing road and rail capacity in addition to the Port of Darwin infrastructure. The products from the processing plant will be packed in bulk bags and transported in standard shipping containers via Darwin and international shipping routes. The RE intermediate product will be shipped via standard existing container freight routes to an offshore separation plant. The cerium carbonate product will be shipped to customers by similar means.

3.10.6 Wastewater and water treatment

Wastewater from the accommodation village and non-process wastewater from the processing site and the mine site will either be pumped to a common sewerage treatment plant located adjacent to the processing plant or to a second small treatment facility installed at the mine site. If pipelines are required they will be located within defined road service corridors.

The sewerage treatment plant will be a package type unit providing the appropriate level of treatment. Treated effluent will be disposed of within the RSFs or recycled through the processing circuits. Sludge residues will be disposed of by a local (Alice Springs) contractor on regular basis as required.

Raw water demand for potable uses will be treated by a filtration and treatment system rated at approximately 250 m^3 per day.

3.10.7 Domestic waste

Domestic waste will include industrial waste, general waste, batteries and tyres. Waste will be managed in accordance with the waste hierarchy where practicable. An on site waste facility will be constructed and managed in accordance with the NT EPA guidelines for the siting, design and management of solid waste disposal sites. Listed waste will be transported for disposal at the licenced waste operator in Alice Springs.

3.11 Water management

3.11.1 Water balance

Arafura intends to design, operate and manage the Nolans site as a zero surface water discharge operation to limit the potential contamination of natural drainage features downstream of the operation.

The overall site raw water demand is projected to be 4,777 ML/y. This includes a demand for processing plant process water of 4,418 ML/y, potable water 91.5 ML/y, and water for dust suppression 267 ML/y (Table 3-14).

On-site water resources will be available from pit dewatering which, due to the limited spatial extent and porous and transmissive nature of the ore body, will be achieved through pumping from bores and/or from in pit sumps to on-site turkeys nest dam. Also available on-site is the recycling of tailings supernatant water that collects within the TSF ponds. Additional on-site water may be available from stormwater management ponds but this is likely to be less significant due to its low frequency of occurrence and limited volume.

A comparison of site water demand with available on-site water resources (Table 3-15) shows that the site will eventually have a water deficit as mine dewatering volumes decline. Additional water will be pumped from the borefield in the Southern Basins to compensate.

Table 3-14 Nolans site water demand

User	Demand (ML/y)
Mine / Concentrator	13.5
Crusher dust suppression	25
Beneficiation make-up	667
Processing plant raw water	2,990
Processing plant potable water	20

User	Demand (ML/y)
Impurity removal residue re-slurry water (RO Plant reject for re-slurry and RO Reject Plant surplus)	761
Mine and haul road dust suppression	242
Accommodation village potable water	58
Total	**4,777**

Table 3-15 Water balance of the mine for average rainfall year (sourced from Appendix I)

Component	Stage 1 (ML/yr)	Stage 2 (ML/yr)	Stage 3 (ML/yr)	Stage 4 (ML/yr)	Stage 5 (ML/yr)	Stage 6 (ML/yr)	Stage 7 (ML/yr)
Open pit rainfall inflow	32	101	139	191	262	335	385
Open pit Groundwater inflow	1088	1243	1243	1391	1451	1461	1461
Open pit Rainfall losses	-28	-91	-125	-172	-236	-301	-346
Open pit de-watering requirement [B]	-1091	-1253	-1257	-1410	-1477	-1495	-1500
Recycling of the TSF supernatant water[A]	2.7	6.1	3.3	9.4	25.7	30.0	12.4
Process water demand (excluding dust suppression)[C]	405	884	479	1399	3792	4418	1841
Dewater + recycle – process demand	689	376	782	20	-2289	-2893	-328
Water deficit (excluding dust suppression)	0	0	0	0	2289	2893	328

Notes: source: [A] pro-rated and based on % reclaim from 'Nolans Project Tailings Storage Facilities Engineering Cost Study, Lycopodium, February 2014' [B] Appendix E of Appendix I [C] Section 4.2

3.11.2 Water supply

Raw water to supply the processing plant and the concentrator will be pumped from an aquifer located in the borefield approximately 25 km to the south west of the processing site. Water will be supplied from multiple active bores at Reaphook Hills borefield area pumping variable rates in accordance with the operation's groundwater management plan to ensure the long-term sustainability of the borefield aquifer system. The actual number of borefields developed will depend on the results of future borefield groundwater investigations to be completed during the mine development phase. The combined maximum sustainable supply of the bores amounts to 6,783 ML/y.

The borefield pumps will be located within fenced compounds containing the head works, manifold, power and control equipment and power supply. A staged pumping system with an intermediate pond and transfer pumping facility has been selected to reduce pump size and pipeline pressure ratings. This system and the associated network of bores will be controlled remotely from the processing plant using telemetry. The transfer pipeline from the intermediate pumping station to the processing plant will run within the access track and overhead power line corridor.

It is anticipated that the raw water demand for potable uses can be supplied from the northern part of the borefield area via a dedicated small transfer pipeline to a treatment facility (size 0.25 Ml/day) at the processing plant. An alternative option of using the main raw water supply is also available. The raw water will be treated by a packaged filtration and treatment system. Once treated, the brine will be sent to evaporation ponds and the potable water will be stored in a potable water tank located within the processing plant. This tank has been sized for two days' storage to cater for unplanned outage events.

Potable water from the tank will be pumped to tanks located within the concentrator / mine services area and the accommodation village via HDPE piping. These transfer pipelines will be located within the road service corridors. All tanks will be fitted with chemical dosing and UV treatment facilities and have protected water reserves for connection to fire systems, safety showers, etc.

3.12 Transport and communications

The materials transport and logistics strategy will use, wherever possible, standardised equipment to optimise performance within the existing regulatory framework.

Additionally, the proximity of the Nolans site to both Alice Springs (135 km to the south east along the Stuart Highway) and Ti Tree (55 km to the north-northeast along the Stuart Highway) facilitates:

- A bus-in bus-out (BIBO) transport strategy for the movement of mine personnel to and from the accommodation village
- An opportunity to base significant maintenance and operations logistical infrastructure associated with the road transport operation in Alice Springs using existing infrastructure and local suppliers and
- The use of the Darwin to Adelaide rail line and rail infrastructure in Alice Springs, to support the total rail transport requirements of the project.

The rail corridor provides direct linkage to the Port of Darwin which is approximately 1,400 km to the north. Port Adelaide to the south offers an alternative back up port facility with very good infrastructure and a similar haul distance, thereby substantially enhancing the security of the supply chain.

Vehicles that are too wide to travel on normal roads will be serviced on site at the mining workshop.

3.12.1 Haulage roads

The mining method is based on a drill, blast, load, haul and dump to the ROM pad, stockpiles or WRDs involving:

- Up to 11 x Caterpillar 777F, 90 t class haul trucks and
- Up to 3 x Hitachi EX1200, 110 t class, diesel hydraulic excavators with 6 m^3 buckets.

All dual pit access ramps have been designed at 30 m width to allow safe two-way access for mine trucks up to 150 t class. One-way pit ramps have been designed with 16 m width with the exception of access to pit bottom where the single ramp width is 30 m.

A short haul road from the pit to the ROM pad will be constructed to allow dump trucks to pass. Interaction with light vehicles and other mine vehicles will be strictly controlled with standard industry protocols to ensure the safety of all personnel and equipment.

3.12.2 Materials transport

The under-utilised capacity on the south bound Darwin – Alice Springs – Adelaide train route will be used to transport quicklime, reagents and sulfur to the Nolans site from Darwin. Rare earth intermediate products from the processing site will also use the railway to Darwin via Alice Springs.

Outbound product will be trucked to Alice Springs in shipping containers after cleaning at the processing plant following unloading of reagents. The RE intermediate product within these containers will be contained in 1 tonne bulk bags. Outbound product will be transported from Alice Springs by rail to Darwin whilst inbound materials are transported by rail from the Port of Darwin.

No material will be transported in bulk with the exception of the carbonate from the planned Woodforde quarry. This may be transported in triple off-road side-tipping road trains.

Once operational the processing plant demand for sulfuric acid will be serviced by an on-site sulfur burning acid plant. Inbound sulfur will be procured on the international sulfur market and it is proposed that bulk shipments be containerised in Darwin for ease of transport by rail to Alice Springs and then road to the Nolans site.

The delivery of reagents and materials for the project will be managed from Alice Springs by an existing logistics operator. Transportation of these materials and reagents will be by standard road trains or B-double truck configurations with 2-3 trucks completing two trips per twelve-hour cycle from Alice Springs to the Nolans site. The quantities of reagent and materials are included in Chapter 17.

Historically the Port of Darwin has handled solid sulfur shipments and Arafura is working with the Port Authority and port operators to finalise the optimal location for a transfer facility.

All vehicles leaving the designated dirty zone at the Nolans site will be washed prior to leaving site. All 20 ft containers will be washed internally, unless dedicated to a specific material (e.g. quicklime). No ISO container will require internal washing.

A summary of the material movement between the mine site and transhipment facilities is provided in Figure 3-15 and Figure 3-16.

3.12.3 Communications

The Nolans site communications networks will comprise multiple systems designed for the required functionality, security and integrity. These systems include:

- Nolans site-wide control system network including telemetry links for remote control and monitoring
- Wide area network linking national network and corporate functions
- Local area network (business)
- Telephony and VOIP
- Radio system
- Mobile phone network and
- Village entertainment network.

The cable infrastructure for these systems will use defined access and infrastructure corridors. Other radio/microwave transmission and receiving structures will be mounted wherever possible on existing other multiuse structures.

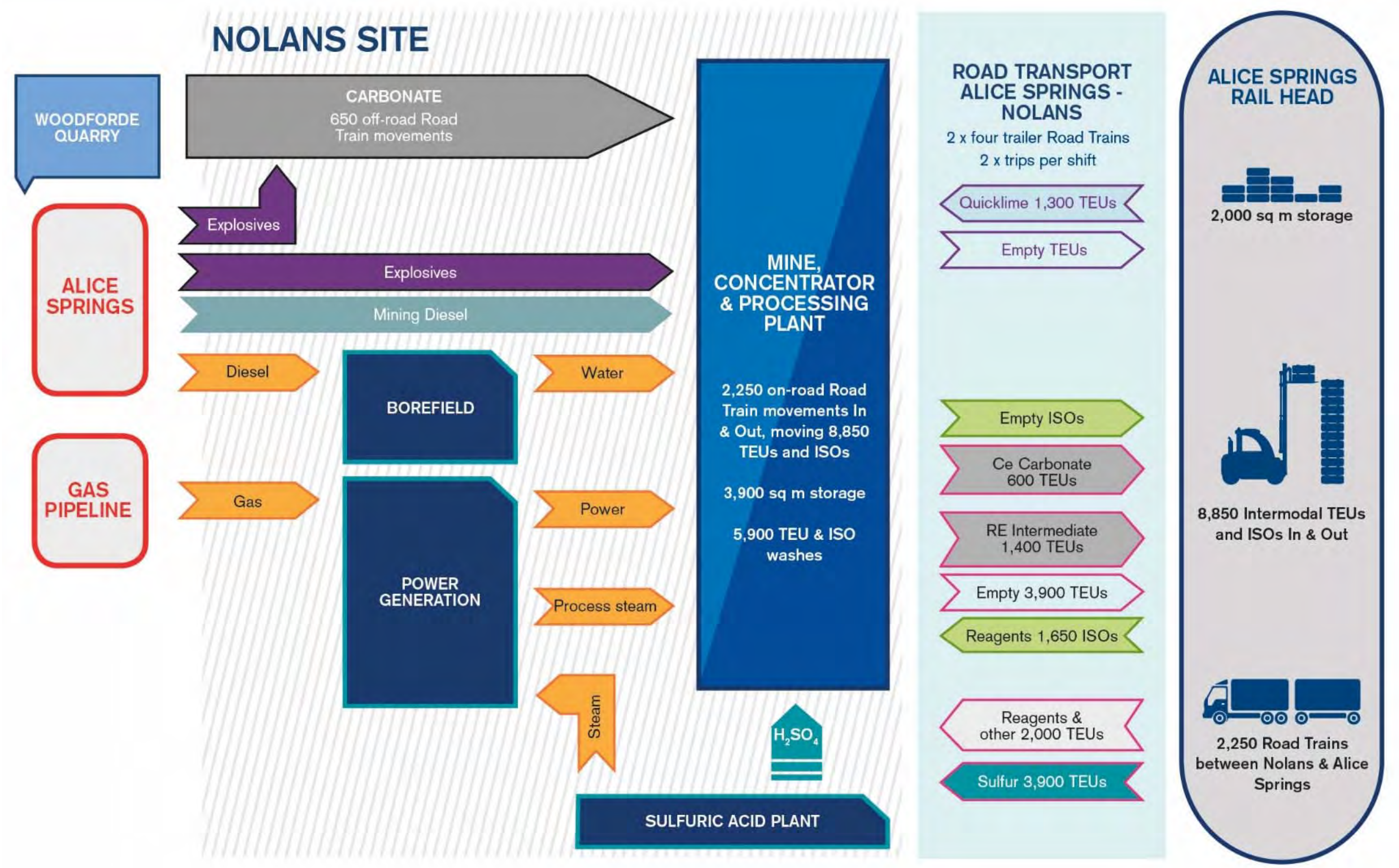


Figure 3-15 Nolans site - Alice Springs transportation (Source: Arafura 2014)

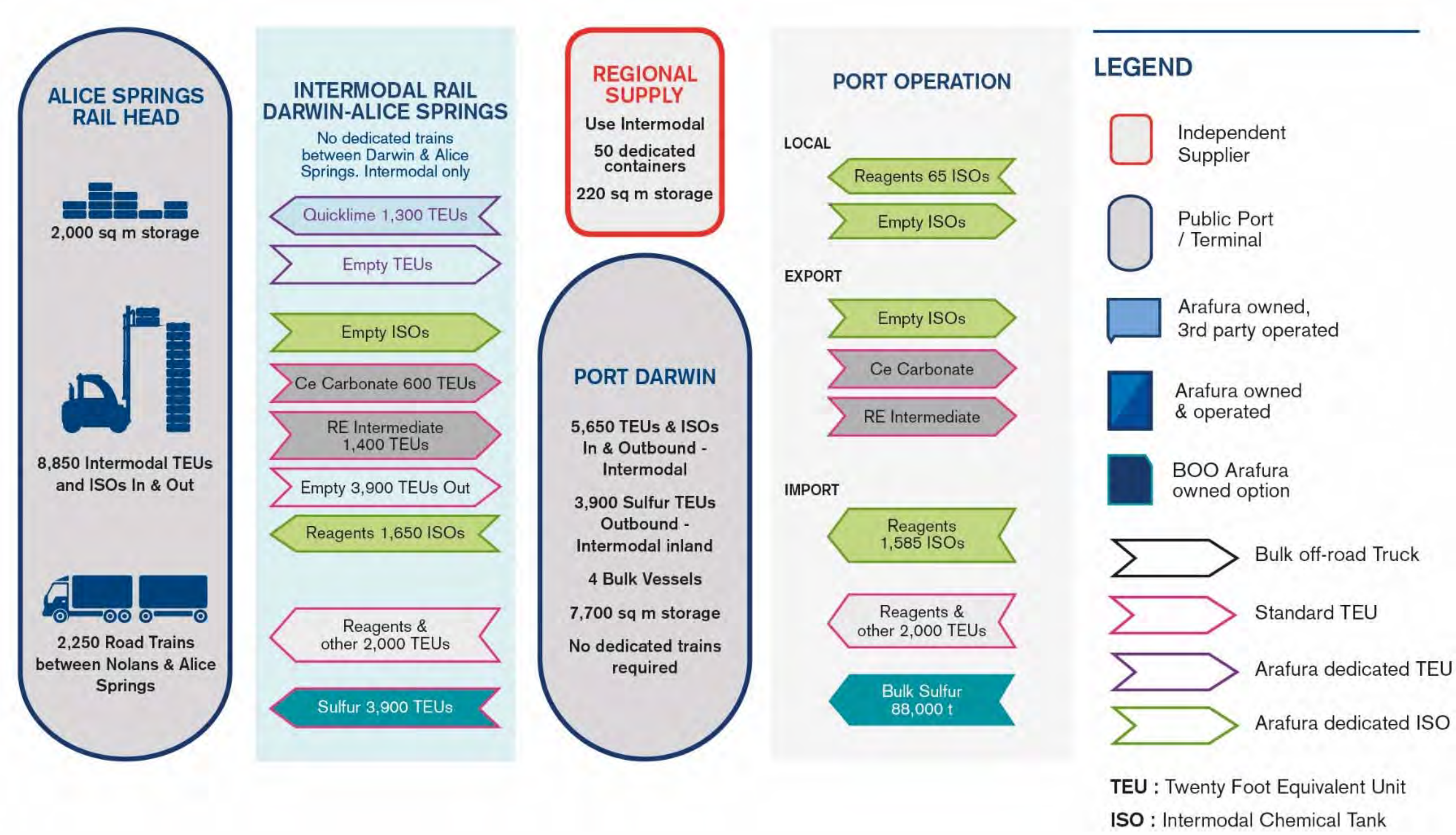


Figure 3-16 Alice Springs – Darwin transportation (Source: Arafura 2014)

3.13 Air

3.13.1 Inventory of air emissions

The inventory of air emissions for the project (detailed in Chapter 13) comprises dust and gaseous generating sources.

Dust generating sources

Dust generating sources are limited to the mine site and include:

- **The open pit and mining environment**

  As the ore body is generally within the aquifer (which will be dewatered ahead of mining), it is envisaged that the ore will have high moisture content and dust generation when mining will be lower than mining waste. Conventional mining methods will be employed using excavators, dump trucks and dozers with limited augmentation from blasting. Mining will progress through the seven stages, and peak years have been identified for each stage (corresponding to nominal year of mine operation) to identify material transfer to be used in developing the emission inventory across seven worst-case scenarios.

  Blasting is not the primary mining method, but will be used on a required basis. It is likely that ammonium nitrate fuel oil (ANFO) will be used in the waste rock because it is hard and relatively dry, while emulsion will be used in the ore as it is porous and a wetter material.

- **Haul road network within the mine site**

  Overburden and waste material will be deposited in purpose constructed WRDs via haul trucks. Dust suppression for haul roads and operating areas (in pit as well as WRDs and ROM pad) is required to limit dust inhalation by pit personnel (radiation requirements) and provide safe visual operating conditions.

- **Stockpiles and concentrator plant**

  Mining operations will deliver broken ore to a ROM pad (from which a front end loader will feed the crushing circuit) as well as to the LTS.

  Flotation tailings are transferred to a TSF. The tailings will be wet and so dust emission from these will be insignificant except if they dry out around their edges.

  Thorium and uranium will be present in the feed material to the concentrator and in material that is both stockpiled and/or disposed to WRDs. Radiation will be emitted and these are to be modelled as area sources from stockpile and waste sources.

  A (non-emitting) slurry transfer pipeline feeds concentrate across to the processing plant at a rate of 52 m^3 per hour.

- **Wind erosion from the mine site**

  A topsoil storage with a footprint of 95 ha and height of three metres is will be present. It will be used and refilled progressively as WRDs are built and closed. Waste soil that is removed from WRD footprints will be added into the stockpile for reuse.

- **Processing site**

  The processing site will require construction of RE extraction processing units, RSFs and evaporation ponds. The waste process residues will be wet and fine.

Gaseous generating sources

Gaseous generating sources will be based at the processing site and include:

- **Processing plant**

  The processing plant emissions will have purpose built scrubbers.

- **Sulfuric acid plant**

  Once operational the processing plant demand for sulfuric acid will be serviced by an on-site sulfur-burning acid plant. It is assumed that the sulfuric acid plant will have a standard arrangement for obtaining SO_2 emissions of 4 lb/ST (2 kg/MT) or 99.7% conversion. Given the sulfur feed rate (11.7 tonnes/hr) the emissions of sulfur dioxide can be calculated.

- **Power station**

  Power demand will be serviced by cogeneration from a sulfuric acid plant and gas-fired on-site generation supplied by a group of combined cycle gas turbine-based generators. The primary pollutants of concern from a gas-fired plant are nitrogen oxides and carbon monoxide. Emissions of particulate matter, sulfur dioxide and other substances have not been considered due to a low emissions value.

3.13.2 Emission controls and dust suppression

Dust emissions from haul trucks can be minimised using various control techniques (discussed in Chapter 13); however, emissions from dumping waste rock have no controls. Only unquantifiable operational controls can be applied to waste rock dumping. These operational controls include gentle dumping of overburden on the WRDs.

A summary of the controls applied for the air emissions modelling are provided in Chapter 13. A maximum 74 per cent reduction in emissions from mining activities was found to be achievable with the application of identified control measures

3.14 Workforce and accommodation

3.14.1 Workforce

The construction and operations workforces are expected to peak at 500 and 300 respectively, however until detailed engineering and construction schedules are finalised, these numbers may change. It is anticipated that the operational workforce will include approximately fifty specialist / skilled positions.

It is expected that the workforce will comprise approximately 70% fly-in fly-out (FIFO) ex Alice Springs, and 30% BIBO ex Alice Springs and other local communities. It is anticipated that the BIBO component of the workforce will comprise 1/3 local workers (i.e. from Alice Springs and surrounding communities), 1/3 NT workers and 1/3 interstate workers who will move to the region to live.

Workers may work a two weeks on, one week off roster and will be housed in a dedicated accommodation village at the Nolans site, with overflow accommodation needs likely to be met by the nearby Aileron Roadhouse during operations. An additional 200-room temporary accommodation camp will be leased over the project’s construction period and will be removed following commissioning of the processing plant.

Workers will be required to use a dedicated bus service to travel to and from the Nolans site to Alice Springs or their local community at the beginning and end of their roster. Contractors are expected to be able to use their own vehicles to get to and from the Nolans site. Roster changes will be timed to coincide with flights in and out of Alice Springs to minimise the amount of time FIFO workers have to wait in Alice Springs.

Environmental management positions

Professional environmental staff will be employed to manage and undertake environmental management duties on the site. The number of staff will be directly proportional to the workload requirements both during construction and operations.

3.14.2 Accommodation

The accommodation village will be laid out to make use of the natural grade for drainage and earthworks and will be subject to a detailed site survey and geotechnical investigation.

The accommodation buildings have been set back to the rear of the site and the central facility buildings and utilities have been located at the front where they will be easily accessible for delivery vehicles. A light vehicle parking area will be located in front of the facility, as will bus drop off and pick up areas.

The most practical construction system for the village will be offsite prefabricated transportable buildings. These buildings are mostly of a modular type construction with larger buildings being multi-module style.

The buildings will use a range of noise and thermal insulation techniques to provide comfort and maximise energy efficiency. The central facility buildings will include the following:

- Kitchen and dining building with the capacity to comfortably cater for up to 400 people at up to 100 percent occupancy. A wet mess will also be included as part of the site facilities.
- Village administration building, office and shop.
- Recreation building that provides for a range of functions including inductions during construction, meeting hall and general assembly building.

Accommodation buildings will generally be provided as single module structures with a number of accommodation units per building. Each unit will comprise a small bed sit room and an ensuite bathroom. A small number of larger size rooms will be provided and these rooms will have separate bed and sitting rooms with facilities to allow personnel to use the accommodation as office space. Two accommodation rooms for disabled persons have also been included in the building design. A gymnasium and swimming pool have been included for recreation.

Utilities services to be provided to the accommodation village include:

- Potable water - Treated water (filtered and chlorinated) will be pumped from the processing plant to the village where it will be stored in a single tank. The tank has been sized for two days’ storage and will be divided into a higher level off take for potable supply and a secure (protected) lower level off take for fire systems. A constant pressure variable flow pump system will deliver potable water around the village using a buried pipe reticulation system. The water will be UV treated by lights in the line as part of the pump skid system. A temporary water supply will need to be established as an interim measure until the plant supply system is commissioned. Depending on the timing for establishment of bores, it may be necessary to truck potable water to site during the initial months.

- Fire systems will include detection systems and active fire suppression systems. Detection systems will include hard wired smoke detectors to all buildings and break glass audible alarms. Suppression systems will include extinguishers fixed outside all buildings, full hose reel coverage of the village and several hydrants located strategically around the core facilities. The hydrants will be supplied from a dedicated electric / diesel fire pump system. A fire break will be maintained around the outer perimeter of the village to minimise the risk from grass/wild fires. Hydrant / hose reel coverage of the perimeter around the village will also be provided. Fire support will be available from a fire unit located at the processing plant.
- Sewage will be collected from around the village using a conventional gravity reticulation system. This will drain to a single pump station within the village compound. From the pump station, sewage will be pumped to a treatment plant located near the processing plant. The treatment plant will be a package type unit providing a level of treatment in compliance with environmental approval conditions.
- Power will be generated at the processing site and transmitted to the village by overhead high voltage (11 kV) conductors. At the village there will be a kiosk substation from where power will be reticulated below ground at low voltage (415 V). Sub mains will lead from the substation to local distribution panels, which will in turn feed the individual building modules. While the process plant is under construction, power will be generated at the village using temporary diesel gensets. One or two of these gensets will be retained in the longer term to provide temporary backup for essential village services in the event of a power outage.
- Communications in the village will comprise mobile telephone services, two-way radio, data / internet services, and television / entertainment services. The provision of head services has been included in the mine and concentrator estimate scope. Reticulation of communications around the village will be achieved using a fibre backbone system installed in common trenching with other utilities. A separate communications building will be established.

Application of the *Department of Health Fact Sheet No. 700 Requirements for Mining and Construction Projects* will be considered during detailed design and operation of the project. The serving of alcohol on site will be in accordance with NT licencing requirements.

04

Project alternatives and cumulative impacts

4. Project alternatives and cumulative impacts

4.1 Introduction

This chapter discusses the alternatives considered during planning and scoping of the Nolans Project in Central Australia, and introduces potential cumulative impacts arising from compounding activities of multiple mining and processing operations, as well as aggregation and interaction of mining impacts with other past, current and future activities.

The TOR for the preparation of an environmental impact assessment issued by the NT EPA provided the following objectives in relation to alternative proposals:

> *Alternative proposals, which allow the objectives of the Project to be met, should be discussed … and the advantages and disadvantages of preferred options and alternatives detailed. The short, medium and long-term potential beneficial and adverse impacts of each of the options should be considered and associated risks should be detailed and analysed.*

Section 3.3 of the TOR provided the following environmental objectives in relation to cumulative impact:

> *An assessment of cumulative environmental impacts should be undertaken … to ensure that any potential environmental impacts are not considered in isolation.*

This chapter describes the project alternatives that have been considered by Arafura as part of the development process, and the potential cumulative impacts stemming from the effects of the Nolans Project on top of impacts that may arise from other significant mining or infrastructure projects within the local area. This includes impacts on community, environment and MNES, the duration of the potential impacts and potential mitigation measures.

4.2 Project history

The Nolans Project was initiated in 2005, and since then technical and commercial scoping and development has been ongoing in order to address the project's opportunities and constraints.

The Nolans Bore rare earths deposit comprises unique mineralogy that presents technical challenges in processing and recovery. The project's development timeframe has therefore been necessarily lengthy and has required a significant research and development phase. The benefit of this lengthy development timeframe is that Arafura has had the opportunity to gain significant insight into the project, the development options and appropriate outcomes for the owners, the stakeholders and the environment.

Various project development streams have been ongoing since project inception that focus on process and recovery including economics, process technical feasibility and treatment options, and marketable products. The planning and development phase has also had a focus on project optimisation, de-risking the project and mitigating the project's impacts, including impacts on the environment.

Accordingly, a range of project locations and processing configurations, project inputs and mitigation options have been considered and investigated.

The project alternatives considered since project inception include:

- Not proceeding with the project
- Location / configuration
- Processing alternatives
- Mining methodology
- Raw water supply
- Raw materials supply
- Carbonate material
- Power supply
- Accommodation
- Project supply, logistics and transportation
- Kerosene Camp Creek diversion
- Rehabilitation and closure.

4.3 Project Alternatives

4.3.1 Not proceeding with the project

Not proceeding with the project is an alternative in an economic environment dominated by falling commodity prices and increasing processing costs.

The Nolans Project has the potential to provide significant short and long term economic and social benefits to the Northern Territory and particularly to the Central Australian region including:

- Annual production and export of up to 43,000 tonnes of intermediate rare earths product (which represents a sizable supply alternative to Chinese production of this strategic material) and a source of production royalties and taxation payable to the Northern Territory and Australian governments
- Capital expenditure of about $850 million on construction of the mine, concentrator and processing plant, which includes nearly $145 million in the Territory and of that, about $70 million in Central Australia
- Operational expenditure of approximately $38 million in the Territory including about $18 million per annum in Central Australia, over the 40+ year life of the project
- 400-500 direct construction jobs
- 250-300 direct operations jobs
- Business opportunities to supply goods and services during construction and operations, with some coming from local suppliers in Alice Springs and other nearby communities
- Community benefits and royalties over the life of the project to local stakeholders.

These and other economic and social benefits are discussed in more detail in Chapter 15 and Appendix S and Appendix T.

4.3.2 Location / configuration

The Nolans Bore deposit contains moderate grades of rare earths and phosphate, and a relatively low grade of uranium. Given the mixed nature of the deposit, there are a range of challenges in economically processing the ore away from the general mine site.

Two options were investigated for an off-site processing location prior to Arafura deciding to locate most of the operation at the Nolans site.

Option 1 - Mineral concentrate transported from Nolans mine site to a Darwin processing plant

The initial project configuration included an open cut mining operation and concentrator, producing about 600,000 tpa of mineral concentrate which was then to be transported via a dedicated haul road, crossing the Stuart Highway, from the mine site concentrator to the Adelaide-Darwin railway line for loading and rail transport to Darwin. A large processing facility including a separation plant was to be built at Wickham Point in Darwin Harbour.

This configuration was eventually rejected based on logistical issues and environmental challenges which included:

- Water supply at the processing site could not be secured
- Land availability at Wickham Point was limited
- The size of evaporation ponds to manage water requirements and rainfall events in a cyclone region was excessive
- The logistics of transferring large volumes of reagents from the Darwin Port through an urban environment to Wickham Point were difficult
- Project power requirements could not be met
- Stakeholder resistance was anticipated, for a project near Darwin Harbour, processing a mineral concentrate containing rare earths and radioactive elements.

Option 2 - Mineral concentrate transported from Nolans mine site to China

The option to export up to 600,000 tpa of mineral concentrate to China for downstream processing was also considered early in the life of the project. However, it was rejected on the following grounds:

- The concentration of radionuclides in the mineral concentrate greatly exceeded the allowable limit of 0.05% defined in the relevant Australian export control regulations. This will make exportation difficult without onerous approvals and chain of custody controls.
- Uncertainty surrounding Chinese Government policy and potential constraints imposed by it on the marketing and commercial viability of rare earths.

Option 3 – Mineral concentrate transported from Nolans mine site to a Whyalla based processing plant

Option 3 considered an open cut mining operation and concentrator, producing 600,000 tpa of mineral concentrate, which was to be transported via a dedicated haul road, crossing the Stuart Highway from the mine site concentrator to the Adelaide-Darwin railway line for loading and rail transport to Whyalla in South Australia. A large processing facility including a separation plant was to be built on land owned by Arrium Steel near the steel works. This location and configuration was also eventually rejected based on a number of logistical and cost issues, and environmental challenges which included:

- Cumulative construction costs associated with the transport infrastructure (haul road, highway underpass and rail siding) linking the Nolans mine with the Adelaide-Darwin railway
- Water supply in Whyalla could not be secured without the construction of a large desalination plant
- The logistics of transferring large volumes of reagents via Port Adelaide and Spencer Gulf, in addition to transporting mineral concentrate from the Nolans mine to Whyalla
- Gas requirements could not be met without substantial pipeline upgrades
- Storage areas and stockpile requirements for processing by-products (e.g. gypsum) were problematic
- Environmental concerns around cumulative project impacts in the Upper Spencer Gulf. The Olympic Dam copper-uranium expansion was being considered at that time and a large desalination facility was being contemplated for that development. The Upper Spencer Gulf is a known breeding ground for the giant cuttlefish
- Cost of construction to build a processing plant to include what would have been Australia's largest chlor-alkali plant (for pre-leach processing and rare earth separation).

Option 4 - Mineral concentrate at Nolans mine site and a Nolans site-based processing plant

Following the discovery of a water supply suitable for the project southwest of the Nolans mine site in late-2012, work then focused on reconfiguring the project for a Central Australia operation. Two sub-options were considered:

- Option 4a – all project infrastructure at the mine site, separation offshore
- Option 4b – project infrastructure split into two parts, separation offshore

Option 4a

Initial project scoping located all project infrastructure at the mine site. After investigation, this configuration was modified to remove the final rare earth separation plant to an offshore location.

The final separation (refining) phase of rare earths recovery requires large quantities of hydrochloric acid and caustic soda. It was concluded that this part of the process should be completed nearer to sources of these reagents where plentiful supply is available as by-products of existing large-scale chemical operations. This aspect of the project was further investigated and two locations have been selected for final scoping and assessment, one in South Korea and one in the Gulf States region of the USA. This decision also removed the requirement to transport very large volumes of liquid reagents to the Nolans site from Darwin Port.

Whilst the project configuration investigation was occurring, environmental studies and community consultation work was ongoing. From these, stakeholder concerns were raised about the placement of the processing plant within the Ti Tree Basin catchment. Arafura did not conduct any hydrological studies to determine if the proposed processing plant would impact on the Ti Tree Basin catchment, but elected to investigate a modified split site configuration to address these perceptions and concerns.

Option 4b

This option considered splitting the site operations into two parts resulting in a mining operation and concentrator at the Nolans Bore site, and a processing facility about eight kilometres south of the mine site. This will place the processing plant in the Southern Basins water catchment, thus removing it from the Ti Tree Basin catchment. A suitable area was selected on shallow basement rock located near the Amadeus Basin – Darwin natural gas pipeline.

Mineral concentrate will be pumped to the processing plant via a bunded slurry pipeline running between the two sites. An access road will connect the two sites and a power and water corridor will follow the road alignment.

The decision to relocate and consolidate the processing plant back to the Nolans site in Central Australia has a number of clear, short and long-term economic benefits for the region and additionally has other logistical and environmental benefits. These include:

- Transport of large quantities of radioactive mineral concentrate (600,000 tpa) via road and rail through communities (e.g. Alice Springs) is eliminated
- All radioactive elements remain at the Nolans site following processing and removal into secure storage
- Reduced importation of reagents and transport requirements
- Increased opportunities for regionally based infrastructure to leverage off the project.

Option 4b is the option proposed in this EIS.

4.3.3 Processing alternatives

Test work and optimisation has been completed to determine the most efficient way to produce a mineral concentrate (i.e. beneficiation) from Nolans Bore. This research and development test work has been ongoing since 2005 and has been supported, in part, by Commonwealth grants and test work in Commonwealth laboratories including CSIRO and ANSTO. The initial comminution test work utilised multistage crushing and screening. This option has now been replaced with an alternative single stage crushing process and a grinding circuit. The most important advantage of this change in the comminution process has been a significant reduction in potential dust emissions, throughout the life of the mine.

Hydrometallurgical test work has been undertaken over the past eight years. These programs have employed a variety of leaching acids to deliver the most cost- and capital-efficient process option. Arafura has investigated a hydrochloric acid-based process, but from an economic and risk management perspective, the case for sufuric acid (i.e. sulfuric acid pre-leach – double sulfate precipitation, or SAPL-DSP) has outweighed the alternative process.

Arafura continues to investigate further process improvements. An alternative pre-leach reagent and purification process currently remains under active consideration, however the SAPL-DSP process is technically proven and financially viable' and is the foundation of the project described in this EIS.

Additionally, Arafura has and will continue to investigate the recovery of all potential products from the Nolans Project, including rare earths, phosphate and uranium. The current SAPL-DSP process is focused only on the commercial recovery of rare earths, however if the economics of phosphate or uranium improves sufficiently; or should a commercial market for thorium emerge, consideration may be given to modifying the process to recover and commercialise some or all of these co-products, or to investigating the viability of co-product recovery from tailings or process residues.

4.3.4 Mining methodology

The Nolans Bore resource is near surface and extensive. It occurs as wide, steeply dipping interconnected veins and zones, and as a consequence, is most efficiently mined using open pit truck and haul methods. The resource is delineated only to a depth of 215 metres below surface however, and deeper drilling demonstrates that mineralisation continues down beneath this level.

Consequently, underground mining may be contemplated in the future, following the open pit mining of the upper section of the orebody; but this is unlikely within the current life of mine plan. The current mining schedule (see Chapter 3) is aimed at optimising recovery of the orebody using the open pit mining methodology.

4.3.5 Raw water supply

In 2010, a source for a sustainable water supply for the mine and concentrator were investigated based on processing off site. Initial investigations focussed on locating a groundwater supply from the Ti Tree Basin, a 25-30 kilometres north and northeast of the mine site. These investigations were successful and established the presence of a suitable groundwater supply for the mine and concentrator requirements, of up to two gigalitres per annum.

In the latter part of 2012 Arafura began scoping a shift of the processing plant from Whyalla back to the Nolans site. As part of this process, and taking account of the likely increased raw water requirements of an expanded operation at Nolans, it became apparent that the concerns of competing users of the Ti Tree Basin and other stakeholders will need to be considered. Consequently, the company undertook a wider regional search for alternative sources of groundwater.

In 2012 alternative studies into securing a larger groundwater supply were initiated, in order to facilitate a shifting of the processing plant back to the Nolans site. The Ti Tree Basin would not be suitable for this process, due to competing users of this resource and stakeholder concerns.

In December 2012, Arafura commenced a water exploration program about 35 kilometres southwest of the mine site. This initial exploration was successful and a follow-up investigation program was completed in early 2013. This program confirmed the presence of an extensive groundwater system of aquifers, and was a key determinant in the company's decision to relocate the processing plant to the Nolans site.

Subsequent investigation and modelling have now confirmed this alternative water supply can sustain the Nolans Project well beyond the present life of mine, whilst also providing water for pastoral usage on a substantial area of Aileron Station which previously was unproductive. Details of the hydrogeological investigation work is provided in Appendix K.

Studies have also been completed to minimise raw water requirements. The production of rare earths is a water intensive process, requiring a number of washing phases for purification. Since the initial process design and test work was completed for the project however, the raw water requirement has been reduced by about 40% from 6 GL to 4.2 GL per annum.

Further optimisation is occurring, with aim of further reducing raw water supply requirements. Groundwater from the mining operation, packaged sewerage treatment plants and tailings return are intended to be recycled and reused throughout the project. A packaged water treatment plant will be incorporated into the processing plant to provide potable water for personnel and a treated supply for critical cleaning aspects of the rare earths processing. Process water that can no longer be recycled will be disposed via the TSF, RSFs or evaporation ponds.

4.3.6 Raw materials supply

The project has a range of raw material requirements for construction and operations. It is intended that the bulk of the raw materials, which includes rock, gravel, sand, topsoil and carbonate material, will be sourced either from within or near the Nolans site.

Rock will be selected during the initial pre-strip of the pit for use in various aspects of construction. Care will be taken to ensure this material is benign in terms of its chemical composition and radionuclide concentrations.

Gravel material will be sourced from an old road construction quarry on the Stuart Highway about 25 kilometres from the processing plant, or from a local source on Aileron Station about 12 kilometres from the plant. Prior to this occurring the necessary regulatory approvals will be sought. Other gravel for cement manufacture will be transported to site from quarries near Alice Springs.

Sand also required for cement making will be mined from that part of the Kerosene Camp Creek that will be mined as part of the open pit. Any additional sand requirements will be sourced locally but appropriate approvals will be sought prior to this occurring.

Topsoil will be removed as construction progresses, and will be stored in designated areas around the operation to ensure adequate quantities are available for use in rehabilitation. It is intended that topsoil removal will be staged as much as is practicable and reused progressively to ensure the viability of the soil is maintained.

4.3.7 Carbonate material

Carbonate material is required in the processing operation to maintain pH control. Arafura has investigated two alternatives for providing the required volumes needed for the project.

Option 1 considers transporting processing reagent requirements for pH control (lime) to the Nolans site from external suppliers (30,000 tpa). This would require additional rail transport and road transport for the life of the mine, on the Stuart Highway.

Option 2 considers site-based and nearby supplies of suitable carbonate material. The preferred strategy is to initially mine known calcrete occurrences at the mine site. These areas will eventually be buried by WRDs.

In addition to these modest resources, a large mapped occurrence of marble is located on Pine Hill Station that adjoins Aileron Station along its north western boundary. Initial test work on this material indicates it may be suitable for acid neutralisation, but further work is required to verify this. Arafura intends to complete an exploration program over the area to confirm sufficient marble is present to support the life of mine requirements of the project.

Should process test work and exploration prove successful, Arafura will seek a separate mining and environmental approval for a small quarrying operation of about 125,000 tpa. This would include the construction of an internal project haul road connecting the quarry with the processing plant (Figure 4-1). This small quarrying operation would provide further economic and social opportunity in the local region, but has not been factored into any of the studies presented in this EIS.

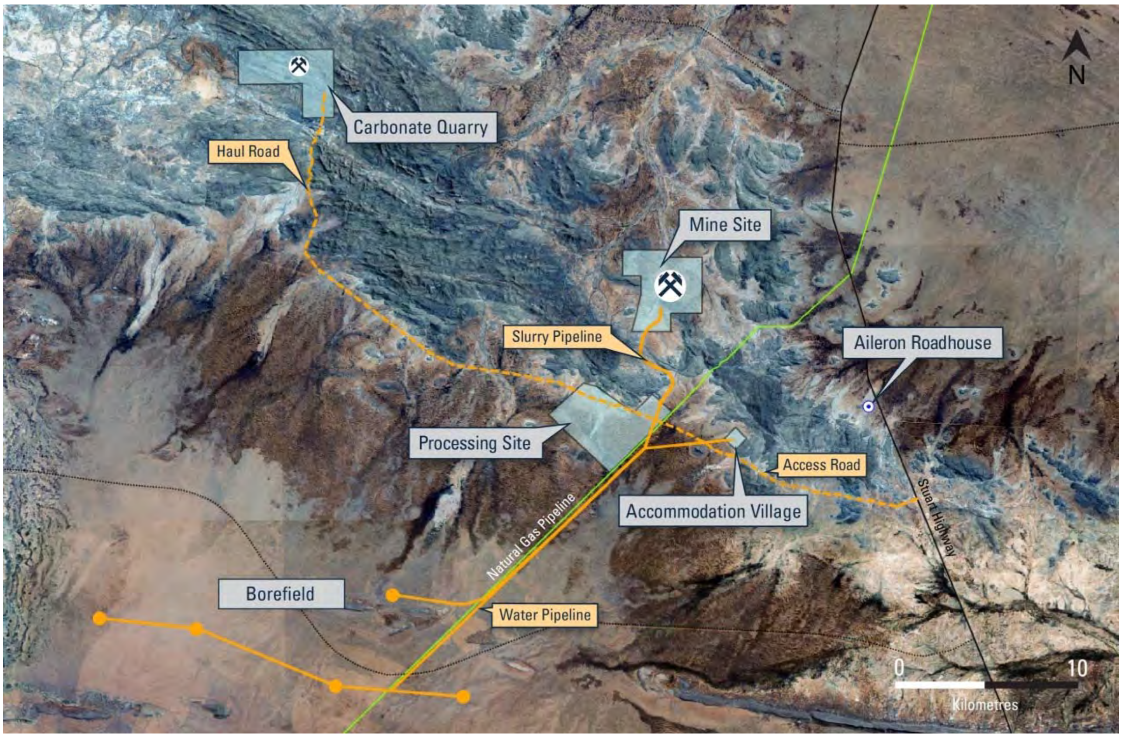


Figure 4-1 Nolans Site Layout, including the Woodforde Carbonate Project (source Arafura 2014)

4.3.8 Power supply

The inclusion of sulfuric acid plant within processing facility will also enable the project to recycle heat energy created from the exothermic reaction when producing sulfuric acid to be used to produce steam for turbines to generate about 6 MW of power. This recycling will enable 6 MW of gas fired generation to be turned off for long periods except when the acid plant is shut down for maintenance or repair, thus providing cost savings and reducing project emissions.

Additionally, Arafura is engaging with a number of power providers to investigate the potential for a regional power station, to not only service the project's requirements, but also the potential needs of local communities and horticultural developments in the Ti Tree Basin.

4.3.9 Accommodation

Two options for providing accommodation to employees have been investigated for the project.

Option 1 considered constructing the project's accommodation needs in close proximity to the Aileron Roadhouse. This was possible when the project's onsite scope was limited to a mine and concentrator, and a smaller estimated workforce of about 150. This would have provided significant growth for facilities at the roadhouse.

Option 2 followed reconfiguration of the project to incorporate a processing plant. It was determined that the placement of an accommodation village near the roadhouse to cater for a much larger workforce (250-300 during operations) would place too significant an impact on the operation and character of this iconic location. Locating a substantially larger village near the roadhouse would also increase the likelihood of interactions between the project workforce and local and passing trade, potentially leading to social tension and related issues.

The project's accommodation village has subsequently been relocated to a site four kilometres southeast of the processing plant. Additional temporary construction accommodation may be required during construction of the project but this will be removed as soon as practicable following completion of construction.

The roadhouse is only 20 kilometres by road from the project. To ensure economic benefits are realised locally, it is intended that visitors, shutdown workers, etc. will still be accommodated at the roadhouse facilities, to reduce the need for ongoing additional accommodation at the project.

4.3.10 Workforce transportation

Options to transport both the construction and operational workforce to the Nolans site from Alice Springs have been investigated.

Option 1 considered a fly-in fly-out operation directly to the Nolans site but this was ruled out because of cost, and because the option did not take advantage of the excellent regional transport infrastructure in Alice Springs.

Option 2 is the current proposal considered within this EIS. The construction and operational workforce will be bused in and out of Alice Springs to the site. Traffic volumes on the section of Stuart Highway between Nolans and Alice Springs are relatively low and the incremental additional traffic resulting from this option is unlikely to have an impact on other highway users or highway safety. Safety concerns with the use of private vehicles to and from site was another contributing factor in reaching this decision.

Consideration may be given to upgrading the Aileron Station airstrip to deal with emergency response situations.

4.3.11 Project supply logistics and transportation

Options have been investigated to provide logistical support and supply transport to the project.

Option 1 intended that a rail siding and logistics handling area would be constructed either 65 kilometres east of the project or just north of the Plenty Highway / Adelaide-Darwin rail intersection. Both of these options were discarded based on construction costs and the operational requirements of these types of facilities. There would also be additional short and long term environmental impacts from the construction and operation of this handling area.

Option 2 is the preferred alternative. This considers using existing logistical facilities and transport operators based in Alice Springs. The incremental impact of using the Stuart Highway as the main supply access to the project is low. This option will also result in the better use of existing local facilities, economic opportunity for local business, and local employment opportunities throughout the life of the mine.

4.3.12 Kerosene Camp Creek diversion

The existing course of the ephemeral Kerosene Camp Creek must be diverted as it intersects the planned open pit. This creek has a catchment of about 26 km^2 upstream of the pit and it is planned to divert the creek early in the establishment of the mining operation. Seven options for this creek have been considered, with four involving realignment. They are:

- Option A. Realign the creek bypass upstream of the pit to the west of the pit perimeter between the open pit and a natural hill at the western end of the pit, following the pit perimeter and then back into the original creek channel
- Option B. Realign the creek bypass upstream of the pit to the west between two natural hills and then around a small natural hill and then east back to the northern edge of the pit perimeter between the open pit and the northern WRD and then back into the original creek channel

- Option C. Realign the creek bypass upstream of the pit to the east around the pit perimeter between the open pit and the ROM pad and concentrator and then north and back into the original creek channel
- Option D. Realign the creek bypass and establish the diversion to the west between two natural hills and establish the channel to flow into a western arm of the Kerosene Camp Creek system
- Option E. Build a wall across the creek upstream of the pit and create an event pond to deal with storm events. Install a pump and pipeline and pump collected flow around the pit and back into the original channel
- Option F. Allow the creek to intersect with the pit and manage flow into the pit via the mine pumping system
- Option G. Mining of the western end of the deposit would not be undertaken and therefore the creek could remain in its original course.

The four realignment options considered (Options A through to D) are shown in Figure 4-2.

All options were investigated and assessed for their level of risk. Options A, B, C all require permanent diversion of the creek with regular prolonged road crossings for mining equipment and trucks that result in increased risks associated with the deposition of contaminated material into the creek bypass. They are also very close to dust sources, which present management challenges. These non-preferred options also feature difficulties in managing anticipated surface runoff from entering the creek system prior to monitoring and potential release.

Option D is the preferred option. This option also requires permanent diversion of the creek but keeps the creek diversion further away from mining activities and substantial ground disturbance, thereby reducing the risk of offsite contamination.

Options E and F present management and safety challenges, and Option G has significant economic implications for the project as a material quantity of ore would be excluded from the mining and processing inventory.

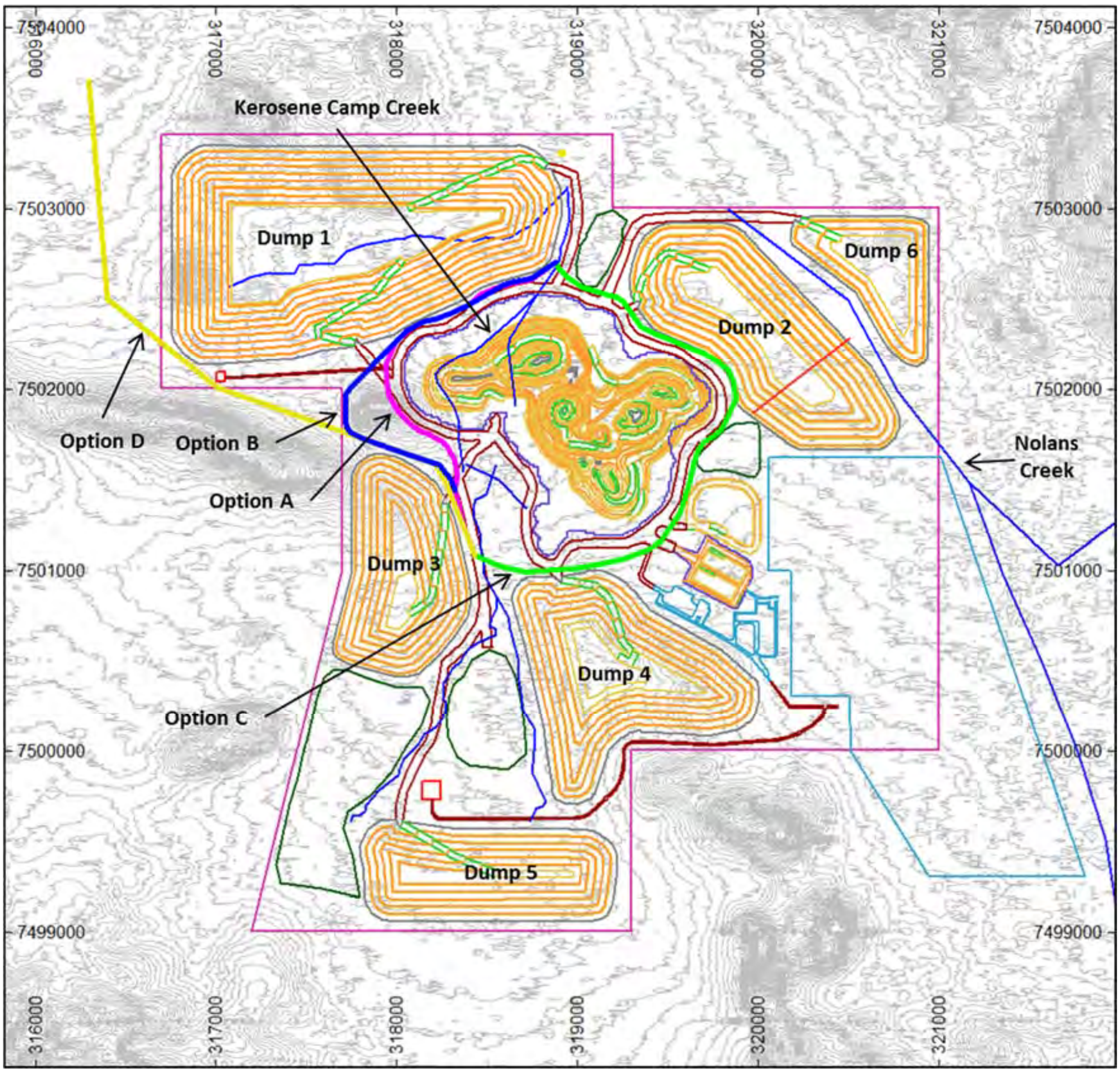


Figure 4-2 Kerosene Camp Creek Diversion Options (Source: Knight Piésold 2014)

4.3.13 Rehabilitation and closure

A closure concept design has been completed for the infrastructure components on the Nolans site, namely WRDs, TSFs and RSFs. These have been sited to avoid, as far as practicable, natural features on the site, and when completed and decommissioned will be rehabilitated to return the land to its pre-mining land use, that being pastoral activity.

It is proposed that all rehabilitation will be progressive on waste rock dumps, and the TSF and RSF cells will be closed down and rehabilitated during the operational phase of the project.

The mine and waste rock dumps are situated on a plain surrounded by natural rocky hills. The locations of the WRDs have been designed to avoid rectangular shapes to ensure they assume a more natural appearance when rehabilitated.

The nearby rocky hills are known to provide habitat for the Black-footed Rock wallaby and it is Arafura's intention during the final rehabilitation process to utilise larger waste rocks from the mining process to artificially create suitable habitat on the WRDs to encourage colonisation post mining.

These WRDs will also be designed as water-retaining structures i.e. to encourage water infiltration and assist vegetation establishment on the tops of the dumps. The tops of the dumps will be broken into a series of small cells so when it rains, water is retained and the vegetation can establish rapidly. These retention cells will also assist in reducing erosion risk from water discharge down the dump face.

Over the life of mine, a total of around 300 million tonnes of waste rock will be mined. Pegmatite and schist lithologies together account for about 25% of the total waste rock mass. The company's geochemical characterisation studies on waste rocks indicate that a small percentage (around 1%) of these particular waste lithologies may require additional management that could include encapsulation within benign waste rock. Confirmation of the quantity of waste rock that falls into this category will be determined pre-production following additional classification studies during pre-strip, etc.

In addition to geochemical characterisation, Arafura has developed a waste rock model to classify the rock lithologies into two broad categories based on radioactivity. A combination of analytical data and geophysical data was used to derive the model which classifies waste rock as either <1 Bq/g (i.e. benign), or >1 Bq/g (i.e. low-level naturally occurring radioactive materials, or low-level NORM). Very conservative parameters were used when constructing the model and consequently the amount of waste rock in the low-level radioactive waste category is likely to be overstated.

Waste rock >1 Bq/g will be managed by placing it within the waste rock dumps and covering it with benign waste rock. It should be noted that waste rock in this classification presents little or no risk to humans; nevertheless, it will be treated very conservatively. About 50% of the total waste rock mass falls into each of the above categories so there is adequate benign waste rock to provide a cover for all mine closure activities. One metre of benign material is more than adequate to encapsulate and shield radioactive material within the WRDs, or in the TSF and RSFs.

The open pit will remain as a pit void at the cessation of mining. The geometry and grade distribution of the Nolans Bore resource does not facilitate open pit mining by multiple pits, which might allow mining and backfill. Mining will commence in individual pits but these will quickly coalesce into a single large open pit as it deepens to access the orebody at depth. Arafura is yet to define the depth extent of the deposit. Arafura cannot justify deeper exploration drilling at present, and in any event, sufficient resources have been delineated to support 40+ years of production.

At the end of mining a pit lake will form in the bottom of the pit. The pit itself will be a natural water sink on the mine site with all natural mine site groundwater flowing into the pit rather than around or away from it.

Arafura is a member of the Minerals Council of Australia (MCA) and as such will, once operational, undertake audits to assess performance against the MCA's 'Enduring Values' charter. The company produces an annual sustainability report and this will be expanded when operations commence to report against the various management plans and objectives. The MCA produces best industry practice guidelines and these will be used to guide and assist rehabilitation and management programs at the Nolans operation. Arafura also intends to develop an integrated management system compliant with Australian ISO 14001, 4801 and 9001 standards. Following an implementation period, Arafura will seek third–party certification of this system.

4.4 Assessment of potential cumulative impacts

4.4.1 Projects

The location of the Nolans site is isolated from other major potential projects. The closest activities and other potential projects to the site are:

- Rum Jungle Resources Ammaroo phosphate mine about 100 km to the north east
- TNG Mt Peake titanium-vanadium mine about 140 km north
- Australian Abrasive Minerals Harts Range garnet mine, about 140 km south east
- KGL Jervois copper mine about 250 km east
- Tellus Chandler salt mine and waste storage facility about 250 km south.

The technical assessments provided in Chapters 7 to 19 provide a description of the existing environment and potential impacts that may result from the Nolans Project, including cumulative impacts.

Section 4.4 below summarises the cumulative impacts that may arise in combination with the projects identified above.

4.4.2 Cumulative socio-economic impacts

The cumulative socio-economic impacts are likely to impact on the larger geographic region, including Alice Springs, as a result of other large projects potentially going through construction and commissioning phases at the same time. Impacts may include drawing on a common workforce, services and supplies or creating cumulative pressures on key government services.

Other potential major projects in Central Australia in addition to those identified in section 4.4.1, include potential expansion of the Newmont Granites gold mine (Tanami) drawing on the same employment pool from around Ti Tree, and Central Petroleum and Metals X nickel-cobalt Wingellina project which may source supplies from Alice Springs.

Additionally, a proposed railway from Tennant Creek to Mt Isa, Jemena's proposed Northern Gas Pipeline and other potential construction projects in and around Alice Springs may also source supplies from Alice Springs. The timelines of these projects are uncertain, however some are imminent.

Some of the key potential positive cumulative impacts arising from concurrent resource project developments, including the Nolans Project, are:

- Opportunity for the establishment of shared regional infrastructure, leveraging off the resource developments (e.g. regional power station potentially providing competitively priced electricity for horticultural development)
- Growth of the horticultural sector around Ti Tree and the opportunity to provide produce to caterers working at accommodation villages (with shortly supply chains and more lucrative local markets)
- Collaborative employment and training programs for local Aboriginal people, both with other resource companies and Central Desert Regional Council
- Combined recruitment campaigns with other employers to encourage families to move to Alice Springs, including a potential pool of migrants moving to Alice Springs for work
- Greater capacity within the Central Australian service and supply industry, with reduced reliance on individual projects

- A greater population base in Alice Springs, with increased retail spending, a stronger regional economy and other spin-offs including more recreational facilities and sponsorships.

Potential adverse cumulative impacts include:

- The balance of water allocation to major projects in both Alice Springs and the broader Central Australian region are perceived to impact on communities, pastoral properties and horticulture
- Demand for accommodation in Alice Springs for both management staff, specialist contractors and FIFO workers impacting on tourism
- Pressure on potential employees and services in Ti Tree and Alice Springs, should both the Nolans Project and TNG's Mt Peake project start work within a similar timeframe
- Compounding workforce and recruitment shortages as people leave existing jobs to work at the mines, particularly for other businesses and the tourism and hospitality industry
- FIFO workers creating pressure on the cost and availability of flights to Alice Springs
- FIFO workers or those who relocate to Alice Springs to work on the projects, congregating in hotels and night spots, leading to antisocial behaviour
- The cumulative pressure of workers and their families exceeding available housing supply (rental and purchase), thus forcing prices and the cost of living up and increasing demand for public housing
- A negative image for the mining industry from wider concerns about legacy issues from mining.

4.4.3 Heritage

Whilst all Aboriginal archaeological places and objects are protected under NT legislation, destruction of some sites may be necessary to allow project activities to proceed. Without mitigation (such as avoiding certain types of landscape features), archaeological resources are also expected to be unknowingly impacted by the proposed infrastructure.

Whilst other projects will not directly impact the same places and objects affected by the Nolans Project, regionally there will be a cumulative increase in the potential impact to Aboriginal heritage across the Central Australian region, through the loss or damage of sites or objects.

4.4.4 Other impacts

The majority of water for the project will be sourced from the Southern Basins borefield. Modelled drawdown from the operation peaks at approximately six metres in the centre of the borefield. The predicted drawdowns are negligible in the Lake Lewis area and not likely to be measureable. Use of the Southern Basins borefield is not proposed by other projects and therefore no cumulative impacts due to other projects are considered likely.

Surface water impacts will be localised to the mine site and therefore will not be increased cumulatively by other projects or activities.

Impacts to flora and fauna have been assessed as relatively low and localised. It is likely that cumulative, localised impacts associated with significant numbers of resource projects in the region have the potential to impact on biodiversity conservation in Central Australian bioregions including the Burt Plain bioregion where the project is located. The Nolans Project has already, and will continue to, contribute to knowledge about the ecological integrity of threatened species populations in the local area.The implementation of a biodiversity management plan containing conservation activities including regular population monitoring surveys will aid this knowledge base. Additionally, Arafura will continue to review and be guided by the current threat abatement and recovery plans for listed species that are relevant to the project.

Traffic volumes on the section of Stuart Highway between Nolans and Alice Springs are relatively low and the incremental additional traffic resulting from the project is unlikely to have an impact on other highway users or highway safety. Any additional traffic from other projects is not expected to significantly restrict capacity of the highway network.

05

Risk assessment

5. Risk assessment

5.1 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 Nolans 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 TOR for the preparation of an environmental impact assessment issued by the NT EPA for the Nolans 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.

5.2 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 5-1.

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 3), 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.

A risk assessment for socio-economic risks was completed in a separate risk assessment workshop. This allowed for methodical consideration of the potential social, economic and heritage impacts of the project, many of which are relatively distinct from other potential environmental impacts.

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

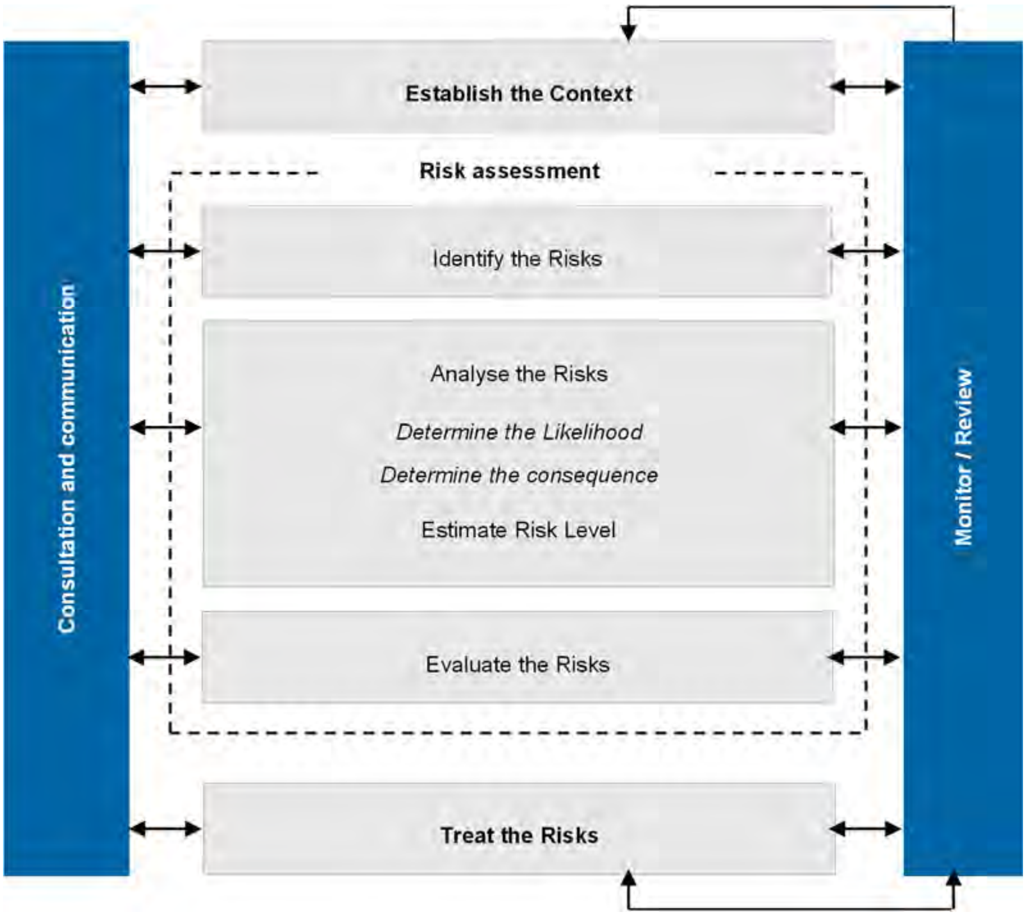


Figure 5-1 Risk management process (AS/NZS ISO 31000:2009)

5.2.1 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 along with existing condition reports 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.

5.2.2 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.*

5.2.3 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 5-1) and a level of likelihood in accordance with likelihood descriptors (Table 5-2).

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.

Some risk events can have consequences on multiple environmental receptors. To provide a meaningful and manageable risk register, these potential impacts were grouped as a risk event with each potential impact assessed separately.

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 (refer to the EMP contained in Appendix X).

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 5-3). The risk was then assessed against relevant criteria as shown in Table 5-4 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 5-5. 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.

5.2.4 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 EMP (Appendix X) 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.

5.3 Risk register

A risk register was established to document the findings of the risk assessment process, presented separately for environmental and socio-economic risks. 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. These are presented in Appendix F (environmental) and Appendix G (social).

Table 5-1 Project consequence descriptors

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
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
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	Local short term decrease in abundance of some species with no lasting effects on local population	Local long term decrease in abundance of some species resulting in some change to community structure	Regional decrease in abundance of some species resulting in some changes to community structure	Regional loss of numerous species resulting in the dominance of a few species
Historic and cultural heritage: Aboriginal and cultural heritage	Minor repairable damage to 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: Safety	Low level short term subjective inconvenience or symptoms. Typically first aid and no medical treatment.	Reversible / minor injuries requiring medical 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.

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Human health and safety: Health	Reversible health effects of little concern, requiring first aid treatment at most.	Reversible health effects of concern that would typically result in medical treatment.	Severe, reversible health effects of concern that would typically result in a lost time illness.	Single fatality or irreversible health effects or disabling illness.	Multiple fatalities or serious disabling illness 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 action level and dose limit (average over five year period).	>20 mSv/y and <50 mSv/y. Measurable increase in radiation dose with outcomes between dose limit (average over five year period) and maximum annual dose.	>50 mSv/y. Measurable increase in radiation dose with outcomes greater than the maximum annual dose.
Radiation: Public exposure	No change from background. Dose not discernible above natural background.	<0.3 mSv/y. Measurable increase in radiation dose with outcomes below public dose constraint.	>0.3 mSv/y and <1 mSv/y. Measurable increase in radiation dose with outcomes between dose constraint and dose limit (averaged over five years) for public.	>1 mSv/y and <5 mSv/y. Measurable increase in radiation dose with outcomes between dose limit (averaged over five years) and maximum annual dose for public.	>5 mSv/y. Measurable increase in radiation dose with outcomes greater than the maximum annual dose for public.
Radiation: Environmental impact	ERICA* RQ < 0.1	ERICA RQ >0.1 and <1.0	ERICA RQ >1.0 plus justification	ERICA RQ >1.0 and no justification	ERICA RQ > 10.0
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.	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.	Medium-term recoverable changes to social characteristics and values of the communities of interest or community has some capacity to adapt and cope with change.	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.	Irreversible changes to social characteristics and values of the communities of interest or community has no capacity to adapt and cope with change.

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
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 on public roads	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.

* Note ERICA is tool for the assessment of impacts of radiation on non-human biota where RQ is the risk quotient value.

Table 5-2 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 5-3 Project risk matrix

	Consequence				
Likelihood	**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 5-4 Risk criteria

Rating	Approach
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 5-5 Project data availability descriptors

Descriptor	Explanation
Low Level	Risk rating is based on subjective opinion or relevant past experience.
Medium Level	Risk rating is based on similar conditions being observed previously and/or qualitative analysis.
High Level	Risk rating 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.

5.4 Discussion of key outcomes

5.4.1 Risk assessment results

The environmental risk assessment identified 81 risk events, of which several had potential impacts on multiple environmental receptors. As a result, 135 impact pathways were identified and assessed through the environmental risk assessment process.

The separate social risk assessment identified and assessed 22 socio-economic risk events, of which 18 were potential negative impacts and four were potential positive impacts. Table 5-6 reflects only negative impacts, and its total of 20 socio-economic risk events includes two community risks and the 18 negative socio-economic risks from the social risk register.

The residual risk rating for most risks was rated as Low (Figure 5-2). Those rated Medium or High were the subject of particular attention in the development of further control measures and management plans.

The risk profile across the study area is presented in Table 5-6 and Figure 5-3, 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 Fauna and Socio Economics. There were no risks identified and assessed with an Extreme risk rating.

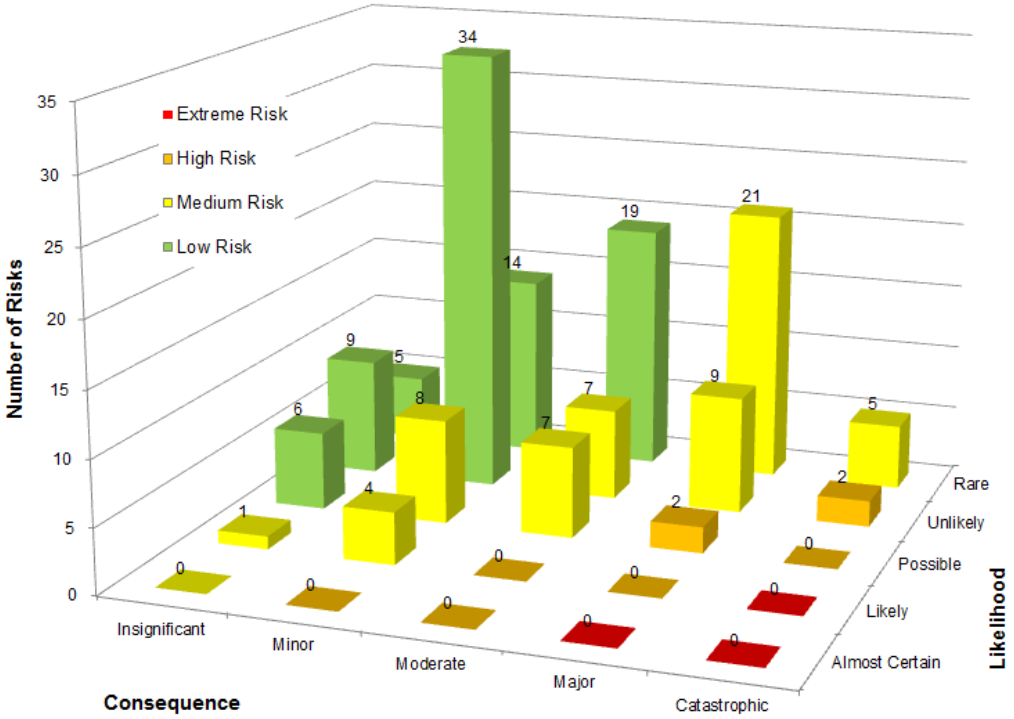


Figure 5-2 Whole-of-project residual risk ratings

Table 5-6 Summary of residual risk ratings by study area

Study Area	Low	Medium	High	Extreme	Total
Air quality	5	2	0	0	7
Socio-economic	12	7	1	0	20
Fauna	16	5	0	0	21
Flora	13	4	0	0	17
Groundwater	10	7	0	0	17
Historic and cultural heritage	4	1	0	0	5
Human health and safety	0	23	2	0	25
Mine closure	4	4	0	0	8
Radiation	12	2	0	0	14
Surface water	11	4	0	0	15
Transport	2	2	0	0	4
Total	89	61	3	0	153

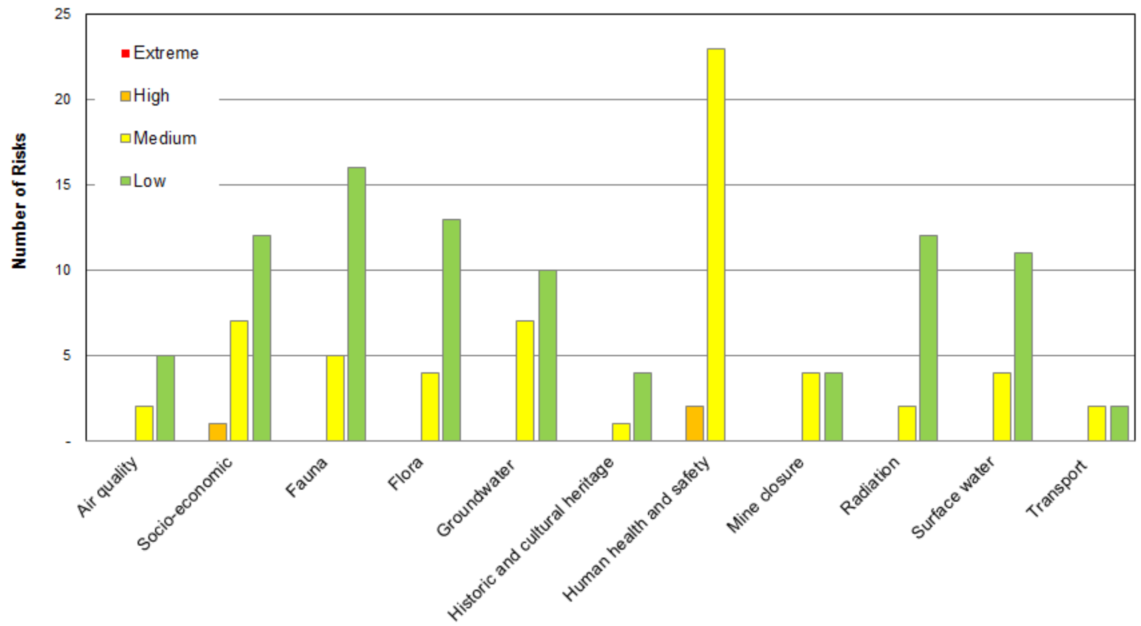


Figure 5-3 Distribution of residual risk ratings by study area

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

- 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 fauna and nearby sensitive receptors, from wind erosion of exposed surfaces and vehicle movement along haul roads
- Flora, vegetation communities and fauna habitat impact from spread of weeds and feral animals due to vehicle movements and/or inappropriate waste management
- Groundwater quality from seepage, embankment failure or overtopping of tailings, residue storage facilities and/or process liquor evaporation ponds
- Decline in availability of water to existing and/or future users, within the Southern basin from progressive water table drawdown arising from groundwater extraction rates
- 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.

After the application of additional control measures, the residual risk profile changes slightly from Figure 5-3 to that presented in Figure 5-4. 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.

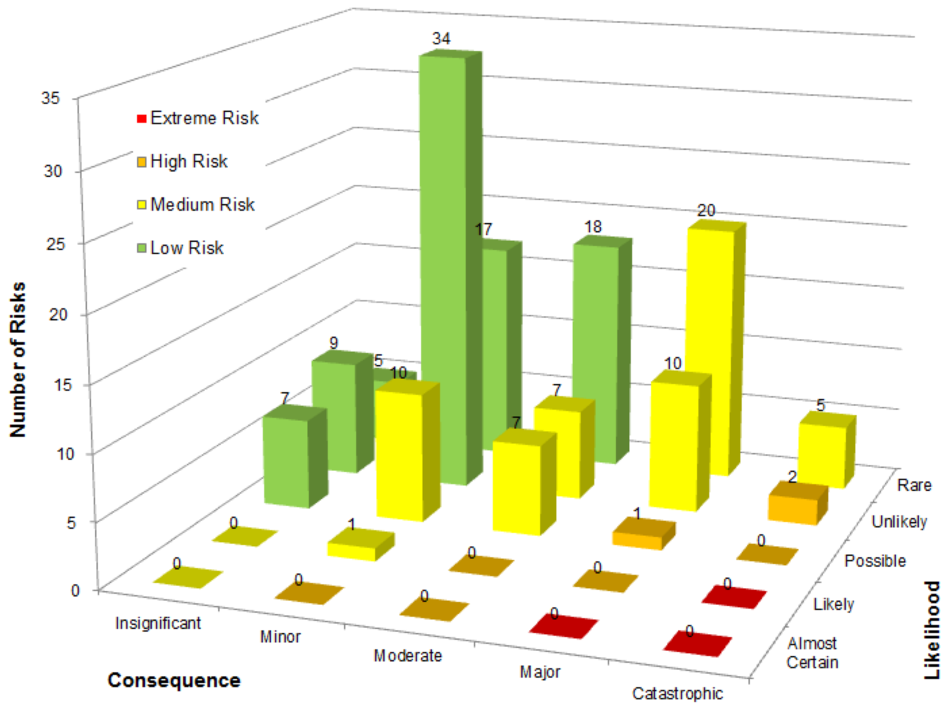


Figure 5-4 Whole-of-project residual risk ratings after additional control measures

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. The top three risks have a residual risk rating of high, and have been acknowledged as key areas for management:

1. Vehicle incident associated with the transport of materials and personnel off-site on public roads
2. Mobile equipment incident on site, including all operational areas and vehicle types
3. Project personnel mental health issues, including potential for self-harm, associated with or exacerbated by living away from home and lack of family / support networks.

5.4.2 Key control measures

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

- Air and Dust Management Plan
- Biodiversity Management Plan
- Cultural Heritage Management Plan
- Emergency Response Plan
- Fire Management Plan
- Hazardous Substances Management Plan
- Mine Closure Plan
- Non-mineralised Waste Management Plan

- Acid Metalliferous Drainage Management Plan
- Water Management Plan
- Erosion and Sediment Control Plan
- Weed Management Plan and
- Social Impact Management Plan.

5.5 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, and in particular the aspects in the EMP and associated sub plans.

06

Consultation

6. Consultation

6.1 Introduction

This chapter describes the consultation process, and key themes raised during consultation, for the proposed Nolans Project. The chapter is based on the *Nolans Project Community Consultation Report* (Michels Warren Munday 2016) provided in Appendix H of the EIS.

This chapter summarises the public consultation between 2007 and December 2015 by, or on behalf of, Arafura. The Community Consultation Report (Appendix H) and chapter address various sections of the TOR.

The approach to community consultation included consideration of the:

- NT EPA TOR
- NT EPA Guidelines for preparation of an Economic and Social Impact Assessment (November 2013)
- International Association of Public Participation (IAP2) Spectrum of Participation and
- *Enduring Value* – Australian Minerals Industry Framework for Sustainable Development (that describes sustainable development as investment in minerals projects that are “financially profitable, technically appropriate, environmentally sound and socially responsible)”.

6.2 Consultation strategy

Consultation for the project began in 2007 when the project was first announced. In addition, a consultation and communication strategy was prepared to guide the environmental impact assessment process.

The consultation goal is to build the relationships, trust and understanding necessary for Arafura to operate in partnership with Central Australian stakeholders and community groups, to capture their aspirations and concerns, and deliver good social outcomes.

The objectives of the consultation strategy include:

- Give Northern Territory and Australian Government regulators confidence that Arafura has informed and listened to stakeholders and the general community
- Ensure social, economic and environmental impacts arising from the project are clearly defined and appropriate management strategies are established to deal with them
- Maintain the confidence of the community and government that Arafura can be trusted to responsively manage all social, environmental and economic impacts and communicate with cultural sensitivity, transparency and openness
- Provide accurate, relevant and timely communication so stakeholders can provide informed input
- Identify all stakeholders and seek their views to inform good decision-making
- Establish a good risk management approach to identify and respond to issues early.

The information and feedback collated during the consultation process has contributed to the social impact assessment (Appendix S) and the social impact management plan (SIMP) (Appendix X). The SIMP outlines strategies for ongoing community engagement and communication to maintain relationships and keep the community informed, particularly once the company makes a decision to proceed with the project.

6.3 Consultation activities

6.3.1 Key stakeholders

Consultation included the following key groups:

- Government departments, agencies and regulators
- Central Desert Regional Council and local authorities
- Central Land Council (CLC)
- Aboriginal communities and traditional owners
- Alice Springs Town Council
- Arid Lands Environment Centre
- Non-Government organisations such as NT Shelter, Waltja Tjutangu Palyapayi and the Multicultural Community Services of Central Australia
- Aileron Roadhouse
- Pastoralists
- Various business entities including Chamber of Commerce, local businesses, other mining companies, employment and training services providers and
- Environmental groups in Darwin and Alice Springs.

6.3.2 Consultation activities

Consultation included:

- 189 stakeholder meetings, including meetings with government departments, agencies and regulators
- 36 dedicated SIA interviews
- Public presentations to industry and business groups, and participation over several years at the Annual Geoscience Exploration Seminar in Alice Springs
- Briefings, presentations, a dedicated project webpage and written communication with stakeholders
- Site visits with key stakeholders
- Attendance at local events
- Community meetings with traditional owners.

6.4 Consultation outcomes

Table 6-1 summarises key issues raised by stakeholders throughout the consultation meetings and events.

Table 6-1 Stakeholder issues and responses

Summary of key issues	Response
Land and water	
Concerns related to impacts on the quality and availability of drinking water and potential for contamination of aquifers. Concerns about the implications of diverting Kerosene Camp Creek. Expectations that Arafura's drilling for water might address the quality and availability of supply to communities, and improve productivity in more barren parts of pastoral properties.	Arafura moved the intermediate processing plant from its initial surface water catchment, following the discovery of substantial groundwater in a deeper aquifer system with few other competing users. Hydrological studies suggest the connection between the Southern Basins and Ti Tree aquifer in an area referred to as The Margins is primarily a subtle groundwater divide with water flowing north of the divide to the Ti-Tree Basin and south of the divide to the Southern Basins. Hydrological studies suggest a low level of impact on Laramba's groundwater supplies, from drawdown or changes in water chemistry. Chapter 7 Surface water summarises impacts to surface water resources including Kerosene Camp Creek diversion. Chapter 8 Groundwater summarises potential impacts to groundwater resources.
Concerns related to impact on visual amenity and the loss of habitats through clearing and fragmentation.	There will be vegetation clearance and ecological studies suggest limited potential impacts on biodiversity (refer to Chapter 9 Biodiversity). There are opportunities for rangers and local people's involvement in ongoing land management.
Concerns regarded impacts from climate change on the project and local area, including increased demand for water as the temperature rises	Water modelling has been undertaken over time and using long-term climate data (refer to Chapter 7 Surface water and Chapter 8 Ground water).
Concern was raised relating to the cumulative impacts of multiple resource projects.	Cumulative impacts are discussed particularly in social impacts (Chapter 15) and biodiversity (Chapter 4) and transport (Chapter 17).
Waste and chemical storage and transport	
Concerns associated with long term storage and management of waste including waste rock and process residue. Particular concerns are uranium and thorium storage and associate health risks, risks of pollution and of tailings dam failures.	All waste will remain on site in engineered storage facilities that are designed in accordance with ANCOLD guidelines. At closure the waste storage facilities will be closed and capped in accordance with mine closure criteria, thus posing a low risk to the public or the environment (refer Chapter 18 mine closure). The presence of uranium and thorium is not expected to exceed naturally occurring background levels of radiation following mine closure. During operations all workers will be monitored regularly to record the level of radiation they are exposed to so Arafura can ensure this exposure does not exceed approved public health levels (Chapter 12 Radiation).
Concerns about chemicals used and the safe transport of these to and from site.	Chemicals will be transported by rail to a loading facility in Alice Springs, then moved to the project site by truck and stored on site. All storage and transportation will comply with Australian Standards. Appropriate

Summary of key issues	Response
	emergency response protocols will be in place in the event of a spillage or an incident (refer to Chapter 11 Human health and safety).
Transport and road safety	
Concerns about increased industrial traffic on the Stuart Highway and access roads on the Aileron station, and the likely impact on local roads Concerns about public road safety.	There will be two road trains working seven days a week on the public road network, and 26 daily one-way-trips will be added to the road network, including daily FIFO buses. The forecast indicates that operations at the site are likely to result in low impacts on the existing road network. FIFO buses are included in this trip generation calculation, and workers will be transported to site by bus to reduce risk. Arafura is working with the Department of Transport to meet safety requirements at intersections. The site access route would be via an existing station track to the Stuart Highway, not via the Napperby Road. All station roads affected by the project will be maintained. Arafura will implement an emergency management plan. Medical facilities will be available on site and operate under remote protocols with Alice Springs Hospital, the Ti Tree Health Clinic and the Royal Flying Doctor Service.
Impact on council and government services	
Concerns that the project will create an influx of people to the local area and put pressure on nearby aboriginal communities Concerns that local employers will lose staff to the mine site and that local and regional services including medical, childcare, housing and utilities for example would be put under pressure from increasing demand	Arafura expects about 95% of its construction workforce and 90% of its operations workforce to be FIFO, given the tight labour market in Central Australia and competing projects. Arafura will work collaboratively with the Council on its workforce development training and recruitment, but some loss of staff to the mine is inevitable. Arafura understands that its workers may create both positive and negative impacts on the local housing market. It will monitor the impacts of accommodating workers, house FIFO workers in temporary accommodation and look at a range of options for managing impacts, such as purchasing and building temporary accommodation. Refer Chapter 15 socio-economic impacts.
Impact on employment and education	
Concerns relating to the barriers to employment for Aboriginal people Concerns over the attractiveness of Alice Springs to encourage relocation by workers.	Employment and training of local Anmatyerr Traditional owners is a priority for Arafura. Arafura is interested in collaborating with other companies operating in Central Australia to run a combined recruitment campaign to encourage potential workers to relocate to Central Australia. This will need to address issues such as lifestyle, health, schooling and community infrastructure.

Summary of key issues	Response
Concerns regarded FIFO workers who would not contribute to the local economy and may cause negative impacts.	Arafura will prioritise local jobs, however a sufficient local labour force may not be available locally, particularly with the likely peak demand during construction and for specialised positions. Arafura will monitor all impacts of employment to minimise social impacts arising from a large construction workforce and adapt its strategy accordingly. Refer Chapter 15 socio-economic impacts.
Concerns that workers would be poached from other local employers.	Arafura is conscious that it may poach good workers from other employers and would work with all parties on a coordinated approach to local employment and training, but this issue is largely out of Arafura's control. Arafura will contribute to a regional workforce strategy that takes account of the skills of all regional employers. Training by the mine will provide professional development and skills that deliver long-term benefits to the region's capacity and individual employers as staff move between jobs. Refer Chapter 15 socio-economic impacts.
Economic development and business opportunities	
Expectation relating to local procurement, improvements to local infrastructure and ensuring benefits are realised during operation. Expectations were raised for new industries and improving quality and safety standards of local businesses. Concerns were raised that local businesses would not be able to complete with larger interstate firms.	Arafura will prioritise the use of local businesses who can meet the company's safety, quality and reliability standards and who are commercially competitive. Arafura will work closely with the Industry Capability Network to identify local companies able to provide services and seek advice on works packaging to maximise local participation. The Aileron Roadhouse will provide overflow accommodation for the project during construction and operations. Arafura will work with the NT Government, Chamber of Commerce and ICN to provide timely and relevant communication on likely opportunities, how to win work and standards that would be expected of all services and supplies. Refer Chapter 15 socio-economic impacts.
Expectations related to employment opportunities for Aboriginal people and women. Concerns regarded health issues, training needs and social issues connected with local populations.	Employment and training of local people, in particular Anmatyerr traditional owners, is a priority for Arafura. Arafura will put in place a range of workforce measures to maximise the success of Aboriginal employment and training, including opportunities in the project's supply chain with sub-contractors and labour hire arrangements with a local provider. Arafura will implement an employment and workplace strategy that addresses immediate and long-term opportunities. Refer Chapter 15 socio-economic impacts.

Summary of key issues	Response
Suggestions made for Aboriginal enterprises including horticultural and involvement in the supply chain.	Arafura will work with the CLC and the Department of Business to help Aboriginal people realise ambitions of enterprise development based on opportunities at the mine. Refer Chapter 15 socio-economic impacts.
Expectations are that economic development would be sustainable and not displace existing industries i.e. tourism.	Arafura will produce an annual sustainability report, to include reporting on commitments such as local jobs, procurement, development of new economic sectors and general contributions to the sustainable development of the Central Australian economy. Refer Chapter 15 socio-economic impacts.
Concerns raised from pastoralists relating to access arrangements, competing land uses and impacts to proposed organic farming.	Arafura will negotiate access arrangements with the pastoral properties affected by the project.
Culture and heritage	
Expectation that Aboriginal connections to country are respected and that access to land for traditional activities would be maintained.	Arafura will incorporate cultural awareness training for staff and strict codes of conduct to maintain respect for Aboriginal connections to country. There may be opportunities for traditional owners to develop small businesses to provide tourism and cultural awareness programs. Arafura will consult with traditional owners about land access issues, and take account of important areas in considering the location of mine infrastructure. Refer to Chapter 16 Historic and cultural heritage.
Concern that sacred sites and Aboriginal would be impacted.	Arafura will obtain the appropriate clearance certificates and, where necessary, the approvals to remove or destroy sites that cannot be avoided. Arafura will work with traditional owners to discuss protection of key sites of significance. opportunities to commemorate the early history of the region through communication about the project, link to tourism ventures and provide interpretive signage, would be considered (refer to Chapter 16 Historic and Cultural Heritage and Appendix X Cultural Heritage Management Plan.)
Other social impacts	
Concerns that cash royalties and/or would have a negative social impact and could result in family conflict and alter the character, cohesion and resilience of a community. Expectation of real community benefits for traditional owners	Arafura is negotiating an agreement with native title claimants, through the CLC, that will include a focus on community benefits rather than cash payments. The CLC has an investment policy and promotes the benefits of community development. An agreement will be negotiated with the CLC on behalf of Native Title Holders. The CLC’s role is to ensure that benefits are distributed to the rightful claimants.

Summary of key issues	Response
Housing stress associated with Aboriginal people moving into the local area because of work Broad concern about the impact of a large group of workers on housing availability and affordability	Arafura will implement an employment and workplace strategy that includes drug and alcohol policies, healthy lifestyle programs and codes of conduct for workers. Management plans will include volatile substance abuse awareness.
Corporate Social Responsibility	
Concerns of legacy issues from mining in the territory, long term rehabilitation, safety and mine closure.	Arafura understands that its workers may create both positive and negative impacts on the local housing market. It will monitor these impacts and will look at purchasing or building additional, temporary accommodation if necessary.
Expectation of sponsorship of local community events, education and sports.	Arafura will develop a sponsorship policy closer to the project starting. Sponsorship and community benefits programs will prioritise projects and activities that foster healthy lifestyles, leadership, discipline and safety.
Expectation of good communication and ongoing engagement with stakeholders.	Arafura adopted a strong engagement approach from the outset and will continue this approach. Arafura will continue to communicate elements of the project, using strategies tailored to suit various audiences.

6.5 Ongoing community consultation

Arafura will continue to communicate elements of the project, using strategies tailored to suit various audiences. Ongoing community consultation and engagement will aim to continue building relationships and provide stakeholder groups with continued opportunities to input into project considerations.

In the event project approval is granted and the project proceeds, Arafura will establish and implement a community consultation/social impact management plan that is likely to include:

- Ongoing community engagement
- Establishment of a community reference group - with membership drawn from interested stakeholder groups and a cross-representation of traditional owner and community families
- Appointment of a community liaison officer - to work with the community
- Development of a communication and community relations strategy to maintain a mechanism for community feedback and consultation about potential relevant impacts as the project evolves
- Development of evaluation procedures to community attitudes towards Arafura and the Nolans Project and project communication.

For more detail, refer to the draft Social Impact Management Plan provided in Appendix X.

07

Surface water

7. Surface water

7.1 Introduction

This chapter describes the existing surface water characteristics and potential impacts on surface water resources within and around the proposed Nolans site. A detailed surface water report is provided in Appendix I of the EIS.

Section 5.3 of the TOR for the project provided the following environmental objectives in relation to surface water resources:

> *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.*
>
> *Proposed creek diversion(s) will maintain equivalent ecological functionality of the waterways, and minimise impacts to linked riparian and aquatic ecosystems for the short and long term.*

This chapter addresses the potential impacts on surface water resources within and around the Nolans site for all stages of the project as required in the TOR. Groundwater resources are discussed in Chapter 8 of this EIS.

7.2 Methodology

A summary of the approach to assessment of surface water resources in the study area is described below and more detail is provided in Appendix I.

Key tasks involved in the preparation of the surface water impact assessment included:

- Desktop review to identify data relating to surface water resources within the study area and identify potential surface water monitoring locations
- Site visit in January 2011
- Surface water quality records obtained from the NT DLRM water data portal
- Rainfall-runoff model (XP-RAFTS) to derive flood peak discharge along the two creeks flowing through the proposed mine site (Kerosene Camp Creek and Nolans Creek)
- 2-D rain-on-grid flood modelling to obtain the extent and depth of flooding during a 1 in 1000-year average recurrence interval (ARI) event together with an indication of flow velocity at locations across the Nolans site
- 1-D flood routing model to investigate the hydraulics of the Kerosene Camp Creek diversion (Appendix A of Appendix I).

7.3 Existing environment

This section describes the surface water resources and related features identified in the study area, and discusses the relative value of the features in the local and regional context.

7.3.1 Topography and land use

The proposed Nolans mine site is at the head of the Kerosene Camp Creek valley on the north facing slopes of an east – west trending ridge of the Reynolds Range, and the processing site is situated on the southern slopes of the same ridge. Topographic elevation is 886 m above sea level (m ASL) at Mt Boothby to the east of the mine site, and 1,006 m ASL at Mt Freeling to the west (Figure 1-6). Most of the Kerosene Camp Creek valley floor at the mine site is typically between 650 and 700 m ASL whilst the processing site is at an elevation of about 670 m ASL. Longitudinal gradients along local creeks to the north and south of the ridgeline are typically less than 0.5 percent with steeper gradients of about 10 percent on isolated hills.

The Nolans site, with the exception of the western part of the borefield, lies wholly within Aileron Station, which is currently operating rangeland cattle grazing.

Third party infrastructure in the vicinity of the Nolans site includes:

- APA Group's Amadeus Basin to Darwin gas pipeline which runs south west to north east along the south eastern boundary of the processing plant and is buried to a depth of about 1 m
- The Stuart Highway which runs north – south about 10 kilometres east of the Nolans site but does not cross surface watercourses downstream of the Nolans site and
- Napperby Station / Laramba access road which runs east – west about 12 kilometres south of the processing site and traverses minor surface watercourses downstream of the processing plant.

7.3.2 Rainfall and evaporation

Prevailing winds are from the southeast and mean monthly minimum and maximum temperatures range between 4.9 °C in July and 37.6 °C in January. Mean annual rainfall at Nolans site is about 310 millimetres and mean annual potential evaporation is about 2,400 millimetres.

Annual total rainfall is erratic from year to year and almost 50 per cent of the annual total rainfall can occur within a single month. Most rainfall tends to occur in the summer months and significant events tend to be limited to one or two occurrences each year. The seasonal distribution of rainfall and potential evaporation is shown in Table 7-1 and Table 7-2, respectively. This shows that on average monthly rainfall is about one seventh of the monthly potential evaporation. Whilst the record shows that occasionally rainfall can exceed potential evaporation in very wet months, actual evaporation will closely match rainfall throughout the year and virtually all the rain that does fall will evaporate.

Table 7-1 Mean monthly rainfall (mm)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Napperby	55	55	39	22	21	11	14	6	7	19	30	40	309
Alice Springs	41	43	31	17	18	13	15	9	8	21	29	37	282
Mine Site	48	73	68	30	11	5	6	1	1	3	35	32	314

Table 7-2 Mean monthly potential evaporation (mm)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Alice Springs	271	221	210	159	112	87	97	134	178	230	238	259	2196
Mine Site	286	240	235	185	137	91	89	163	200	249	257	265	2396

7.3.3 Surface water drainage

Semi-arid regions such as the area in which the mine is located are typically characterised by conditions in which evaporation closely matches rainfall and virtually all rainfall evaporates during events resulting in almost no surface runoff. This general situation will alter if intense rainfall occurs. Therefore, the occurrence of surface runoff and flows within local creeks is likely to be infrequent and only occur during exceptional rainfall events, such as those associated with the occasional southward extension of a monsoon trough or periodic incursion of north-west cloud bands over the interior of the continent.

Kerosene Camp Creek is an ephemeral creek and flows through the centre of the mine site before joining with a major tributary three kilometres further to the north where after it eventually flows into Woodforde River. Minor tributaries of Kerosene Camp Creek occur upstream of the mine site between the processing site and the mine site and have a combined catchment area of approximately 19.5 km^2 (Figure 7-1). Nolans Creek is a major tributary of Kerosene Camp Creek and has a catchment area of approximately 26 km^2 upstream of the open pit. It flows adjacent to the eastern boundary of the proposed TSF and will pass between WRDs 2 and 6 where after it joins Kerosene Camp Creek (Figure 7-2).

The Woodforde River, into which Kerosene Camp Creek flows, passes through the western margins of the Ti Tree Basin aquifer which is about 20 kilometres downstream of the mine site (Figure 7-1). The aquifer at this location along the Woodforde River is about 60 m below ground level (~550 metres ASL) (NRETAS 2007) and is down gradient of the mine site.

The access road from the Stuart Highway to the mine site crosses the drainage paths from catchments on the upper slopes of the Yalyirimbi Range (Figure 7-3). Drainage continues to flow towards the Southern Basins and Lake Lewis 40 kilometres to the west of the Nolans site. Catchments upstream of the access road are relatively small, typically less than 3 km^2 with one catchment of about 12 km^2 located towards the eastern end of the access road.

The processing site also receives drainage from the upper slopes of the Yalyirimbi Range (Figure 7-2). Due to their small catchment area, channels tend to be ill-defined with runoff likely to be dispersed across the south facing hillslope before combining into distinct creeks which eventually drain into the Southern Basins and Lake Lewis 40 kilometres to the west. Catchments upstream of the processing plant are typically less than 1 km^2 in extent.

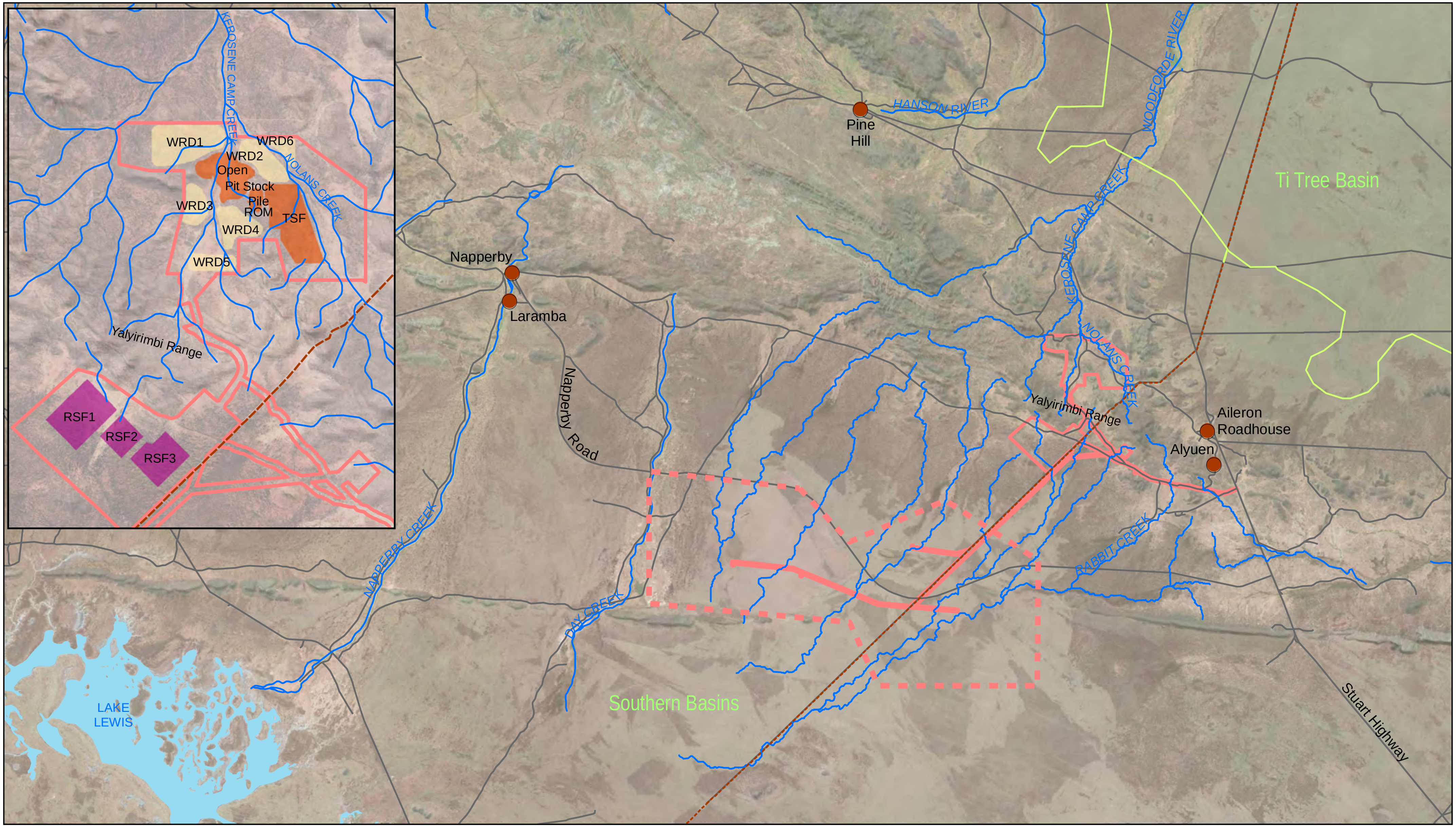
7.3.4 Surface water monitoring

Long-term gauging of flow in watercourses that traverse or flow close to the proposed mine site has been carried out at Arden Soak Bore on the Woodforde River. This gauge is located approximately 26 kilometres downstream of the mine site and includes the runoff from catchments at the mine site.

Flow records show that flow events are relatively infrequent with only 25 per cent of days during the 41-year record having a total daily flow greater than 3 Ml (arbitrarily selected discharge of 0.03 m^3/s) and thus even fewer days with larger flow volumes.

The occurrence of surface runoff is most likely in months during the summer season, December to March (refer Figure 7-4). Records at Arden Soak Bore suggest that only one or two flow events can be expected in most years. The maximum recorded flow at Arden Soak Bore (Figure 7-5) is 206 m^3/s (January 2010) during which flow was recorded over a period of just three days indicating the relatively 'flash' response and short duration of flow events for drainage systems in this region.

Anecdotal evidence suggests that surface runoff infiltrates to the alluvium of creek channels where after it will form shallow groundwater flow moving down gradient along the creek channel.



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0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

- Outstations and Communities
- Roads
- Groundwater basin boundary
- Project Areas
- Gas pipeline
- Borefield Area
- Waterways
- Waterbodies

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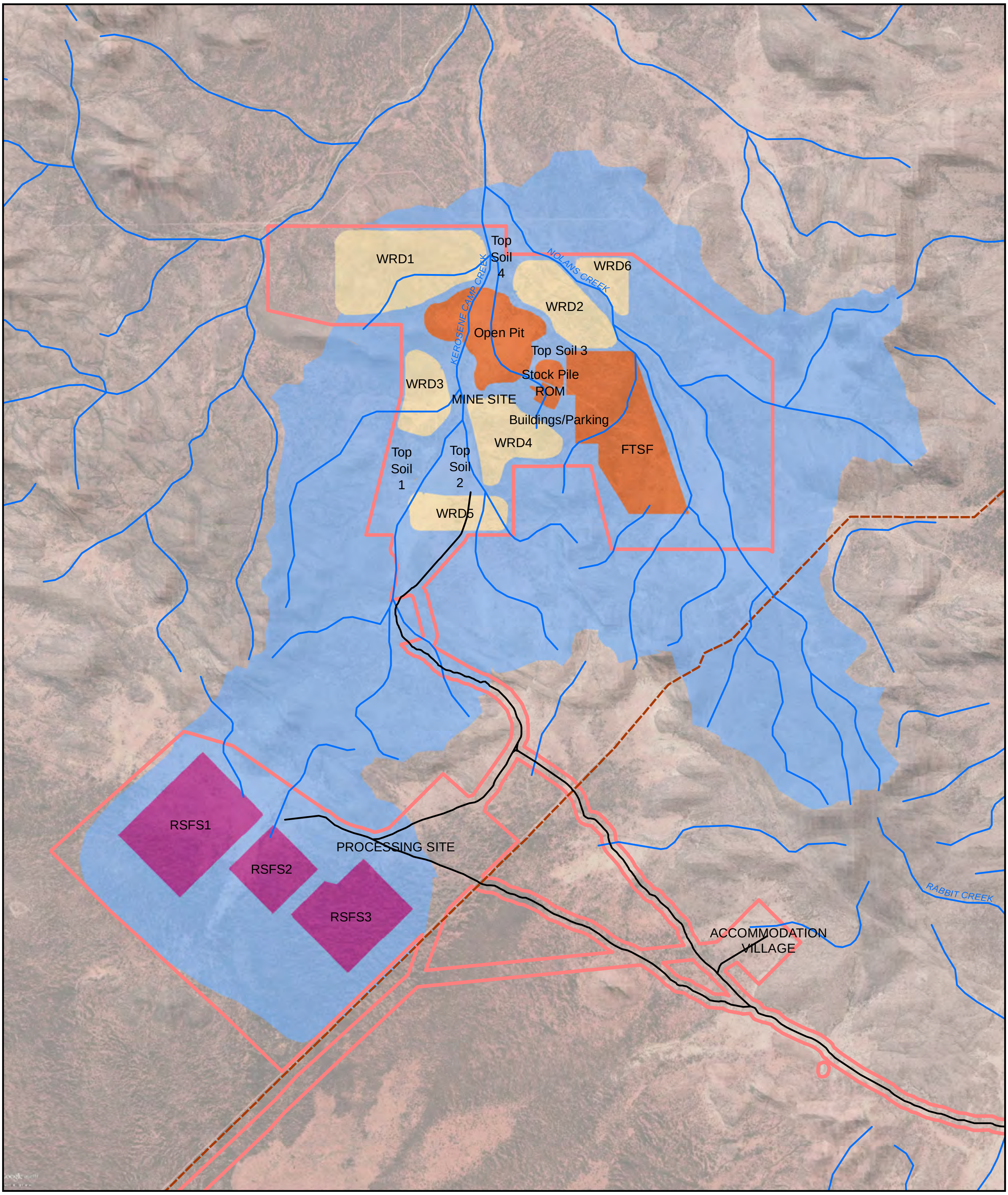
Surface water drainage network

Figure 7-1

G:\43\22301\GIS\Maps\4322301_574_SurfaceDrainageNetwork.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, Placenames, Placenames, Lakes, Imagery (2015). ESRI - Shaded Relief (2009). ARL - Project Areas (2015). GHD - Waterways, Outstations and Communities (2016). Created by: CM



LEGEND

Access Road		**Water Type**		Process	
Waterways		Clean		Sediment	
Gas Pipeline		Ore Contact			
Project Areas					

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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

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Date 13 Apr 2016

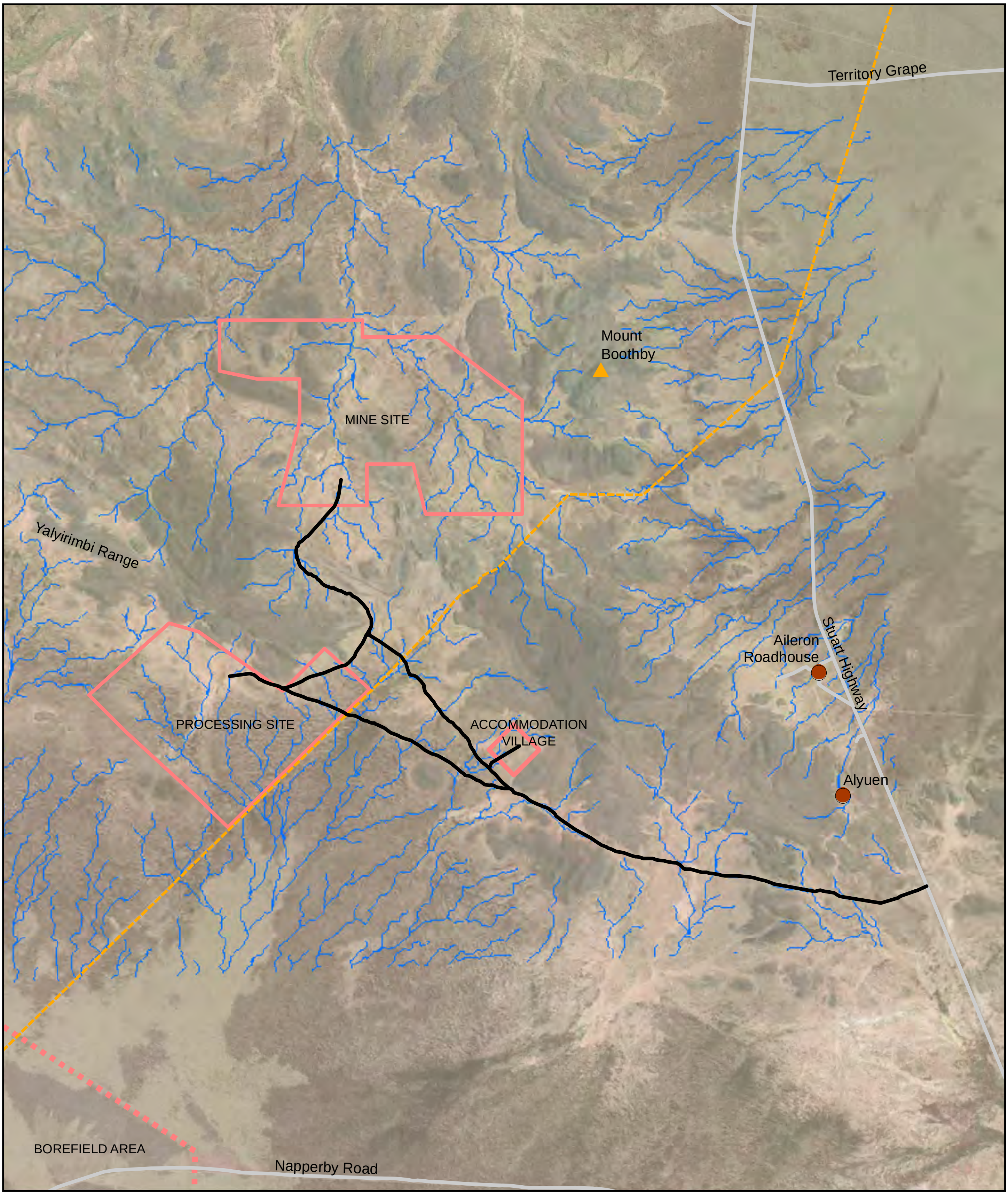
Surface drainage network at the mine site and processing site

Figure 7-2

G:\43\22301\GIS\Maps\4322301_573_SurfaceWaterType_Fig7-2.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, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 11/02/2016). ARL - Project Areas (2015). GHD - XPRafts Model (2016). Created by: CM



LEGEND

- Mountain
- Outstations and Communities
- Roads
- Access Track
- Gas Pipeline
- Natural drainage
- Project Areas

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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

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Access road drainage network

Figure 7-3

G:\43\22301\GIS\Maps\4322301_575_AccessRoadNaturalDrainage.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, Placenames, Placenames, Lakes, Images (2015). ESRI - Shaded Relief (2009). ARL - Project Areas (2015). GHD - Natural drainage (2016). Created by: CM

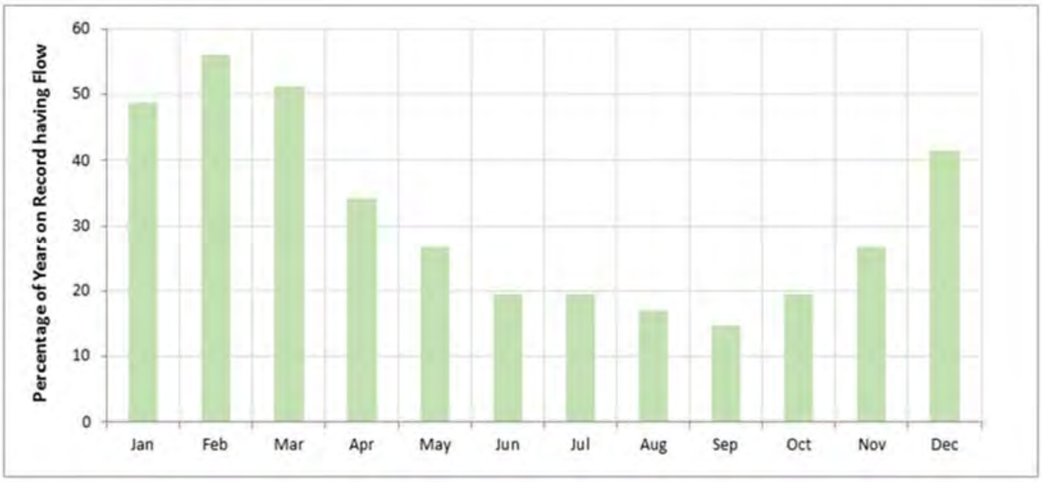


Figure 7-4 Occurrence of flow at Arden Soak Bore on Woodforde River

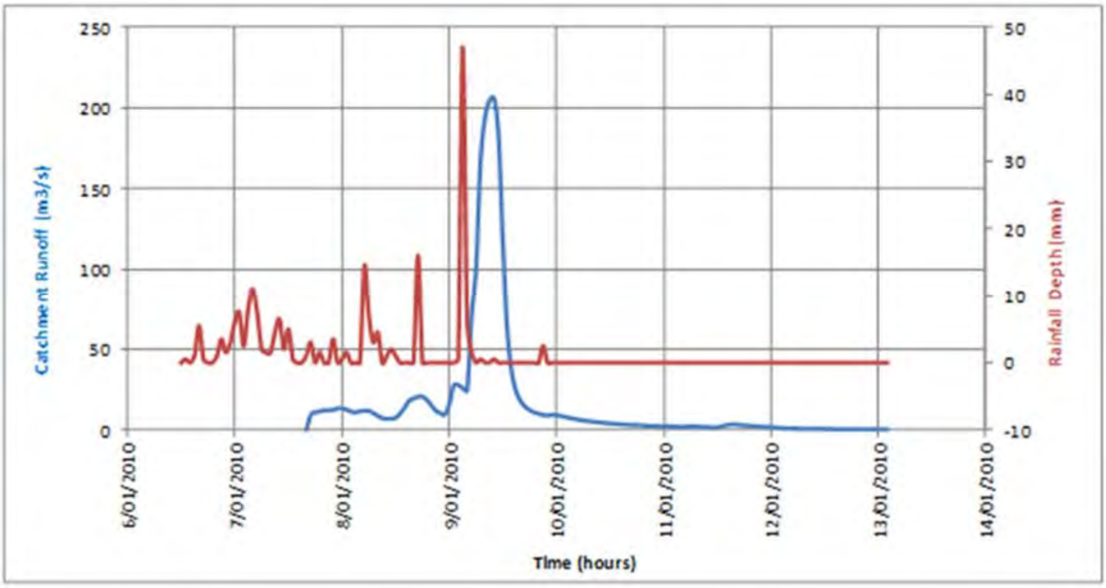


Figure 7-5 Maximum recorded flow at Arden Soak Bore on Woodforde River

7.3.5 Geomorphology

Creeks flowing through the mine site are generally straight with gentle bends and grades of approximately 1 in 400 (0.25 per cent).

The existing channel of Kerosene Camp Creek has bankfull widths in the order of 10 to 15 metres and depths in the range of 1 to 2 metres. The channel invert typically consists of a relatively featureless bed of sand with some gravel. In cross-section, the channel is symmetrical and relatively simplistic in form with limited evidence of features such as pools, bars or benches. Banks are composed of alluvially deposited sand and silt and are vegetated with low grasses and scattered shrubs and trees. Bedrock occasionally outcrops in the banks and bed providing some control on channel form and bed levels.

Nolans Creek is set within a terraced valley with the contemporary valley floor extending up to approximately 100 metres. The inset floodplains typically bound either side of the channel, with the surrounding terrace surfaces rising 1 to 2 metres above the floodplains. Based on bank exposures the floodplains are likely to be dominantly composed of silty sand. The floodplain surfaces are largely vegetated with low shrubs and are dissected by shallow flood channels.

7.3.6 Surface and groundwater interaction

The groundwater characteristics of the region within which the Nolans site is located are described in Chapter 8 of this EIS.

Regionally, the mine site is located near the southern margin of the Ti Tree Basin (Figure 7-1). Groundwater is approximately 15 metres below the ground surface at the mine site location. The processing plant is located on the northern margin of the Whitcherry Basin which is one of a series of interconnected basins termed the 'Southern Basins' that drain westward and toward Lake Lewis, 40 kilometres southwest of the processing plant (Figure 7-1). The Ti Tree and the Southern Basins are considered to connect at the eastern margin of the Southern Basins near the Stuart Highway in an area termed 'The Margins'. The Margins area is considered to be a subtle groundwater divide with water flowing north of the divide to the Ti-Tree Basin and south of the divide to the Southern Basins. The Yalyirimbi Range ridgeline between the mine site and processing site is the surface water divide between the Ti Tree and Southern Basins.

The ephemeral nature of creeks indicates no sustained support of surface flow from groundwater. In addition, the large disparity between evaporation and rainfall throughout the year suggests that recharge of aquifers is limited to periods of intense rainfall which are infrequent (once or twice a year) and relatively short lived.

The local aquifer at the mine site is thought to approximately correspond to the geographical extent of the ore body which is surrounded by much lower permeability basement rocks that act as an aquitard (Appendix K). It is expected that, due to the porous nature of soils in the area and the surface outcropping of the ore (apatite), this local aquifer will be recharged directly from surface infiltration during infrequent rainfall events and by leakage through the overlying creek bed when Kerosene Camp Creek is flowing.

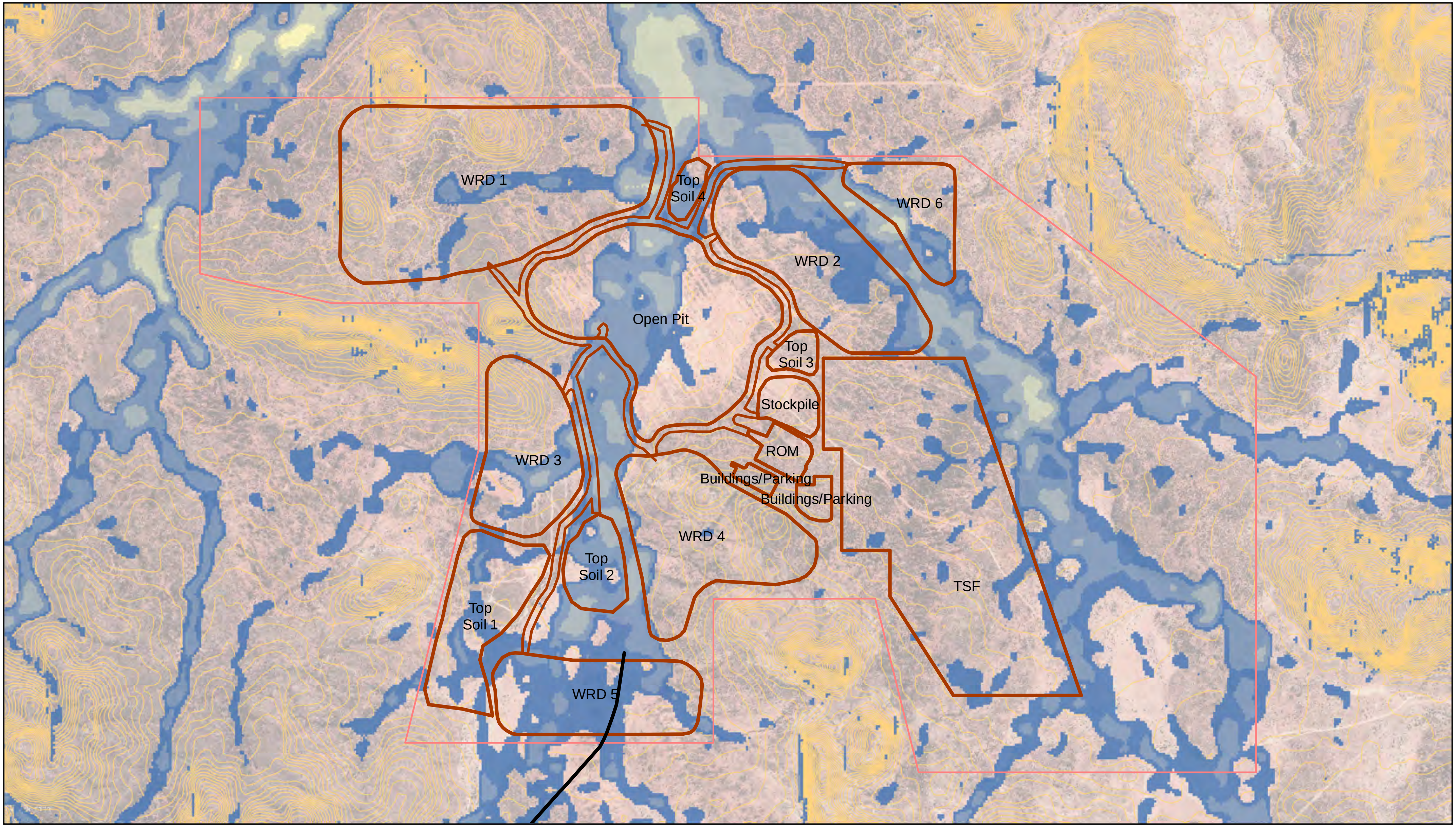
7.3.7 Flood risk

Flow events are infrequent and the probability of the mine site experiencing flood events with annual recurrence intervals of between 10 and 1,000 years during the 43-year LOM can be summarised as follows:

- 1 in 10-year ARI flood event has a 99 per cent probability of occurring during the LOM
- 1 in 50-year ARI flood event has a 58 per cent probability of occurring during the LOM
- 1 in 100-year ARI flood event has a 35 per cent probability of occurring during the LOM
- 1 in 1,000-year ARI flood event has a 4 percent probability of occurring during the LOM.

The lateral extent, depth, and velocity of flooding for existing site conditions (pre-mining) is shown in Figure 7-6 and Figure 7-7, and a summary of indicative flood depth and velocity at significant locations is provided in Table 7-3. Flood peak discharge along the two creeks flowing through the proposed mine site (Kerosene Camp Creek and Nolans Creek) has been obtained from hydrological modelling described in Appendix I.

Estimates of flood peak discharge assume a 4.5 hour storm rainfall event which is equivalent to the time of concentration for catchments draining to the downstream boundary of the proposed mine site. It is recognised that the critical storm duration will vary across the site and therefore more detailed modelling will be required during the design stage.



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0 250 500 750 1,000

Metres

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

N

LEGEND

- Access Roads
- Haul Roads
- 2m Contours
- Infrastructure
- Mine Site Boundary

Pre-Mining Flood Depth (m)

- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 4.0 - 4.5

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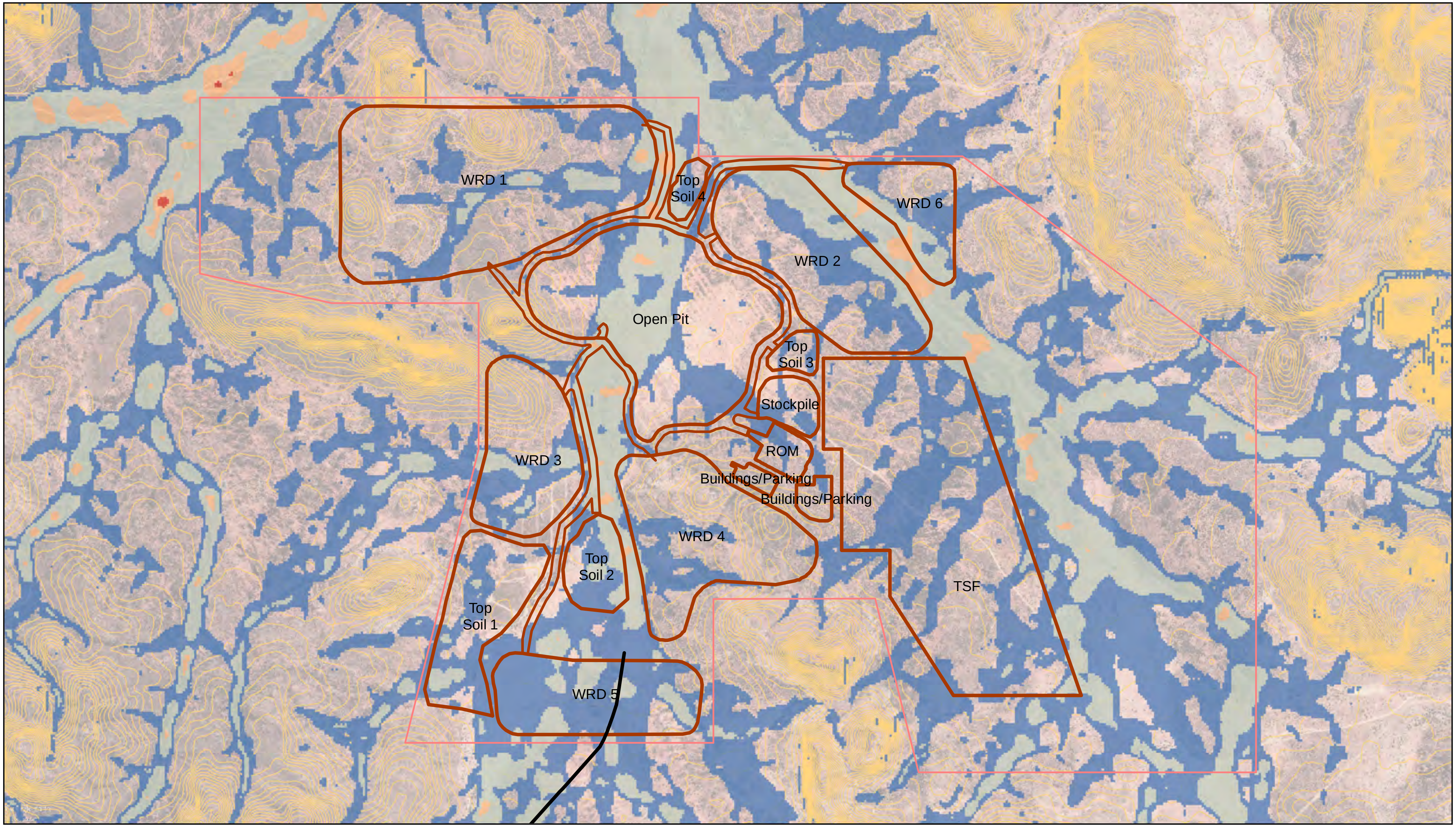
Flood depth for 1 in 1000 year ARI design storm event - pre-mining Figure 7-6

G:\43\22301\GIS\Maps\4322301_022_FloodDepthPreMine.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Haul Roads, Existing Creek Channels, Proposed Infrastructure (2015). CSIRO - 2m Contours (derived from SRTM) (2015). GHD - Flood Data (2016). Created by: CM



1:35,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

- Access Roads
- Haul Roads
- 2m Contours
- Proposed Infrastructure
- Mine Site Boundary

Pre-Mining Flood Velocity (m/s)

- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

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Flood velocity for 1 in 1000 year ARI design storm event - pre-mining Figure 7-7

G:\43\22301\GIS\Maps\4322301_576_FloodVelPreMine.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Haul Roads, Existing Creek Channels, Proposed Infrastructure (2015). CSIRO - 2m Contours (derived from SRTM) (2015). GHD - Flood Data (2016). Created by: CM

Table 7-3 Design flood characteristics – pre-mining

Creek	Location	Upstream Area (km^2)	1 in 1,000-year ARI – 4.5 hr flood event [a]	
			Velocity (m/s)	Depth (m)
Nolans	Upstream mine site boundary	26.3	0.9	1.3
Nolans	Downstream mine site boundary	28.2	0.6	1.3
Kerosene Camp	Upstream mine site boundary	12.3	0.3	0.2
Kerosene Camp	Proposed diversion inlet	20.4	0.8	1.0
Kerosene Camp	Downstream mine site boundary	25.8	0.7	1.6
Kerosene Camp	Downstream of confluence of Kerosene Camp Creek and Nolans Creek	58.7	0.7	1.7
Tributary of Kerosene Camp	Proposed diversion outlet	46.0	0.7	1.8

Notes: [a] storm duration corresponds to the time of concentration at mine site boundary

7.3.8 Water quality

The character of surface water quality is influenced by land use and the mineral composition of soils and near-surface geology. The absence of a sustained base flow contribution to watercourses is likely to limit the influence of deeper bedrock geology on surface water quality.

Baseline ambient water quality of surface water systems (when they flow) has been determined from the results of water monitoring. Surface water quality records are available from the DLRM water data portal. This data is limited to just two locations in the vicinity of the mine site, namely Arden Soak Bore (G0280010) which is on the Woodforde River 26 kilometres downstream of the mine site, and Allungra Waterhole (G0280004) which is on a different river system 42 kilometres to the east of the mine site. These records are limited to just a few individual samples taken in February and March 2011.

The available records include salinity, pH, dissolved oxygen, temperature and turbidity.

The water sampled in the Woodforde River was fresh but very turbid, neutral in pH and with sufficient dissolved oxygen to support aquatic life. Conditions at the mine site (which is a smaller catchment) may exhibit higher salinity and turbidity due to the lower volume of flow and thus its smaller dilution capacity.

7.3.9 Existing water users

Environmental water use is constrained by the sporadic nature of rainfall and surface runoff. Vegetation and fauna are either capable of surviving in between rainfall events or are able to access shallow groundwater. Depth to groundwater is generally greater than the reach of root systems, except along watercourses where the channel alluvium provides access to shallow groundwater, particularly along the Woodforde River downstream of the mine site.

Lake Lewis and its surrounds is a declared Site of Conservation Significance (SOCS) with a rating of National Significance. The processing site is located in the catchment of the Southern Basins, which drains toward Lake Lewis 40 kilometres to the south-west.

7.4 Project water balance

Water storage facilities should be designed to handle and control required inflows and outflows including unpredictable fluctuations due to exceptional storm inflow. Consideration of such inflows and outflows in a water balance will help identify storage requirements and minimise the risk of uncontrolled overflow and thus structural failure.

A monthly water balance has been carried out to identify whether the Nolans Project is likely to be in water deficit or surplus regarding its water supply requirements.

Available water resources will include water sourced from the borefield (located in the Southern Basins aquifer southwest of processing site), pit dewatering, tailings water that will be recycled from the TSF, and infrequent and short-lived water available from stormwater management ponds.

Open pit dewatering rates have been estimated by groundwater modelling which is reported in Chapter 8.

Project water demands (Figure 7-8) comprise the requirements for ore processing (crushing, beneficiation and processing plants), dust suppression along haul roads and at the ROM pad, together with potable water demands for the site.

7.4.1 Project water use

The overall site raw water demand is projected to peak at 4,777 ML/y. This includes a demand for process water of 4,418 ML/y, potable water 91.5 ML/y and dust suppression 267 ML/y.

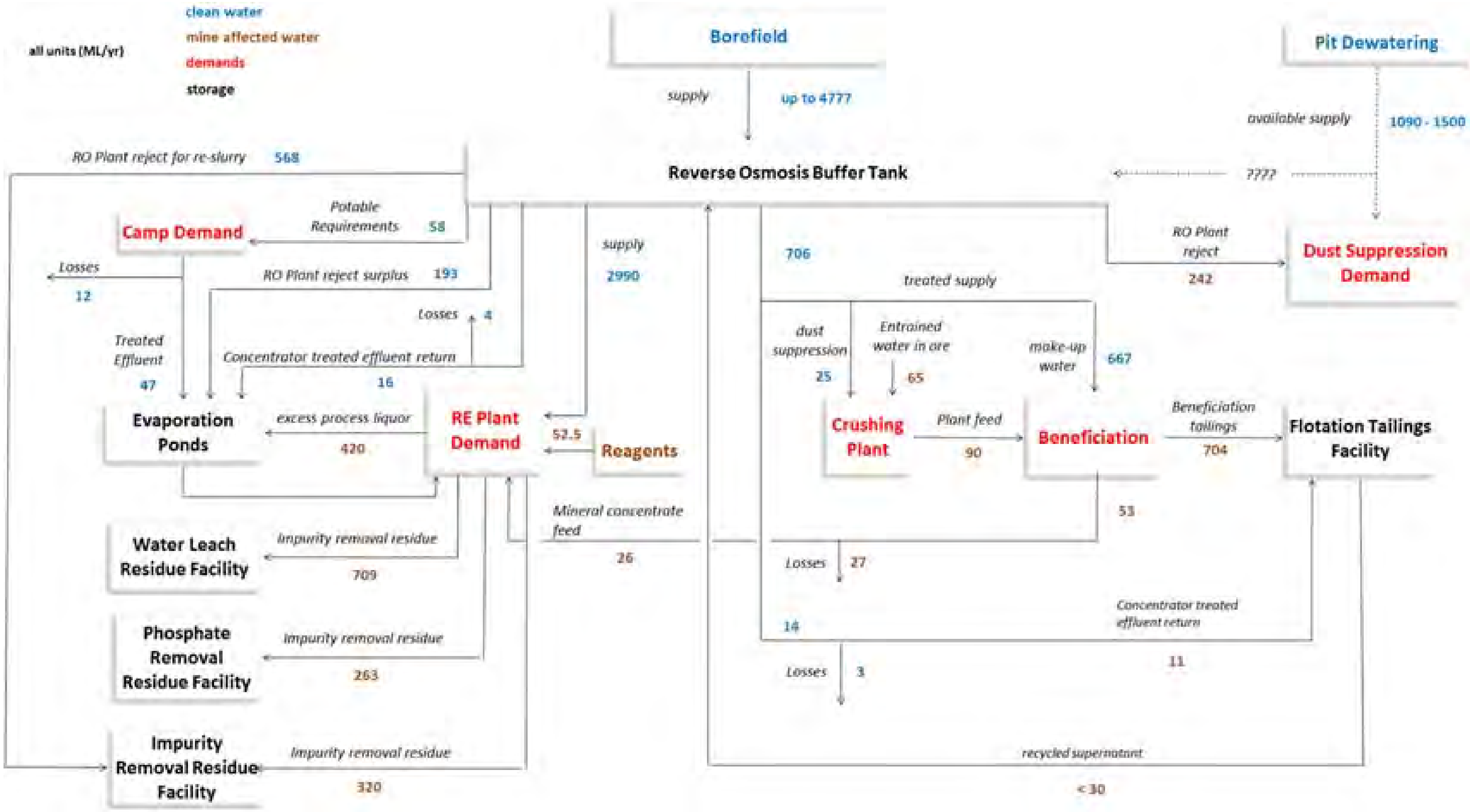


Figure 7-8 Schematic of project water demands (ML/yr) adapted from Lycopodium (2014)

The results of a mine site water balance are summarised in Table 7-4, based on the following:

- Seven mine development stages corresponding to the open pit development stages
- Monthly rainfall and evaporation comparable to conditions during an average year
- Estimation of recycled supernatant water from the TSF based on a slurry inflow of 0.45 Mtpa, which is assumed to correspond with mine development Stage 6 when the maximum quantity of material is mined. Quantities of recycled water for other mine development stages have been pro-rated from this maximum value by means of the relative quantity of mined material (Appendix D of Appendix I)
- Estimation of runoff within the open pit assumes a conservative rainfall loss of 90 percent from evaporation and seepage
- Groundwater inflow of up to 46 L/s depending on the pit water level (Appendix E of Appendix I)
- Pro-rating of the peak processing water demand (4,510 ML/yr) to provide estimates of water demand during other mine development stages. This has been achieved using estimates of the quantity of material mined in each development stage
- De-watering maintains a dry pit floor throughout the year, and
- Recycling of the water captured in sediment ponds at WRDs is assumed to be impractical due to the infrequent nature of surface runoff events.

The water balance for the processing site is excluded, as it comprises a closed system of incident rainfall 314 mm/yr and evaporation 2196 mm/yr only, with no transfers of water or catchment and groundwater inflow.

Table 7-4 Site water balance for average rainfall year

Component	Stage 1 (ML/yr)	Stage 2 (ML/yr)	Stage 3 (ML/yr)	Stage 4 (ML/yr)	Stage 5 (ML/yr)	Stage 6 (ML/yr)	Stage 7 (ML/yr)
Open pit rainfall inflow	32	101	139	191	262	335	385
Open pit groundwater inflow	1088	1243	1243	1391	1451	1461	1461
Open pit rainfall losses	-28	-91	-125	-172	-236	-301	-346
Open pit de-watering requirement [B]	-1091	-1253	-1257	-1410	-1477	-1495	-1500
Recycling of the TSF supernatant water[A]	2.7	6.1	3.3	9.4	25.7	30.0	12.4
Process water demand (excluding dust suppression)[C]	405	884	479	1399	3792	4418	1841
Dewater + recycle –	689	376	782	20	-2289	-2893	-328

Component	Stage 1 (ML/yr)	Stage 2 (ML/yr)	Stage 3 (ML/yr)	Stage 4 (ML/yr)	Stage 5 (ML/yr)	Stage 6 (ML/yr)	Stage 7 (ML/yr)
process demand							
Water deficit (excluding dust suppression)	0	0	0	0	2289	2893	328

Notes: source: [A] pro-rated and based on % reclaim from 'Nolans Project Tailings Storage Facilities Engineering Cost Study, Lycopodium, February 2014' [B] Appendix E of Appendix I {rainfall + groundwater inflow – losses} C Section 1.1.1 of Appendix I.

A comparison of the project process water demand with available on-site water resources indicates a potential surplus of water due to pit dewatering during the first four stages of mine development and a potential deficit in the supply of water demands thereafter.

Surplus water will be pumped to a turkey nest pond located at the mine site from where it will be recycled to augment project water supply, whilst deficits in demand will be met by groundwater supply from the borefield.

7.5 Assessment of potential impacts on surface water resources

7.5.1 Overview

The risk of an impact will occur if all three elements of a 'source – pathway – receptor' are present. In this instance the source – receptor of impact is

- Mine affected runoff from the mine site or processing site impacting on downstream receptors e.g. drainage lines or infrastructure e.g. access roads
- Upstream catchment flood water impacting on the mine site or processing site infrastructure or roads
- mine site or processing site construction impacting on normal flows or flood flows in downstream creeks and waterways (due to "removal" of catchment area of the mine from the normal/natural catchments)
- access road construction impacting on normal flows or flood flows across the landscape and in drainage channels.

In terms of surface runoff, the pathway can be:

- Sheet flow
- Channel flow
- Near-surface flow within the channel bed (groundwater pathways are discussed in Chapter 8).

Receptors may include:

- Third party infrastructure
- Water supplies
- Locations with environmental or heritage value
- Nolans site infrastructure

The level of risk posed to surface water resources by each source of impact was assessed using standard qualitative risk assessment procedures, which have been described in Chapter 5 and Appendix F. These risks are described in more detail below.

The elimination of risk is achieved by removing a source, pathway or receptor. If this proves impractical then a risk is managed by the implementation of project controls which are outlined below and dealt with in more detail in the water management sub plan contained within the Environmental Management Plan (Appendix X).

7.5.2 Separation of clean and mine affected water

Potential impact

Significant areas of catchment occur upstream of the mine site boundary comprising 16 km^2 within Kerosene Camp Creek catchment, 26 km^2 within Nolans Creek catchment and 16 km^2 within catchments upstream of the access road and processing plant (Figure 7-9). Due to natural flow paths, runoff that originates from upstream catchments will pass through the mine site and processing site and could therefore increase the volume of mine affected water.

If left undiverted, the open pit has the potential to capture 31 % of the runoff in Kerosene Camp Creek based on relative catchment areas upstream of the pit (19.5 km^2) and at the confluence of Kerosene Camp Creek with a major tributary of Kerosene Camp Creek (63 km^2) (Figure 7-9).

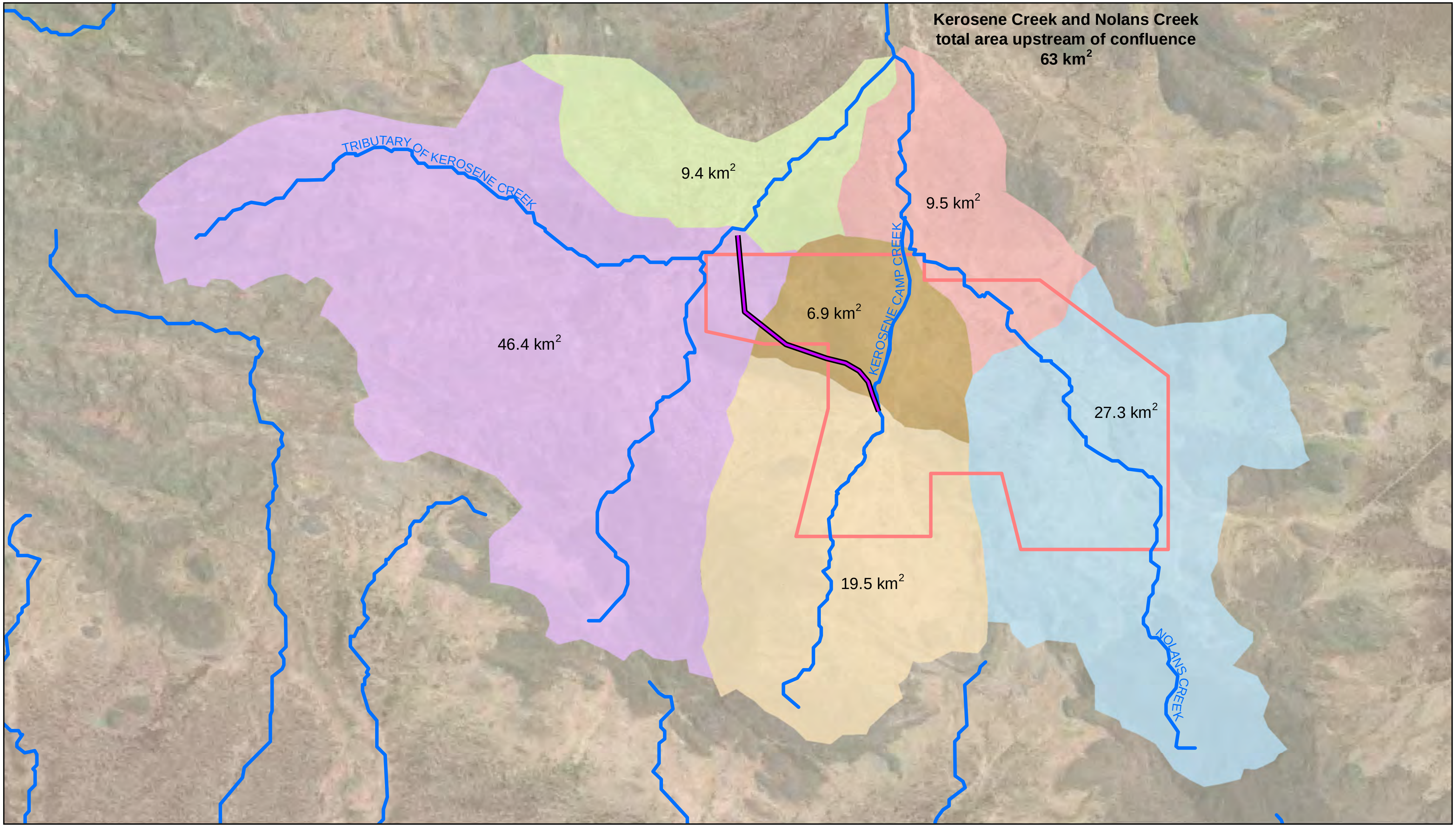
A proposed diversion of Kerosene Camp Creek will cause a change in the direction of flow within Kerosene Camp Creek. An options study (appended to Appendix A of Appendix I) suggests that this will cause an increase in water depth during a 100-year ARI flow event of 1.5 m immediately upstream of the diversion inlet and reduce the flow velocity and shear stress. Additional preliminary modelling suggests the water level upstream of the diversion inlet would increase by a further 0.2 m during a 1 in 1,000-year ARI flow event.

The Kerosene Camp Creek diversion outlet will also cause an increase of 30 percent in the catchment area contributing flow to a major tributary of Kerosene Camp Creek that will cause flows in this receiving watercourse to increase by a similar amount. The design study also suggests that the diverted flow will have flow energies and erosion and sediment transport potential similar to existing conditions in the receiving channel. As a result, the additional flow discharge from the diversion is not expected to have a significant impact on the morphology of the receiving channel (Appendix I).

Controls

Areas adjacent to the creek diversion will need to be protected against over-bank flow by means of a flood protection levee along the approach channel. The final longitudinal profile for the diversion channel will be designed to achieve flow conveyance and sediment transport in the approaches to the diversion that are close to existing conditions within Kerosene Camp Creek.

The diversion of clean water runoff around the processing site will be achieved by means of flood protection bunds and shallow drainage ditches. Conceptual designs are included in the Environmental Management Plan (Appendix X).



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0 500 1,000 1,500 2,000

Metres

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

N

LEGEND

Diversion Channel

Waterways

Mine Site Boundary

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number | 4322301
Revision | A
Date | 23 Mar 2016

Kerosene Camp Creek diversion catchments

Figure 7-9

G:\43\22301\GIS\Maps\4322301_572_NolansDiversion.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: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM

7.5.3 Sedimentation and soil erosion

Potential impact

Vegetation clearing and site establishment, including construction of roads will occur during construction of the project including:

- site preparation and topsoil stripping
- excavation of WRD footprints
- creation of top soil stores
- establishment of haul roads and access roads, and construction of cross drainage structures such as culverts and floodways
- construction of processing facilities including tailings and residual storage, and
- construction of the accommodation village.

The construction of project infrastructure and use of heavy machinery in and around existing drainage channels may degrade the structural integrity of the channel edge or deposit material within the channel, thereby impeding or altering existing waterways.

Depending on the carrying capacity of the stream, sediments may be deposited or bank erosion may occur to increase the sediment load in the water to its "carrying capacity".

Whilst creek beds are generally mobile due to the unconsolidated nature of bed material, the relatively shallow gradient of longitudinal profiles limits creek flow velocities to generally less than 1.5 m/s during a 1 in 1,000-year ARI event (Appendix I). This limits the potential for erosion during extreme flood events. Small areas between mine infrastructure have larger gradients and therefore have greater potential for erosion.

Controls

Controls to reduce overland flow-induced erosion are set out in the Environmental Management Plan (Appendix X) and include:

- contouring, such as the creation of a series of benches, swales, furrows or irregularities that cause the precipitation to pond, and infiltrate or evaporate rather than translate into runoff
- construction of water containment structures to hold sediment laden run off and prevent its release to the downstream environment
- vegetation, once established, is probably the most cost-effective erosion control measure.

7.5.4 Construction of linear infrastructure and cross drainage structures

Potential impact

Haul roads and access roads will cross a large number of minor creeks with small upstream catchments.

Construction activities have the potential to cause a reduction in the existing capacity of channels or an increase in channel bed gradient. This could lead to a localised increase in flow velocity during rainfall events, leading to the potential for erosion of creek beds.

Conversely, if channel widths are increased or channel bed gradients reduced this could result in a reduction in the velocity of flow and an increased potential for the deposition of sediment.

To prevent problems associated with erosion or sedimentation at road crossings, changes to the drainage path and flow conveyance capacity of creeks will be minimised where practicable.

Preliminary flood modelling of catchments upstream of proposed haul roads suggests that flood depths and velocities during a 1 in 1,000-year ARI event will not exceed 0.5 m and 1.0 m/s, respectively. Flood depths and flood velocities during more frequent storm events such as a 20-year ARI event would be significantly less.

Controls

Given the limited depth and likely duration of flood flows at roads it is likely that floodways consisting of a localised depression in the elevation of the road formation and reinforcement of the road verge to facilitate the spillage of flow across the depressed section of road; will be the most appropriate method of 'bridging' creeks.

Where creeks are wide, the gradient of creek banks steep, or roads are susceptible to erosion, it will be necessary to use culverts instead of floodways.

7.5.5 Flooding

Potential impact

Preliminary flood modelling of the Nolans site and its upstream catchments has been undertaken to provide an estimate of flood levels and velocity during a 1 in 1,000-year 4.5 hr ARI storm event. Changes in flood levels and flood velocities as a result of mine development have also been assessed (Appendix I) and are summarised for significant locations across the mine site in Table 7-5.

Table 7-5 Design flood characteristics – post-mining

Creek	Location	1 in 1,000-year ARI – 4.5 hr flood event [a]			
		Velocity (m/s)	Depth (m)	Velocity Change [b] (m/s)	Afflux [b] (m)
Nolans	upstream of mine lease boundary	0.9	1.4	0.0	+0.1
Nolans	downstream of mine lease boundary	0.6	1.4	0.0	+0.1
Kerosene Camp	upstream of mine lease boundary	0.2	0.4	-0.1	+0.1
Kerosene Camp	Upstream of proposed diversion inlet	0.3	1.7	-0.5	+0.7
Kerosene Camp	downstream of mine lease boundary	0.5	1.1	-0.2	-0.5
Kerosene Camp	downstream of confluence of Kerosene Camp Creek and Nolans Creek	0.6	1.3	-0.1	-0.4

Notes: [a] storm duration corresponds to the time of concentration at mine site boundary [b] change from pre-mining conditions

Nolans Creek flows along what will be the eastern boundary of the TSF and between the proposed locations for WRDs 2 and 6. The location of Nolans Creek in close proximity to mine infrastructure creates the potential for flooding and erosion. However, due to the shallow gradient of the creek and narrowing of the Nolans Creek floodplain due the WRDs, modelling suggests only a small flood level afflux of 0.1 m and no significant increase in flood flow velocity.

Kerosene Camp Creek enters the mine site adjacent to the proposed WRD 5, and proposed top soil stores in this area further impinge on the Kerosene Camp Creek. However, gradients in this area are relatively shallow and mine development is predicted to cause a small flood level afflux upstream of the mine site boundary of 0.1 m and an insignificant decrease in flood velocity of 0.1 m/s.

The proposed creek diversion will cause an abrupt change in the direction of Kerosene Camp Creek that will result in flow depth immediately upstream of the diversion inlet of about 1.7 m and a slowing of flood water flow by about 0.5 m/s during a 1 in 1,000-year ARI event (for more information see the Diversionreport at Appendix A of Appendix I). This will increase the potential for localised over-bank flooding and spillage from the diversion into the open pit and possibly sedimentation problems upstream of the diversion inlet.

Runoff generated from areas between the open pit, processing site and WRDs represents an additional potential source of water ingress to the open pit with typical flood depths of up to 0.2 m and small localised areas where flood depths reach 0.75 m, and velocities of up to 0.5 m/s.

Controls

The positioning and design of mine infrastructure will take account of the risk of flooding and erosion along existing watercourses and will either position infrastructure outside the 1 in 1,000-year ARI flood extent; or incorporate flood protection measures into flood prone areas. Flood protection measures will include:

- A flood protection levee constructed around the perimeter of the open pit rim to height of 1 m
- A flood protection levee in the approaches to the Kerosene Camp Creek to be constructed to a minimum height of about 2 m and profiling of the diversion inlet to equalise its velocity with that of the existing upstream natural channel
- Provide rock protection to the eastern external embankment of the TSF where flood velocities of to 0.5 m/s can be expected, along the toe of WRDs 2 and 6 adjacent to Nolans Creek (velocities of up to 1.5 m/s), and along the toe of WRDs 3 and 4 (velocities of up to 1 m/s) and WRD 5 and the neighbouring soil store (velocities of up to 2 m/s), and
- Incorporate drains along the western toe of WRD 3, along the southern toe of WRDs 4 and 5, and around the northern, western and southern sides of the TSF, to prevent ingress of runoff from adjacent catchments.

Conceptual designs of water management controls are included in the Environmental Management Plan (Appendix X).

7.5.6 Contaminated water

Contaminated water (by contact with ore and waste rock) will be generated by activities involving the extraction of ore (pit dewatering), its subsequent processing at the mine site (tailings from crushing and beneficiating the ore) and processing site (residue streams), and possibly during hauling of material to WRDs.

Potential impacts - open pit

The open pit will receive groundwater flow during excavation along with incident rainfall, and pit dewatering will be required to maintain dry working conditions. During the first development stage the pit void is at its smallest and the risk of pit overflow is highest should dewatering activities cease. A void space in excess of 4 Mm^3 will be achieved relatively quickly towards the end of stage one and would exceed the average annual volume of inflow from groundwater and incident rainfall.

In addition to the low risk of pit overflow, the low sulfur content, generally low metal toxicant content and low metal and salt leachability of the mined material, further limits the risk of acid mine drainage at the mine site (refer Appendix L of this EIS).

Potential impacts - waste rock dumps

WRDs will occupy a large proportion (590 ha) of the mine site area and will rise to a height of around 50 m. The material to be stored is largely non-acid forming (Appendix L). Detail of the likely water retention capacity of dumps is not available, however given the height and potential void space of stored material, the water retention is likely to be comparable with extreme (1 in 100-year ARI) storm rainfall events (depth of 295 mm) and annual average rainfall (depth of 310 mm). Therefore, the majority of incident rainfall over WRDs will infiltrate and result in negligible surface runoff or return of seepage to the ground surface.

Depending on the properties of material used in the base of the WRDs infiltrating water within the dumps will eventually seep into the underlying ground where it will follow prevailing hydraulic gradients. Following excavation of the pit void and implementation of dewatering activities, hydraulic gradients within the mine site are likely to be directed towards the open pit thereby reducing the potential for migration of mine-affected water to groundwater systems beyond the mine site.

Potential impacts - tailings and residue storage facilities

Due to the prevailing topography of the mine site, uncontrolled overflow from the TSF, should it occur; would discharge contaminated water into Nolans Creek where after, depending on the rate of overflow and the amount and flow of water within Nolans Creek, it could potentially reach the downstream Woodforde River system and the Ti Tree Basin.

Uncontrolled overflow from RSFs at the processing site, should it occur, would enter multiple small watercourses that flow southwards towards the Southern Basins and eventually the project's borefield water supply.

Climatic conditions that could cause overflow conditions to occur are also likely to result in the generation of flow within downstream creeks. Flow records for the Woodforde River suggest that during exceptional rainfall events surface flow can persist for at least one day. Due to the smaller extent of headwater catchments upstream of the mine and processing sites, the duration of flow in those local creeks is likely to be much shorter. Even so, assuming a moderate flood flow velocity of 0.5 m/s, it is likely to provide sufficient time for contaminated water to reach:

- The tributary of Kerosene Camp Creek (11 kilometres and 6 hours travel time) downstream of the TSF, or
- The edge of the Southern Basins area (10 kilometres and 5.5 hours travel time) downstream of the RSFs.

The migration of contaminated water beyond these distances would take more than one day and would be exposed to high levels of dilution by the ever increasing runoff volume from surrounding catchments.

Should overflow from tailings and residue storage facilities occur during dry conditions then contaminated outflow would seep into the shallow alluvium of adjacent local creeks. Anecdotal evidence suggests that subsurface flow occurs within the alluvium of creeks and this could presumably provide a path for the dispersion of contaminants.

Topographic gradients to the north of the mine site are about 0.2 percent whilst those to the south of the processing site are slightly steeper at 0.3 percent. Thus, an approximate estimate of subsurface flow velocity within the sandy creek beds (hydraulic conductivity 0.001 m/s) is in the region of 100 metres per year and the travel time to reach the tributary of Kerosene Camp Creek and the Southern Basins is therefore in excess of 100 years.

Controls

The mine site lies in the headwaters of the Woodforde River drainage system that flows across the western extension of the Ti Tree Basin. The processing site lies in the headwaters of the Southern Basins and the project's water supply borefield. For this reason, the storage capacity of TSF and RSFs will maintain a negative water balance (i.e. evaporation exceeding water inputs).

The TSF and RSFs will have a design storage capacity that is able to contain a 1 in 100-year ARI average annual rainfall whilst retaining sufficient additional freeboard to accommodate a probable maximum precipitation (PMP) 72-hour storm rainfall event. Water balances have shown that the accumulation of supernatant water can be controlled by natural evaporation, given this design storage capacity.

The storage facilities will also have maximum reporting levels above which water levels will invoke emergency measures to prevent overflow. In addition to evaporation, the supernatant water accumulating in the TSF will be controlled by recycling.

Due to adverse water quality the recycling of supernatant water is not permissible from the RSFs, these being the Water Leach Residue, Phosphate Residue and Impurity Removal Residue facilities.

Additionally, all storage facilities will have low permeability liners and leakage collection systems to reduce the risk of seepage to groundwater.

WRDs will be constructed with an inward sloping top and inward sloping mid-slope bench to trap incident rainfall and promote seepage to internal water storage. Given the relatively high height (50 m) of WRDs and low annual rainfall it is unlikely that internal pore spaces of the dump will become fully saturated where seepage emerging from its base would match infiltration at its surface.

Sediment ponds will be used to capture surface runoff from all mine affected areas to promote evaporation and seepage to ground.

The open pit will require dewatering to allow dry working conditions throughout its operation. Inflow from groundwater, and to a lesser degree incident rainfall, will be pumped to an on-site storage pond for recycling to the concentrator, processing site and/or dust suppression.

Dewatering of the open pit will cause a local drawdown of groundwater levels in the surrounding area. This will cause any seepage of surface water from WRDs and other areas of the mine site to migrate towards the pit, thereby reducing the risk of potential impact on the surface water or groundwater of areas beyond the zone of groundwater drawdown (i.e. more or less coincident with the mine site boundary).

The transfer pipeline between the mine site and processing site will be HDPE. The pipeline will run above ground within a bunded corridor. In the event of leaks or pipe failure, slurry will be captured within the bunded corridor and within event ponds located at significant low points along the eight-kilometre alignment. Specific details of event pond sizing and tiered bund levels will be considered during detailed design.

Additional information

A Failure Impact Assessment study (refer to Appendix J) was undertaken for the TSF to establish the potential risk to downstream residents from a hypothetical dam-break scenario. The risk is specified by a consequence category based on the concept of Population at Risk (PAR) and Potential Lives Lost (PLL).

PAR is the number of people expected to be within the failure impact zone in the event of a dam failure, including both a 'Sunny Day Failure' (pipe failure with no warning and dry downstream creeks) and 'Flood Failure' (breach failure with warning and flow in downstream creeks equivalent to a 1 in 100-year ARI event). At risk is defined as 300 mm of flooding within occupied buildings.

The assessment of PAR and PLL considered the following locations:

- Ti Tree, Waste Transfer Station,
- Pmara Jutunta community, water treatment station.

The assessment excluded site personnel within the model domain. The Stuart Highway is not shown to be inundated by a dam break and road users are therefore not considered to be at risk. Additionally, due to the remoteness of the region, small access tracks and dirt trails within the model domain were assumed unoccupied.

Neither of the above-mentioned occupied locations were shown to be inundated by a dam break flood involving the Sunny Day Failure scenario. The incremental PAR, as caused by a Flood Failure scenario in addition to that caused by natural flooding, is estimated to be less than one. Because the PAR is less than one, there is zero PLL.

The assessment of a consequence category under Australian National Committee on Large Dams (ANCOLD) Consequence Guidelines (2012a) is based on PAR and severity of damages criteria. Knight Piésold (2014) previously assessed the 'severity of damage and loss' for the TSF as having a worst-case impact of 'High'.

Therefore, in the context of a PAR of less than one and a severity of damage and loss of medium, the appropriate ANCOLD consequence category for the TSF is 'Low'.

7.6 Mitigation and monitoring

7.6.1 Mitigation

In addition to the control measures described above in section 7.5, the following administrative controls will be included:

- A water management plan (included in Appendix X) will be implemented including measures to manage flood and stormwater related issues such as:
  - Appropriate consideration of surface water flow in design, placement of infrastructure and construction
  - Proposals to capture surface runoff to small dams for monitoring/sediment control prior to release or recycle
  - Layout of construction ancillary facilities to avoid flood risk areas

- Amenities and equipment would be located outside high flood hazard areas
- The extent of works located in high flood risk areas
- Diversion of overland flow either through or around work areas in a controlled manner
- Runoff from disturbed areas would be diverted into sediment ponds and not discharged into the natural environment
- Construction programme will be staged to occur in dry season;
- Monitoring weather conditions and staging works to avoid periods of heavy rain
- Developing flood emergency response procedures to remove temporary works during periods of heavy rainfall.
- Progressive rehabilitation of WRDs to minimise exposed material and dust generation.

- Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance
- Embankment piezometers and survey pins, regular dam inspections
- Adherence to prescribed maximum operating level and retention of freeboard
- Monitoring program for phreatic levels within Embankment
- Biannual geotechnical inspection of TSF Embankment
- Procedures for spill events and tailings failure or overtopping, including:
  - Above ground pipeline within a bunded corridor
  - Processing plant notification of disruption to flow
  - Flow meters
  - Pressure sensors
  - Shift based visual inspections
  - Design - spray deflectors on welded joints
- Fire and emergency management procedures
- Establish maintenance procedures to ensure all water management equipment is installed and functional.
- An erosion and sediment control plan will be implemented prior to construction including:
  - Use of buffer zones, sediment fences and sediment ponds to arrest the transport of water borne sediment from the site
  - Progressive stabilisation of cleared land as activities are completed, to limit continued exposure of bare soils.
  - Rising stage samplers and gauging stations would be installed and maintained in creeks in and around the mine site to monitor surface flows and water quality in creeks.

7.6.2 Surface water monitoring

Surface water monitoring locations have been selected to meet baseline and ongoing monitoring requirements for the life of the operation and during closure. Details of surface water and water quality monitoring are provided in the Environmental Management Plan (Appendix X).

Surface water monitoring

Surface water monitoring sites for level and water quality will be located along Kerosene Camp Creek, Nolans Creek and headwater tributaries of the Southern Basins. Monitoring will incorporate existing gauges which includes rising stage surface water sampling points and water level gauges.

Bank stabilisation may be required at certain sites; however, the installation of low flow weirs is not recommended. It is considered that the beds at the sites, whilst mobile, provide a relatively consistent cross-section, whereas introducing a low flow structure in the channel may propagate change to the cross-sections through undercutting or sedimentation.

Theoretical rating curves would be required for the channel reaches at each of the surface water monitoring sites to enable conversion of the measured water depths to flow rates established through topographical surveys of the channel reaches and hydraulic modelling. Flow (current) gauging would be undertaken (if practical) to further calibrate the theoretical rating curves. Additional survey may be required, as needed, to establish if there has been any significant change to the channel cross section and/or morphology.

Sediment monitoring

Due to the relatively infrequent nature of streamflow events, sediment sampling would be undertaken to augment water quality sampling. Accumulation of radionuclides, rare earth elements, and other elements in the sediment would provide an indicator of surface water quality. Contaminant progression would be assessed through the distribution and dissipation/accumulation of such elements within the vicinity of and downstream of the mine site and processing site.

The sediment sampling procedure is provided within the Environmental Management Plan (Appendix X) and will include locations along Kerosene Camp Creek and Nolans Creek.

Sediment sampling will be undertaken annually throughout the life of the Project and into closure.

Shallow groundwater monitoring

Nested groundwater monitoring bores will be installed at key locations coinciding with proposed site infrastructure which is identified as a potential source of contamination. In addition, some background monitoring bores will be established. Further details are provided in the Environmental Management Plan (Appendix X).

08

Groundwater

8. Groundwater

8.1 Introduction

A detailed groundwater impact assessment report is provided in Appendix K of this EIS and an acid, metalliferous or saline drainage (AMD) assessment and management plan is provided in Appendix L.

Section 5.3 of the TOR for the preparation of an environmental impact assessment issued by the NT EPA for the project provided the following environmental objectives 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, including the risk of AMD generation and the potential impact of groundwater extraction from the borefield. This chapter also considers the cumulative effects of extraction of groundwater from the mine site during operation and beyond closure as required in the TOR for the project.

8.2 Methodology

A summary of the approach and limitations to the groundwater impact assessment in the study area is summarised below and more detail is provided in Appendix K.

A hydrogeological investigation was undertaken on the Nolans Project using inputs from:

- previous studies on the Ti Tree Basin
- field studies at the mine site and
- field studies of the Southern Basins and Margins Area.

A dataset was developed from mineral exploration drill holes and investigation water bores. Of these, 75 water bores were drilled specifically as part of the Nolans Project.

A numerical groundwater flow model was developed based on these hydrogeological investigations. This was calibrated to steady state observed conditions and used to predict future conditions over time. This model provides the following outcomes:

- An estimate of future conditions
- Potential impacts and a quantification of the key impacts at key locations across the study area under the influence of the project operating conditions and under closure conditions
- Conceptual flows which consider:
  - Boundary conditions
  - Recharge
  - Evapotranspiration and
  - Groundwater extraction.

Modelled impacts to groundwater availability are considered from the perspective of groundwater flows (volumes over time), groundwater elevations (heads), groundwater flow direction and groundwater drawdown. In addition, the modelled impacts are considered in terms of impacts to groundwater chemistry and quality.

A desktop review of historical geochemical data and detailed geochemical analysis was undertaken to characterise waste rock and ore in terms of hazardous material and potential to develop AMD at the Nolans mine site.

A summary of the approach and limitation to the AMD assessment in the study area is summarised below and more detail is provided in Appendix L.

To gain an understanding of the relative rate of acid production and neutralisation over time as well as the mobility of metals in leachate testing the following key tasks were undertaken:

- Static AMD testing has been carried out on 200 samples (Stage 1) of potential waste rock and
- Splits from 25 of the Stage 1 samples were selected from each of the major rock types and from samples showing the highest indication of AMD risk as well as generally representative samples.

8.3 Existing environment

The following sections describe the groundwater resources identified in the study area and discuss the relative value of these resources in the local and regional context.

8.3.1 Extent of hydrogeological study area

The study area (Figure 8-1) is defined as covering the following four key groundwater areas (from north to south):

- The Ti Tree Basin
- Nolans mine site and surrounding fractured rock aquifer/basement
- The area referred to collectively as the Southern Basins
- The area where the Ti Tree Basin borders or abuts the Southern Basins which is referred to as The Margins.

The study area measures approximately 200 km east to west and 125 km north to south, and occupies a total of 19,000 km^2. In this report, these groundwater areas are collectively referred to as the groundwater system.

8.3.2 Topography

The topography of the study area is dominated by a flat plain, ranging from approximately 650 m AHD to 570 m AHD (over 120 km heading west) in the Southern Basins and from 650 m AHD to 505 m AHD (over 85 km heading north east) in the Ti Tree Basin. Above this plain, the Hann Range and Reaphook Hills rise up to approximately 150 m, and peaks of the Reynolds Range and Yalyirimbi Range up to almost 500 m above the plain

8.3.3 Study area climate

The study area climate consists of low rainfall (refer Appendix K) and high summer maximum temperatures (average of 37°C) and low minimum winter temperatures (average 6°C), typical of central Australian arid climates.

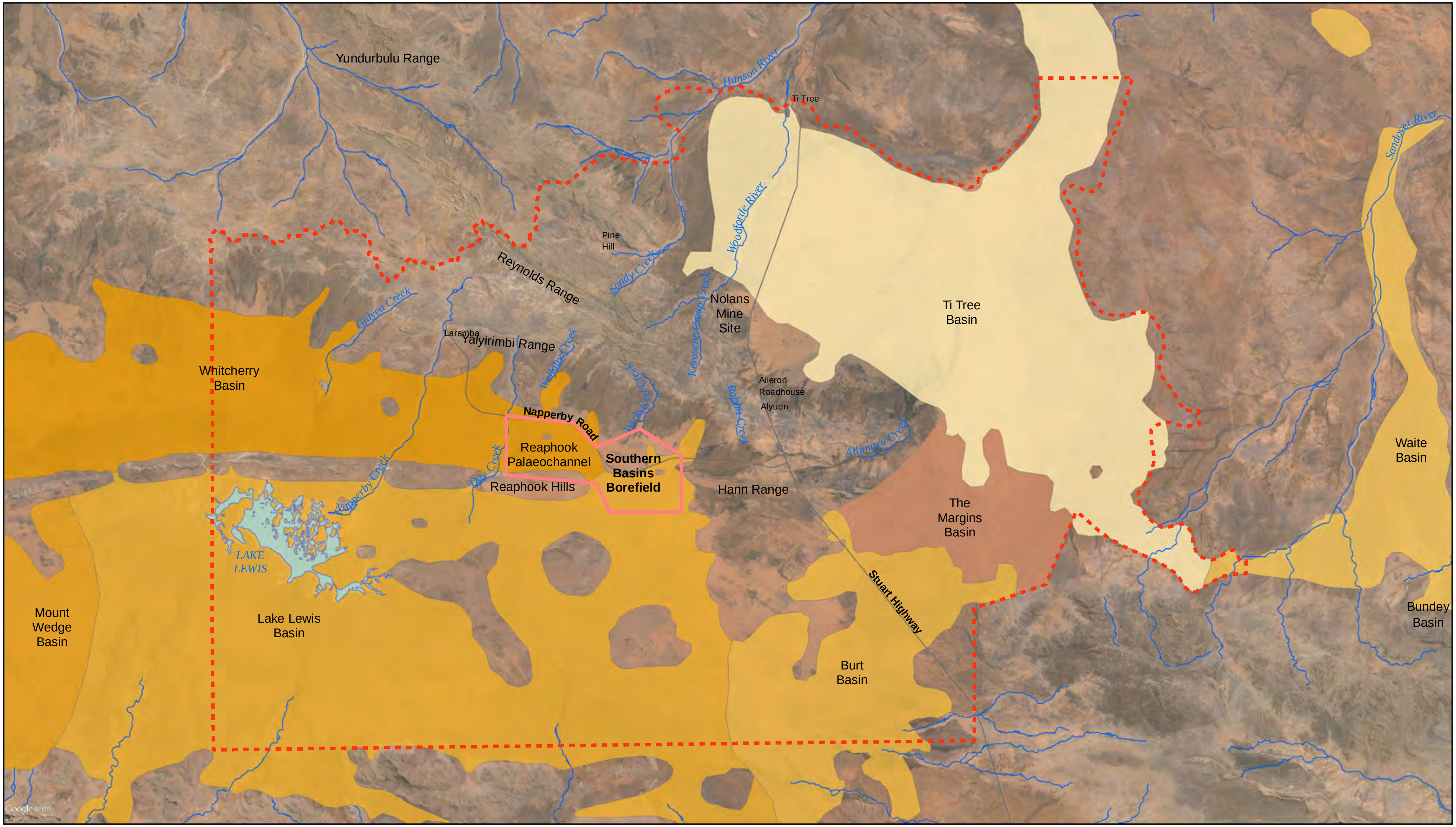
Precipitation averages approximately 320 mm/year but importantly for groundwater recharge, precipitation can fall as large rainfall events. Using the Territory Grape Farm weather station data (Appendix K), rainfall events were examined over a 28-year period. Twelve events were recorded for 60 mm or more per day, and 19 events were above 50 mm per day. Considering multiple day events (over five consecutive days), there are two occurrences exceeding 250 mm. Considering the low average rainfall, these events are significant as it is likely that most groundwater recharge and stream flow events result from rare, high-rainfall events rather than steady annual recharge. Ride (2014) documents a monthly rainfall of 100 mm or more being required to result in surface water flow in the Ti Tree Basin.

8.3.4 Basins

The basins (Southern Basins and Ti Tree Basin) in the study area are hydrogeologically similar (although not identical) to each other and to adjacent basins across central Australia. Unlike the Ti Tree Basin, which has been studied in detail and used extensively as a groundwater source, the Southern Basins in the study area have not previously been investigated in detail nor have they been used extensively as a groundwater source.

The Southern Basins encompass Cenozoic sedimentary basins previously referred to as the Whitcherry Basin, the Mount Wedge Basin, the Burt Basin and Lake Lewis Basin (Figure 8-2).

The Southern Basins are considered to be connected to the Ti Tree Basin in an area referred to as The Margins. Despite the connection, The Margins are primarily a subtle groundwater divide with water flowing north of the divide to the Ti Tree Basin and south of the divide to the Southern Basins. To the east, the Ti Tree Basin is connected to the Waite Basin (and then Bundey Basin) and to the north it is believed to be connected to the Hanson Palaeovalley (Figure 8-2).



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Hydrogeological study area

Figure 8-1

G:\43\22301\GIS\Maps\4322301_023_HydrogeologicalStudyArea.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: Google Earth Pro - Imagery (Date extracted: 14/05/2015). GA - Roads, Waterways, Lake Lewis, Placenames (2015). GHD - Groundwater Study Area, Southern Basins Borefield (2015). Created by: CM

1:3,000,000 @ A4

0 25 50 75 100

Kilometres

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

N

LEGEND

- Groundwater Study Area
- Southern Basins Borefield
- Lakes

Distant Basins & Palaeovalleys
- Ti Tree Basin
- Bundey Basin
- Hanson Basin
- Mackay (Wilkinkarra)
- Waite Basin

Southern Basins
- Burt Basin
- Lake Lewis Basin
- Mount Wedge Basin
- Whitcherry Basin
- The Margins

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Revision | 0
Date | 13 Apr 2016

Key regional basins and palaeovalleys

Figure 8-2

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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: Google Earth Pro - Imagery (Date extracted: 14/05/2015). GA - Roads, Lakes, Placenames, Palaeovalleys (2015). GHD - Groundwater Study Area, Southern Basins Borefield (2015). Created by: CM

8.3.5 Surface water features

Surface water features important to the study area are also presented in Figure 8-3. The important surface water drainage features within the study area flow only as a result of precipitation falling within the study area. Surface water flows originate in the catchments of the Reynolds Range and Yalyirimbi Range. These flows typically result in terminal creeks (i.e. their flow does not make it to a secondary water feature, i.e. a lake or river) including the named features Gidyea Creek, Day Creek, Wallaby Creek, Wicksteed Creek, Kerosene Camp Creek, Rabbit Creek and Allungra Creek. Napperby Creek is the exception in that it discharges to the endorheic basin, the ephemeral Lake Lewis, following periodic high rainfall events. Likewise, the Woodforde River also discharges to the Hanson River downstream (north) of the study area. No significant surface water drainage features originate from the Hann Range, Reaphook Hills or in the low-lying dune country of the relatively flat plains of the Ti Tree Basin and Southern Basins.

8.3.6 Water users

Groundwater from the basins is the primary source of drinking water in the study area. Power and Water Corporation provide groundwater to communities at Ti Tree, Pmara Jutunta, Laramba (Napperby); and the Central Desert Regional Council provides water to the Alyuen Community, Aileron Station Homestead and Aileron Roadhouse. Groundwater is also used for domestic purposes at the other stations' homesteads in the study area, notably Napperby Station Homestead and Pine Hill Station Homestead.

Pine Hill Station Homestead is adjacent to a large permanent/semi-permanent surface water hole visible on aerial imagery, and it is understood Napperby Station Homestead sources drinking water from a permanent/semi-permanent surface water source located in the adjacent hills.

In addition to this domestic use, groundwater is important for the following uses:

- Stock water - primarily for cattle, is extracted from groundwater within the basins and basement rocks across the study area; and
- Irrigation for agriculture - extracted from the Ti Tree Basin mainly for table grapes and mangoes at Ti Tree Farms.

Environmental users of water (not necessarily groundwater) in the study area include riparian vegetation, vegetation on the plains and in the hills, as well as fauna. With no permanent surface water across the study area, vegetation and fauna are either capable of surviving in between rainfall events or are able to tap into groundwater. Depths to groundwater levels are known to be shallow in isolated areas across the study area, but over the vast majority of the area are generally well below the reach of most vegetation (i.e. greater than 15 m). The following environmental users of groundwater have been identified:

- Riparian vegetation (dominated by *Eucalyptus camaldulensis*, colloquially referred to as river red gums) line the larger creeks and rivers in the study area. These larger creeks and rivers with riparian vegetation include, but may not be limited to, Napperby Creek, Day Creek and Woodforde River (Figure 8-1). It is conceivable that such riparian vegetation could tap groundwater (potentially even at depths greater than 15 m) and therefore these areas are potential groundwater dependant ecosystems, and are considered in this impact assessment.
- Water appears to be important for vegetation in floodout areas and at the toe of hills and ranges where runoff is highest. These areas are primarily dominated by *Acacia aneura* (mulga) woodland. These areas are considered in this impact assessment.

- Lake Lewis and surrounds is considered a site of conservation significance at a rating of National Significance. Due to this significance, Lake Lewis is considered in this impact assessment, despite the lake itself being a significant distance (30 km) from the borefield.
- Where water pools in basement rock-holes along drainage lines or in depressions in the outcropping rock mass, these provide a source of water for environmental use until evaporation depletes the water. Such features are present in the hills and ranges across the study area and these features are considered in this impact assessment, despite their distance from extraction points and their low permeability settings.

Water users are depicted in Figure 8-4.

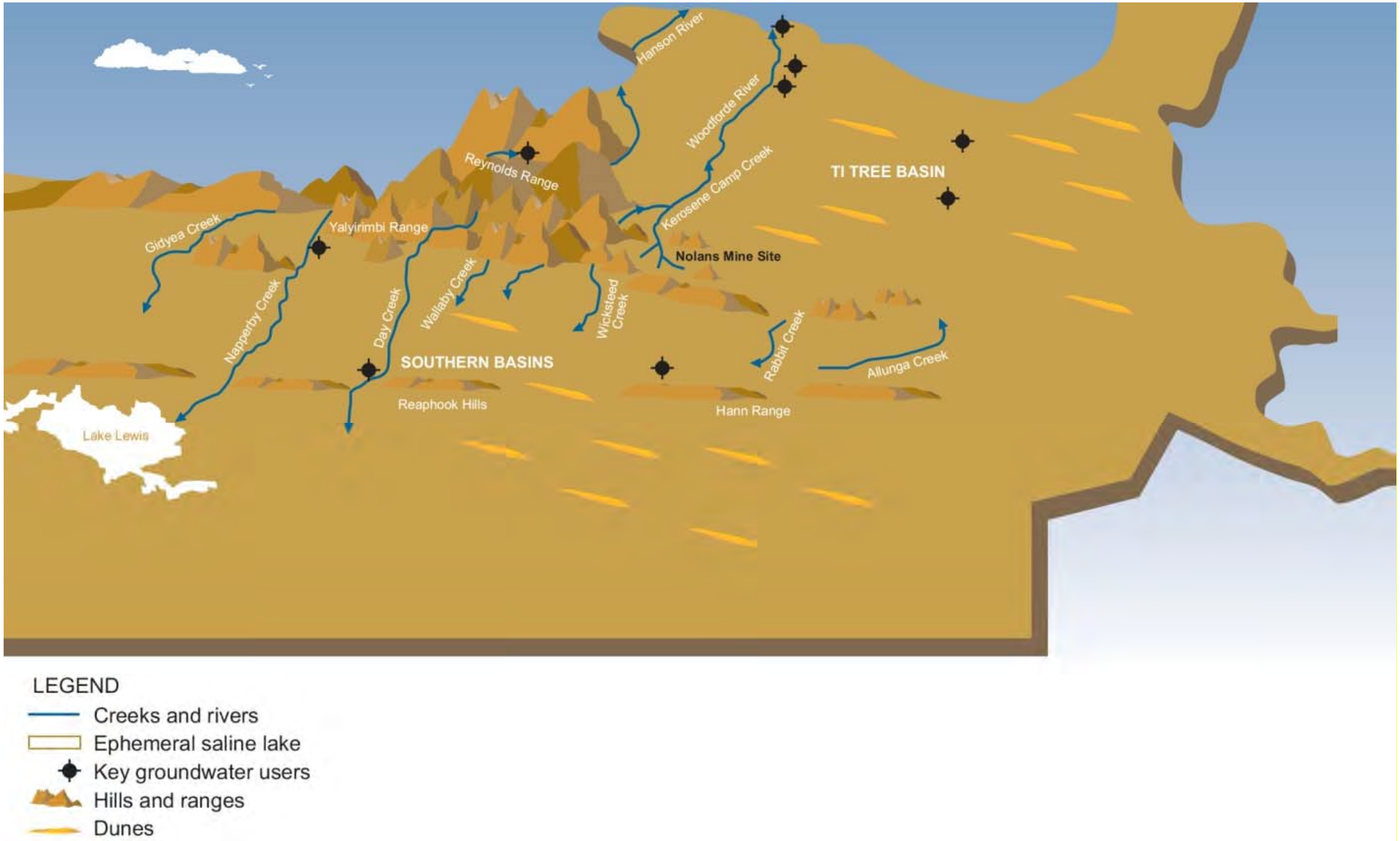

Figure 8-3 Study area surface water features

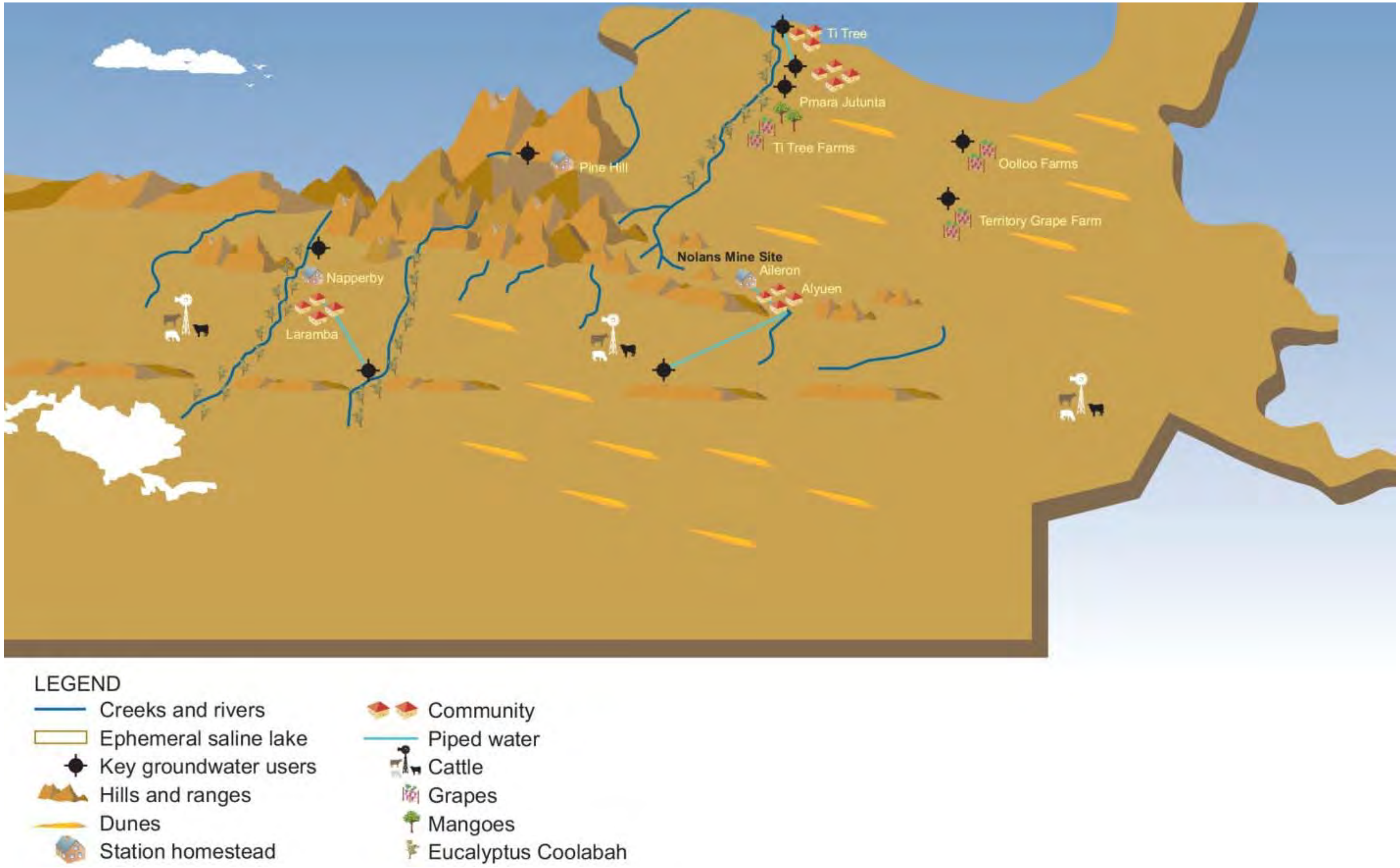

Figure 8-4 Study area water users

8.3.7 Conceptual water flows

Conceptual flows are represented in Figure 8-5 and are divided into the following groups:

- Boundary conditions
- Recharge
- Evapotranspiration and
- Groundwater extraction.

Boundary conditions

Upper no flow boundaries are the topographic high of the ranges and no flow boundaries of the basin boundaries. The divide between the Ti Tree Basin and the Southern Basins is a connected groundwater high, and thus no boundary condition is applied.

The Southern Basins have three key groundwater flow outputs (Figure 8-5):

- North of the Reaphook Hills westward through the deep aquifer
- South of the Reaphook Hills westward through the aquifer and
- Potentially through discharge at surface into Lake Lewis.

No surface water, significant to the hydrogeological assessment, flows into the study area but surface water leaves the system through the Hanson River and Woodforde River.

Recharge

Recharge throughout the Ti Tree Basin has been the subject of multiple studies and the groundwater assessment (Appendix K) makes use of the previous findings and estimates. Throughout this broader study area, classification of recharge (Figure 8-5) includes recharge through:

- Fractured rocks of the ranges and hills
- Alluvial fans and plains immediately adjacent to the ranges and hills where runoff infiltrates into the plains and
- Infiltration from Lake Lewis and areas locally referred to as ‘swamps’ and ‘clay pans’, following inundation events.

Evapotranspiration

The most evident illustration of evapotranspiration is the ephemeral, saline Lake Lewis where water clearly leaves the system as evaporation. Diffuse evapotranspiration occurs across the study area from vegetation, soil (as well as sediments and rock) and water bodies. Additionally, where water tables are shallow, trees (primarily mulga in the study area), shrubs and grasses (i.e. spinifex) are likely to tap groundwater and provide areas of higher evapotranspiration.

Groundwater extraction

Groundwater is extracted from the Ti Tree Basin for irrigation, stock and domestic purposes as discussed above in Section 8.3.6 and these locations are represented in Figure 8-4 at the key bores. Elsewhere in the study area, localised small-scale groundwater extraction occurs for stock and domestic purposes. An additional groundwater extraction of 4.5 GL/year for a 43-year period is proposed for the Nolans Project. The impact of this extraction is the focus of this study.

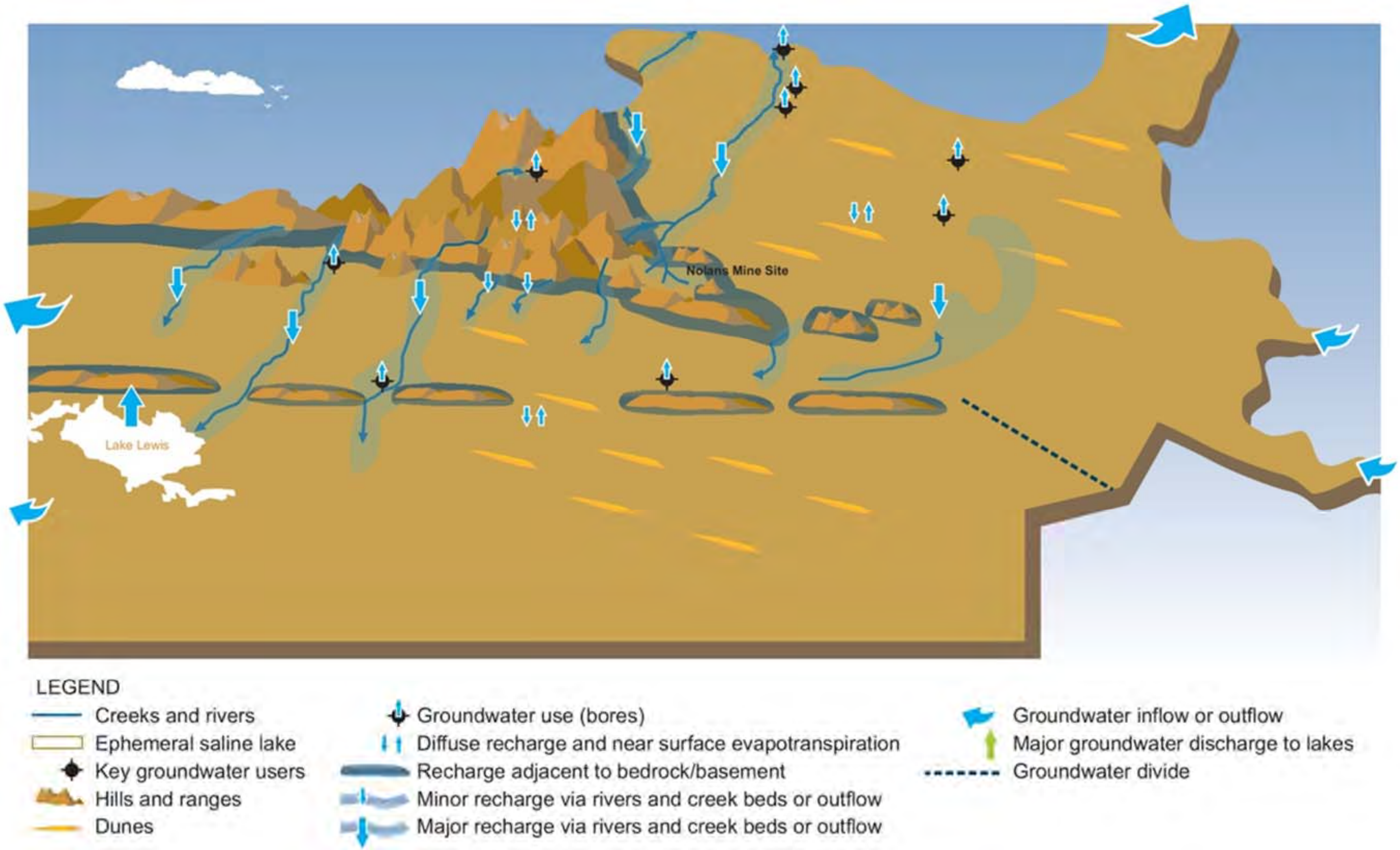

Figure 8-5 Study area conceptual water flows

8.3.8 Groundwater chemistry

A groundwater sampling and analyses dataset consisted of 158 samples from 71 bores (the dataset is summarised in Appendix K). The groundwater chemistry plotted by aquifer type displays a broad spread of water types, but there is a linear trend likely to be resulting from increases in chloride (Cl) content which may be associated with the evolution of groundwater, potentially driven by evaporation.

Groundwater quality (and chemistry) is variable in all units, however the general trend is that alluvial, shallow fluvial, and calcrete aquifers are 'fresher' than the Reaphook Palaeochannel aquifer and the upper Ti Tree Basin aquifer, which in turn are 'fresher' than basement aquifers. There are exceptions to this, but the general trend for the conceptual model is hypothesised to be that groundwater quality:

- Deteriorates with proximity to basement rocks (due to dissolution associated with weathering) and discharge locations (due to evaporation and subsequent concentration of constituents) and
- Improves marginally with proximity to preferential recharge locations (i.e. the Day Creek and Reaphook Range intersection) and where diffuse recharge is not associated with runoff from basement rocks (i.e. the centres of basins and The Margins area).

8.4 Groundwater modelling

A numerical groundwater model was built to represent the:

- Existing groundwater system (a steady-state numerical groundwater flow model)
- Groundwater system under the influence of the project's operating conditions (a predictive transient numerical groundwater flow model)
- Groundwater system under closure conditions (a long-term [1,000 year] predictive transient numerical groundwater flow model).

The model is calibrated to groundwater level information and not groundwater flow information. The model relies on boundary conditions and material hydraulic conductivity information based on assumptions and estimations from previous investigations and those made during the field program.

According to the Australian Groundwater Modelling Guidelines, models are suitable for the following key specific uses (refer to Appendix K for more information):

- Predicting long-term impacts of proposed developments in low-value aquifers
- Estimating impacts of low-risk developments
- Understanding groundwater flow processes under various hypothetical conditions
- Provide first-pass estimates of extraction volumes and rates required for mine dewatering
- Developing coarse relationships between groundwater extraction locations and rates and associated impacts.

The model is designed to test two primary stresses (sources of flow in or out of the model) that will be added to groundwater system as a result of the Nolans Project. These are:

- The mine (modelled as drain cells to represent and quantify sump pumping, i.e. flows are outputs from the model)
- The borefield (modelled as well cells to represent bore pumping, i.e. flows are inputs to the model).

Secondary stresses include stock bores, Ti Tree Basin bore pumping for horticultural irrigation, and community bores (Pmara Jutunta, Alyuen and Laramba). These bores are included in the transient model as constant-rate stresses, such that the impacts of the mine and borefield can be isolated from these pre-existing stresses.

Tertiary stresses include recharge and evapotranspiration. Like the bores, recharge and evapotranspiration are included in the transient model as constant-rate stresses, such that the impacts of the mine and borefield can be isolated.

The modelled solution represents a non-unique solution. A different combination of parameters could be applied resulting in an equally valid prediction which could result in impacts with differing magnitudes; however, the modelling does provide a valuable tool capable of quantifying the impacts based on reasonable documented inputs.

Obtaining a temporal dataset (ideally through the deployment of a fleet of water level loggers) and calibrating the transient model to a temporal dataset should be considered the next step in refining the groundwater model.

8.5 Assessment of potential impacts

This section examines the potential impacts the Nolans Project will have on groundwater quality, chemistry and drawdown.

8.5.1 Modelled flows

The groundwater flow regime is predicted to significantly change in the mine area and result in a permanent sink (i.e. perpetually discharging low point) due to evaporation exceeding pit water inflow.

The predicted mine dewatering peaks at 4,000 m^3/day (46 L/s or 1,450 ML/year) and steady-state post-closure inflows at approximately 700 m^3/day (8 L/s or 250 ML/year). The primary source of the water is from the basement rocks and only a minor proportion is from the Ti Tree Basin. In previous assessments, the basement water has not been considered a contribution to the Ti Tree Basin or Southern Basins, however, in reality it is likely to make some minor contribution.

Despite the 8 L/s of long-term modelled pit inflow, there was no significant change in the Ti Tree outflow. The modelled outflow only decreased by 0.03% representing a peak change of 4 m^3/day or 0.05 L/s at the end of the 1,000-year closure modelled period.

Flowthrough of the Ti Tree Basin is unlikely to be impacted at a measureable or observable amount. Flowthrough and availability for evapotranspiration within the Southern Basins is likely to be lower but not by an amount that a material impact is envisaged.

8.5.2 Modelled groundwater elevation and flow directions

The modelled groundwater flow regime displays almost no change (i.e. no impact) at the model (regional) scale when viewed from a flow direction or groundwater head perspective. At this scale, the impacts to flow direction and groundwater head are very localised to the mine area and adjacent to the Southern Basins borefield bores in the Reaphook Palaeochannel area while in operation.

No reversal of groundwater flow direction occurs anywhere within the model area during mining, except for immediately adjacent to the pit and immediately adjacent to the borefield bores (but not across aquifer, i.e. groundwater flow in the borefield aquifers is still westwards despite the pumping).

The modelled area of reversal at the end of the 1,000-year closure period extends within the basement rocks radially from the mine for approximately four kilometres towards the Aileron Station Homestead and Aileron Roadhouse area.

The modelled area of inflow towards the pit is limited to an area with the following average radii measured from the centre of the pit (which itself has an average radius of approximately 0.75 km):

- After 10 years of mining, approximately 1 km
- After 20 years of mining, approximately 1.5 km
- After 30 years of mining, approximately 2 km
- At the end of mining, approximately 2.5 km
- After 100 years of closure, approximately 4 km and
- After 1,000 years of closure, approximately 5 km and extending northwest along the basement rocks.

This demonstrates that the modelled extent of the inflow cone during mining is limited in extent to almost only the area actually disturbed by mining (i.e. much of this area is beneath the waste rock dumps and TSF.

8.5.3 Modelled drawdown at the mine site

The drawdown associated with mine site groundwater extraction is presented visually in Figure 8-6 to Figure 8-10. The modelled groundwater drawdown is very large at the pit site, but is likely to have very steep gradient due the low permeability of the rock mass surrounding the orebody.

Peak pit groundwater inflows of 4,000 m^3/day (46 L/s), equates to approximately 260 m of drawdown in the mine area at the completion of mining. Steady state post closure inflows to the pit of approximately 70 m^3/day (8 L/s), equates to approximately 80 m of drawdown during closure as the water rebounds to a level where groundwater flow equates to evaporation.

Riparian vegetation

Groundwater levels are predicted to be lower within the drawdown cone associated with the open pit, and the riparian vegetation immediately adjacent to the mine area will be directly, and irreversibly, impacted by this, both upstream and downstream in Kerosene Camp Creek.

The impact will likely be the result of groundwater drawdown as described above, but also the complete removal of periodic surface water flow, either directly via creek flow or indirectly during recharge to groundwater, due to the creek diversion works associated with mining operations.

The extent of the impact to riparian vegetation will be greatest immediately adjacent to the pit and decrease radially with distance from the pit. A reasonable estimate for the down gradient extent of this has been made, based on the both the modelled drawdown cone and the point where Kerosene Camp Creek receives additional surface water flow from adjacent catchments (which is likely to in part mask this impact) at the confluence with Nolans Creek. This length of Kerosene Camp Creek beyond the mining area, that is unlikely to capable of maintaining the current riparian vegetation, is less than one kilometre.

At this point the groundwater model predicts a drawdown of two metres during mining but approaches 20 m in the long-term closure model (1,000 years). This impact may, in part, be masked by recharge from continued surface water inflow beyond the confluence of Nolans Creek but this has not been explicitly incorporated into the modelling.

Stock water use

The small aquifer largely confined to the orebody at the mine pit will be almost completely removed during mining operations. Aileron Station water supplies near the pit will be impacted by the proposed mine dewatering and remain impacted beyond mine closure. At other existing bores in basement aquifers and adjacent materials, the drawdown impacts are likely to be minor in the long term but not materially affected by mine drawdown during their anticipated operational life.

At Pine Hill Station, groundwater for stock water in the Kerosene Well area eight kilometres downstream of the mining lease (bores RN010759 and RN012624) is beyond the cone of depression during mining. It is conceivable that these local resources may be impacted due to the pit void limiting flowthrough beyond mine closure; however, groundwater modelling predicts no impact at the Pine Hill Station Homestead and nearby outstation.

Groundwater availability for stock use within the Ti Tree Basin itself is highly unlikely to be measurably impacted. Despite the 8 L/s of long-term modelled pit inflow, there was no significant change in the Ti Tree outflow.

Irrigation for horticulture and viticulture

Groundwater availability for irrigation for horticulture and viticulture within the Ti Tree Basin is highly unlikely to be measurably impacted. The same measure for water availability for stock use has been applied to water availability for irrigation for horticulture within the Ti Tree Basin. The groundwater modelling indicates that, for example, the Ti Tree Farms area is beyond the cone of depression during mining, and beyond any measureable drawdown impact during the 1,000-year closure modelled period.

Drinking and domestic water

Like the above uses, drinking water supplies within the Ti Tree Basin including those at Pmara Jutunta, private farms and station homesteads are not likely to be impacted by drawdown associated with mine dewatering.

There are no drinking water users in the mine area and existing groundwater is not of a quality that drinking water could be a future beneficial use.

It is understood that drinking water for Aileron Station Homestead, Aileron Roadhouse and Alyuen Community is currently sourced from the Southern Basins.

At the location of existing basement bores in the Alyuen Community and the Aileron Station Homestead and Aileron Roadhouse area, that may have previously been used for drinking water, groundwater levels may be impacted in the long term by mine drawdown. It should be noted that these waters are not currently considered to be of a quality to have a beneficial use as drinking water.

8.5.4 Modelled drawdown at the borefield

The Southern Basins borefield is planned to be operated at approximately 13,000 m^3/day (150 L/s or 4,700 ML/year). Modelled drawdown in the water table from the operation of the Southern Basins borefield peaks at approximately six metres the centre of the borefield. The drawdown associated with borefield groundwater extraction is presented visually in Figure 8-6 to Figure 8-10.

The modelled groundwater drawdown is very large in terms of its extent. As such the flow rates should not be considered ‘sustainable’ in the long term (i.e. indefinitely) as it is unlikely to be replaced by recharge at the same rate as the proposed abstraction rate. However, despite it being unsustainable in the long term, the borefield is considered an appropriate use of the aquifer provided borefield abstraction ceases at the end of mining and processing operations and the aquifer be allowed to recover. The minor current and potential future uses should not be impacted in a material manner, although it is recognised that some drawdown at nearby stock and drinking water sources is likely to occur.

In the vicinity of the Laramba and Napperby groundwater supply area, modelled drawdown from the borefield peaks in the order of 1.3 m and rebounds rapidly once pumping ceases (Appendix K). This drawdown could result in minor incremental increases in pumping costs and minor decreases to yields in existing bores. Groundwater supply bores in such settings are commonly designed and operated with tens of metres of contingency for drawdown (to minimise impacts of drawdown from the operating bore itself) and this is the case at the Laramba groundwater supply area. The modelled drawdown therefore will be very unlikely to have any material impact on the volume of water available to supply Laramba and Napperby at either the actual bores or within the overall aquifer. Even if demand at Laramba and Napperby were to increase substantially, the modelled drawdown would be very unlikely to have any material impact on the water availability from the Laramba and Napperby groundwater supply area, and be very unlikely to be a limiting factor for water supply. In any event, given the setting, it is not the aquifer itself but the number of bores, current yields or size of pipelines (or other infrastructure) that are likely to be limiting factors for supply, to be able to meet potential significant increases in demand.

Riparian vegetation

Modelled drawdown from the borefield peaks in the order of 1.5 m in the vicinity of Day Creek (Appendix K) and rebounds rapidly once pumping ceases.

Water table level observations in an adjacent bore indicate water levels at up to 28 m below ground level. If riparian vegetation is currently dependent on the groundwater at this location, tree roots must be capable of extracting water from greater than 20 m deep, even accounting for the river bank and collar heights. If vegetation is capable of extending its root systems to such depths it is hypothesised that it is reasonable to expect that it could gradually extend its root system a further 1.5 m over the predicted 41-year drawdown period during mining.

There are no planned surface works in the Day Creek catchment that are likely to affect the recharge to either the surficial alluvials or the deeper aquifer material. If the vegetation is reliant on shallower or more temporary sources of water, there is no indication that there are any works proposed (including pumping of the borefield) that would alter these conditions.

Like Day Creek, there are no planned surface works in the Napperby Creek catchment that are likely to affect recharge to the area. However, unlike Day Creek, the modelled drawdown cone does not extend with significant magnitude to the Napperby Creek area during operations, but doubles in magnitude in the approximate 50 years following closure (Appendix K) as the aquifer recovers at the centre and extends laterally. The magnitude however is half that predicted at Day Creek and therefore it is reasonable to assert that even less impact (if any) is expected at Napperby Creek.

Floodout vegetation

In the Southern Basins, there may be minor localised impacts to floodout vegetation and/or soaks due to a decrease in groundwater availability for evapotranspiration. The impact will be determined by the current groundwater dependence and how the difference in availability of groundwater affects floodout vegetation and soaks. Given the scale of distance, the minor drawdowns predicted, the percentage differences in groundwater available and the gradual nature of the predicted changes, it is assumed that this impact will be low.

In the Reaphook Palaeochannel area of the Southern Basins the modelled difference in groundwater available for evapotranspiration peaks at approximately 100 years after closure. This is well after the pumps in the borefield in the modelled scenario have ceased but corresponds with the period the drawdown cone is still expanding laterally but decreasing in its vertical extent at the epicentre. The peak decreases in groundwater availability for evapotranspiration in the Reaphook Palaeochannel area is 12% or 306 m^3/day (3.5 L/s) and this rebounds to approach steady state at a decrease of approximately 1% or 31 m^3/day (0.36 L/s).

Lake Lewis and surrounds

The key indication for impact to Lake Lewis is whether the area is within the modelled drawdown cone but also if modelled net discharges to the area are affected.

The predicted drawdowns are negligible in the Lake Lewis area and not likely to be measureable. Despite this, the groundwater available for evapotranspiration, like in the Reaphook Palaeochannel area to the north, is likely to be impacted in the Lake Lewis area. The peak decreases in groundwater availability for evapotranspiration in the Lake Lewis area of the Southern Basins is 3% or 712 m^3/day (8 L/s) and this rebounds to approach steady state with a decrease of approximately 0.5 % or 103 m^3/day (1 L/s).

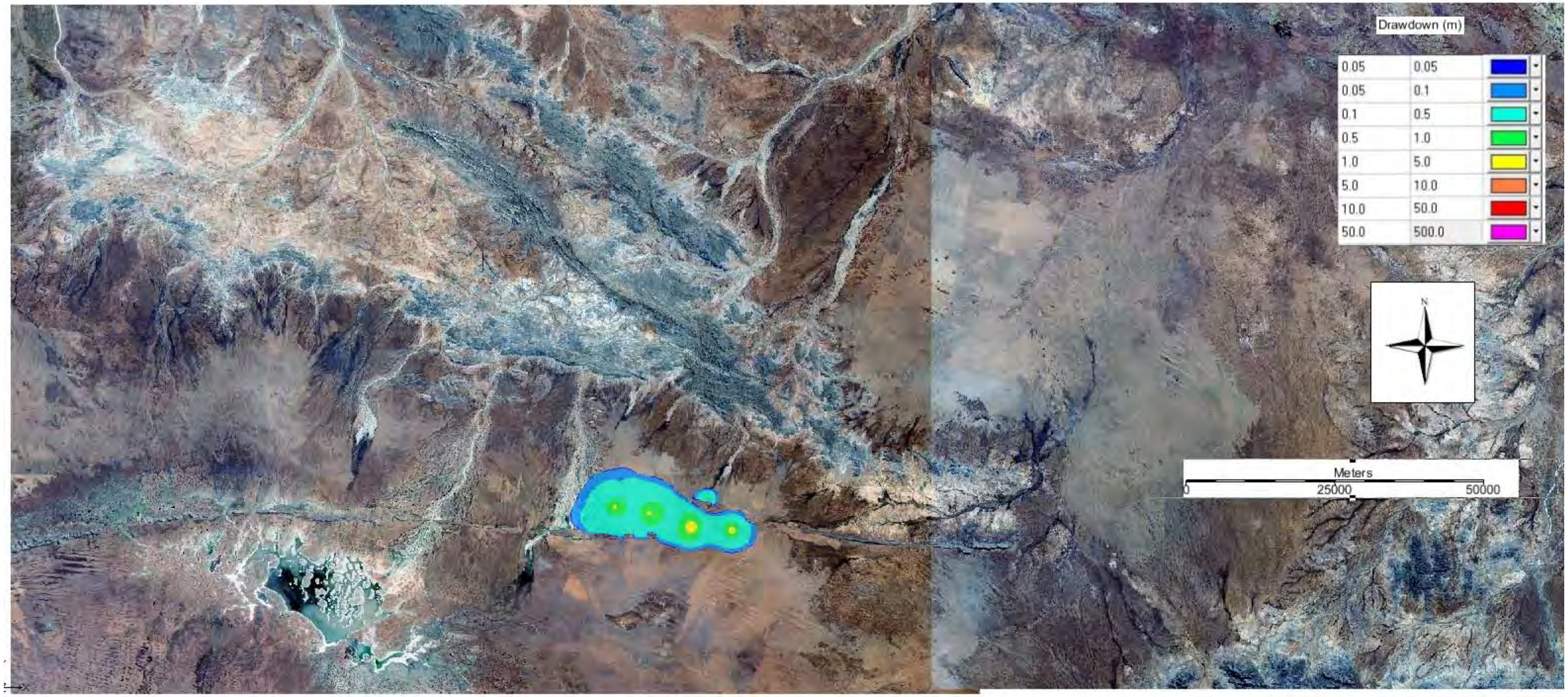

Figure 8-6 Modelled drawdown at commencement of mining 1/1/2020

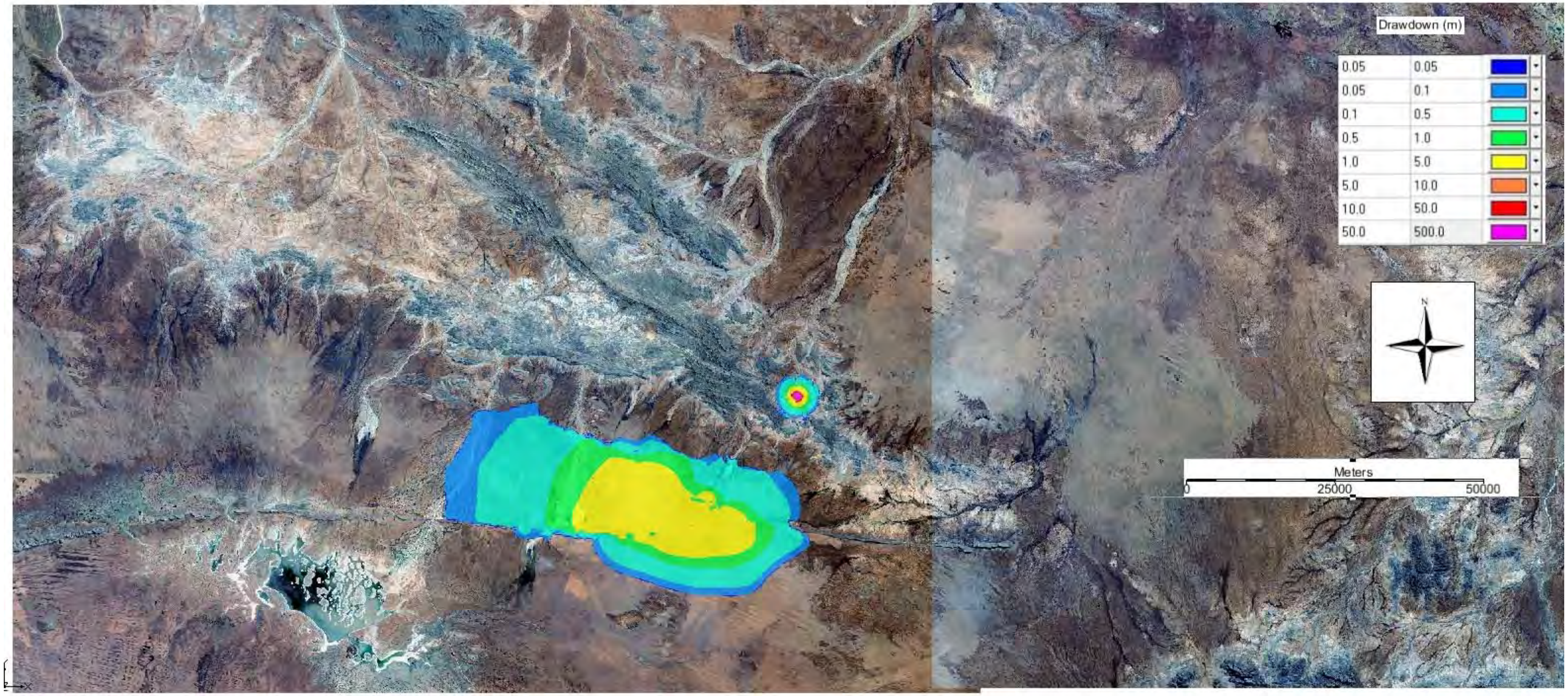

Figure 8-7 Modelled drawdown at approximately mid-way through mining 1/1/2040, 20 years after commencement of mining

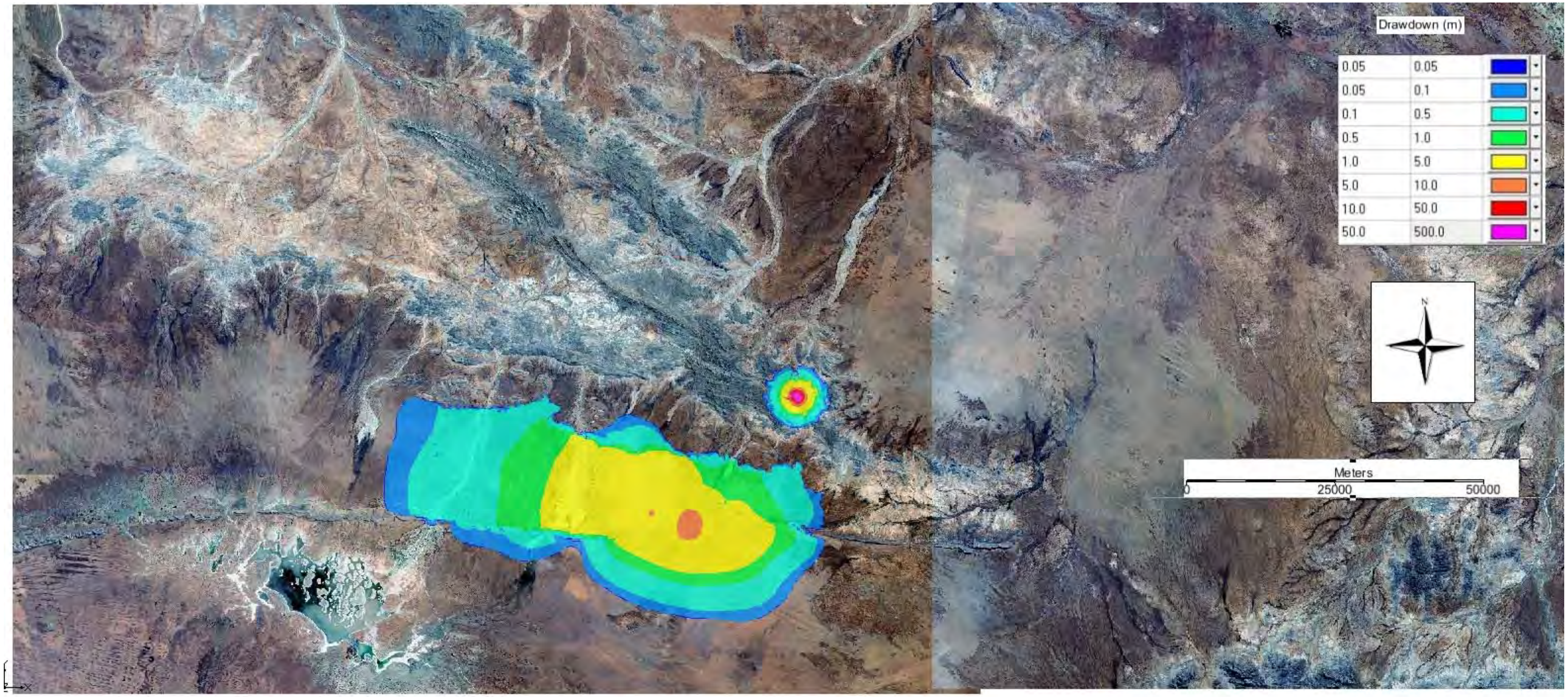

Figure 8-8 Modelled drawdown at end of mining 1/1/2060

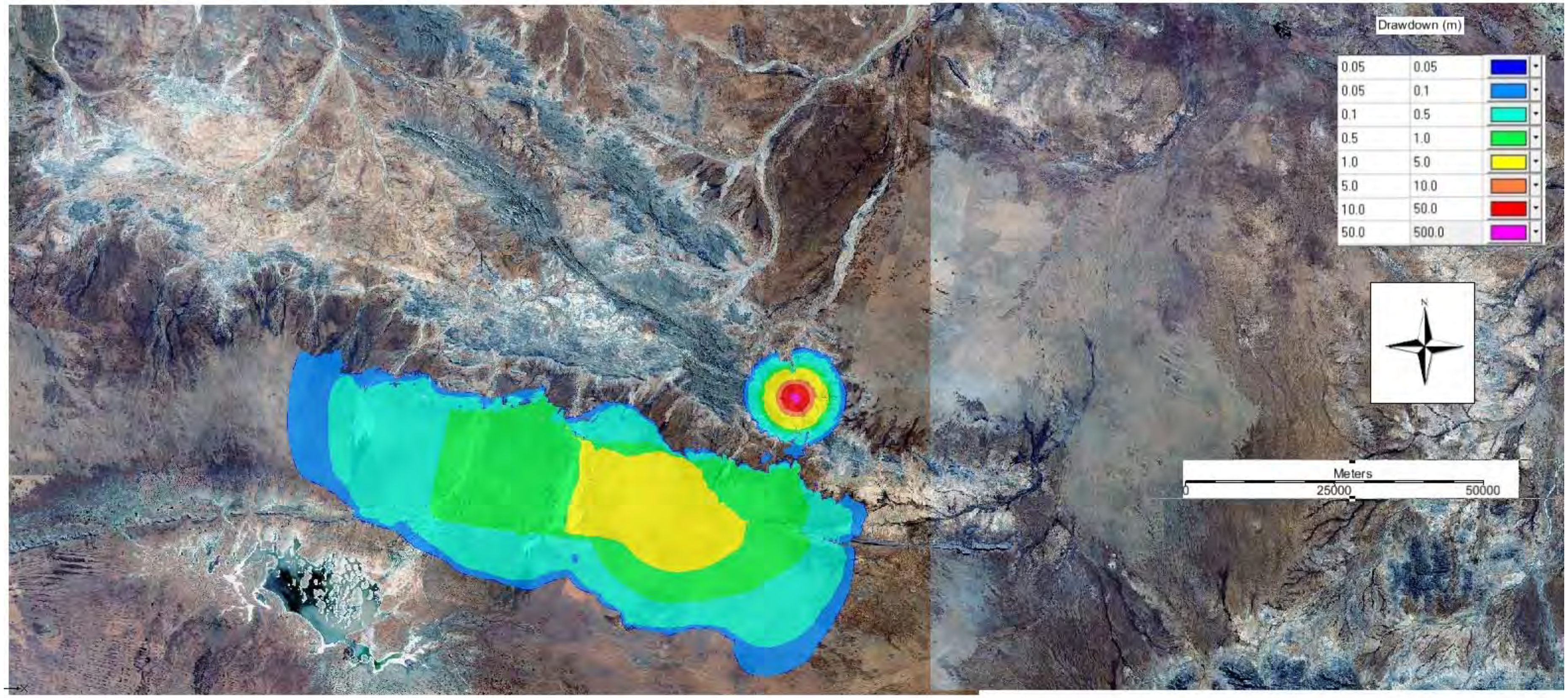

Figure 8-9 Modelled drawdown at 100 years of closure 1/1/2160

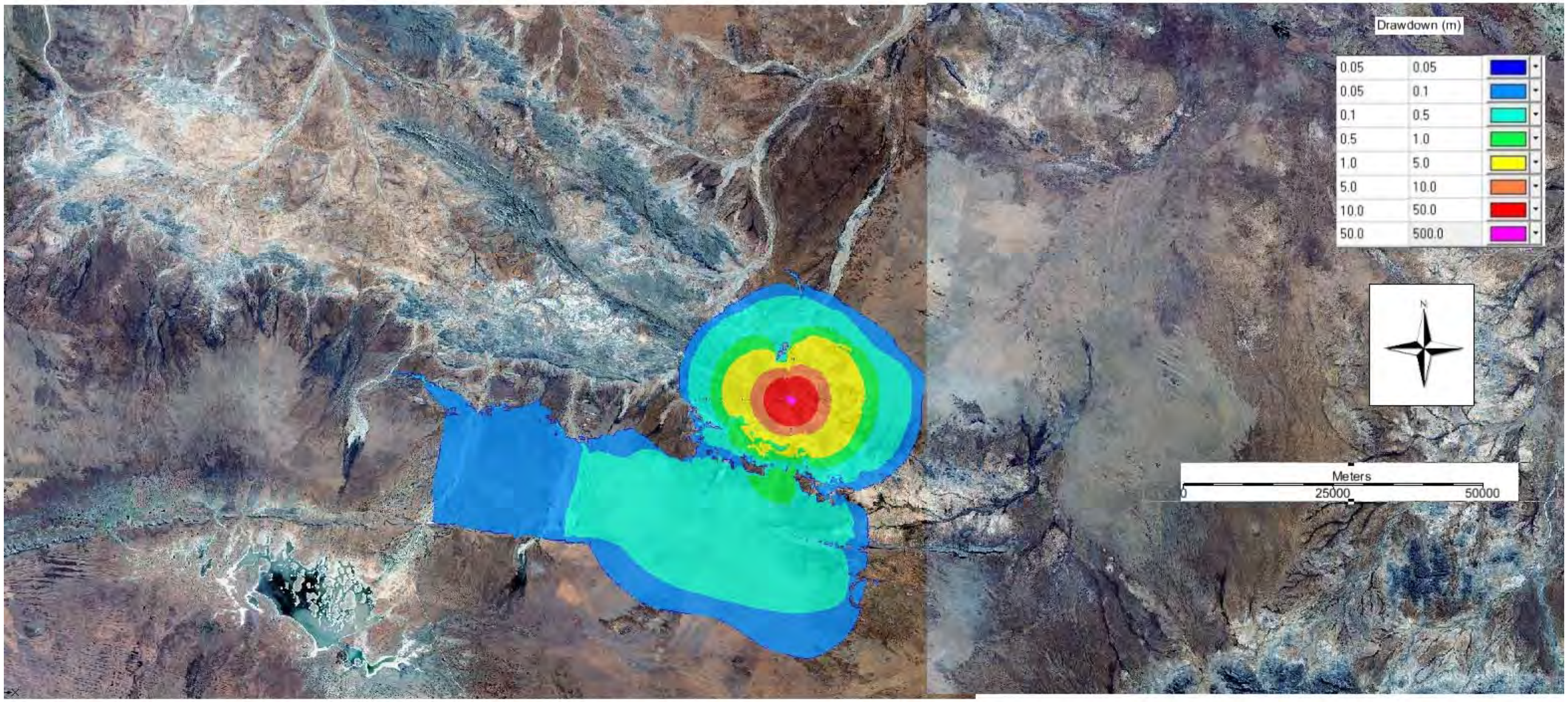

Figure 8-10 Modelled drawdown at 1,000 years of closure 1/1/3060

8.5.5 Groundwater chemistry and quality

The modelled groundwater flow regime displays almost no change (i.e. no impact) at the model (regional) scale when viewed from a flow direction or groundwater head perspective. As such, there is no justification for any speculation of material changes in groundwater chemistry or quality within the aquifer.

Despite this, conceptually there still remains the minor potential for hypothesised impacts based on the following:

- Extraction of groundwater from the Southern Basins could result in more groundwater with lower quality flowing from storage within the basement rocks
- Extraction of groundwater from the Southern Basins could draw fresher water associated with recharge from Day Creek eastwards altering the quality of drinking water available for extraction.

The aquifer under the influence of the proposed Southern Basins borefield pumping regime is likely to be under significantly more dynamic conditions than at present and under such conditions, a more uniform groundwater chemistry may develop.

Mine area

The chemistry of groundwater flowing towards the mining pit is unlikely to be materially different from the existing groundwater chemistry in the area. Once mining ceases, groundwater near the pit will begin the process of rebounding. A pit lake will form and the pit will slowly, partially fill until the water level reaches equilibration where the net evaporation is equal to natural groundwater inflow. This will then result in a process where water quality will slowly deteriorate and over time results in a hypersaline pit lake. Flow will be radially towards the pit lake and thus contribute to the concept of a zero discharge site. The likely chemistry of this pit lake has not been modelled; however, it is highly likely to be of no beneficial use.

In the highly unlikely event that the pit is filled and decants either to the surface water bodies or groundwater system (i.e. the pit lake rises above adjacent groundwater levels to the point where it is no longer behaving as a sink), this contaminated water could discharge. The mine closure design should ensure that all surface water runoff is diverted around and away from the pit so that the pit remains a groundwater sink.

Acid and metalliferous drainage

Characterisation of Nolans waste rock and ore was undertaken for AMD predictions using chemical analysis, XRF and static and kinetic AMD testing. Further details are presented in Appendix L.

A total 154 static AMD tests comprising static net acid generation/net acid producing potential (NAG/NAPP) tests were carried out. Of the 154 samples, 25 samples represented pegmatite, 34 mineralisation, 25 gneiss and 70 schist. Only one sample out of 154 subjected to NAG/NAPP testing was identified as potentially acid forming (PAF). The tests indicated a very low risk of acid generation either during short-term storage of ore, or long-term storage of waste rock. A conservative threshold of 0.15% sulfur was recommended for confirmation NAG testing during operation.

Leachate salinity was low and fluoride was only slightly elevated in one sample but at a concentration consistent with ambient groundwater, hence the risk of generating saline or fluoride-rich leachate is low.

Seepage from ore or waste rock could contain elevated concentrations of some metals (particularly Zn, Al and Cr) and leached samples consistently exceeded ANZECC & ARMCANZ

(2000) Freshwater Aquatic Ecosystems 95% threshold and ambient groundwater concentrations. However, all leachate samples were within ranges acceptable for stock watering, where guidelines are provided in ANZECC & ARMCANZ (2000), including those for uranium and gross alpha and beta radiation, based on the total thorium and uranium content.

It is unlikely that leachate from the waste rock dumps will impact on existing poor quality groundwater or ephemeral surface water quality, when typical dilution factors are considered. Based on the overall chemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is low and the material can generally be managed as non-acid-forming.

The AMD Management Plan (Appendix L) provides for separate storage of all potentially acid-forming material, or blending of any potentially acid-forming material with non-acid-forming and acid-consuming material. This management process will ensure that any residual AMD impacts can be minimised.

The AMD assessment shows that with appropriate design and operational control measures (refer section 8.6) the residual AMD risk on site is very low. This residual risk will be monitored to confirm that waste rock dump design and operational controls and management measures are effective.

Processing site, tailings and residue storage facilities

As all storage facilities are designed as zero discharge facilities (i.e. evaporation controlled), they will be designed or managed such that they do not breach or decant either to the surface water bodies or seep into groundwater systems.

A breach or seepage of contaminated water from the processing site is likely to be in direct contact with the Southern Basins aquifer either via the shallow Quaternary material or along the interface between the Quaternary or Cainozoic material and the underlying basement material. Particle travel distances have been calculated based on assumed effective porosity values and key outputs from the model. These calculated particle travel distances are in the order of 100 m in a year or 10 to 20 km over the 1,000-year closure period. If the flow was to be through basement material alone, then particle travel distance is only in the order of hundreds of metres over the 1,000-year closure period. Monitoring bores near the processing site will allow detection of potential contamination and allow mitigation measures to be implemented to limit these potential impacts.

A breach or decant at the TSF would represent a similar outcome, however, depending on the scale, duration and timing, could be self-managed by the down-gradient pit acting as a groundwater sink. Like the processing site, a potential mechanism would be flow in the unsaturated Quaternary material or along the interface with the underlying basement material (i.e. along the Nolans Creek drainage line). These calculated particle travel distances are in the order of 50 m in a year, and as such flow would, within years, leave the site towards the north. In contrast, particle travel distances if flow was only within the basement material were calculated at less than 100 metres of flow outwards over the entire mining and early closure period before turning inward towards and ultimately being captured by the pit. As with the processing site, monitoring bores will be located near the TSF to allow detection of such an event and enable appropriate mitigation / management measures to be implemented.

These facilities will be designed to an appropriate standard and managed. They will be monitored during operation and through closure in order to maintain the long-term security of the tailings, residues and associated liquors.

8.6 Mitigation and monitoring of impacts

Monitoring the impact as well as monitoring to validate the predicted impacts will be required. Mine facilities will have a network of groundwater monitoring bores installed. The bores will be monitored for water levels, water chemistry and water quality as per the Water Management Plan (Appendix X).

In addition, the borefield will be monitored for water levels, water chemistry and water quality. As a minimum existing bores will be included for monitoring of the aquifer during and after the pumping period and for the monitoring of key specific potential impacts as outlined in Table 8-1.

Table 8-1 Proposed Southern Basins borefield monitoring

Location	Aquifer	Monitoring for potential Impact
West of Day Creek	Reaphook Palaeochannel	Day Creek
East of Day Creek	Reaphook Palaeochannel	Day Creek and Laramba/Napperby drinking water supply
Gap between Hann Range and Reaphook Hills	Reaphook Palaeochannel	Drawdown towards the south
South of gap between Hann Range and Reaphook Hills	Reaphook Palaeochannel	Southern extent of drawdown
Centre of Southern Basins borefield	Reaphook Palaeochannel	Epicentre of borefield drawdown
Centre of Southern Basins borefield	Reaphook Palaeochannel	Epicentre of borefield drawdown
Immediately north east of Southern Basins borefield	Reaphook Palaeochannel	Drawdown immediately towards the north east
Immediately east of Southern Basins Borefield	Reaphook Palaeochannel	Drawdown immediately towards the east
North eastern extent of Southern Basins	Alluvials	Drawdown towards the east
North of Southern Basins borefield	Reaphook Palaeochannel	Drawdown towards the north
North of Southern Basins borefield	Basement	Drawdown towards the north
North eastern extent of Southern Basins	Basement	North eastern extent of drawn

Implementation of the following management plans (Appendix X) would occur prior to construction commencing and would include groundwater management and protection:

- Mine Management Plan
- Sediment and Erosion Control Plan
- Water Management Plan including a groundwater monitoring program.

Measures to prevent potential spills from impacting groundwater will include:

- Development and implementation of a hazardous substances management plan

- Provision of self bunded storage for 110 per cent of the largest storage volume, in accordance with Australian Standards
- No underground piping would be included in the proposal design.

The mine pit will include the following features to minimise contamination of water resources:

- Potentially acid forming (PAF) material encapsulation cells within ex-pit waste rock dumps, if PAF is encountered
- Dumps and fill areas profiled to shed and capture runoff
- Clean, dirty and contaminated water drainage systems
- Surface water management basins
- Selective materials handling and placement using mine schedule and geochemical model
- Controlled and managed site drainage and release
- Compaction of construction material and waste rock.

To monitor for potential breaches of the slurry pipeline from the processing plant, the plant would include:

- Notification of disruption to flow to minimise impacts from spill
- Flow meters
- Pressure sensors
- Shift based visual inspections
- Design - spray deflectors on welded joints and
- Periodic visual inspections of pipeline corridors, to occur twice per shift.

To prevent seepage of tailings and residue water containing metals at levels potentially exceeding guideline thresholds the following measures will be considered:

- Selection of appropriate risk category and adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance
- Provision of a seepage interception and collection system
- Embankment piezometers and survey pins, regular dam inspections
- Adherence to prescribed maximum operating level and retention of freeboard
- Monitoring program for phreatic levels within embankments
- Testing to confirm chemical properties
- Thickener on concentrator to reduce volume of entrained water entering the tailings storage facility
- Supernatant reclaim
- Ongoing AMD sampling and analysis
- Multi-stage neutralisation process (pH control).

Throughout mining, the following hydrogeological studies will be undertaken:

- Ongoing hydrogeological monitoring and analysis ad
- Validation, re-calibration and additional predictive groundwater flow modelling.

Sampling and analysis will be undertaken as detailed in the site procedure in the AMD Management Plan. The results will be used to validate AMD risk and management strategies in subsequent revisions of the document.

Additional testing and monitoring will be undertaken in the pre-production phase. This will include:

- Identification of suitable capping/encapsulation material and testing for dispersion, exchangeable cation, and general capping geotechnical parameters
- Additional laboratory testing
- Column and or barrel leach tests to commence to provide long-term leachate generation information and
- Additional metals to be added to laboratory and field analyses, if required, to cover the range of potentially elevated or mobile metals.