



Appendix H

Fauna Assessment Report





TNG Limited

Mount Peake Project
Fauna Assessment Report

November 2015

Executive Summary

Project description and objectives of this assessment

TNG Limited is proposing to develop the Mount Peake Project (the Project) consisting of:

- The mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Road haulage of the concentrate approximately 100 km to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed Darwin Refinery at Middle Arm.

Mined ore will be transported by haul truck from the mine pit and stockpiled on-site at a run of mine (ROM) pad prior to processing. Mining will commence with a "starter pit" accessing high grade and low strip ratio ore. The mining rate will progressively increase to 8.4 million tonnes per annum (Mtpa) and, following processing, up to 1.8 Mtpa of magnetite concentrate will be produced. The life of the mine is expected to be 19 years inclusive of construction (2 years), mining and production (15 years), and closure and rehabilitation (2 years).

The mining area is located approximately 235 km north north-west of Alice Springs and approximately 50 km west of the Stuart Highway.

The main objective of this report is to satisfy the fauna assessment requirements of the Terms of Reference set by the Northern Territory Environment Protection Authority (NT EPA) for assessment of the Mount Peake Project.

Methods used for this assessment

Information presented in this report was obtained using the following methods:

- Desktop searches of government database information relating to fauna distributions, including the Commonwealth Department of the Environment (DotE) PMST and the NT Department of Land Resource Management (DLRM) Fauna Atlas database
- Undertaking a six-day fauna survey (9 – 14 April 2013) of the study area, using a range of trapping and non-trapping sampling techniques designed to gain as complete a description as possible of the relationships between fauna and the available habitats, and target the presence of fauna species listed as threatened/migratory under the *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Assessing the regional and national significance of the fauna and its populations of threatened species
- Determining ways in which the proposed mining operation might impact on the fauna and threatened species, proposing mitigation measures to reduce the risk of impacts, and determining residual risks to fauna including threatened species.

Legislative context for this assessment

Matters of National Environmental Significance, as defined under the EPBC Act, are known or considered likely to occur within the Project Area. A referral under the EPBC Act was submitted to the Commonwealth Department of the Environment in October 2013. In November 2013, the Commonwealth Minister for the Environment determined that the action (Project) is a "controlled action" and requires formal assessment and approval under the EPBC Act.

The Project is being assessed at the level of Environmental Impact Statement under the NT *Environmental Assessment Act 1982*. This will be done under the NT/Commonwealth bilateral environmental assessment process.

Results and discussion

Fauna habitats and landscape condition

More than 80% of the Burt Plain Bioregion is used for pastoralism. The Project Area lies mainly within Stirling Station which is used for cattle grazing. In general, remnant native vegetation occurs across the vast majority of the Project Area. Historical clearing was typically confined to pastoral infrastructure sites, and impacts from pastoral activities (trampling, grazing and weed invasion) were localised and generally confined to watering points, ephemeral watercourses and stockyards. Low level grazing impacts were evident across much of the Project Area, however, vegetation was generally healthy and active seedling recruitment was evident. Some modification to vegetation structure from fires has occurred within the Project Area.

Sixteen sites were established in a representative range of vegetation/habitat types, in locations chosen to maximise the likelihood of detecting fauna, including threatened species: mulga woodland (8 sites), riparian woodland (2 sites), rocky shrubland (3 sites), spinifex grassland (2 sites), and *Corymbia* woodland (1 site). For the most part, habitat classification is based on landscape features of note (e.g. rocks, waterway, species of dominant trees). Note, however, that while only two sites were formally categorised as spinifex grassland sites, other sites supported spinifex grasses also, particularly rocky shrubland sites and some mulga sites.

Fauna species

In total, 280 fauna species were identified for the Project Area. This species list includes the PMST report, DLRM database and the fauna survey results. Of the species, 268 are native to the Northern Territory (40 mammals, 145 birds, 74 reptiles and nine amphibians).

Six days of intensive fauna sampling by eight zoologists, under suitably dry and warm weather conditions in April 2013, resulted in a list of 116 fauna species (24 mammals, 58 birds, 34 reptiles and no frogs). Each of the sampling techniques resulted in effective sampling of differing taxonomic groups or combinations of groups. In combination, the sampling techniques effectively sampled the fauna as a whole, although species' accumulation curves showed that additional sampling time would have likely resulted in the detection of additional species. The absence of frogs is explained by the dry conditions prior to and during the survey.

Eighteen species detected during the survey had not previously been recorded on the DLRM database for this area. These include 11 native species of mammal (one dunnart and 10 insectivorous bats), three native species of bird and four native species of reptile.

Fauna species – patterns among sites and habitats

Fauna richness varied among the 16 sites and the five habitats, although statistical analysis suggested that the patterns were very weak. Birds were the most numerous species group, and variation in bird species richness tended to reflect variation in overall species richness. Mammal species richness, while seemingly low at all sites, was boosted by numerous species of insectivorous bats detected at most sites and was considered relatively good for arid Australian habitats. The richness of reptile species was generally low, but varied among sites.

When sites were grouped by habitat, fauna species richness was found to be far higher in the mulga habitat than in any other habitat. The rocky shrubland habitat had intermediate to high richness, while *Corymbia* and riparian woodland habitats had intermediate to low richness. The sites that had spinifex grassland only (and which were treeless, shrubless, and recently burned) had the lowest richness. Patterns in richness were partly explained by the numbers of sites of each habitat type (survey effort).

Up to 38% of species were detected in one habitat type only, which suggests a relatively high degree of fauna specialisation among the habitat types, rather than an even distribution of fauna among the habitat types. This contrasts with the results of the statistical analysis of fauna assemblage patterns, which suggested that distributional patterns were very weak (i.e. an even distribution of fauna among the habitat types). Differences among sites were not driven simply by numbers of species, but were more likely due to subtle differences in the types and/or abundance of fauna that occurred at the sites.

Threatened, near-threatened and migratory fauna species

The DLRM Fauna Atlas and the PMST results identified 22 threatened vertebrate fauna species (15 mammals, 6 birds and one reptile) for the Project Area. Twenty of these are listed under the EPBC Act and all are listed under NT legislation (TPWC Act). Some of the species (all mammals) are considered extinct in the Northern Territory, and others are predicted to occur but have never before been recorded within the Burt Plains Bioregion.

Sixteen threatened or near-threatened species (six mammals, six birds, three reptiles and one frog) are considered likely to occur within the Project Area, either as residents or visitors. Most of these are expected to be rare or very rare. Seven of these species were detected during the fauna survey in April 2013. These include:

- Brush-tailed Mulgara (*Dasycercus blythi*)
- Bilby (*Macrotis lagotis*)
- Grey Falcon (*Falco hypoleucos*)
- Emu (*Dromaius novaehollandiae*)
- Australian Bustard (*Ardeotis australis*)
- Woma Python (*Aspidites ramsayi*)
- King Brown Snake (*Pseudechis australis*).

The Brush-tailed Mulgara and Bilby were not observed, but were considered likely to be present on the basis of indirect signs (burrows, diggings and scratchings). Our confidence in the identification of the mulgara burrow was relatively high – the burrow was fresh and active, and showed the characteristic signs of a burrow of this species (as experienced by GHD zoologists in the Pilbara region in Western Australia, where live animals have been captured). Failure to detect a live animal at the burrow thereafter (remote sensing camera) may be explained by the species' known sensitivity to disturbance, and the likelihood that mulgaras have numerous burrow entrances that would be used preferentially in response to disturbance. Our confidence in the Bilby diggings is lower, but still reasonably high (J. Kuiper, GHD Ecologist; pers. comm.; Formerly with Australian Wildlife Conservancy). This determination is made on the basis of the habitat, apparent intent of the diggings (i.e. targeting a food source of termites and/or shallow roots), the appearance and characteristics of the scratchings (e.g. sharp edge to scrapes, two or three obvious claws marks), and proximity to historical Bilby records.

Given the survey effort during this assessment, failure to detect a live Bilby or a live mulgara suggests that neither species is in large numbers within the Project Area. However, arid fauna typically have breeding strategies that allow them to respond rapidly to improving conditions. Thus, future population sizes may differ greatly from current population sizes.

All of the threatened and near-threatened species detected are species that have broad distributions across Australia. The narrowest distributions are those of the two mammal species, whose distributional ranges have declined in recent decades, most likely in response to a combination of predation by feral cats, habitat disturbance and degradation due to grazing, weed invasion, and changes in the use of fire across the landscape.

Five of the seven threatened species detected are ground-dwelling species (reptiles, non-volant mammals, flightless birds) that have limited mobility across the landscape. These species are perhaps most at risk from localised habitat changes that may result from construction and operation of a mine in the Project Area.

Of the other threatened species considered likely or possible to occur within the Project Area, but *not* detected during the survey, seven are considered possible in particular habitats, as follows:

- Common Brushtail Possum (Southern NT) (*Trichosurus vulpecula vulpecula*) – in hollow-bearing eucalypts along the waterways in the Project Area, particularly Hanson River, Murray Creek and Bloodwood Creek
- Black-footed Rock-wallaby (*Petrogale lateralis*) – in and near rocky outcrops and associated steep rocky slopes (presence confirmed in nearby ranges by GHD ecologist during helicopter flight)
- Kultarr (*Antechinomys laniger*) – anywhere in open woodland or shrubland, which includes most of the Project Area
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) – anywhere in open woodland or shrubland, which includes most of the Project Area
- Bush Stone-curlew (*Burhinus grallarius*) – anywhere in open woodland, which includes much of the Project Area
- Great Desert Skink (*Liopholis kintorei*) – may occur within open sandplain within spinifex (*Triodia spp.*) understorey
- Giant Frog (*Litoria (Cyclorana) australis*) – may be restricted to more northerly parts of the Northern Territory, but if present, likely to be in large numbers. Only detectable if conditions and season are suitable (warm and wet).

Two additional species have a chance of occurring anywhere within the Project Area if conditions are suitable, but for the most part are considered unlikely to highly unlikely to occur there, or to be extremely rare. These are:

- Princess Parrot (*Polytelis alexandrae*)
- Night Parrot (*Pezoporus occidentalis*).

Seven species of birds identified for the Project Area are listed as Migratory under the EPBC Act. Of these, the Rainbow Bee-eater (*Merops ornatus*) is the only one known to occur historically (NT DLRM Database), and this species was detected during the survey.

Feral / pest species

Twelve non-native fauna species are identified for the Project Area (10 mammals, one bird and one reptile). Of the ten mammals, seven have been recorded previously on the DLRM database, and four of those (Cat, European Rabbit, Donkey and Cattle) were detected during the baseline survey by GHD in April 2013. Cattle are present as an agricultural asset, but all others are present as feral animals. Despite the confirmed presence of non-native fauna (particularly mammals), the Project Area does not appear to be unusually or excessively overrun by feral animals. That said, the non-native fauna that occurs at the site is likely to have had, and to continue to have, an adverse impact on the area's ecology. The removal or control of feral animals would be expected to result in positive changes to fauna habitat and fauna communities, particularly if done in association with weed control, grazing control and appropriate fire management.

Impact assessment, mitigation and monitoring

The Project Area has the potential to support a range of threatened fauna species, including eight listed as *vulnerable* or *endangered* under the EPBC Act. These species are likely to occupy the full range of available fauna habitats within the Project area, but the sandplain spinifex habitat has the potential to support more threatened species than other habitats. The threatened fauna relevant to the Project can be categorised as follows:

- Fauna in rocky habitat (Black-footed Rock-wallaby (MacDonnell Ranges race), *Petrogale lateralis*)
- Ground-dwelling sandplain fauna with limited mobility (Greater Bilby, *Macrotis lagotis*; Brush-tailed Mulgara, *Dasycercus blythi*; Great Desert Skink, *Liopholis kintorei*; Southern Marsupial Mole, *Notoryctes typhlops*)
- Arid-zone avifauna with high mobility (Night Parrot, *Pezoporus occidentalis*; Red Goshawk, *Erythrorhynchus radiatus*; Princess Parrot, *Polytelis alexandrae*; Grey Falcon, *Falco hypoleucos*)
- Fauna in riparian habitat (Common Brushtail Possum (Southern N.T.), *Trichosurus vulpecula vulpecula*).

The Project poses a range of potential impacts on some of these threatened fauna species. Before mitigation, a small number of impacts have the potential to be medium or high risk. The main sources of impact on fauna are expected to be from:

- Clearing of vegetation, particularly for the 100 km access road
- Unplanned wildfire, inadvertently started by mine construction or operation
- Collisions between fauna and traffic during construction and operation, particularly in spinifex sandplain habitat and particularly at night
- Introduction and/or spread of weeds (particularly through inadequate site reinstatement)
- Increase in population size of native and non-native predators (particularly through inadequate management of garbage/waste, which could attract vermin, and subsequently their predators such as cats and foxes).

The extent and severity of impact that this Project has on fauna depends entirely on the level of management and mitigation effort given. There is potential for all impacts and risks to be reduced to an acceptable level through the use of effective and appropriate management and mitigation. Inadequate management and mitigation has the potential to lead to irreversible long-term impacts on some threatened fauna species. Monitoring will be required to measure the effectiveness of mitigation and to identify where changes in effort may be required.

Table of contents

Executive Summary	i
1. Introduction.....	1
1.1 Project description and overview	1
1.2 Objectives and assessment.....	2
1.3 Scope and limitations.....	3
2. Mount Peake Project Area	5
2.1 Location and area	5
2.2 Climate	5
2.3 Burt Plain Bioregion	6
2.4 Sites of National Conservation Significance	6
2.5 Other important environmental sites/feature near the Project Area	7
2.6 Vegetation communities in the Project Area.....	7
2.7 Current land use	7
3. Legislation relevant to the Project.....	8
3.1 Commonwealth Legislation.....	8
3.2 Northern Territory Legislation	8
3.3 Northern Territory Policies and Guidelines	11
4. Methods.....	12
4.1 Desktop assessment.....	12
4.2 Baseline fauna survey.....	12
4.3 Exploration of patterns in fauna diversity and habitats	18
4.4 Limitations of the baseline fauna survey.....	19
4.5 Nomenclature.....	19
5. Results	20
5.1 Overview	20
5.2 Weather conditions experienced	20
5.3 Review of existing data	21
5.4 Results of the baseline fauna survey.....	22
5.5 Threatened and near-threatened species.....	48
5.6 Migratory species	62
5.7 Feral / pest animals.....	62
6. Discussion	67
6.1 How well do the results represent the fauna of the Project Area?	67
6.2 Effects of environmental conditions on the results	67
6.3 Fauna diversity patterns.....	68
6.4 Threatened species	69
6.5 Introduced species.....	70
6.6 Implications for Legislation	70

7.	Potential Impacts on Fauna	72
7.1	Environmental risks.....	72
7.2	Potential sources of impact.....	72
8.	Management and mitigation measures and proposed monitoring.....	85
8.1	Mitigating against habitat clearing and fragmentation	85
8.2	Mitigating against impacts on surface and ground water	86
8.3	Mitigating against soil compaction	87
8.4	Management of Waste Materials – industrial waste	87
8.5	Management of Waste Materials – domestic waste and refuse	87
8.6	Mitigating noise generated by mining and processing activities.....	87
8.7	Mitigating dust generated by mining and processing activities	87
8.8	Mitigating visual disturbance during construction and operation - lighting	88
8.9	Mitigating against unplanned wildfire	88
8.10	Mitigating the risks associated with traffic during construction and operation.....	89
8.11	Mitigating the introduction and/or spread of exotic plants and animals	89
8.12	Mitigating the effects of poisoning fauna with tailings dam water	90
8.13	Mitigating against inappropriate/ineffective rehabilitation	90
9.	Risk assessment of impacts on fauna	91
9.1	Species considered.....	91
9.2	Risk assessment method.....	92
9.3	Risk assessments - threatened species	93
9.4	Evaluation of impact significance under the EPBC Act	113
9.5	Impact significance for each EPBC Act-listed species	114
10.	Conclusion.....	124
11.	References	125
12.	Acknowledgements	130

Table index

Table 1-1	Disturbance areas.....	2
Table 2-1	Rainfall and temperature statistics (BoM 2013; Territory Grape Farm NT 1987-2012)	5
Table 4-1	Summary of fauna survey effort during baseline surveys in the Project Area.....	17
Table 5-1	Weather conditions experienced prior to and during the survey (BOM; Territory Grape Farm NT).....	21
Table 5-2	Numbers of species (by vertebrate group) detected during the fauna survey undertaken by GHD	23
Table 5-3	Description of fauna habitats in the Project Area	24
Table 5-4	Success of sampling techniques in detecting species of different taxonomic groups	27

Table 5-5	Diversity and recorded abundance of sub-groups of mammals detected during the survey	28
Table 5-6	Diversity and recorded abundance of sub-groups of birds detected during the survey.....	29
Table 5-7	Diversity and abundance of sub-groups of reptiles detected during the survey.....	30
Table 5-8	Statistical results of ANOSIM for pairwise comparisons of fauna results (all fauna) at each habitat type	41
Table 5-9	Threatened fauna species identified for the Project Area (50 km buffer)	49
Table 5-10	Near-threatened and Data Deficient fauna species identified for the Project Area.....	58
Table 5-11	EPBC Act-listed Migratory fauna species identified for the Project Area (50 km buffer).....	62
Table 5-12	Non-native fauna species identified for the Project Area.....	63
Table 6-1	Threatened fauna species identified for the Project Area (50 km buffer)	69
Table 7-1	TNG Mount Peake project fauna habitat and vegetation communities and proposed clearing area for each community	73
Table 9-1	Matrix of habitat association of threatened species that may occur within the Project area.....	91
Table 9-2	Qualitative risk analysis matrix	92
Table 9-3	Definitions of level of likelihood.....	93
Table 9-4	Definitions of level of consequence	93
Table 9-5	Project Risk Assessment – Black-footed Rock-wallaby (MacDonnell Ranges Race) (<i>Petrogale lateralis</i>)	94
Table 9-6	Project Risk Assessment – Sandplain ground-dwelling fauna (Greater Bilby, Brush-tailed Mulgara, Great Desert Skink, Southern Marsupial Mole).....	98
Table 9-7	Project Risk Assessment – Arid zone avifauna with high mobility (Night Parrot, Red Goshawk, Princess Parrot, Grey Falcon).....	103
Table 9-8	Project Risk Assessment – Fauna in riparian habitat (Common Brushtail Possum (Southern NT)).....	108
Table 9-9	EPBC risk assessment for Black-footed Rock-wallaby (vulnerable) before mitigation.....	115
Table 9-10	EPBC risk assessment for Greater Bilby (vulnerable) before mitigation	116
Table 9-11	EPBC risk assessment for Brush-tailed Mulgara (Vulnerable) before mitigation	117
Table 9-12	EPBC risk assessment for Southern Marsupial Mole (Endangered) before mitigation.....	118
Table 9-13	EPBC risk assessment for Red Goshawk (Vulnerable) before mitigation	119
Table 9-14	EPBC risk assessment for Princess Parrot (Vulnerable) before mitigation	120
Table 9-15	EPBC risk assessment for Night Parrot (Endangered) before mitigation	121
Table 9-16	EPBC risk assessment for Great Desert Skink (Vulnerable) before mitigation	122

Figure index

Figure 1-1	Project Location, Mount Peake Project Area.....	4
Figure 4-1	Fauna Site Locations	14
Figure 5-1	Records of vertebrate species in each taxonomic group showing relative abundance of species (DLRM records)	21
Figure 5-2	Accumulation of species (all species and by group), as detected during the survey (actual curves for all groups).....	31
Figure 5-3	Accumulation of species (all species and by group) detected during the survey	32
Figure 5-4	Species richness of all fauna recorded at each site	33
Figure 5-5	Species richness of all fauna recorded in each habitat	34
Figure 5-6	Species richness of all fauna recorded per site in each habitat (mu = mulga; ri = riparian; ro = rocky; sp = spinifex; wo = woodland)	35
Figure 5-7	Accumulation of species detected during the survey in each habitat (Actual curves for all groups)	36
Figure 5-8	Accumulation of species detected in different habitats during the survey.....	37
Figure 5-9	Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of all fauna species (slice line added at similarity = 28)	40
Figure 5-10	Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of all fauna species	40
Figure 5-11	Multidimensional scale (MDS) plot for all fauna recorded at the 16 sites, labelled by habitat. Cluster grouping shown for similarity = 28 (and 33 for comparison)	41
Figure 5-12	Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of mammal species.....	42
Figure 5-13	Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of mammal species.....	43
Figure 5-14	Multidimensional scale (MDS) plot for mammal fauna recorded at the 16 sites, labelled by habitat.....	43
Figure 5-15	Multidimensional scale (MDS) plot for mammal fauna recorded at 14 sites (Site 12 and Site 13 removed), labelled by habitat. Cluster grouping shown for similarity = 63	44
Figure 5-16	Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of bird species (slice line added at similarity = 25)	45
Figure 5-17	Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of bird species.....	45
Figure 5-18	Multidimensional scale (MDS) plot for bird fauna recorded at the 16 sites, labelled by habitat. Cluster grouping shown for similarity = 25	46
Figure 5-19	Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of reptile species (slice line added at similarity = 22)	47
Figure 5-20	Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of reptile species	47

Figure 5-21 Multidimensional scale (MDS) plot for reptile fauna recorded at the 16 sites,
labelled by habitat. Cluster grouping shown for similarity = 22 48

Figure 5-22 Active burrow (Mulgara) at site 16, as monitored by the motion-detecting
camera (Camera 1; M2).....60

Appendices

Appendix A - Results of the EPBC protected matters search

Appendix B - List of fauna species for the Project Area recorded during the current and
previous surveys

Appendix C - Fauna species (numbers of individuals per species) recorded during the fauna
survey

Appendix D – Results of the remote surveillance cameras used during the fauna survey

1. Introduction

1.1 Project description and overview

TNG Limited (TNG) is proposing to develop the Mount Peake Project (the Project) consisting of:

- The mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Road haulage of the concentrate approximately 100 km to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed Darwin Refinery at Middle Arm.

The proposed mine will be an open-pit truck and shovel operation. Extracted ore will be transported by haul truck from the mine pit and stockpiled on-site at a run of mine (ROM) pad prior to processing. Mining will commence with a "starter pit" accessing high grade and low strip ratio ore. The mining rate will progressively increase to 8.4 million tonnes per annum (Mtpa) and, following processing, up to 1.8 Mtpa of magnetite concentrate will be produced. The life of the mine is expected to be 19 years inclusive of construction (2 years), mining and production (15 years), and closure and rehabilitation (2 years).

The project is located approximately 235 kilometres north-west of Alice Springs and approximately 50 km west of the Stuart Highway (Figure 1-1).

New facilities proposed at the Mount Peake Project Area include:

- Open cut mine
- Waste rock dump (WRD) with up to 70 Mt capacity
- Run of mine (ROM) pad
- Four long term stockpiles of up to 4 Mt capacity each
- Process plant
- Tailings storage facility (TSF) with up to 63.41 Mt capacity
- Access road between the mine site and Adnera Loadout Facility including an underpass of Stuart Highway (for concentrate trucks) and intersections with Stuart Highway (for mine site access)
- Borefield and associated water pipeline
- Concentrate stockpiles
- Water and sewage treatment plants
- Gas fired power station
- Explosives and detonator magazines
- Accommodation village
- Administrative buildings, laboratory, workshops and warehouses
- Gatehouse and weighbridge
- Fuel farm
- Concentrate loadout facility and rail siding at Adnera.

Over the life of the project the total area of disturbance is estimated to be 1060 hectares. A breakdown of disturbance areas is provided in Table 1-1.

Table 1-1 Disturbance areas

Item	Disturbance Area (ha)
Pit	77
Waste Rock Dump	90
Long-term stockpiles	47
Mine facilities including ROM pad, process plant and associated stockpiles and ponds, mine offices and workshops, fuel storage facility, water treatment plant, power station and site roads	71
Tailings Storage Facility	475
Accommodation village	5.5
Access road	234
Adnera Loadout Facility	10
Borefield, delivery line and access road	50
Access road borrow areas	To be determined
Total	1058

Mining and processing will occur within the mining area, located within Mineral Lease Application (MLA) 28341 for the mine pit and MLA 29855 for all mining facilities. The accommodation facilities will be located within MLA 29856, 5 km to the east of the mine site.

The site access road runs 100 km south-east and then east from the mining area to a proposed new rail siding and load-out facility near Adnera.

1.2 Objectives and assessment

The main objective of this report is to satisfy the fauna assessment requirements of the Terms of Reference set by the Northern Territory Environment Protection Authority (NT EPA) for assessment of the Mount Peake Project.

The assessment objective is achieved by:

- Desktop searches of government database information relating to fauna distributions, including the Commonwealth Department of the Environment (DotE PMST and the NT Department of Land Resource Management (DLRM) Fauna Atlas database
- Undertaking a fauna survey of the study area using a range of sampling techniques designed to gain as complete a description as possible of the relationships between fauna and the available habitats
- Undertaking fauna surveys targeted specifically on locating and assessing the presence of fauna species listed as threatened/migratory under the *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Assessing the regional and national significance of the fauna and any populations of threatened species
- Determining ways in which the proposed Project might impact on fauna and threatened species

- Assessing the levels of risk to fauna and threatened species posed by sources of potential impact
- Proposing mitigation measures to reduce the risk of impacts that may be significant
- Determining the residual risks to fauna including threatened species.

1.3 Scope and limitations

This report has been prepared by GHD for PNG Ltd. and may only be used and relied on by PNG Ltd. for the purpose agreed between GHD and PNG Ltd. as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person/entity other than PNG Ltd. arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

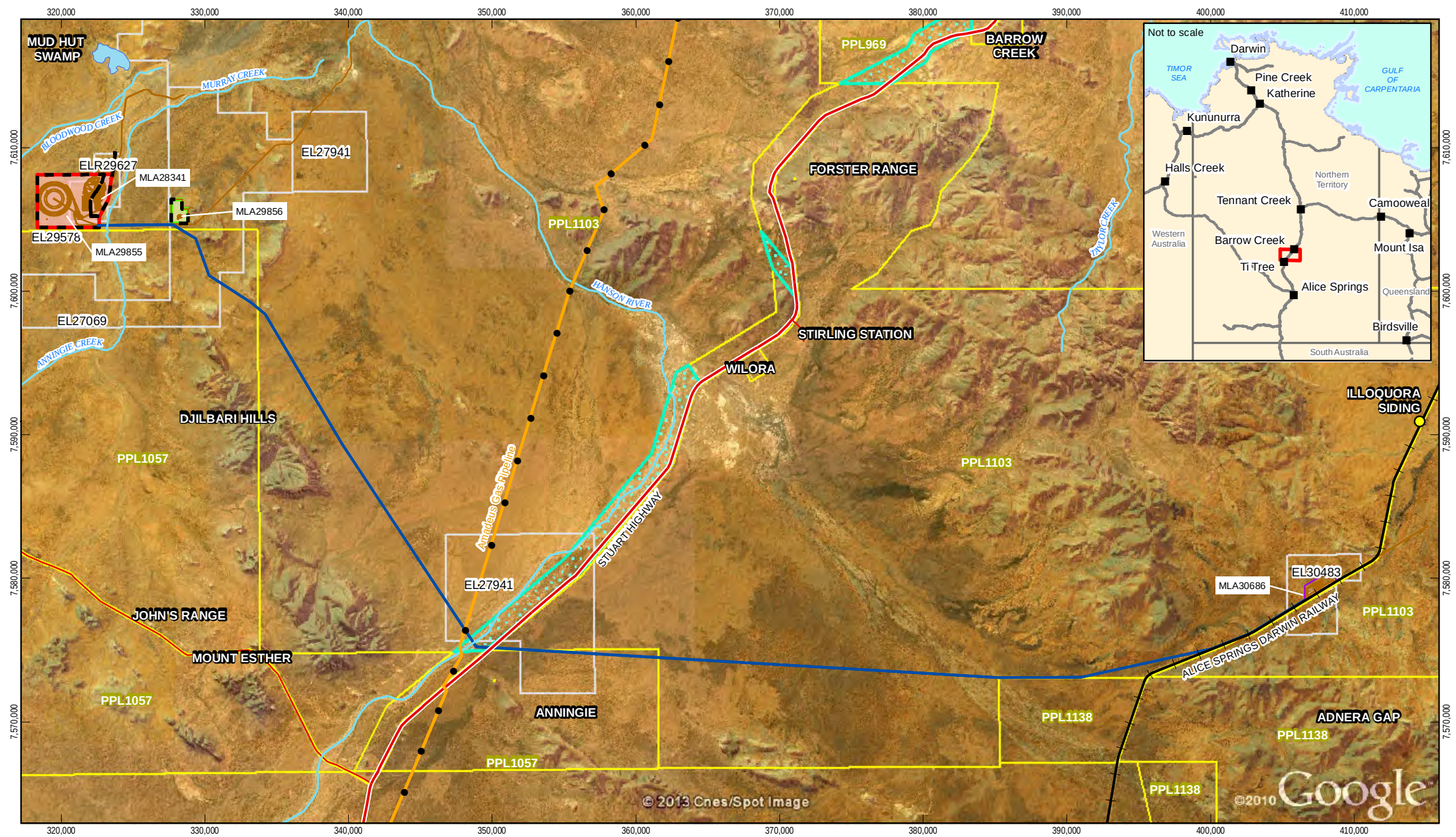
The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD, and described in this report where relevant. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by PNG Ltd. and others (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of access tracks, services, vegetation, and topographic features. As a result, not all relevant site features and conditions may have been identified in this report. The proposed borefield, associated delivery pipeline and access road, and borrow pits were not specifically surveyed.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

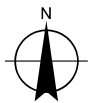


Paper Size A4

0 2.5 5 7.5 10

Kilometres

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



LEGEND

Illoquora Siding	Amadeus Gas Pipeline	Crown Land
Principal Road	Mine Site Facilities	Camp Facilities
Minor Road	Mud Hut Swamp	Mount Peake Mineral Leases
Major Watercourses	Rail Siding Loading Facility	Cadastral Boundaries
Railway	Mount Peake Mining Area	Access Road



TNG Ltd
Mount Peake EIS

Project Location
Mount Peake Project Area

Job Number 61-29057
Revision A
Date 23 Oct 2015

Figure 1-1

G:\61\29057\11 GISMaps\MXD\6129057_001_Fig1ProjectLocation.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

© 2015. Whilst every care has been taken to prepare this map, G.A, GE, GHD and TNG make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Data source: TNG - Gas / Slurry Pipeline Study Corridor, Camp Facilities, Transport Study Corridor, Mount Peake Mining Area, Mount Peake Granted Tenements (2015). Geoscience Australia - Waterways, mainland, placename, road (2008). Google Earth Pro - Imagery (Date extracted: 13/02/2014). Created by: RB

2. Mount Peake Project Area

2.1 Location and area

The Mount Peake Project Area (Project Area) is located in central Northern Territory, approximately 235 km north-north-west of Alice Springs (Figure 1-1).

The Project Area is located in the Central Desert Shire and within the Burt Plain Bioregion.

The Project Area spans a large area; the proposed mine area is approximately 50 km west of the Stuart Highway, while the existing Alice Springs to Darwin railway is approximately 50 km east of the highway. The Project Area is primarily located on the Stirling pastoral station with a small component of the access road potentially located on Anningie pastoral station. The closest town is Barrow Creek, approximately 60 km north east of the mining area. The main site access road will intersect the Stuart Highway approximately 20 km south of Wilora.

2.2 Climate

The Project Area experiences hot and arid conditions. The hottest months are November to February, with the monthly mean of daily maximum temperatures above 35°C, and monthly mean of daily minimum temperatures not dropping below 18 °C (Table 2-1). The coolest months are May to August, with the monthly mean of daily maximum temperatures remaining at or below 25.3°C, and monthly mean of daily minimum temperatures not rising above 10°C.

The mean annual rainfall is approximately 319 mm, with a reasonably strong seasonal pattern of more summer rainfall than winter rainfall. Average monthly rainfall totals range from 4.6 mm in July to 68.0 mm in February (Table 2-1). Average three-monthly rainfall totals range from 18.8 mm in June/July/August to 171.8 mm in December/January/February. However, any month can receive relatively large rainfall totals, or little or no rain at all.

Table 2-1 Rainfall and temperature statistics (BoM 2013; Territory Grape Farm NT 1987-2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)												
Highest	280.4	342.2	109.2	151.7	136.3	53.8	34.2	39.4	96.6	56.8	119.2	115.7
95 th %ile	154.7	255.0	97.7	93.2	100.4	49.5	21.6	27.9	41.8	52.5	82.8	96.6
Mean	57.2	68.0	21.9	17.7	23.7	9.3	4.6	5.0	10.9	16.5	31.9	46.6
5 th %ile	3.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.2	8.6
Lowest	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Temp (°C)												
Maximum ¹	37.5	36.2	33.9	30.4	25.3	22.2	22.5	25.2	30.2	33.0	35.4	36.3
Minimum ²	21.8	21.7	19.5	14.4	9.2	6.0	5.1	7.0	12.0	15.6	18.6	21.0

Notes: ¹ Monthly mean maximum temperature is the average of the available daily maxima for a month.

² Monthly mean minimum temperature is the average of the available daily minima for a month.

2.3 Burt Plain Bioregion

The Project Area occurs entirely within the Burt Plain Bioregion, which is characterised by the following:

- The bioregion is broadly characterised by plains of Acacia shrubland, tussock and hummock grasslands, Acacia and Eucalyptus woodlands, and mountain ranges in the east, north and west of the bioregion. More than 80% of the bioregion is devoted to pastoralism
- The bioregion supports some of Australia's best developed and most extensive mulga woodlands
- As with other central Australian bioregions, the overall condition of the Burt Plain Bioregion is masked by a very strong rainfall effect, with degradation sometimes difficult to detect following a series of good seasons
- Much of the bioregion has been impacted by a range of pervasive factors such as grazing by livestock and/or feral animals, feral predators and weed infestations
- The bioregion has suffered substantial losses of its mammal fauna over the last century and there are ongoing declines of some bird and mammal populations. Exotic predators are widespread and there are fifteen declared weed species currently listed under the *Northern Territory Weeds Management Act 2001* known to occur in the Burt Plain Bioregion. Other exotic plants species, most notably buffel and couch grass, also pose significant threats to some habitats
- Many species have been lost from this bioregion over the last 150 years. Of those that persist, 13 species are currently listed as threatened at the National and/or Territory level.

2.4 Sites of National Conservation Significance

2.4.1 Mud Hut Swamp

Mud Hut Swamp has been identified by NRETAS (now the Environment Protection Authority) as a Site of Conservation Significance and is listed in the "*Inventory of sites of international and national significance for biodiversity values in the Northern Territory*".

Mud Hut Swamp lies approximately 7.7 km north of the proposed mine area.

Mud Hut Swamp is a large, isolated, coolabah (*Eucalyptus victrix*) swamp that is fed by Bloodwood and Murray Creeks in the south-east and runoff from low hills and rises to the north and west (NRETAS 2009a). This is the largest swamp in the Burt Plains bioregion and remains inundated for a relatively long time after flooding, possibly retaining water for several months following inundation. The swamp is likely to support a range of wetland birds, fish and plants.

TNG (2012) notes that any interruption or alteration of surface water drainage in the vicinity of the Project Area has the potential to adversely affect the downstream ecosystem, including Mud Hut Swamp.

2.4.2 Anmatyerr North (including Stirling Swamp)

The Anmatyerr North site is located across Stirling, Anningie and Ahakeye Stations. This site includes Stirling Swamp, a large wetland complex comprised of claypans, lignum swamp, semi-saline samphire and temporary open water, and the adjacent Hanson River (NRETAS 2009b). The Site extends to low rocky ranges about 20 km south of Stirling Swamp to encompass the known extent of the threatened giant sweet potato (*Ipomoea polpha* subsp. *latzii*).

Stirling Swamp is noted to form occasionally at the northern edge of the Ti-Tree Basin, storing flood waters discharged from the Hanson River and the ridges to the east of Wilora. This area is believed to act as an evaporation area for the basin (NRETAS 2009b).

2.4.3 Wood Duck Swamp

Wood Duck Swamp is an ephemeral swamp that may hold water for many months in an otherwise dry landscape. It fills periodically after heavy rain. Wood Duck Swamp is dominated by smooth-barked coolabah *Eucalyptus victrix*. It is one of the largest such swamps in the Burt Plains bioregion (NRETAS 2009c).

Wood Duck Swamp is entirely pastoral leasehold land within one pastoral lease (Mount Skinner). The main land use within the site and broader catchment is cattle grazing on native pastures.

Wood Duck Swamp is located approximately 10 km south of the access road, outside of the Project Area.

2.5 Other important environmental sites/feature near the Project Area

Other environmental site or features in the vicinity of the Project Area include:

- the Djilbari Hills, approximately 14 km south east of the proposed mining area
- The Walabanba Hills, approximately 12 km west of the proposed mining area
- Bloodwood Creek, approximately 2.5 km north west of the proposed pit
- Murray Creek, approximately 400 m east of the proposed pit at its closest point
- Hanson River, approximately 25 km north east of the proposed pit, and crossing the access road on-route to the railway siding.

2.6 Vegetation communities in the Project Area

Existing vegetation mapping for the Project Area and surrounding bioregions is limited due to the lack of previous detailed vegetation survey. Vegetation mapping that does exist for the site includes vegetation mapping that has been completed for the whole Territory at 1:1,000,000 scale (Wilson *et al.* 1990). This mapping was used to help determine locations for fauna sites across the Project Area, and is shown as the base layer for Figure 4-1.

The GHD flora assessment of the Project Area (conducted concurrently with the fauna survey in April 2013) identified eight vegetation communities in the Project Area. These are all described in detail in GHD (2015). The eight communities provide five habitat types for fauna, and these are presented and discussed in Section 5.4.1.

2.7 Current land use

More than 80% of the Burt Plain Bioregion is used for pastoralism. The Project Area lies mainly within Stirling Station which is currently used for cattle grazing.

3. Legislation relevant to the Project

3.1 Commonwealth Legislation

3.1.1 Environment Protection and Biodiversity Conservation Act 1999

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), any development requires formal assessment if it has the potential to impact significantly on one or more Matters of National Environmental Significance (MNES). MNES include:

- World Heritage properties
- National Heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Listed threatened species and ecological communities
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- A water resource, in relation to coal seam gas development and large coal mining development.

MNES relating to fauna are relevant to the Mount Peake Project. Consequently, a referral under the EPBC Act was submitted to the Commonwealth Department of the Environment (DotE; but Department of Sustainability, Environment, Water, Population and Communities DSEWPoC at the time) in October 2013. In November 2013, the Commonwealth Minister for the Environment determined that the action (Project) is a “controlled action” and requires formal assessment and approval under the EPBC Act.

The Project will be assessed at the level of Environmental Impact Statement (EIS) under the Northern Territory *Environmental Assessment Act 1982*. This will be done under the NT/Commonwealth bilateral environmental assessment process.

3.2 Northern Territory Legislation

3.2.1 Environmental Assessment Act 1982 and Environmental Assessment Administrative Procedures 1984

The *Environmental Assessment Act 1982* (EA Act) and Environmental Assessment Administrative Procedures 1984 ensure each matter affecting the environment is fully examined and taken into account in relation to:

- Formulation of proposals
- Carrying out of works and other projects
- Negotiation, operation and enforcement of agreements and arrangements (including agreements and arrangements with authorities of the Commonwealth, the states and other territories)
- Making of, or the participation in the making of, decisions and recommendations
- Incurring of expenditure.

TNG submitted a Notice of Intent (NOI) for the Project to the Northern Territory Environment Protection Authority (NT EPA) on 4 July 2013 for consideration under the NT EA Act. On 13 November 2013, the NT EPA decided that the Project required assessment under the Act at the level of an Environmental Impact Statement (EIS). The Terms of Reference for the Mount Peake Project, finalised in March 2014, identify assessment requirements for both the NT EPA and Commonwealth DoE.

3.2.2 Territory Parks and Wildlife Conservation Act 2006

The extended title of the TPWC Act is:

“An Act to make provision for and in relation to the establishment of Territory Parks and other Parks and Reserves, and the study, protection, conservation and sustainable utilisation of wildlife”.

The TPWC Act has provisions for 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. Protected wildlife is protected whether or not the property with the wildlife is vested in the Territory.

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 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 Territory’s Wildlife regulations as being species that are ‘extinct’, “critically endangered”, “endangered” and “vulnerable”.

This study assesses the likelihood that fauna listed under the TPWC Act occur within the study area and their potential to be impacted by the proposal.

3.2.3 Mining Management Act 2001

The *Mining Management Act 2001* provides for authorisation of mining activities, management of mining sites, protection of the environment on mining sites and related purposes. The Act is administered by Department of Mines and Energy (DME). The objectives of the Act are:

- ensure the development of the Territory’s mineral resources in accordance with environmental standards consistent with best practice in the mining industry;
- protect the environment by:
 - requiring authorisation for and monitoring of mining activities;
 - requiring appropriate management of mining sites through implementation of management systems;
 - facilitating consultation and cooperation between management and workers in implementing environment protection management systems;
 - implementing audits, inspections, investigations, monitoring and reporting to ensure compliance with agreed standards and criteria; and
 - specifying the obligations of all persons on mining sites with respect to protection of the environment.

- assist the mining industry to introduce programs of continuous improvement to achieve best practice environmental management;
- enable persons connected with the mining industry to participate in the implementation of this Act through the establishment of a Mining Board to advise the Minister on:
 - guidelines for the industry;
 - specification of competencies required by persons involved in the industry;
 - best practice in mining activities; and
 - minimising the liability of the Territory by requiring the payment of security to provide for the rehabilitation of mining sites or to rectify environmental harm caused by mining activities.

The Mining Management Amendment Bill 2011 was passed and came into force on 1 July 2012. Key changes include:

- enabling the Chief Executive Officer (CEO) of DME to require investigations of less-serious environmental incidents that do not result in material environmental harm (in addition to the current requirements for incidents causing material environmental harm);
- allowing the publication of reports by operators or mining officers following environmental incidents;
- obligation for mining operations on mineral leases to publically report environmental performance in the form of a Environmental Mining Report (EMR) which forms part of the annually submitted Mining Management Plan (MMP);
- introducing new environmental offences and confirming the application of Part IIAA of the Criminal Code Act (NT) (the Criminal Code) to offences under the Act; and
- Community Benefits Plan (CBP) required for authorisation of a new mine.

Approval for the proposed work is required from the Minister of Primary Industry, Fisheries and Resources. The environmental assessment process will allow the Minister to be informed of potential environmental impacts and proposed management to assist in the decision making process.

An approved Mining Management Plan will be required prior to commencement of proposed works if the Project is approved. The Minister will require security for potential costs of rectifying environmental harm and rehabilitating the site.

3.2.4 Northern Territory Environment Protection Authority Act 2012

The *Northern Territory Environment Protection Authority Act 2012* commenced on 1 January 2013. The Act establishes the new Northern Territory Environment Protection Authority (NT EPA) as an independent regulatory authority and makes consequential amendments to the Waste Management and Pollution Control Act and the Environmental Assessment Act.

Amendments to the Waste Management and Pollution Control Act identify the NT EPA as the entity responsible for administration of the regulatory functions of that Act.

Amendments to the Environmental Assessment Act identify the NT EPA as the entity responsible for administration of the assessment functions and impose additional transparency and reporting responsibilities on the Environment Minister and the responsible Minister for specific projects (NT Government 2012).

3.2.5 Planning Act 2009

The *Planning Act 2009* defines "development" as an activity that involves carrying out works on land, including clearing of native vegetation. "Works" is defined as any activity on land other than mining or agriculture, resulting in a physical change to the land or a part of the land.

The planning scheme requires native vegetation to be cleared in accordance with the Land Clearing Guidelines 2010 (NRETAS 2010), which contain guidelines for clearing, including the submission of a property management plan by the applicant. The Land Clearing Guidelines do not apply to this project, because the proposed works are being undertaken as part of a mining operation. However one of the requirements stipulated in the Environmental Impact Statement (EIS) guidelines (NT EPA 2013) is to discuss proposed clearing with regard to issues raised and recommendations contained in the Clearing Guidelines.

3.2.6 Other Legislation

Other legislation that may be applicable to the Project includes:

- *Weeds Management Act 2001*
- *Bushfires Act 2009*
- *Soil Conservation and Land Utilisation Act 1980.*

3.3 Northern Territory Policies and Guidelines

3.3.1 Northern Territory Environment Protection Authority draft Guidelines

In November 2013, the NT EPA released a series of draft guidelines related to implementation of the *Environmental Assessment Act 1982* and the *Waste Management and Pollution Control Act 2009*. Those draft guidelines relevant to this Assessment are:

- Guidelines on Environmental Offsets and Associated Approval Conditions
- Guidelines on Assessment of Impacts on Terrestrial Biodiversity.

This fauna assessment was prepared in accordance with the draft guidelines outlined above.

The NT Government has developed standardised methods for surveying terrestrial fauna in the Northern Territory (*Terrestrial fauna survey for environmental impact assessment in the Northern Territory, July 2011*). These guidelines were complied with when undertaking this assessment.

4. Methods

4.1 Desktop assessment

A desktop review of government databases relating to fauna distributions included the following:

- The Commonwealth Department of the Environment (DotE) PMST was used to identify matters of national environmental significance potentially occurring in the Project Area (Appendix A). The PMST only considers flora and fauna species and communities listed in one or more provisions of the EPBC Act, and is based on predicted distributions of flora and fauna species and communities and/or their habitat, rather than known records. The PMST may predict the occurrence of a species or community in an area when there are no documented records from the area. The PMST was used to identify matters of national environmental significance up to a distance of 50 km beyond the Project Area. Information was downloaded in February 2013 (and checked in November 2015 for additions/revisions) in the form of an Environmental Report from the website <http://www.environment.gov.au/erin/ert/epbc/index.html> (Appendix A)
- The DLRM Fauna Atlas database was used to identify records of all fauna species known to occur (rather than predicted to occur) in the Burt Plain bioregion (the area encompassed by Lat: -21.41213 to -22.13333; Long: 133.03458 to 134.12140).

4.2 Baseline fauna survey

4.2.1 Scheduling

A baseline fauna survey across the Project Area was conducted by eight GHD ecologists from the 9th to 14th April 2013.

The fauna survey was conducted in accordance with a Territory Parks and Wildlife Conservation Act permit issued to GHD by the NT Parks and Wildlife Commission (Permit number 40623, expiry date 30 April 2014). Fauna survey techniques used in the baseline surveys conform to the Environmental Assessment Guidelines: Terrestrial Fauna Survey promulgated by DLRM.

4.2.2 Weather

Weather observations were obtained from the Bureau of Meteorology Territory Grape Farm weather station: 015643.

4.2.3 Selection of sample sites

Prior to the site visit, aerial imagery and maps were used as a basis for selection of sites for fauna survey. This allowed selection of sites in a representative range of vegetation/habitat types. Sites were ground-truthed on the first day at the site, to verify their vegetation/habitat characteristics, or to move them to more appropriate locations. Areas selected were those considered to provide higher quality habitat for fauna, based upon vegetation structure, topographic location, and habitat features (e.g. presence of rock outcrops, hollow-bearing trees, long grass, leaf litter). The choice of sites was made in an effort to maximise the likelihood of detecting fauna, including threatened species.

Sixteen survey sites were established proportionately across the five main vegetation types represented in the mine leases, as follows:

- Mulga woodland (8 sites)
- Riparian woodland (2 sites)
- Rocky shrubland (3 sites)
- Spinifex grassland (2 sites)
- Corymbia woodland (1 site).

For the most part, the habitat classification is based on landscape features of note (e.g. rocks, waterway, species of dominant trees). Note, however, that while only two sites were formally categorised as spinifex grassland sites, other sites supported spinifex grasses also, particularly rocky shrubland sites and some mulga sites.

Each survey site was focussed on a 50 m x 50 m area (0.25 ha). Figure 4-1 shows the locations of the fauna survey sites and the vegetation types as mapped prior to GHD's flora and vegetation impact assessment (GHD 2015), which was used to help inform selection of sites.

4.2.4 Survey techniques

Survey methods followed the *Standard terrestrial vertebrate survey methods used by the Department of Land Resource Management* (Appendix A in NT EPA 2013¹). Table 4-1 provides a summary of survey effort in each site (focussed on a 50 m x 50 m area). Additional explanatory notes are provided below.

1. **Habitat assessment** – Vegetation characteristics across the Project Area were assessed by GHD botanists. Information collected by the botanists was augmented during the fauna surveys with assessments of the fauna habitat features of each fauna site.
2. **Baited Elliot-type traps** – Twenty Elliot-type box traps (size A) were placed approximately 8 m apart along the perimeter of the quadrat boundary at each site. Each trap was placed in a suitable microhabitat (e.g. with suitable cover and shade) and marked with a labelled piece of flagging tape attached to a nearby tree or shrub to assist with finding traps during the period of the survey and to ensure that all traps were accounted for at the end of the survey. Traps were baited with a suitably moist mixture of rolled oats, honey and peanut butter (widely used standard recipe for attracting small mammals). Every second trap was also baited with 'Good O' dry dog food to attract carnivores. Traps remained open for four days and four nights (which exceeds the minimum period of three nights/days required by NT EPA). Traps were checked once each morning and once each mid-late afternoon. Bait was refreshed once during the survey period.
3. **Baited cage traps** – One cage trap was placed at each corner of the quadrat boundary of each site (four cage traps per site). Traps were placed in suitable microhabitats (e.g. in suitable cover and shade). Each trap was individually marked with a labelled piece of flagging tape attached to a nearby tree or shrub to assist with finding traps. Traps were baited with a mixture of rolled oats, honey and peanut butter and with 'Good O' dry dog food. Traps remained open for four days and four nights (which exceeds the minimum period of three nights/days required by NT EPA). Traps were checked once each morning and once each mid-late afternoon. Bait was refreshed once during the survey period.

¹ Guidelines for assessment of impacts on terrestrial biodiversity. Northern Territory Environment Protection Authority; April 2013, Version 1.2

4. *Pitfall buckets* – Four pitfall traplines were established in the quadrat at each site. Each pitfall trap comprised a single 20-litre bucket dug into the ground such that its lip was flush with ground-level, and bisected by a fly-wire 'drift fence' (10 m long and 35 cm high) to direct animals into pits. Each bucket was supplied with approximately 3 cm of soil, a piece of bark and some leaf litter in its base to provide protection for animals while in the trap. Traps remained open for four days and four nights (which exceeds the minimum period of three nights/days required by NT EPA). Pits were scattered through the different microhabitats in the quadrat (e.g. in open ground; in dense grass; close to trees; in rocky areas). Traps were checked once each morning and once each mid-late afternoon.

In an effort to increase the fauna capture rates, each pitfall trapline was also allocated two funnel traps (one at each end of the fence) (see next paragraph). This exceeds the NT EPA survey guidelines. It was noted where fauna were captured in the additional traps as distinct from the pitfall buckets.

5. *Funnel traps* - Two funnel traplines were established in the quadrat at each site. Each funnel trapline consisted of a fly-wire 'drift fence' (10 m long and 35 cm high) to direct animals into traps. Traps were placed on each side of the fence, mid-way along (two funnel traps per trapline). Each funnel trap was covered with aluminium foil to protect and shade animals while in the trap. Traps remained open for four days and four nights (which exceeds the minimum period of three nights/days required by NT EPA). Funnel lines were placed in different microhabitats in the quadrat (e.g. in open ground; in dense grass; close to trees; in rocky areas). Traps were checked once each morning and mid-late afternoon.

Pitfall traplines (see previous survey technique) were also allocated two funnel traps (one at each end of the fence) in an effort to increase the fauna capture rates.

6. *Anabat[®] bat call detection* – Anabat[®] bat call detection units were used to collect the high frequency calls of micro-chiropteran bats. Anabat[®] units were deployed for one night at each site, and placed in an open area (i.e. devoid of nearby vegetation to avoid interference and non-bat noise) with the microphone oriented upwards at 45°. Recordings were downloaded and referred to a bat specialist for analysis.
7. *Bird surveys (including Instantaneous Bird Count)* – Bird survey counts involved one zoologist compiling a complete list of all birds seen, heard or otherwise detected in the vicinity of the survey quadrat. GHD ecologists incorporated the standard NT 'instantaneous' bird count method from a single point, but then increased the survey effort by moving gradually around the 50 m x 50 m quadrat area (also covering a width of around 25 m on all sides of the transect) to survey a 1 ha area (approximately) over a 20-minute time period (times actually ranged from 15 minutes to 25 minutes). Notes were kept on whether birds were inside or outside the quadrat, and whether species were detected during the 'instantaneous' count or during the period that followed. Where possible, numbers of individuals were noted, along with any detected breeding activity, unusual habitat use or other specific interactions (e.g. potential predation). The surveys were mostly completed early in the morning (within two hours of sunrise) and in the late afternoon when birds were most active (i.e. not during the heat of the day). The numbers of bird surveys conducted varied among the survey sites because of time constraints during the establishment and maintenance of 16 sites.

8. *Active search (Diurnal)* – Generally, active searches involved one or more zoologist/s thoroughly searching in daylight for the presence or signs of animals, usually over a period of approximately 20 minutes. Active searching can be useful for detecting cryptic ground and tree-dwelling fauna, particularly reptiles, that may not be captured in traps. Ground, rock and tree surfaces are scanned, and under surfaces of rocks, logs, bark, clumps of vegetation and other debris (if present) examined for reptiles and other animals. All vertebrate fauna detected were noted. Where possible, reptiles were captured or photographed for identification. Some species were identifiable without the need for capture. Indirect evidence of fauna species was documented or collected for later identification (i.e. tracks, scats, bones, sloughed skin and hair samples).

Typically, three diurnal active searches are conducted at each site (in accordance with NT EPA 2013). However, due to the hot dry conditions during the site visit, and the unsuitability of those conditions for detecting fauna, more effort was devoted to nocturnal active searches (see next paragraph) than to diurnal active searches for this project. Diurnal active searches at sites were conducted opportunistically.
9. *Active search (Nocturnal)* – During the survey, two or more nocturnal surveys were conducted at sites and at other locations thought to be most likely to yield signs of threatened species. Searches were conducted by teams of two ecologists for at least 20 minutes at any site, using strong head-torches to aid the identification (and possibly capture) of fauna species. All vertebrate fauna detected were noted. Searches were also undertaken at night along the access tracks and the existing gas pipeline easement by teams of two ecologists from slow-moving vehicles.
10. *Remote surveillance cameras* - In addition to the standard survey techniques, Motion-triggered remote surveillance cameras were used opportunistically in an effort to gain more information on specific features that were found (e.g. areas that had active burrows). Motion-triggered remote surveillance cameras have been used in an increasing number of surveys for fauna (particularly mammals) across Australia. They are now generally accepted as a realistic and viable means to test for presence of some animals within a study site, as well as obtaining an estimate of detection probabilities against other survey methods for cryptic species. The camera units used for this project consisted of a regular digital camera modified to respond to a sensor that detects changes in motion and heat as an animal moves across the field of view. The camera and sensor are housed in a weatherproof case designed to allow operation in most conditions. An infrared flash allows the camera to photograph animals in darkness. Each unit was secured to a tree, and a clear line of sight was established towards bait, which was buried shallowly within range of the camera's motion detector. A mix of peanut butter, honey, oats and sardines was used as bait. Five units were deployed during the survey, with the main objective of detecting the Bilby (*Macrotis lagotis*) and the Brush-tailed Mulgara (*Dasycercus blythi*), as these species can be difficult to detect, particularly when in small populations.
11. *Opportunistic observations* - Eight ecologists over the entire survey period, including six 12-hour days during set-up and survey.

Table 4-1 Summary of fauna survey effort during baseline surveys in the Project Area

Survey type	Survey effort
Habitat assessment	Conducted over approximately two person-hours per site, investigating quadrat area through various survey methods.
Elliot trapping	20 baited Elliot traps (type A) per site, checked twice daily for four days and nights. 1280 trap-nights in total; 80 trap-nights per site.
Cage trapping	Four baited cage traps per site, checked twice daily for four days and nights. 256 trap-nights in total; 16 trap-nights per site.
Pitfall trapping	Four 10 m pitfall traplines (each with one bucket) per site, checked twice daily for four days and nights. 256 trap-nights in total; 16 trap-nights per site.
Funnel trapping	Two 10 m traplines (each with two funnel traps) per site, checked twice daily for four days and nights; Two funnel traps on each pitfall trapline (four pitfall lines). 768 trap-nights in total; 48 trap-nights per site.
Anabat	One survey-night at each site; 16 survey-nights in total
Bird surveys	At least three 20 minute diurnal surveys at each site, incorporating 'instantaneous bird counts'. 48 bird counts in total.
Active searches	Conducted opportunistically by at least one ecologist at sites and other locations, depending on conditions.
Nocturnal searches	At least two 20-minute nocturnal searches by two ecologists at each site or at other locations. Road spotlighting through study area and along the existing gas pipeline access road. Minimum of 24 person-hours active searching in total.
Remote surveillance cameras	Five units were deployed during the survey, for up to four days and nights each. >15 trap-nights in total.
Scat / hair / bone / skin / pellet analysis	Assessed / Collected opportunistically
Opportunistic observations	Eight ecologists over the entire survey period, including six 12-hour days during set-up and survey. Minimum of 576 person-hours of opportunistic observation.

4.2.1 Bat call analysis (using Anabat)

Bat calls were recorded using four Anabat detectors (Titley Scientific, Brisbane). Survey data were downloaded from the detectors and saved as zero-crossing (ZC) format call sequence files (i.e. "Anabat files"). The resulting data set of 3803 ZC files was sent to *Balance! Environmental* for further analysis.

All Anabat files were viewed by *Balance! Environmental* using AnalookW (Corben 2013), with species identification achieved manually by comparing the sonograms with those of reference calls from Queensland and the Northern Territory and/or with published call descriptions (e.g. Reinhold *et al.* 2001; Milne 2002; Pennay *et al.* 2004). Calls with fewer than four clearly-defined, non-fragmented pulses were excluded from the identification process. Species' identification was also guided by considering probability of occurrence based on general distribution information (Churchill 2008; van Dyck & Strahan 2008) and/or database records obtained from the Atlas of Living Australia (<http://www.ala.org.au>).

Species nomenclature for bats follows Churchill (2008); except *Mormopterus eleryi* (Reardon *et al.* 2008).

4.3 Exploration of patterns in fauna diversity and habitats

The results from the standardised surveys at sites (i.e. excluding opportunistic or incidental observations that were not made at sites or during a standard survey activity) were investigated for patterns that may help to describe the way that fauna use the landscape.

Trapping methods were compared to investigate the relative effectiveness of trapping methods, and to compare survey effort with capture success (for all species and by species group).

Species richness and abundance were compared for sub-groups within species groups (i.e. different types of mammals, birds, reptiles).

Patterns in species accumulation were investigated, to determine how effectively the fauna survey had sampled the fauna in the area. This was done for all species combined, and for species groups, by day. This was then repeated for all species at each habitat type (again by day). Species accumulation curves were generated on the basis of the observed data, and also on the basis of smoothed and statistically predicted data, to provide context for the curves observed.

Species richness and abundance across sites and across habitats was compared, first for all species combined, then for species groups (mammals, birds, reptiles).

Using abundance data for each species at each site, resemblance (similarity) matrices of fauna at sites were obtained using the S17 Bray Curtis similarity measure. Data were square-root transformed prior to analysis. Multidimensional Scaling (MDS) was then applied to each resemblance matrix. This analysis explored the abundance data of fauna at the sites and plotted them in multidimensional space according to their similarity to other sites. This was done first for all fauna groups combined, then separately for each group (mammals, birds and reptiles).

Following the MDS, one-way Analysis of Similarities (ANOSIM) was performed on the site data, using habitat as a factor. The number of permutations used was 999, as a random sample from 10,810,800 combinations of the data (as determined by the analysis program, Primer 6.0, on the basis of the input data). This analysis tests the strength of similarity between habitats, on the basis of site data. Thus, it provides an overall (global) statistic for the analysis, then an R statistic value for each pairwise habitat combination. The pairwise R statistics can be compared to determine which habitats most closely resemble others on the basis of their fauna results.

In association with the MDS, Hierarchical Cluster Analysis was performed on the fauna data to explore the similarity/dissimilarity in the fauna at different sites. Cluster analysis was used to inform patterns and groupings in MDS plots.

All data management was done using Microsoft Excel and data analysis was done using statistical software Primer 6.0.

4.4 Limitations of the baseline fauna survey

The fauna assessment focused on species of terrestrial vertebrate fauna (mammals, birds, reptiles and amphibians). Existing databases and species prediction tools are biased towards vertebrates.

The occurrence of terrestrial invertebrates was not assessed. Unlike terrestrial vertebrate fauna, there are relatively few data or identification tools available for terrestrial invertebrates in the region.

Aquatic fauna (fish and aquatic invertebrates) were not assessed as part of this survey. Free standing water, other than at cattle watering points, was not present during the survey period.

The standard requirements for fauna surveys in the NT include three days/nights only for a trapping program (Elliot, cage, pitfall and funnel traps). This duration for trapping is likely to influence the numbers and diversity of fauna detected. Animals that visit the surveyed area only occasionally are less likely to be detected than animals that live nearby. Rare or less common animals may be more likely to be detected with additional survey effort. GHD ecologists conducted the trapping program over four days and nights.

Anabat used a “zero crossing” processing method that tends to pick up the strongest sound at any one time. Bats with soft or whispering calls were generally not detected (e.g. *Nyctophilus* sp. and *Hipposideros* sp.). On most occasions, Anabat detectors and recorders gave “all night” recordings (i.e. no battery or other technical problems). Anabat failure resulted in no data being collected from two sites (Sites 12, 13) and only a half-night of data from Site 9.

Each of the limitations presented is at least partially overcome by supplementing the survey results with those of previous assessments (e.g. DLRM database results).

The hand-held GPS and Trimble units used to record site information are typically accurate to within 10 m. Maps presenting site information and species records should not be relied on for detailed design during construction or operation of the mine.

4.5 Nomenclature

Common and scientific names for birds follow Christidis and Boles (2008). The DLRM fauna database was used for the nomenclature of mammals, reptiles and amphibians.

5. Results

5.1 Overview

In total, 280 fauna species are identified for the Project Area (Appendix B). This species list is derived from a combination of information contained in the PMST report (22 species), DLRM database (249 species), and the GHD baseline fauna survey in April 2013 (116 species). Many of these species would be expected to use one or more of the habitat types in the Project Area, either as residents, occasional or seasonal visitors, fly-overs or vagrants.

Of the 280 species, 268 (40 mammals, 145 birds, 74 reptiles and nine amphibians) are native to the Northern Territory and 12 species (11 mammals and one bird) are non-native.

Thirteen of the 22 species predicted by the PMST to occur in the Project Area have not been recorded historically (DLRM database). This includes four mammals, eight birds and one reptile. Two of the mammals (Brush-tailed Mulgara *Dasycercus blythi* and Bilby *Macrotis lagotis*) were or may have been detected (through indirect evidence, i.e. diggings and ground scratchings) during the baseline fauna survey by GHD in April 2013.

Eighteen species (11 mammals, three birds and four reptiles) detected during the GHD baseline fauna survey in April 2013 have not previously been recorded in the area.

Six days of intensive fauna sampling by eight zoologists in April 2013, using a range of observations and trapping methods, resulted in a list of 116 species (24 mammals, 58 birds and 34 reptiles). This is less than half of the number of species (249) recorded from the area historically (DLRM database), which suggests that many of the fauna species identified for the Project Area are likely to be occasional or seasonal visitors or vagrants to the area. Some species that were recorded historically (mostly small to medium-sized mammals) are now considered to be extinct in the Northern Territory.

5.2 Weather conditions experienced

Environmental conditions during the survey were warm, dry and sunny. Maximum daily temperatures ranged from 31.1 to 33.6°C, and overnight minima ranged from 14.2 to 16.8°C (Table 5-1). Conditions were windy, with average maximum wind gusts of 46 km/h in a SE/ESE direction. No rain fell during the six days.

In the months prior to the survey, the Mount Peake area experienced hot and dry conditions (Table 5-1). Mean daily maxima and minima between February and April were higher than the long-term averages (Table 2-1). Only 7.0 mm of rain fell in the area in the two weeks prior (April 4-5). Rainfall during the preceding year (from April 2012 to the end of March 2013) totalled 162.2 mm, which was 151.1 mm (48.2%) lower than the long-term (25-year) average for that period. Between February and April, only 29.0 mm of rain fell, which was 27% of the long-term mean rainfall (107.6 mm) for that period.

Table 5-1 Weather conditions experienced prior to and during the survey (BOM; Territory Grape Farm NT)

Month / Day	Rainfall (mm)	Mean max. temp (°C)	Mean min. temp (°C)
Feb 2013	8.0	37.7	22.0
March 2013	14.8	37.5	21.5
April 2013	7.0	32.2	15.5
April 9	0.0	32.1	16.8
10	0.0	31.2	15.9
11	0.0	31.4	14.2
12	0.0	31.1	15.3
13	0.0	32.3	15.3
14	0.0	33.6	15.5

5.3 Review of existing data

In regard to species abundance, there are 2,189 individual records of 249 vertebrate fauna species within the DLRM database for the study area (225 mammals, 1,240 birds, 663 reptiles and 61 frogs). As is characteristic of fauna abundance patterns, many of the species recorded for the area are uncommon or rare, and relatively few species account for the majority of records (Figure 5-1). More than half of the species (127) have been recorded five or fewer times. The most abundant 25% of species (i.e. 63 of the 249 species) account for more than 65% of records.

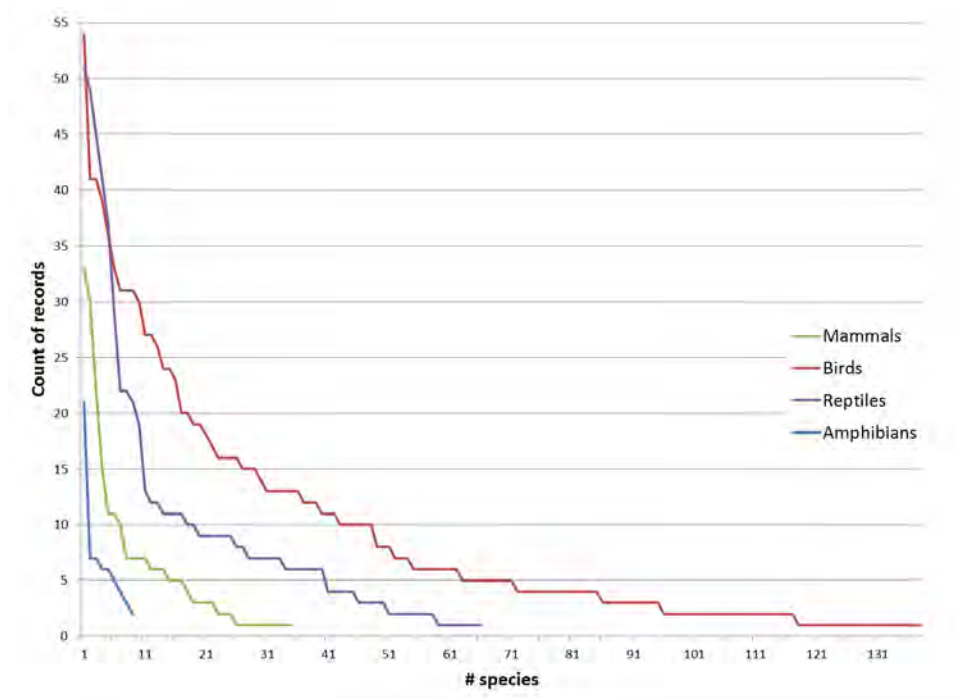


Figure 5-1 Records of vertebrate species in each taxonomic group showing relative abundance of species (DLRM records)

Mammals

A total of 28 native mammal species have been recorded historically in the Project Area. Seventeen of those are listed as threatened or near-threatened under the TPWC Act and/or EPBC Act. Eight of the threatened species are considered to be extinct in the Northern Territory, and four are considered to be extinct in Australia. Of all the taxonomic groups, mammals have the worst conservation history in Australia.

Seven introduced mammal species have been recorded from the Project Area: House Mouse (*Mus musculus*), Cat (*Felis catus*), European Rabbit (*Oryctolagus cuniculus*), Donkey (*Equus asinus*), Horse (*Equus caballus*), Pig (*Sus scrofa*) and Cattle (*Bos taurus/lindicus*).

Birds

A total of 134 native bird species have been recorded historically in the Project Area. Seven of those are listed as threatened or near-threatened under the TPWC Act and/or EPBC Act.

One introduced bird species (Rock Dove, *Columba livia*) has been recorded from the Project Area.

Reptiles

A total of 69 native reptile species have been recorded historically in the Project Area. Two of those are listed as near-threatened under the TPWC Act. No reptile species recorded from the area are listed as threatened under the EPBC Act.

One introduced reptile species (Asian House Gecko, *Hemidactylus frenatus*) has been recorded from the Project Area.

Amphibians

A total of nine native frog species have been recorded historically in the Project Area. Two of those are listed as Data Deficient under the TPWC Act. No frog species recorded from the area are listed as threatened under the EPBC Act.

No introduced frog species have been recorded from the Project Area.

There are only 61 individual frog records from the Project Area. This suggests either a lack of survey effort for amphibians in the study area or inappropriate timing of survey effort to coincide with rainfall events that initiate activity in arid zone frogs. Additional survey effort following rainfall events in the study area is likely to result in the documentation of additional frog species.

5.4 Results of the baseline fauna survey

5.4.1 Fauna habitats

In general, remnant native vegetation was present across the vast majority of the Project Area, with historical clearing typically confined to pastoral infrastructure sites. High to moderate level impacts from pastoral activities (trampling, grazing and weed invasion) were reported as localised and generally confined to watering points, ephemeral watercourses and wetlands, and stockyards. Low level grazing impacts were evident across much of the Project Area, however, vegetation was generally healthy and active seedling recruitment was evident. Some modification to vegetation structure from fires has occurred within the Project Area.

The impact of grazing on native fauna was not measured. Fauna sites were chosen for their likelihood of supporting native fauna species, particularly threatened species, so were generally chosen to be away from the influence of human and agricultural disturbance (e.g. grazing).

In terms of fauna habitats that dominate the Project Area, the eight vegetation types identified in GHD (2015) provide five habitat types:

- Mulga woodland
- Riparian woodland
- Rocky rises
- Spinifex grassland
- *Corymbia* woodland.

These are listed and illustrated in Table 5-3, with a brief description of their occurrence and habitat attributes, and their relationship to the vegetation communities identified in GHD (2015). Note that sites other than those formally categorised as spinifex grassland sites also supported spinifex grasses, particularly rocky shrubland sites and some mulga sites.

Note also that, in many parts of the Project Area, these fauna habitats merged with each other to some degree (e.g. areas of mulga woodland contained small treeless areas that were dominated by spinifex grassland). Where possible, sites were located in larger patches of each habitat type, such that they better represented the habitat they were trying to sample.

5.4.1 Species detected

GHD's survey resulted in records of 116 fauna species, which included 24 mammal species, 58 bird species, 34 reptile species and no amphibians (Table 5-2).

Eighteen species detected during the survey were new records for this area and had not previously been recorded on the DLRM database for this area. These include 11 native species of mammal (one dunnart and 10 insectivorous bats), three native species of bird and four native species of reptile.

The total of 116 species includes two threatened species of mammal (Brush-tailed mulgara, *Dasycercus blythi* and Bilby, *Macrotis lagotis*) that were detected via indirect signs only (burrows, diggings), but not actually seen during the survey. It also includes one species of snake (Desert Death Adder, *Acanthophis pyrrhus*) which was detected on the Stuart Highway just north of the Project Area.

Table 5-2 Numbers of species (by vertebrate group) detected during the fauna survey undertaken by GHD

Group	Native	Non-native	Total
Mammals	20	4	24
Birds	58	0	58
Reptiles	34	0	34
Amphibians	0	0	0
Total	112	4	116

All species detected during the surveys are listed in Appendix C.

Table 5-3 Description of fauna habitats in the Project Area

Fauna habitat	Vegetation community (GHD 2015)	Fauna sites (Figure 4-1)	Description	Photo
Mulga woodland	Mulga shrubland on sandy red earths (VT 2) and Tall Acacia shrubland on stony quartz plains (VT 8).	3, 4, 5, 9, 11, 13, 14, 16	Tall acacia shrubland to 4 m characterised by <i>Acacia aneura</i> and <i>A. aptaneura</i> with scattered <i>Corymbia</i> and <i>Hakea</i> over a shrub layer dominated <i>Acacia</i> and <i>Eremophila</i> . Ground layer dominated by tussock grasses including <i>Aristida</i> , <i>Eragrostis</i> and <i>Enneapogon</i> . Variable habitat: some areas dominated by dense thickets of tall mulga; other areas characterised by low sparse shrubland. Heterogeneity likely to reflect soil type, landscape position and fire regime.	
Riparian woodland	Riparian woodland along watercourses and drainage channels (VT 3) and Floodplains dominated by <i>Eucalyptus victrix</i> (VT 5).	10, 12	Habitat dominated by <i>Eucalyptus camaldulensis</i> , <i>Erythrina vespertilio</i> and <i>Atalaya hemiglauca</i> , with <i>Corymbia</i> also present along smaller channels. VT5 occurs particularly on flood out areas of Hanson River and Bloodwood Creek, and is dominated by <i>Eucalyptus victrix</i> with <i>Acacia estrophiolata</i> and <i>Eucalyptus camaldulensis</i> also present. Shrub layer typically sparse with <i>Acacia</i> , <i>Jasminum</i> , <i>Melhanian</i> , and <i>Senna</i> (VT4), or <i>Eremophila</i> , <i>Indigofera</i> and <i>Carissa</i> (VT5). Ground layer dominated by diverse array of tussock grasses and forbs, including <i>Eulalia</i> , <i>Themeda</i> , <i>Crotalaria</i> , <i>Bothriochloa</i> , <i>Calotis</i> , and <i>Brachyscome</i> . The introduced grass <i>Cenchrus ciliaris</i> is also abundant throughout the ground layer. Sedges may also be present. Soils comprise fine texture sands and clay hardpans.	

Fauna habitat	Vegetation community (GHD 2015)	Fauna sites (Figure 4-1)	Description	Photo
Rocky shrubland	Low open Eucalyptus woodland on limestone ridges (VT 1).	6, 7, 15	Characterised by stony surfaces with limestone outcropping. Occurs on undulating limestone platform that runs in northwest to southeast direction towards eastern end of Project Area. Characterised by low mallee <i>Eucalyptus</i>, with scattered <i>Corymbia</i> and <i>Hakea</i>. Shrub layer is sparse, dominated by <i>Acacia</i>, <i>Eremophila</i> and <i>Senna</i>. Ground layer dominated by spinifex (<i>Triodia</i>), with other common grasses and forbs, including <i>Ptilotus</i>, <i>Scaevola</i>, <i>Eriachne</i> and <i>Solanum</i>.	
Spinifex grassland	Triodia grassland on sand plains (VT 6) and Low Acacia shrubland on rocky slopes (VT 7)	1, 2	Ground layer is dominant vegetation stratum, characterised by spinifex grasses (<i>Triodia pungens</i> and <i>Triodia basedowii</i>) and other tussock grasses (mainly <i>Eragrostis</i> and <i>Aristida</i>). Sparse overstorey and shrub layer, dominated by scattered <i>Corymbia</i>, <i>Acacia</i>, <i>Atalaya</i>, <i>Eremophila</i>, <i>Grevillea</i> and <i>Hakea</i>. Occurs on flat to gently undulating sand plains. Considerable local variation; some areas characterised by dense ground cover, while others have open ground layer with dense low mixed acacia shrub layer. Heterogeneity likely to reflect differences in grazing and fire regimes. VT7 also characterised by low acacias growing on granite or quartzite stony rises, with shallow soil and rocky surface fragments.	

Fauna habitat	Vegetation community (GHD 2015)	Fauna sites (Figure 4-1)	Description	Photo
Corymbia woodland	Low Corymbia open woodland on plains with red earths (VT 4)	8	Occurs on fertile alluvial floodplains surrounding creek lines where moisture availability and fertility is greater. Also at the base of rocky ranges receiving water and nutrient runoff. Canopy dominated by <i>Corymbia opaca</i> and <i>Hakea macrocarpa</i>, with scattered <i>Acacia</i> and <i>Atalaya</i>. Sparse shrub layer dominated by <i>Acacia</i> and <i>Senna</i>. Ground layer dominated by tussock grasses including <i>Eragrostis</i>, <i>Aristida</i>, <i>Enneapogon</i>, <i>Abutilon</i>, <i>Gossypium</i> and <i>Evolvulus</i>.	

5.4.2 Assessment of sampling techniques

Each of the sampling techniques resulted in effective sampling of differing taxonomic groups or combinations of groups. For example, pitfall and funnel trapping were particularly successful at detecting reptiles, while the most successful technique for detecting birds was bird surveys, although nearly as many species were detected incidentally or opportunistically (Table 5-4). In combination, the sampling techniques effectively sampled the fauna as a whole.

Table 5-4 Success of sampling techniques in detecting species of different taxonomic groups

Group	Bird surveys	Pits / funnels	Elliots / cages	Active (night)	Anabat / (Harp)	Motion-detecting cameras	Incidental obs.
Mammals	2	4	3	4	11 (2)	3	9
Birds	44	0	0	3	0	4	43
Reptiles	4	19	1	6	0	1	19
Amphibians	0	0	0	0	0	0	0
Total	60	23	4	13	11 (2)	8	71

Of the 116 species detected, 62 (54%) were detected by one method alone and 53 were detected by more than one method. Of the 116 species, 32 (28% of all species detected) were detected once only (i.e., one individual or one sighting).

Sampling at the 16 sites resulted in the detection of 89 fauna species. The additional 26 species (thus, 116 total) were detected as incidental records between sites.

More detail for the remote surveillance camera results is provided in Appendix D.

5.4.3 Fauna diversity and abundance

Mammals

Twenty-four species of mammal were detected during the survey. This included four non-native species (Cat, *Felis catus*; Donkey, *Equus asinus*, Cattle, *Bos taurus/indicus* and European Rabbit, *Oryctolagus cuniculus*). A complete list of mammal species recorded during the surveys is provided in Appendix C.

The native mammals detected comprised the following ecological/morphological/taxonomical sub-groups:

- Bats – 11 species of micro-chiropteran bats (insectivorous bats)
- Carnivores – 1 species: dingo (*Canis lupus dingo*)
- Grazers – 1 species: Red Kangaroo (*Macropus rufus*)
- Small mammals – 7 species: Brush-tailed Mulgara (*Dasyurus blythi*), Bilby (*Macrotis lagotis*), Spinifex Hopping-mouse (*Notomys alexis*), Desert Mouse (*Pseudomys desertor*), Sandy Inland Mouse (*Pseudomys hermannsburgensis*), Fat-tailed Dunnart (*Sminthopsis crassicaudata*) and Lesser Hairy-footed Dunnart (*Sminthopsis youngsoni*).

Bats had the highest species richness (11 species), followed by small mammals (seven) (Table 5-5).

Table 5-5 Diversity and recorded abundance of sub-groups of mammals detected during the survey

Sub-group	Species	Individuals / sightings
Bats	11	2429 calls*
Carnivores	1	10
Grazers	1	6
Small ground mammals	7	139
Non-native mammals	4	9 [#]
Total	24	164**

* the number of bat calls does not necessarily equate to the number of individuals, because multiple calls are likely to have been emitted by the same individual.

** bats not included; [#] excluding Cattle.

Other than bats, most mammals were detected by opportunistic (incidental) observations. Small mammals were an exception – of the 139 individuals seen, most (116) were sightings of one species (Spinifex Hopping-mouse, *Notomys alexis*) seen during nocturnal active searching. Many more observations were not reported (e.g., driving at night, while returning from site). Sampling techniques used to target small and medium-sized ground-dwelling mammals (Elliot traps, cage traps and pitfall traps) resulted in the detection of four additional species.

Two species of mammal detected or potentially detected during the survey are listed as Vulnerable under Northern Territory legislation and Vulnerable under the Commonwealth EPBC Act (Bilby, *Macrotis lagotis* and Brush-tailed mulgara, *Dasycercus blythi* - note that the mulgara is listed under the EPBC Act as the Crest-tailed mulgara, *Dasycercus cristicauda*, because it was listed prior to publication of the species' currently accepted taxonomical distinction; see Section 5.5.1). The presence of neither species was confirmed during the survey (i.e. animals were not seen), but the conclusion is drawn that both are likely to occur in the Project Area, possibly only in small numbers. Our confidence in the identification of the mulgara burrow was relatively high – the burrow was fresh and active, and showed the characteristic signs of a burrow of this species (as experienced by GHD zoologists in the Pilbara region in Western Australia, where live animals have been captured). Failure to detect a live animal at the burrow thereafter (remote sensing camera) may be explained by the species' known sensitivity to disturbance, and the likelihood that mulgaras have numerous burrow entrances that would be used preferentially in response to disturbance. Our confidence in the Bilby diggings is lower, but still reasonably high (J. Kuiper, GHD Ecologist; pers. comm.; Formerly with Australian Wildlife Conservancy). This determination is made on the basis of the habitat, apparent intent of the diggings (i.e. targeting a food source of termites and/or shallow roots), the appearance and characteristics of the scratchings (e.g. sharp edge to scrapes, two or three obvious claws marks), and proximity to historical Bilby records.

The Spinifex Hopping-mouse (*Notomys alexis*) was the most commonly detected mammal (116 individuals recorded) (excluding bats).

Birds

In total, 58 species of bird (all native) were detected during the survey. Birds showed the highest species diversity of all the taxonomic groups of vertebrate fauna. A complete list of bird species recorded is provided in Appendix C.

The birds detected were assigned to sub-groups determined on the basis of taxonomy (i.e. related types of birds) and/or ecology (e.g. similar habitat use). As far as practicable, sub-groups were determined by taxonomy (e.g. raptors, parrots/cockatoos), but in an effort to reduce the numbers of groups, some taxonomic groups were combined on the basis of ecology (e.g. woodland birds, waterbirds, grassland birds). The following sub-groups were recorded:

- Grassland birds – four species, including finches, fairy-wrens and spinifexbird, generally associated with non-treed habitats
- Ground birds – two species that tend to remain on or near the ground (Australian bustard, Emu)
- Honeyeaters – eight species of honeyeaters and their allies
- Night birds – four species of nocturnal birds (owls, nightjars and owlet-nightjar)
- Parrots/cockatoos – five species of parrots and cockatoos
- Pigeons/doves – three species of bronzewings, pigeons, doves
- Raptors and scavengers – 11 species of falcons, goshawks, eagles, kites, crows, magpies and butcherbirds
- Wetland and waterbirds – two species that show a strong association with ponds, lakes, swamps, water courses or riparian habitats (Hoary-headed grebe and Black-fronted Dotterel)
- Woodland birds – 19 species generally associated with treed habitats, including cuckoo-shrikes, thornbills, babblers, woodswallows and robins.

Woodland birds and raptors/scavengers were the most species-rich groups (Table 5-6).

Fourteen bird species (24% of birds) were detected once only. The ten most commonly recorded bird species accounted for more than half (54%) of all bird records. In order of highest to lowest numbers of records, these are: Zebra Finch, Singing Honeyeater, Australian Ringneck, Crested Bellbird, Crested Pigeon, Major Mitchell's Cockatoo, Rufous Whistler, Budgerigar, Willie Wagtail and Black-faced Woodswallow.

Table 5-6 Diversity and recorded abundance of sub-groups of birds detected during the survey

Sub-group	Species	Individuals
Grassland birds	4	91
Ground birds	2	9
Honeyeaters	8	81
Night birds	4	18
Parrots/cockatoos	5	96
Pigeons/doves	3	35
Raptors/scavengers	11	52
Wetland/waterbirds	2	5
Woodland birds	19	157
Total	58	544

Three species of bird detected during the survey are listed as threatened or near-threatened under the NT TPWC Act: Australian Bustard (*Ardeotis australis*) (near threatened), Emu (*Dromaius novaehollandiae*) (near threatened), and Grey Falcon (*Falco hypoleucos*) (vulnerable).

No species of bird detected during the survey are listed as Threatened under the EPBC Act, but one (Rainbow Bee-eater, *Merops ornatus*) is listed as Migratory under the EPBC Act.

Reptiles

Thirty-four species of reptile (all native) were detected during the survey. A complete list of reptile species is provided in Appendix C.

Reptiles detected were categorised into the following taxonomical sub-groups: agamids (dragons), geckoes, skinks, snakes and varanids (monitors). Of the sub-groups, geckoes, skinks and snakes were the most diverse, with eight, eight and seven species detected respectively (Table 5-7).

Table 5-7 Diversity and abundance of sub-groups of reptiles detected during the survey

Sub-group	Species	Individuals
Agamids	6	7
Geckoes	5	11
Skinks	15	109
Snakes	5	8
Varanids	3	5
Total	34	140

Skinks were easily the most abundant in regard to numbers of individuals recorded (109 individuals captured/observed, at an average of 7.3 individuals per species). Geckoes, agamids and snakes were the relatively equal in their abundance, with fewer than 10 individuals of any group captured or observed, at an average of 2.2 individuals or less per species. Varanids were the least common of the groups, with only 5 sightings of 3 species.

Thirteen reptile species (38% of reptiles) were recorded once only. The ten most abundant species were responsible for 73% of reptile individuals captured or observed. In decreasing order of abundance, these were: Greer's Ctenotus (*Ctenotus greeri*), Leopard Ctenotus (*Ctenotus pantherinus*), Clay-soil Ctenotus (*Ctenotus helenae*), Barred Wedgesnout Ctenotus (*Ctenotus schomburgkii*), Striped Rainbow Skink (*Carlia munda*), Desert Rainbow Skink (*Carlia triacantha*), Grey's Menetia (*Menetia greyii*), Lined Fire-tailed Skink (*Morethia ruficauda*), Northern Spiny-tailed Gecko (*Strophurus ciliaris*) and Two-toed Lerista (*Lerista bipes*).

Two species of reptile detected during the survey are listed as near-threatened under the NT TPWC Act: King Brown Snake (*Pseudechis australis*) and Woma Python (*Aspidites ramsayi*).

No species of reptile detected during the survey are listed as Threatened under the EPBC Act.

Amphibians

Given the dry conditions and time of year, no amphibians were detected during the survey.

5.4.4 Accumulation of detected species with time

When each of the taxonomic groups and all species combined are considered, the survey exhibited species accumulation curves (using actual observations and the order observed) through time that tended towards a plateau, suggesting that the majority of species susceptible to the sampling techniques had been detected prior to the conclusion of the survey (Figure 5-2). Overall, 104 (90%) of the 115 species (cattle are excluded) had been detected by the end of day 3, and 114 (>99%) species had been detected by the end of day 4. Only one additional species (<1%) was detected on the final day (one bird).

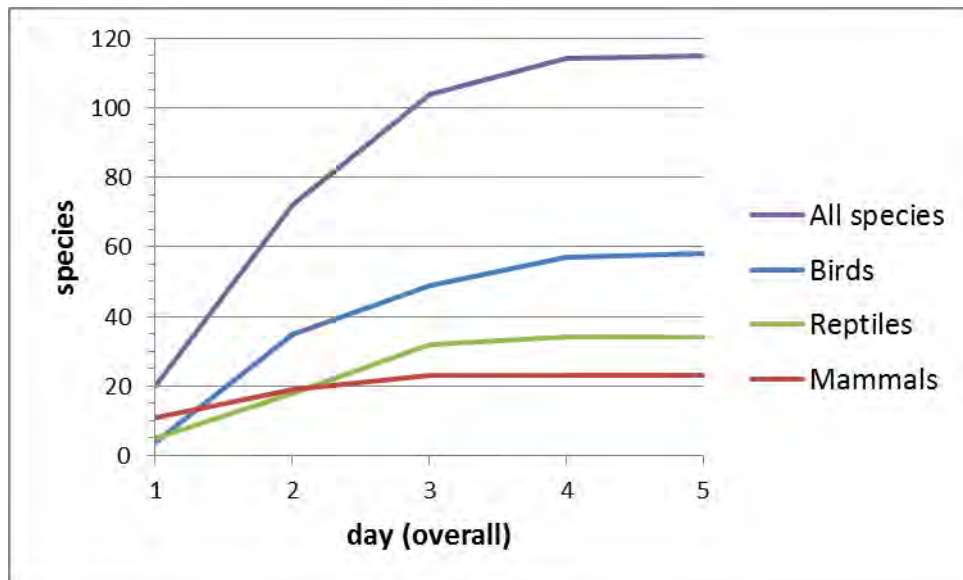


Figure 5-2 Accumulation of species (all species and by group), as detected during the survey (actual curves for all groups)

To provide context for these curves, three curves are fitted for each species accumulation analysis:

1. Observed data, as recorded (Actual)
2. Permuted (smoothed) species accumulation, whereby the order of observations made at sites over different days is repeatedly randomised (999 iterations) in an effort to smooth the curve and make better sense of the final trajectory. This curve by definition ends on the same species total (e.g. 115 species overall)
3. An extrapolated 'Bootstrap' species accumulation curve that attempts to predict the true total number of species that would be observed as the number of samples tends to infinity (i.e. the asymptote).

All species

When all species are considered, comparison of the Actual data with the smoothed curve (Figure 5-3; top left, blue and red lines) shows that Day 1 resulted in well-below expected numbers of species being detected/recorded during the survey, but that from Day 2 onwards, the numbers of species recorded was closer to the smoothed line, and after Day 3 exceeded the expected curve. The trajectory of the smoothed curve at Day 5 was steeper than the Actual curve, suggesting that the survey results had not sampled the fauna quite as adequately as was apparent from the Actual curve, and that additional sampling, or sampling over a longer period, would benefit the results.

Comparison of the Actual data with the Bootstrap predicted curve (Figure 5-3; top left, green line) shows that our survey resulted in fewer than expected fauna species. The Bootstrap curve, based on the survey data, predicts (with hypothetical infinite sampling) the detection of approximately 130 species after five days, whereas our survey detected 115 (excluding cattle). With the benefit of the DLRM database, we know that records of 249 indigenous species exist from a very long observation period.

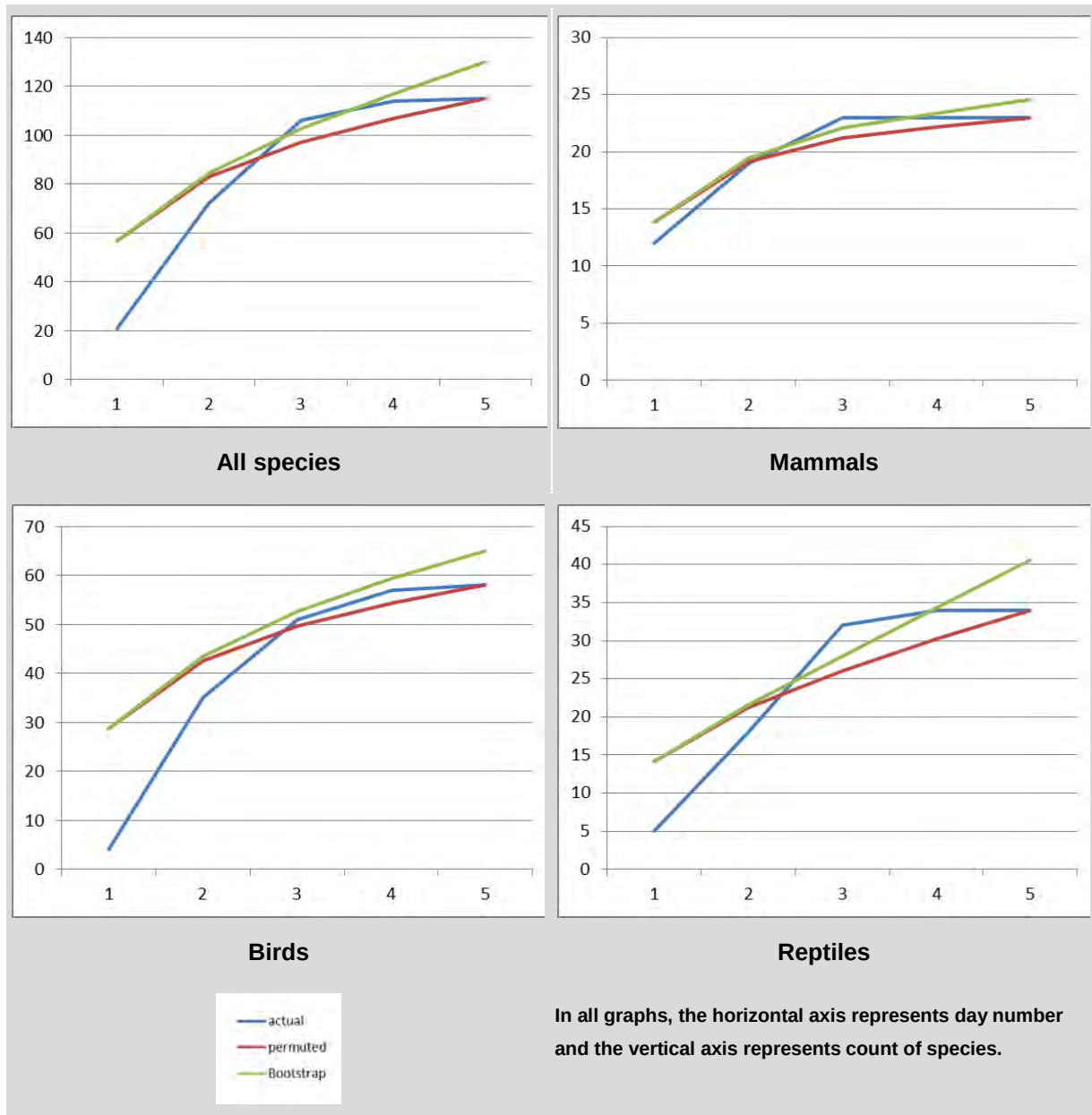


Figure 5-3 Accumulation of species (all species and by group) detected during the survey

Mammals, Birds, Reptiles

When divided into taxonomic groups (Figure 5-3), the comparison of Actual curves and smoothed curves for birds and reptiles show that for both groups, the trajectory of the smoothed curve at Day 5 was markedly steeper than the Actual curve (particularly for reptiles), suggesting that the survey results had not sampled those fauna groups quite as adequately as was apparent from the Actual curves, and that additional sampling, or sampling over a longer period, would benefit the results for those groups. For mammals, the trajectories of the curves at Day 5 were closer, suggesting that the survey results had sampled mammal fauna relatively well.

The Bootstrap curves for each group predict a total (after five days) of approximately 25 mammal species (actual observed was 23, excluding cattle), 65 bird species (actual observed was 58) and approximately 41 reptile species (actual observed was 34) with infinite sampling. The DLRM database contains records of 28 native mammal species, 134 bird species and 69 reptile species from a very long observation period.

5.4.5 Fauna richness - variation among sites and habitats

This analysis is restricted to data obtained over the course of the survey from the 16 sites only. Incidental observations made from other locations are not included.

Fauna richness varied among the 16 sites and the five habitats. This section identifies the spatial patterns recorded. The combined taxonomic groups are evaluated, then each taxonomical group (mammals, birds, reptiles) is evaluated separately to determine which species and groups contributed most to the variation in richness.

Variation in richness among sites

Species richness of the fauna varied across sites. Total numbers of fauna species were highest at Sites 8 and 7 (34 and 31 species respectively) and lowest at Sites 13 and 14 (13 species each) (Figure 5-4).

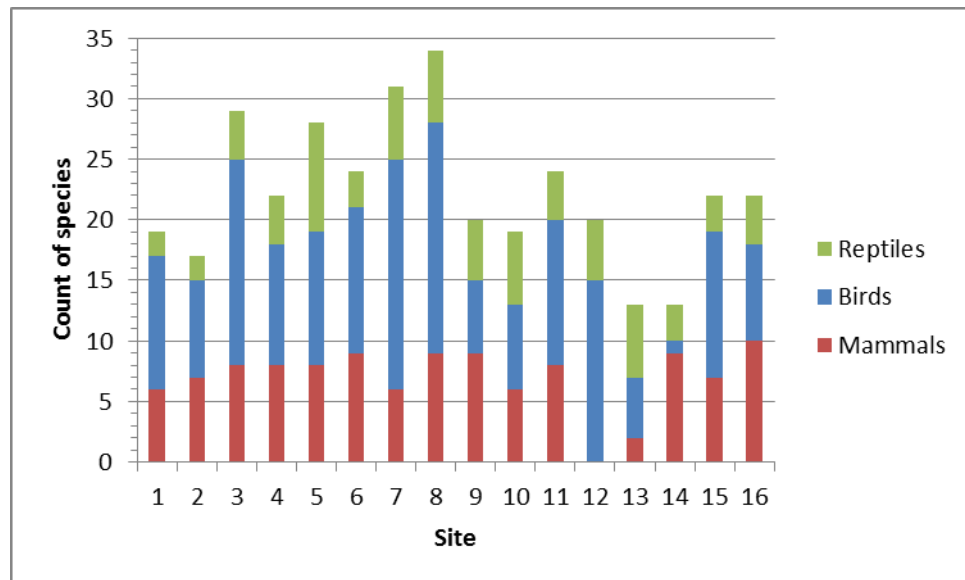


Figure 5-4 Species richness of all fauna recorded at each site

Birds were by far the most numerous species group, and as a result of that, variation in bird species richness tended to reflect the variation in overall species richness. Birds were most diverse at Sites 7 and 8 (19 species each), and least diverse at Site 14 (1 species only).

Mammal diversity was boosted by numerous species of insectivorous bats, but species' counts were still seemingly low at most sites. However, it was considered relatively good for arid Australian habitats post-European settlement. It was highest at Site 16 (10 species) and lowest at Sites 12 and 13 (0 and 1 species respectively). Detection of bats via Anabat units boosted the numbers of mammals recorded at most sites. The numbers of bat species detected at sites ranged from 5 (sites 1 and 9) to 8 (sites 5, 14 and 16), with an average of 6.64 species per site. The Anabat detector unit failed at two sites (12 and 13) resulting in detection of no bats there, and these are the sites that recorded the lowest mammal richness and the lowest vertebrate richness.

The diversity of reptiles was generally low, but varied. Nine species were recorded at Site 9, but only two species were recorded at sites 1 and 2. Reptiles were detected at all sites.

Variation in richness among habitats

When sites are grouped by habitat (see Table 5-3), species richness of the fauna showed a marked pattern. Fauna diversity was far higher in the mulga habitat than in any other habitat, with 68 species recorded (17 mammals, 31 birds, and 20 reptiles) Figure 5-5. The mulga habitat had the highest recorded diversity for each taxonomic group (mammals, birds, reptiles). Rocky habitats had intermediate to high diversity (46 species), while Corymbia woodland and riparian habitats had intermediate to low diversity, with 34 and 33 species recorded respectively. The spinifex habitat had the lowest diversity, with 26 species recorded.

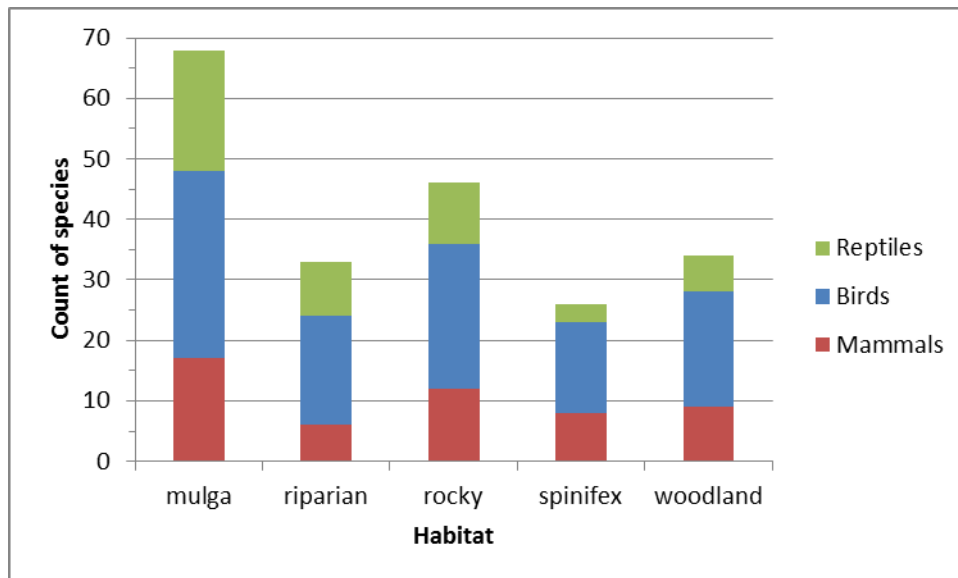


Figure 5-5 Species richness of all fauna recorded in each habitat

This pattern is partly explained by the numbers of sites of each habitat type, which equates to relative survey effort. Sites were chosen to be representative of the extent of habitats within the area, and as such, only one Corymbia woodland site was sampled, along with two riparian sites, two spinifex sites, three rocky sites and eight mulga sites.

However, when numbers of sites per habitat are factored in to the observed species richness, the highest overall fauna richness seen in the mulga habitats (68 species) is shown to be an aggregated result of higher survey effort. The mean number of fauna species at any mulga habitat site was 21.4, which was exceeded by the mean values at rocky sites (25.7 species; three sites) and at the woodland site (34.0 species; one site). With only one site sampled, the woodland habitat stands out as the most species rich habitat with 34 species, the highest of any site (Figure 5-6). Spinifex and riparian habitats were similar in their relatively low richness (means of 18.0 and 19.5 respectively; two sites each).

Anabat failure at two mulga sites contributed to lower than expected mammal richness at those sites. When those sites are excluded, the mean number of fauna species at any mulga site is 24.2, which is only marginally less than the mean value at rocky sites.

Of the 89 species detected at the 16 sites, 34 (38%) were detected in one habitat type only (16 birds, 6 mammals and 12 reptiles). This suggests a relatively high degree of fauna specialisation among the habitat types, rather than an even distribution of fauna among the habitat types. Of the 34 species, 17 were from mulga habitats (seven of which were reptiles), nine were from rocky habitats, and six species were found only in the riparian habitat. Spinifex and woodland sites had one species each that was not detected in other habitats.

At the other end of the scale, eleven species were ubiquitous, being found across all habitat types. This included five species of birds (Australian Ringneck, Budgerigar, Crested Bellbird, Grey Shrike-thrush and Singing Honeyeater) and five species of volant mammal (Gould's Wattled Bat, Inland Broad-nosed Bat, Inland Forest Bat, Lesser Long-eared Bat and Little Broad-nosed Bat). Only one reptile of the 25 reptile species was found across all five habitats: Leopard Ctenotus, *Ctenotus pantherinus*. Thus, 26% of bird species detected at sites were found across all five habitats, compared with 11% of mammals and 4% of reptiles. This reflects the specialist nature of many reptile species, and to some extent mammal species, and the dispersive and/or generalist nature of arid country birds in this part of central Australia.

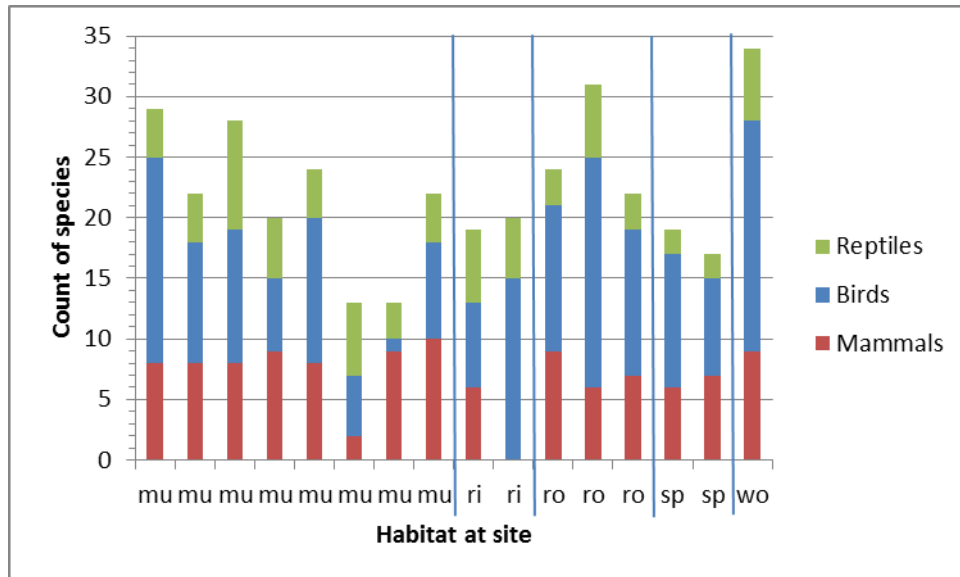


Figure 5-6 Species richness of all fauna recorded per site in each habitat (mu = mulga; ri = riparian; ro = rocky; sp = spinifex; wo = woodland)

5.4.6 Accumulation of detected species by habitat

The following analysis is restricted to data obtained over the course of four nights (spanning five days) from the 16 sites only. Incidental observations made from other locations are not included. Observations of cattle are not included.

When each habitat was considered separately, the survey exhibited species' accumulation curves (using actual observations and the order observed) through time that, by the end of the survey, were continuing to rise and were only just beginning to tend towards a plateau. This indicated that there were likely to be still more species to detect in those habitats (Figure 5-7). The final trajectory for the rocky habitat was the closest to an asymptote, with only one new species (2% of the total) detected in that habitat on Day 5. The final trajectory for the spinifex habitat was the furthest from asymptote, with four new species (15% of the total) detected in that habitat on Day 5.

To provide context for these curves, three curves are fitted for each species accumulation analysis, as described in section 5.4.4. Each habitat is discussed separately below.

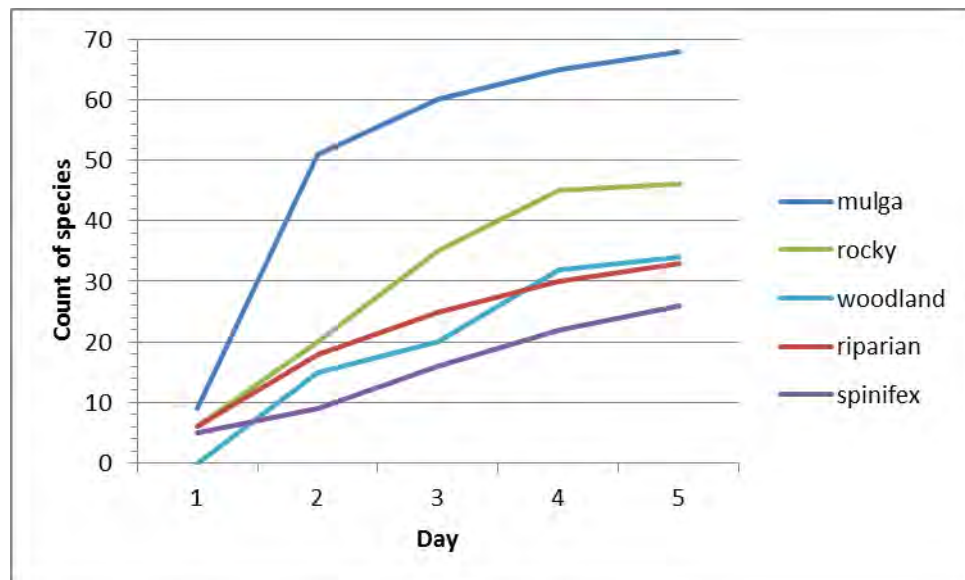


Figure 5-7 Accumulation of species detected during the survey in each habitat (Actual curves for all groups)

Mulga habitat

For the mulga habitat, comparison of the Actual data with the smoothed curve (Figure 5-8; top left, blue and red lines) shows that the plateauing trajectory that was observed was fairly closely matched by the smoothed curve after Day 2, particularly over the course of the final days of survey. The final trajectory of the smoothed curve was steeper than the Actual curve, but not greatly, suggesting that the results of the five-day sampling in that habitat came close to describing the fauna species adequately. That said, additional sampling, or sampling over a longer period, would still be expected to result in the detection of more species. Comparison of the Actual data with the Bootstrap predicted curve (Figure 5-8; top left, green line) shows that our survey resulted in fewer than expected fauna species in the mulga habitat. The Bootstrap curve, based on the survey data, predicts the detection of approximately 78 species in mulga habitat after five days (with infinite randomised sampling), whereas our survey detected 68.

Rocky habitat

For the rocky habitat, comparison of the Actual data with the smoothed curve (Figure 5-8; centre left, blue and red lines) shows that the plateauing trajectory that was observed was not closely matched by the smoothed curve. The final trajectory of the smoothed curve was steeper than the Actual curve, suggesting that more than five days of sampling in that habitat was required to describe the fauna species adequately. Comparison of the Actual data with the Bootstrap predicted curve (Figure 5-8; centre left, green line) also shows that our survey resulted in fewer than expected fauna species in Rocky habitats. The Bootstrap curve, based on the survey data, predicts the detection of approximately 55 species after five days (with infinite randomised sampling), whereas our survey detected 46.

Corymbia woodland

For Corymbia woodland, the Actual observed data (Figure 5-8; bottom left, blue line) does not show a typical species accumulation curve, with more new species added on Day 4 (12 species added) than on Day 3 (5 species added). Comparison of the Actual data with the smoothed curve (blue and red lines) shows that the final trajectory of the smoothed curve was steeper than the Actual curve, suggesting that the results of the five-day sampling in that habitat do not describe the fauna species adequately, and that additional sampling, or sampling over a longer period, would result in the detection of more species.

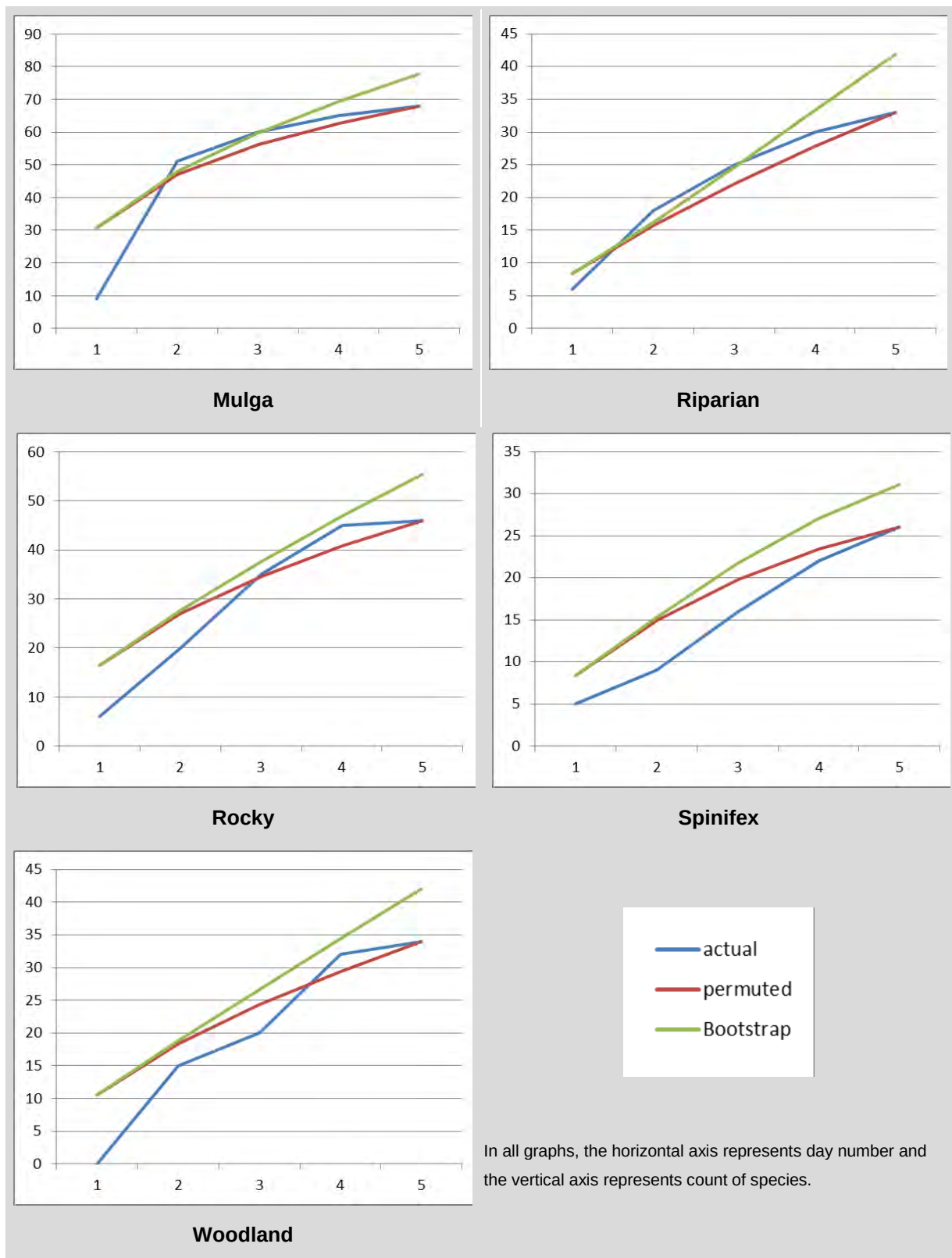


Figure 5-8 Accumulation of species detected in different habitats during the survey

Comparison of the Actual data with the Bootstrap predicted curve (Figure 5-8; bottom left, green line) also shows that our survey resulted in fewer than expected fauna species in Corymbia woodland. The Bootstrap curve, based on the survey data, predicts the detection of approximately 42 species after five days (with infinite randomised sampling), whereas our survey detected 34. The fact that the final trajectory of the Bootstrap curve is noticeably steeper even than the smoothed curve, also suggests that there are more fauna species to detect in woodland habitat, and that a longer sampling period is necessary.

Riparian habitat

For the riparian habitat, comparison of the Actual data with the smoothed curve (Figure 5-8; top right, blue and red lines) shows that the plateauing trajectory that was observed was fairly closely matched by the smoothed curve. The final trajectory of the smoothed curve was steeper than the Actual curve, but not greatly, suggesting that the results of the five-day sampling in that habitat came close to describing the fauna species adequately. That said, additional sampling, or sampling over a longer period, would still be expected to result in the detection of more species. Comparison of the Actual data with the Bootstrap predicted curve (Figure 5-8; top right, green line) shows that our survey resulted in fewer than expected fauna species in the riparian habitat. The Bootstrap curve, based on the survey data, predicts the detection of approximately 42 species in riparian habitat after five days (with infinite randomised sampling), whereas our survey detected 33. The fact that the final trajectory of the Bootstrap curve is noticeably steeper even than the smoothed curve, also suggests that there are more fauna species to detect in the riparian habitat, and that a longer sampling period is necessary.

Spinifex habitat

As for woodland, the Actual observed data for the spinifex habitat (Figure 5-8; centre right, blue line) does not show a typical species accumulation curve, with fewer new species added on Day 2 (4 species added) than on Days 3 or 4 (7 and 6 species added respectively). However, comparison of the Actual data with the smoothed curve (blue and red lines) shows that the plateauing trajectory observed over the course of the final days of survey (after Day 2) becomes fairly closely matched by the smoothed curve. The final trajectory of the Actual curve was steeper than the smoothed curve, but not greatly, suggesting that the results of the five-day sampling in that habitat described the fauna species adequately after the sampling period. Comparison of the Actual data with the Bootstrap predicted curve (Figure 5-8; centre right, green line) shows that our survey resulted in fewer than expected fauna species in the spinifex habitat. The Bootstrap curve, based on the survey data, predicts the detection of approximately 31 species over five days (with infinite randomised sampling), whereas our survey detected 26.

5.4.7 Patterns of fauna assemblages among habitats

Multidimensional Scaling (MDS) and Hierarchical Cluster Analysis were used to explore similarity/dissimilarity in the fauna at different sites, and plot abundance data (square-root transformed) of fauna at the sites in multidimensional space according to their similarity to other sites.

In the cluster analysis dendrograms, relationships among sites and groups of sites can be visualised, and the strength of the similarity/dissimilarity can be gauged from the Bray Curtis similarity index along the horizontal axis. Sites/groups that branch from others towards the lower end (i.e. similarity of 0 – 40) show clearer and stronger differences from the others (dissimilarity) than sites/groups that branch towards the higher end (i.e. similarity of 80 – 100).

In the MDS graphs, two points plotted near to each other have greater similarity to each other in their fauna results than two points plotted further from each other. The MDS output indicates a stress level for the analysis: low stress (tending towards zero) means that the pattern is relatively clear and strong; higher stress (tending towards one) means that the pattern is unclear and weak.

Groupings shown on the MDS plots are determined by arbitrarily chosen slice lines of similarity from the cluster analysis dendrogram. These lines/groupings are applied in an attempt to show the groupings (or lack thereof) of the sites and the relative strength or weakness of the groupings.

Sites were labelled and colour-coded according to habitat type.

One-way Analysis of Similarities (ANOSIM) was used to test the strength of similarity between habitats, on the basis of site data. This analysis provides an overall (global) statistic for the analysis, then an R statistic value for each pairwise habitat combination. The higher the global statistic value (0 - 1), the stronger the overall pattern among all sites and habitats. The higher the R statistic value (0 - 1), the bigger the pairwise difference. The pairwise R statistics can be compared to determine which habitats most closely resemble others on the basis of their fauna results.

All species

MDS and Cluster analysis showed interesting but weak patterns for abundance of fauna (all species) among sites and habitats. There was a clear pattern that the fauna composition at Sites 12 and 13 differed from the fauna composition at other sites (Figure 5-9 and Figure 5-11). This was almost certainly driven by the Anabat failure at those sites, which resulted in fewer mammals being detected at those sites than at all other sites. The next largest distinction was that sites 10 and 14 were grouped separately from the others (as shown in Figure 5-11 by the Similarity = 33 grouping), then Sites 1, 9 and 16. Interestingly, Sites 10 and 14 do not represent the same habitat (riparian and mulga respectively), nor do Sites 1, 9 and 16 (spinifex, mulga and mulga respectively). At the other end of the spectrum, Sites 6 and 2 also represented different habitat types (rocky and spinifex respectively), yet had fauna assemblages that most resembled each other. These results suggest that the fauna patterns generally across this landscape are indistinct and weak (i.e. many of the fauna species present in the landscape occur across numerous or all habitat types).

The differences among sites are not driven simply by numbers of species, because the sites that group together vary widely in species richness (Figure 5-4). This suggests that the differences found are more likely to be due to subtle differences in the types and/or abundance of fauna that occur at the sites.

When fauna results (all species) per habitat were investigated using Cluster analysis (Figure 5-10), there was a reasonably clear pattern showing similarity between the fauna assemblages in riparian and Corymbia woodland habitats, and between the fauna assemblages in rocky and mulga habitats. The fauna assemblage in the spinifex habitat differed somewhat from other habitat types, but was closer to rocky and mulga habitats than to riparian and Corymbia woodland habitats.

ANOSIM results showed a Global R statistic of -0.052, which is low and suggests that the overall pattern among sites/habitats is weak. Pairwise statistics are shown in Table 5-8, but should be regarded with caution given that the Global R statistic is so low. The pairwise statistics indicate that the largest difference in fauna assemblages is between spinifex and riparian habitats, and the least difference is between woodland and riparian habitats.

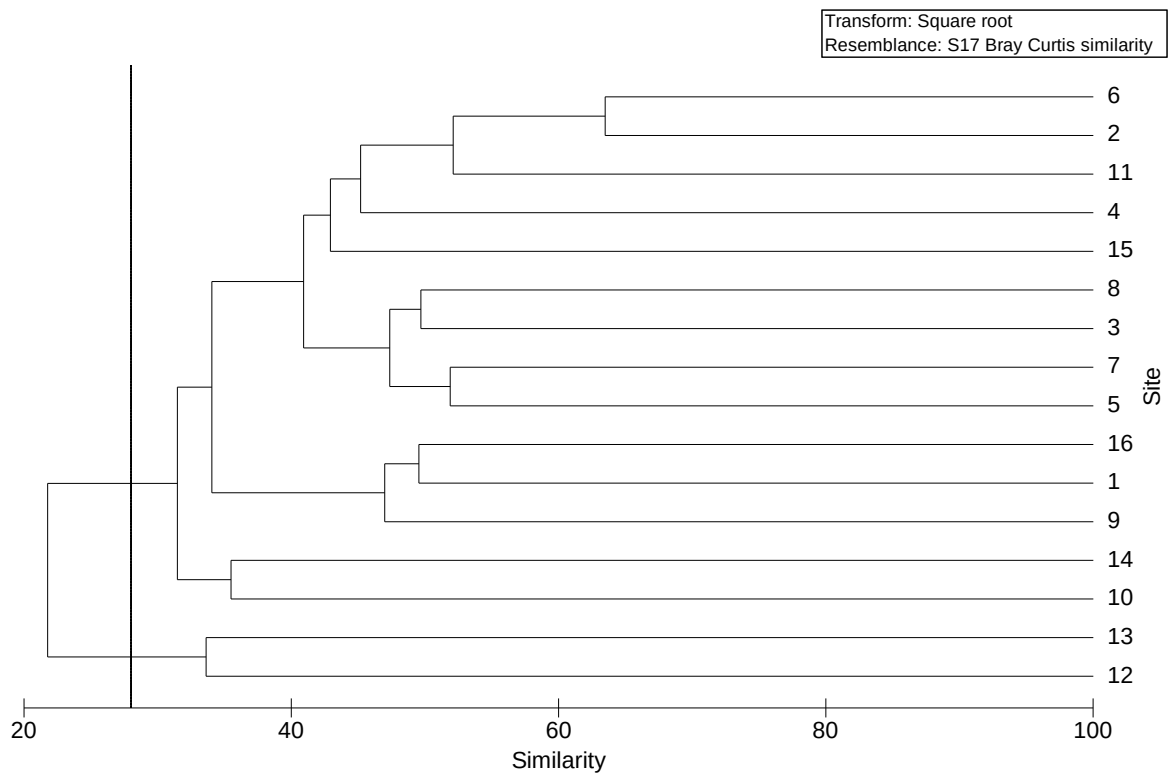


Figure 5-9 Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of all fauna species (slice line added at similarity = 28)

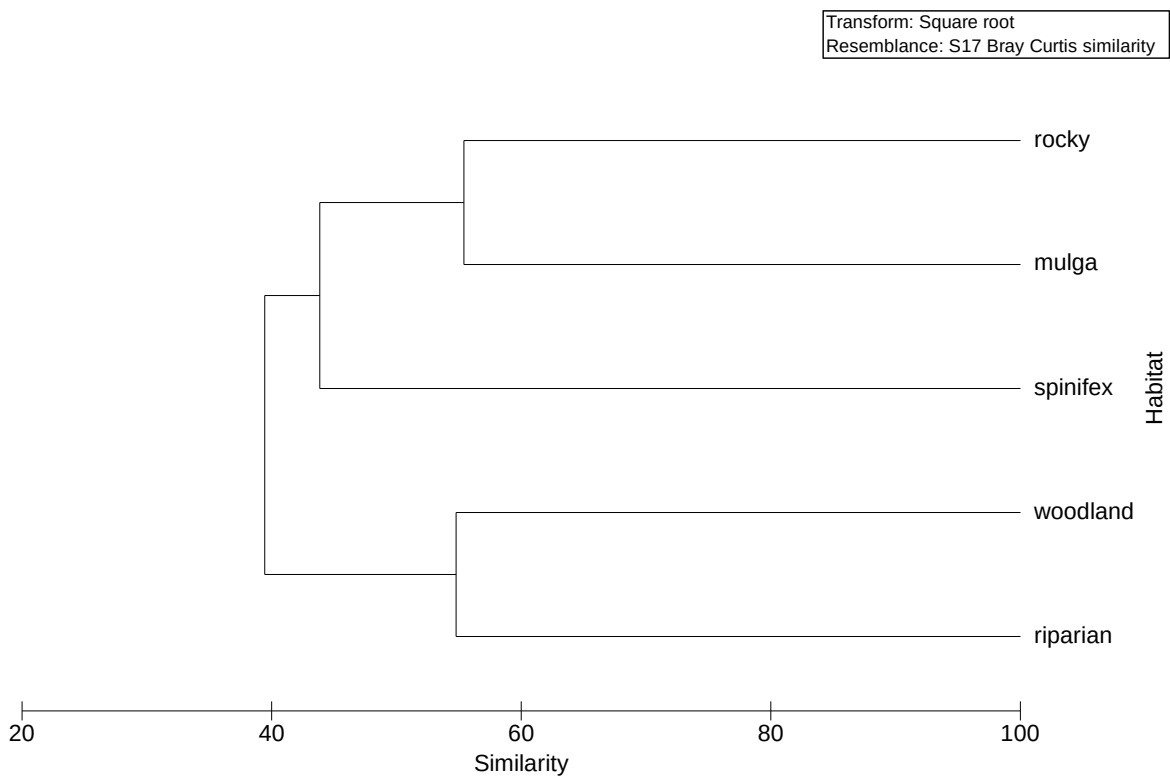


Figure 5-10 Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of all fauna species

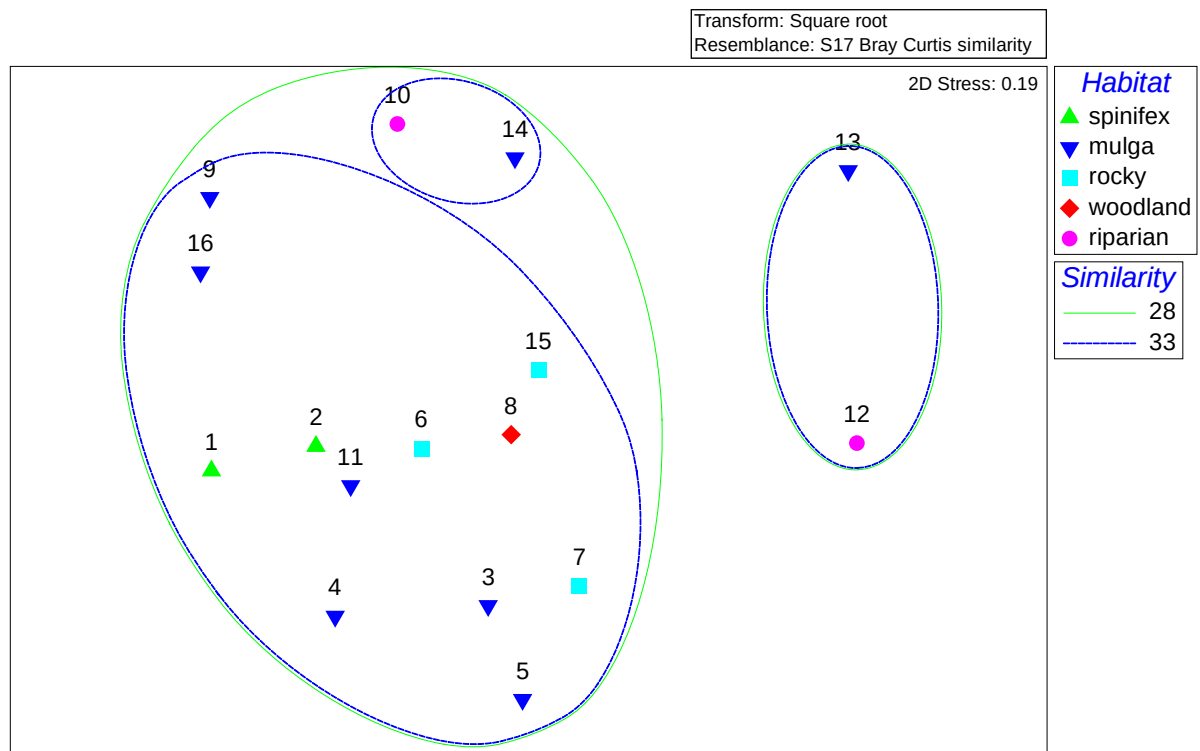


Figure 5-11 Multidimensional scale (MDS) plot for all fauna recorded at the 16 sites, labelled by habitat. Cluster grouping shown for similarity = 28 (and 33 for comparison)

Table 5-8 Statistical results of ANOSIM for pairwise comparisons of fauna results (all fauna) at each habitat type

Pairwise Tests	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
spinifex, riparian	0.750	33.3	3	3	1
spinifex, rocky	0.667	10	10	10	1
rocky, riparian	0.667	10	10	10	1
mulga, riparian	0.323	8.9	45	45	4
spinifex, woodland	0.000	66.7	3	3	2
mulga, rocky	-0.105	69.1	165	165	114
rocky, woodland	-0.111	50	4	4	2
spinifex, mulga	-0.237	84.4	45	45	38
mulga, woodland	-0.455	88.9	9	9	8
woodland, riparian	-1.000	100	3	3	3

Mammals

When all sites are considered, patterns in mammal abundance and distribution show the strongest pattern of any of the analyses. The mammal assemblages at Sites 12 and 13 are entirely different from those at other sites (Figure 5-12 and Figure 5-14). However, this is caused directly by the Anabat failure at those two sites, resulting in fewer mammal species being detected at those sites (i.e., no bats). Removing Sites 12 and 13, the next strongest pattern is that Site 9 differs from the others, and then that Sites 1, 8 and 16 differ from a group of ten sites (Figure 5-15). Assigning habitat categories to these sites shows that there is no clear grouping of sites on the basis of habitat.

The differences among sites are not driven simply by numbers of species, because the sites that group together on the basis of mammal fauna patterns vary in mammal species richness (Figure 5-4). This suggests that the differences found are more likely to be due to subtle differences in the types and/or abundance of mammal fauna that occur at the sites.

When mammal results per habitat were investigated using Cluster analysis (Figure 5-13), there was a reasonably clear pattern showing that the mammal assemblage at mulga sites differed from the assemblages in all other habitats. Again, this is likely to be influenced to some degree by the absence of bat data from Site 13 (mulga). Aside from that, there was evidence of mammal fauna similarity between riparian and Corymbia woodland habitats, and between rocky and spinifex habitats.

ANOSIM results for all 16 sites showed a Global R statistic of -0.044, which suggests there is no statistical pattern or separation in mammal composition between sites/habitats. When Sites 12 and 13 are excluded, ANOSIM results showed an equally low Global R statistic of -0.106. Pairwise statistics for the pairwise habitat comparisons from those analyses are not shown.

These results for mammals suggest that the patterns generally across this landscape are indistinct and weak (i.e., many of the mammal species present in the landscape occur across numerous or all habitat types).

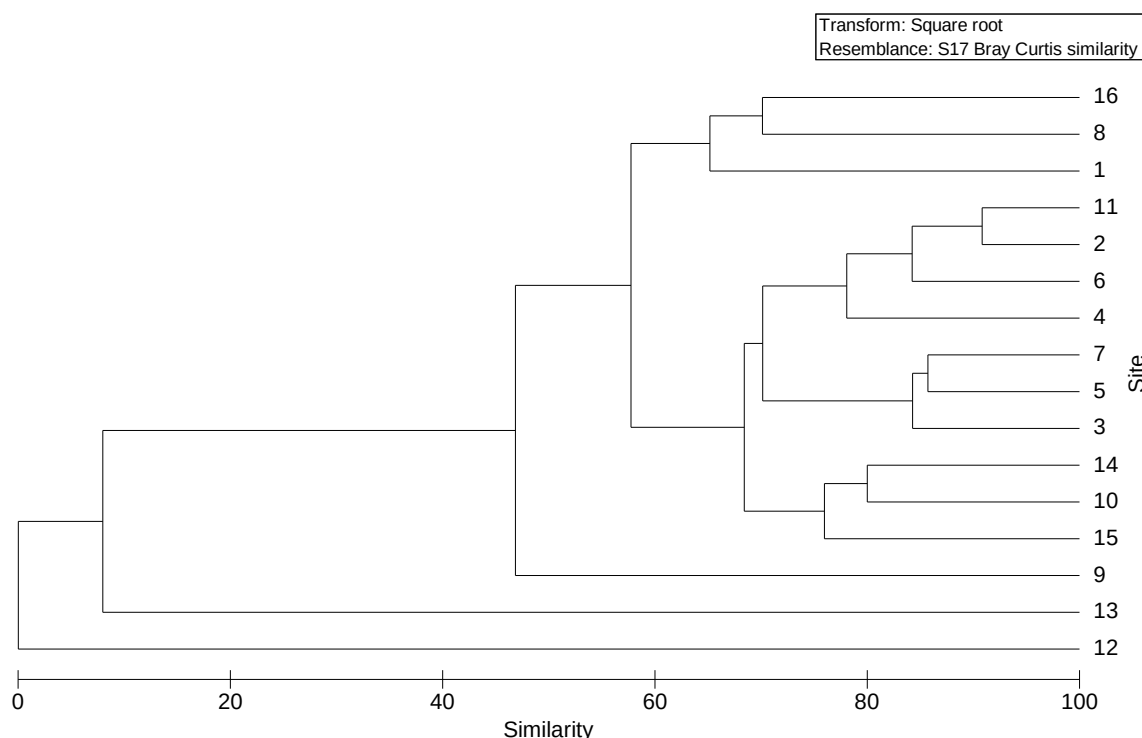


Figure 5-12 Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of mammal species

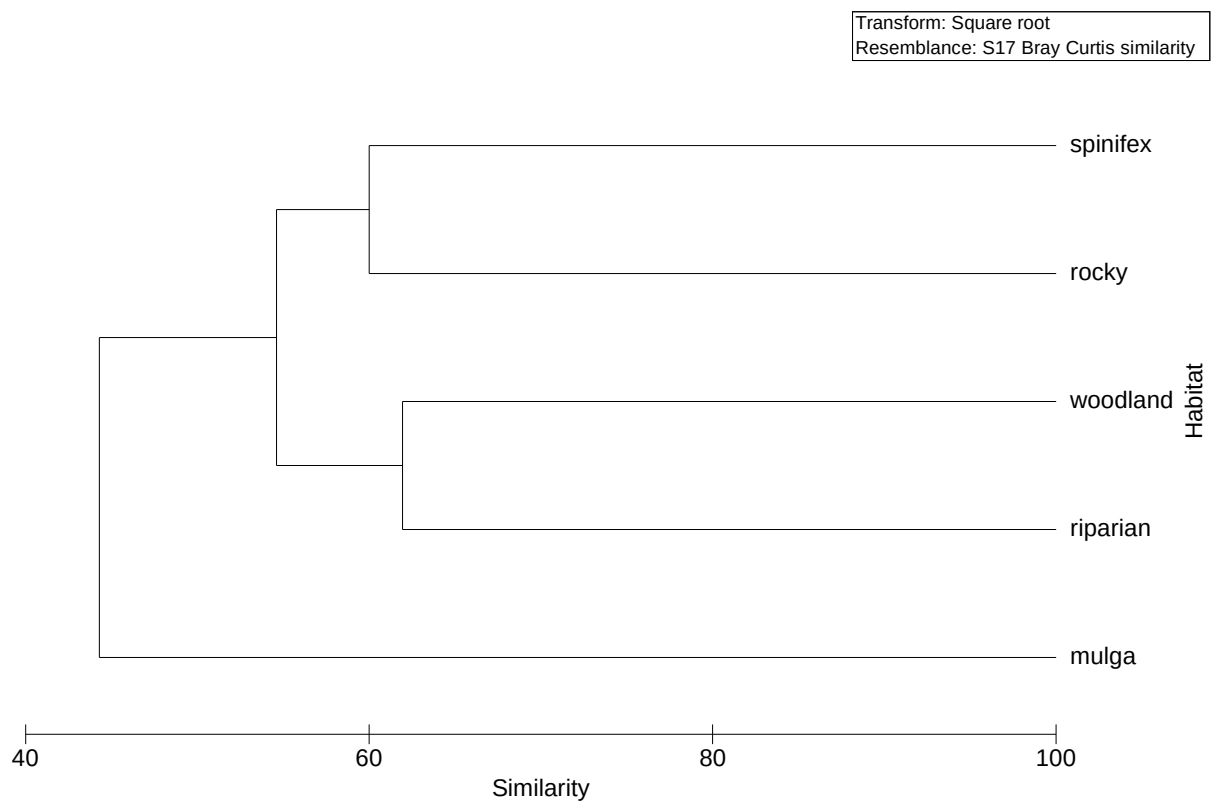


Figure 5-13 Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of mammal species

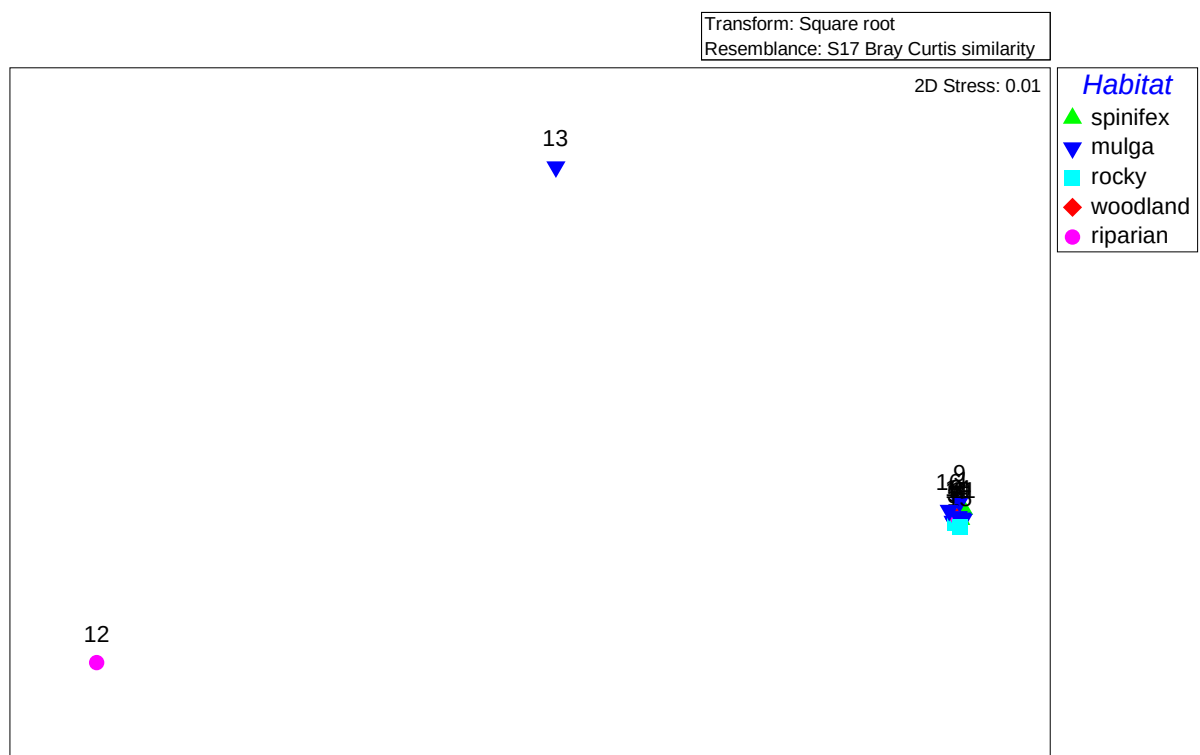


Figure 5-14 Multidimensional scale (MDS) plot for mammal fauna recorded at the 16 sites, labelled by habitat

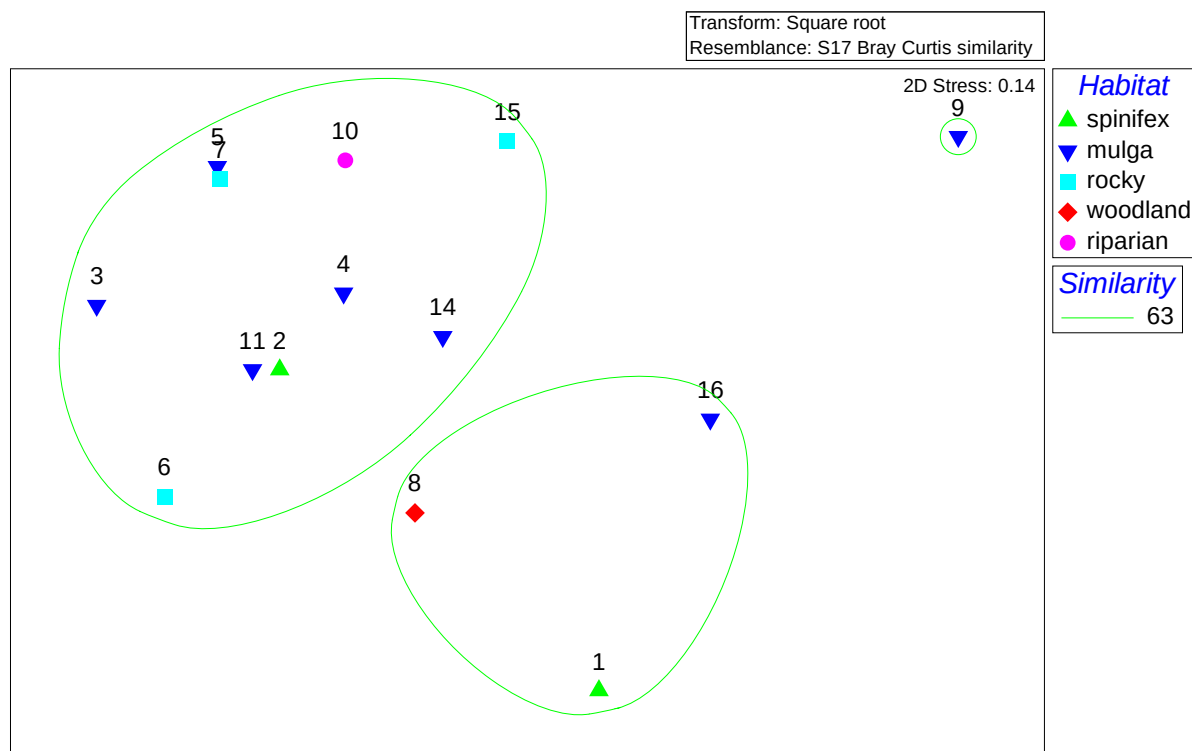


Figure 5-15 Multidimensional scale (MDS) plot for mammal fauna recorded at 14 sites (Site 12 and Site 13 removed), labelled by habitat. Cluster grouping shown for similarity = 63

Birds

Patterns in bird abundance and distribution among sites and habitats show a relatively weak and indistinct pattern (Figure 5-16 and Figure 5-18). Sites 13 and 14 (both mulga sites) differed marginally from all other sites, and Site 10 (riparian) also differed from most other sites. Assigning habitat categories to sites showed that there was no clear grouping of sites on the basis of habitat (Figure 5-18). Sites 13 and 14 had the lowest bird richness of any of the sites, with 5 and 1 species respectively. Site 10 also had relatively low bird richness (7 species).

When bird results per habitat were investigated using Cluster analysis (Figure 5-17), there was a reasonably clear pattern showing similarity between the fauna assemblages in riparian and Corymbia woodland habitats, and between the fauna assemblages in rocky and mulga habitats. The fauna assemblage in the spinifex habitat differed somewhat from other habitat types, but was closer to rocky and mulga habitats than to riparian and Corymbia woodland habitats. This pattern in bird fauna closely resembled the pattern evident for all fauna (Figure 5-10), which is explained by the fact that birds accounted for approximately half (average = 46%) of the fauna species at every site (Figure 5-4).

ANOSIM results showed a Global R statistic of -0.125, which suggests there is no statistical pattern or separation in bird fauna composition between sites/habitats. Pairwise statistics for the pairwise habitat comparisons from the analyses are not shown.

These results for birds suggest that the patterns generally across this landscape are indistinct and weak (i.e. many of the bird species present in the landscape occur across numerous or all habitat types).

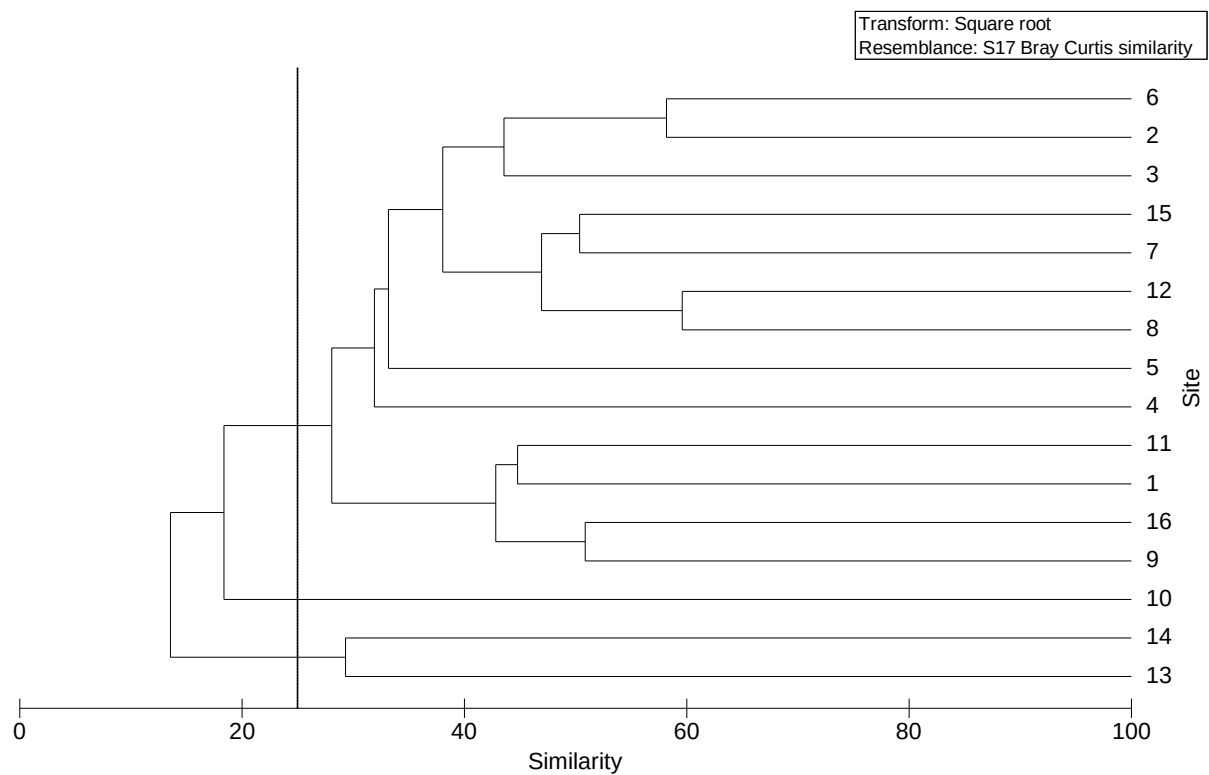


Figure 5-16 Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of bird species (slice line added at similarity = 25)

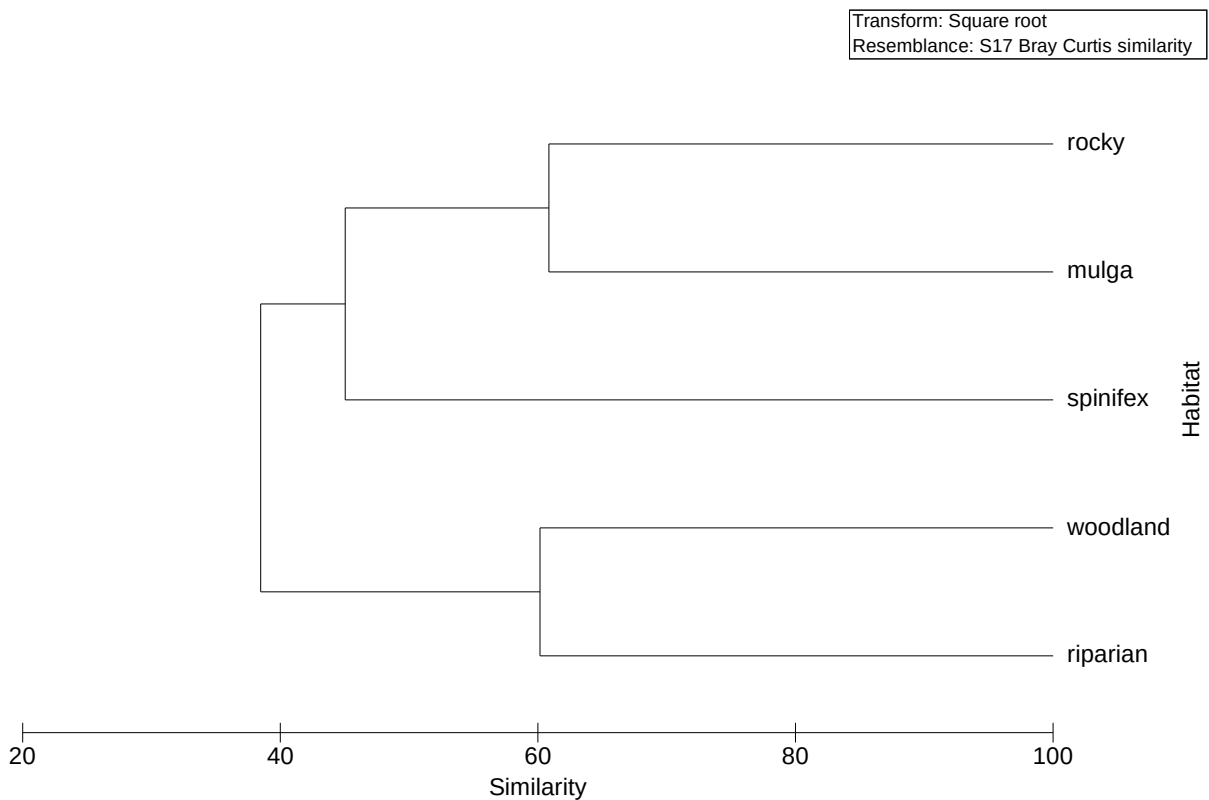


Figure 5-17 Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of bird species

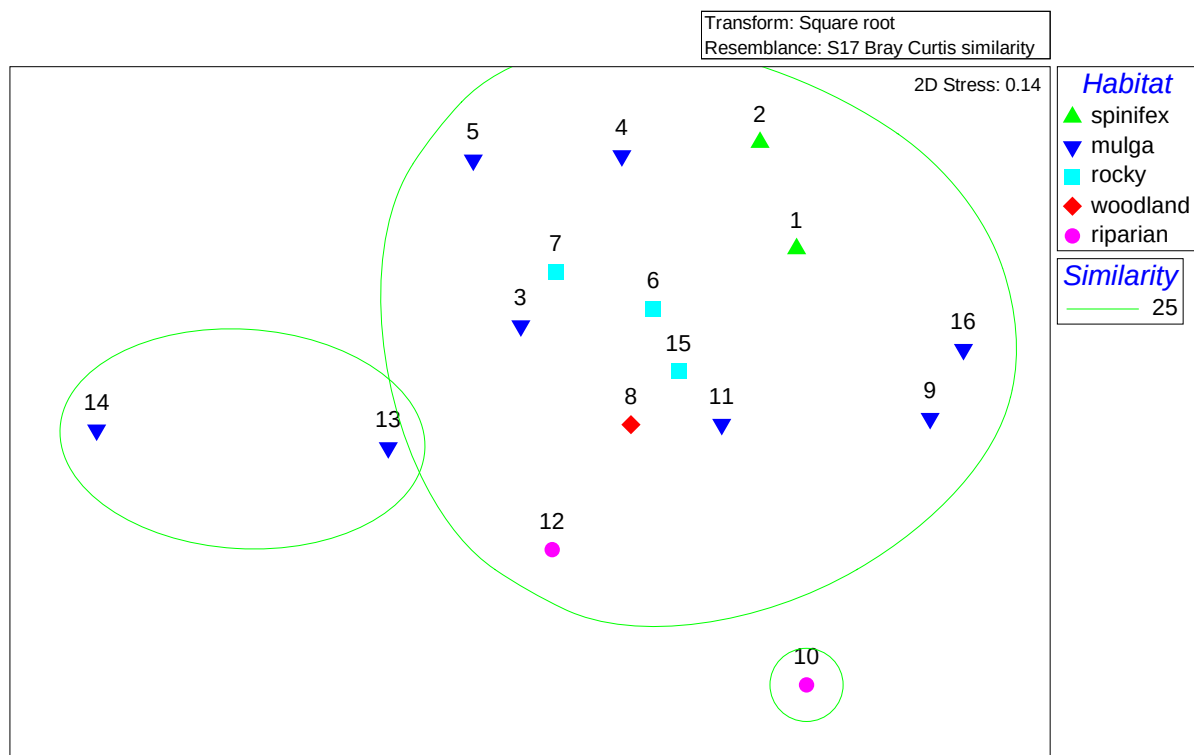


Figure 5-18 Multidimensional scale (MDS) plot for bird fauna recorded at the 16 sites, labelled by habitat. Cluster grouping shown for similarity = 25

Reptiles

Patterns in reptile abundance and distribution among sites and habitats differ from those for other species groups (i.e. mammals, birds, all species). That said, the pattern for reptiles is, as for other groups, relatively weak and indistinct.

Site 14 (mulga) has a reptile fauna assemblage that differs most (but not strongly) from all other sites and the remaining sites tend to separate into three sub-groups that differ to small degrees (Figure 5-19 and Figure 5-21). Assigning habitat categories to sites showed that there was no clear grouping of sites on the basis of habitat (Figure 5-21).

It is not clear what drives the distinction of Site 14. The three reptile species recorded there (Inland Snake-eyed Skink, *Cryptoblepharus australis*; Grey's Menetia, *Menetia greyii*; and Northern Spiny-tailed Gecko, *Strophurus ciliaris*) were not unique to that site nor recorded in extraordinary abundance. Site 14 was, however, the only site to have all those three species recorded.

When reptile results per habitat were investigated using Cluster analysis (Figure 5-20), the pattern showed weak similarity in the reptile assemblages in spinifex and Corymbia woodland habitats, and in the reptile assemblages in rocky and mulga habitats. The reptile assemblage in the riparian habitat differed somewhat from other habitat types, but was closer to rocky and mulga habitats than to spinifex and Corymbia woodland habitats.

ANOSIM results showed a Global R statistic of 0.141, which suggests there is no statistical pattern or separation in reptile fauna composition between sites/habitats. Pairwise statistics for the pairwise habitat comparisons from the analyses are not shown.

These results for reptiles suggest that the patterns generally across this landscape are indistinct and weak (i.e. many of the reptile species present in the landscape occur across numerous or all habitat types).

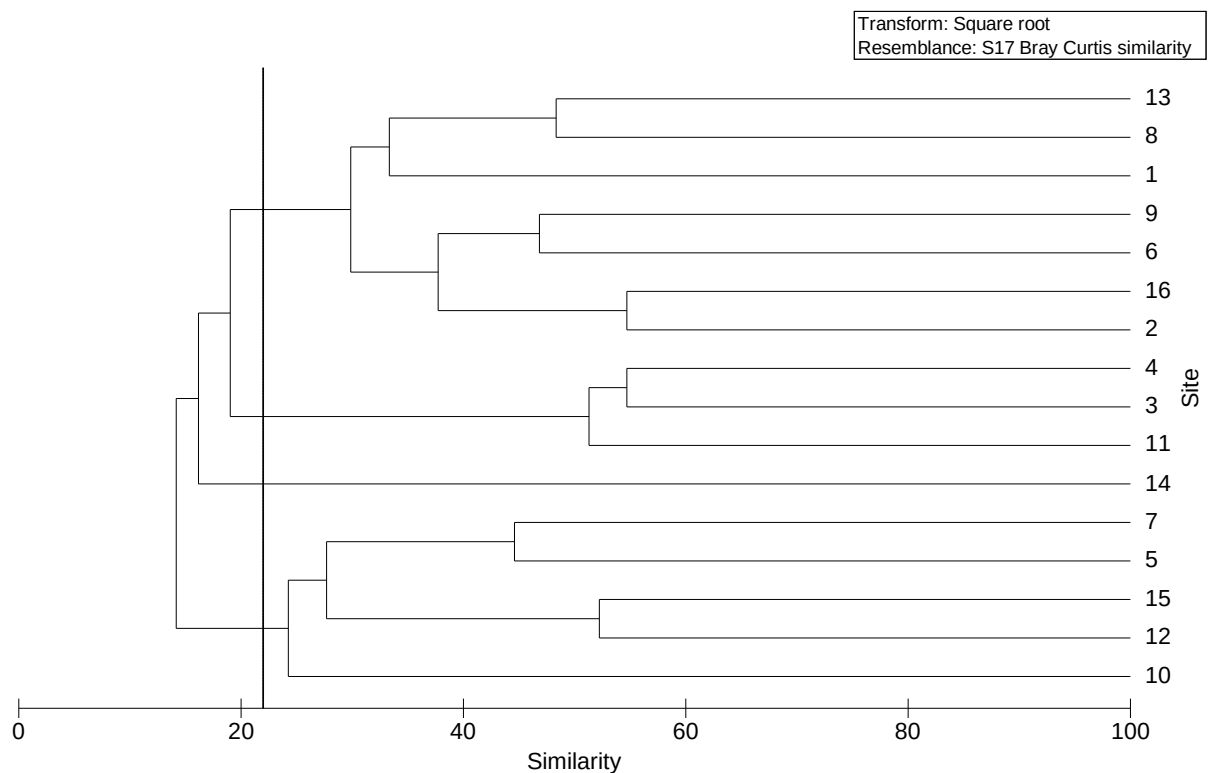


Figure 5-19 Cluster analysis dendrogram showing similarity (group average) among sites on the basis of observations of reptile species (slice line added at similarity = 22)

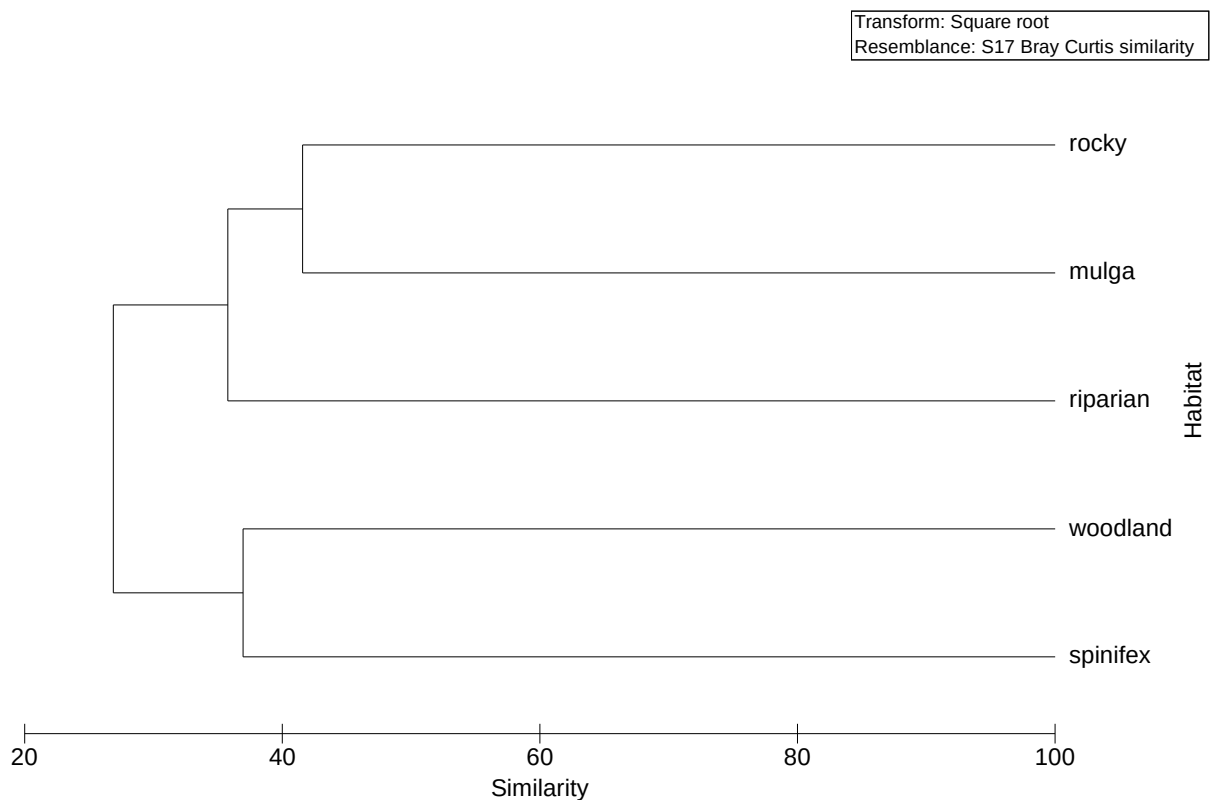


Figure 5-20 Cluster analysis dendrogram showing similarity (group average) among habitats on the basis of observations of reptile species

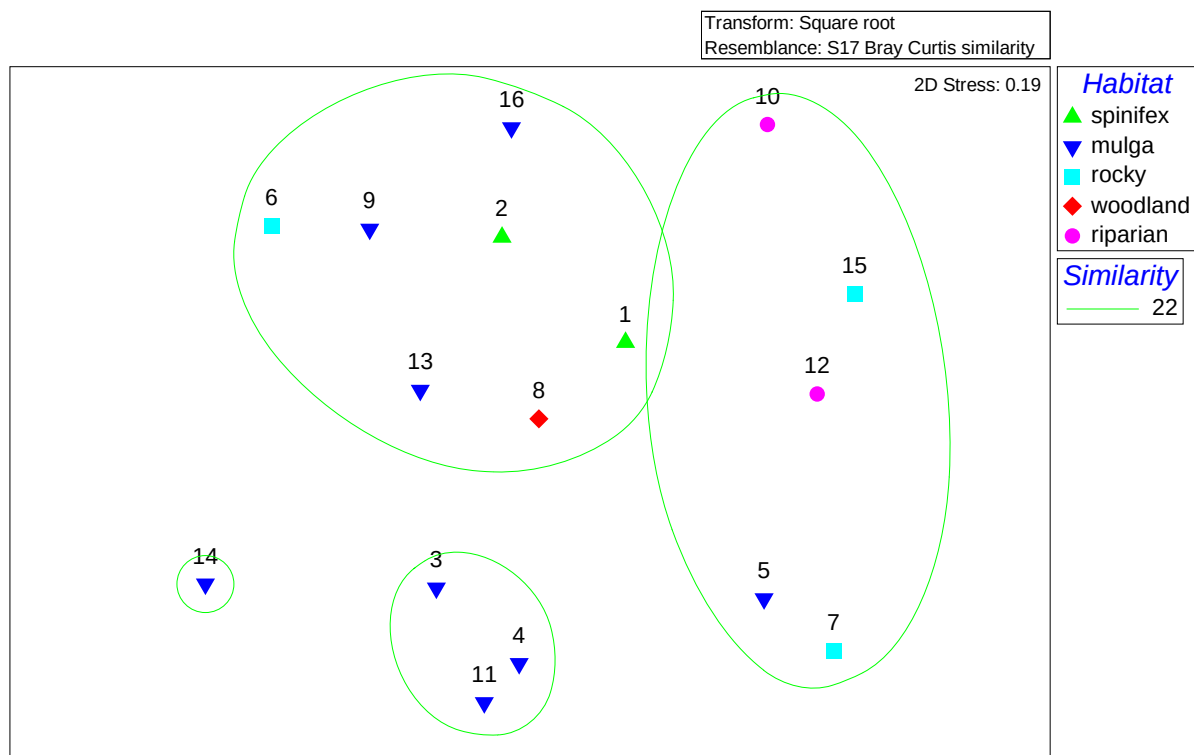


Figure 5-21 Multidimensional scale (MDS) plot for reptile fauna recorded at the 16 sites, labelled by habitat. Cluster grouping shown for similarity = 22

5.5 Threatened and near-threatened species

5.5.1 Threatened species identified for the Project Area

The DLRM Fauna Atlas and the DotE PMST results identified 22 threatened vertebrate fauna species (15 mammals, 6 birds and one reptile) that may or do occur within the Project Area (Table 5-9). Twenty of these are listed under the EPBC Act and all are listed under NT legislation (TPWC Act).

Some of the identified threatened species (all mammals) are considered extinct (EX), extinct in the wild (EW) or regionally extinct (RX) in the Northern Territory. These are: Kowari (*Dasyuroides byrnie*), Western Quoll (*Dasyurus geoffroii*), Red-tailed Phascogale (*Phascogale calura*), Pig-footed Bandicoot (*Chaeropus ecaudatus*), Lesser Bilby (*Macrotis leucura*), Burrowing Bettong (*Bettongia lesueur*), Mala (*Lagorchestes hirsutus*), and Long-tailed Hopping-mouse (*Notomys longicaudatus*). These species are not considered further.

Many of the threatened species either have not been recorded in or near the Project Area for many years, or have not been recorded there at all. These species, if present in the Project Area, are likely to be very rare. Excluding the mulgara, four of the identified threatened species have not been recorded in the area on the DLRM database: Red Goshawk (*Erythrorhynchus radiates*), Australian Painted Snipe (*Rostratula australis*), Princess Parrot (*Polytelis alexandrae*) and Great Desert Skink (*Liopholis kintorei*).

Species that have the potential or are known to occur within the Project Area are discussed in more detail below.

Table 5-9 Threatened fauna species identified for the Project Area (50 km buffer)

Common Name	Scientific Name	EPBC	TPWC	Source	Most recent (DLRM)	Likelihood of occurrence within the study area
MAMMALS						
Brush-tailed Mulgara	<i>Dasycercus blythi</i>	VU	VU	DLRM, GHD?	1901 (2013 GHD?)	Present – occurs in a range of vegetation types, but the principal habitat is mature hummock grasslands of spinifex, especially <i>Triodia basedowii</i> and <i>T. pungens</i> (Masters <i>et al.</i> 2003; DNREA 2006a). At least one active burrow located during baseline survey. Thus, species may occur wherever suitable habitat is present in the study area. Population size known to fluctuate greatly with quality of season.
Crest-tailed Mulgara	<i>Dasycercus cristicauda</i>	VU	VU	PMST	NA	Unlikely – Limited to the Simpson Desert, where its principal habitat is sandy dunes with canegrass (DNREA 2006b).
Kowari	<i>Dasyuroides byrnei</i>	VU	RX	DLRM	1901	Highly unlikely – considered to be regionally extinct in the Northern Territory.
Western Quoll	<i>Dasyurus geoffroii</i>	VU	RX	DLRM	1969	Highly unlikely – considered to be regionally extinct in the Northern Territory.
Red-tailed Phascogale	<i>Phascogale calura</i>	EN	RX	DLRM	1901	Highly unlikely – considered to be regionally extinct in the Northern Territory.
Pig-footed Bandicoot	<i>Chaeropus ecaudatus</i>	EX	EX	DLRM	1901	Highly unlikely – considered to be extinct.
Golden Bandicoot	<i>Isodon auratus</i>	VU	EN	DLRM	1969	Highly unlikely – Historical records near the Project Area; most recently 1969. Species now restricted (in the Northern Territory) to islands off Arnhem Land (Woinarski <i>et al.</i> 2007), and not recorded outside that small area since 1971. The species is considered highly unlikely to still be present in this part of the Northern Territory.
Bilby (= Greater Bilby)	<i>Macrotis lagotis</i>	VU	VU	DLRM, PMST, GHD?	1969 (2013 GHD?)	Possible/Present – Recorded historically within the Project Area, most recently 1969. Diggings/scratchings observed in suitable habitat during the GHD 2013 fauna survey are thought to have been made by a Bilby. Suitable habitat includes a broad range of open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas. The species is considered likely to still be present in this part of the Northern Territory, albeit possibly in small numbers.

Common Name	Scientific Name	EPBC	TPWC	Source	Most recent (DLRM)	Likelihood of occurrence within the study area
Lesser Bilby	<i>Macrotis leucura</i>	EX	EX	DLRM	1901	Highly unlikely – considered to be extinct.
Common Brushtail Possum (Southern N.T.)	<i>Trichosurus vulpecula vulpecula</i>		EN	DLRM	1969	Possible – occupies large hollow-bearing eucalypts in association with riparian habitats and rocky outcrops. Previous records within 10 km of Project Area, but not since 1969. Has the potential to occur along the waterways in the Project Area, particularly Hanson River, Murray Creek and Bloodwood Creek.
Burrowing Bettong	<i>Bettongia lesueur</i>	EX	RX	DLRM	1969	Highly unlikely – considered to be regionally extinct in the Northern Territory.
Mala	<i>Lagorchestes hirsutus</i>	EN	EW	DLRM	1969	Highly unlikely – considered to be extinct in the wild.
Black-footed Rock-wallaby	<i>Petrogale lateralis</i>	VU	NT	DLRM, PMST	2006	Present – occurs mainly in rocky outcrops and associated steep rocky slopes. Most of the area covered by the mine area and proposed access road is not typically suitable habitat, but rocky outcrops scattered throughout the area are likely to be suitable. There are two recent records approximately 7 km east of the proposed camp facilities. Species not detected during the the GHD 2013 fauna survey, but presence in nearby ranges confirmed by GHD ecologist during a helicopter flight for vegetation mapping.
Southern Marsupial Mole	<i>Notoryctes typhlops</i>	EN	VU	DLRM, PMST	1901	Unlikely – Difficult species to detect, so presence may go unnoted. Probably restricted to sandy desert country including dunefields and flats and country with deep loose soils, which typically lie outside Project Area.
Long-tailed Hopping-mouse	<i>Notomys longicaudatus</i>	EX	EX	DLRM	1901	Highly unlikely – considered to be extinct.
BIRDS						
Malleefowl	<i>Leipoa ocellata</i>	VU	CR	DLRM	1930	Highly unlikely – not recorded in the Northern Territory since the early 1960s and the most recent record near the Project Area is 1930.
Red Goshawk	<i>Erythrotriorchis radiatus</i>	VU	VU	PMST	NA	Highly unlikely – inhabits coastal and subcoastal tall, open forests and woodlands, tropical savannas with tree-lined waterways and the edges of rainforests. There are three widely-spaced, recent confirmed sightings in central Australia (DotE 2015). However, no breeding has been recorded in

Common Name	Scientific Name	EPBC	TPWC	Source	Most recent (DLRM)	Likelihood of occurrence within the study area
						central Australia and these records are thought to be of dispersive individuals (Czechura 2005, pers. comm., in DotE 2015). No historical records within 50 km of the Project Area.
Grey Falcon	<i>Falco hypoleucos</i>		VU	DLRM, GHD	1967 (2013 GHD)	Present – broadly distributed across most of the drier parts of Australia, including much if not all of the Northern Territory. Generally scarce. Numerous records near the Project Area, most recently 1967. Observed during the baseline survey by GHD in 2013.
Australian Painted Snipe	<i>Rostratula australis</i>	EN	VU	PMST	NA	Highly unlikely – occupies ephemeral and permanent terrestrial shallow freshwater wetlands, and occasionally brackish wetlands, including modified habitats. No suitable habitat observed during survey, and no historical records within 50 km of the Project Area.
Princess Parrot	<i>Polytelis alexandrae</i>	VU	VU	PMST	NA	Possible – No historical records within 50 km of the Project Area, but nomadic species that is difficult to detect. May occur very occasionally within Project Area in habitats including sand flats and open woodlands and shrublands that usually consist of scattered stands of Eucalyptus, Casuarina or Allocasuarina trees, an understorey of shrubs, and a ground cover dominated by Triodia species.
Night Parrot	<i>Pezoporus occidentalis</i>	EN	CR	DLRM	1930	Possible – Historical records very near the Project Area. Ongoing persistence of this species confirmed in recent years. Given the nature of the habitat used by this species (hummock grassland and chenopod shrubland), and the widespread availability of this habitat across much of arid Australia, including within the Project Area, it is possible that the species uses habitats within the Project Area as an extremely rare and nomadic, transient visitor, in response to suitable conditions.
REPTILES						
Great Desert Skink	<i>Liopholis kintorei</i>	VU	VU	PMST	NA	Possible – No historical records within 50 km of the Project Area, but species occurs within open sandplain within spinifex (<i>Triodia spp.</i>) understorey. If present, likely to be rare.

Brush-tailed Mulgara (*Dasycercus blythi*)

This species occupies spinifex (*Triodia* spp.) grasslands, and burrows in flats between sand dunes. It is generally a solitary species that hunts at night, although it is not strictly nocturnal (Woolley 2008).

There is one old historical record (1901) of a mulgara in the Mount Peake area: Brush-tailed Mulgara (*Dasycercus blythi*). However, two species of mulgara are identified for the Project Area (Brush-tailed Mulgara, *D. blythi*; and Crest-tailed Mulgara, *D. cristicauda*), but it is likely that only one species occurs there, and there is uncertainty in the literature surrounding which species it may be. The Brush-tailed Mulgara and Crest-tailed Mulgara were largely synonymous (as *D. cristicauda*) between the 1960s and early 2000s. The species listed as Vulnerable under the EPBC Act is the Crest-tailed mulgara, *D. cristicauda*, but this listing includes the mulgara species at Mount Peake, because the listing was made prior to publication of the two species' currently accepted identification. It has now been determined that the mulgara species in the Mount Peake area is the Brush-tailed Mulgara (*D. blythi*) (DotE 2014) and the Crest-tailed Mulgara (*D. cristicauda*) is now considered to be restricted to sand-dune habitats in south-eastern Northern Territory, and to have never occurred in the Mount Peake area.

The Brush-tailed Mulgara was not observed, but is considered likely to be present on the basis of a burrow observed during the GHD 2013 fauna survey (Section 5.5.3).

The mulgara's habitat has been adversely affected by the grazing of introduced species (e.g., camels, rabbits, cattle), and changes to the fire regime. It is also possible that predation by introduced feral cats and foxes may threaten this species. Climate change is likely to pose a threat to this species in the future (Woolley 2008).

Black-footed Rock-wallaby MacDonnell Ranges Race (*Petrogale lateralis*)

The species most recently recorded in or near the Project Area is the Black-footed Rock-wallaby *Petrogale lateralis* (2006, NT Database). Northern Territory animals of this species belong to a currently undescribed subspecies, centred in the MacDonnell Ranges (Pavey 2006).

There are two recent records approximately 7 km east of the proposed camp facilities (Figure 4-1). This species is a habitat specialist (rocky ranges and slopes) and is likely to occur in any suitable habitat throughout the area. They feed on grass, but some herbs and some leaves and fruits are eaten. Though occasionally drinking when water is present they can survive extended periods without water. Water requirements are reduced by sheltering during the day in caves and under boulders where relative humidity is higher and air temperatures cooler. They usually emerge in the late afternoon or early evening to feed. Animals may bask in the sun during the early morning following a cold night (Pavey 2006).

Most of the area covered by the mine area and access road is not typically suitable habitat for rock-wallabies, but there are rocky outcrops scattered throughout the area that are likely to be suitable. Individuals are likely to move between patches of suitable habitat also.

While this species was not detected during the the GHD 2013 fauna survey, presence of the species in nearby ranges was confirmed by a GHD botanist during a helicopter flight for vegetation mapping.

Major threats faced by isolated rock-wallaby populations include predation by introduced (red fox, feral cat) and native (wedge-tailed eagle) predators, and habitat degradation caused by grazing by introduced herbivores (Pavey 2006).

Southern Marsupial Mole (*Notoryctes typhlops*)

The Southern Marsupial Mole (*Notoryctes typhlops*) is distributed across much of Australia's sandy desert country in Western Australia, Northern Territory and South Australia. The species inhabits desert country, most often recorded on sand dunes with various acacias and other shrubs, sometimes in association with spinifex (Benshemesh 2004). They can occur in sandy plains and possibly river flats, especially where aeolian dunes occur. Most locations are those with deep loose soil (Benshemesh 2004). It is a subterranean species and is likely to be extremely difficult to detect. The most efficient method of surveying marsupial moles is to count the number of tunnels underground (Benshemesh 2004).

Its likelihood of presence in the Project Area is unknown.

Predation by feral cats, red foxes and dingoes, and soil compaction by stock movements or by vehicles, may be potential threats to the long-term survival of the species. Other threats such as altered fire regimes and grazing may change the abundance of ants, insect larvae and termites (Benshemesh 2004), which form the bulk of the food source.

Common Brushtail Possum (Southern N.T.) (*Trichosurus vulpecula vulpecula*)

The Common Brushtail Possum (Southern N.T.) (*Trichosurus vulpecula vulpecula*) occurs in isolated populations in the southern NT. It commonly occupies riverine habitat that is close to rocky outcrops and moist gullies within the ranges or rocky slopes (Kerle *et al.* 1992). A range of sites is used by the possum as shelter, including caves and rock holes, tree hollows and the tops of dense trees. Its diet consists of the flowers, fruits and leaves of a wide range of non-eucalypt species (Evans 1986).

The Common Brushtail Possum has the potential to occur in the Project Area and is most likely along the waterways, where large River Red-gums provide hollows for dens. The Brushtail Possum has not been recorded in this area since 1969.

The decline of the species in central Australia has been attributed to the interaction between severe drought and threatening processes such as grazing by introduced herbivores (cattle and rabbits), increased hunting around Aboriginal settlements and (historically) for the commercial fur trade, altered fire regimes, and predation (Kerle *et al.* 1992; Woinarski 2004).

Golden Bandicoot (*Isoodon auratus*)

The Golden Bandicoot (*Isoodon auratus*) was once widespread across the Northern Territory, but its populations declined dramatically following European settlement and the species is now restricted (in the Northern Territory; it occurs in Western Australia also) to islands off the north-eastern part of Arnhem Land (Woinarski *et al.* 2007). According to official information on the DLRM website, it has not been recorded outside that small area since 1971. The last specimen of this species from the desert country of mainland Northern Territory was reportedly from the northwest Tanami in 1952. There are historical records near the Project Area (e.g. along the Stuart Highway, approx. 25 km north of the proposed access road), and the most recent of these is reportedly 1969. The species is considered highly unlikely to still be present in this part of the Northern Territory.

Most information on the ecology of the golden bandicoot is from a single short-term study on Marchinbar Island (Southgate *et al.* 1996). There it occurs mainly in heathland and shrubland on sandstone or sandsheets, and avoids vegetation with greater tree cover.

The most likely threat to the species is predation by feral cats, rather than land-use factors.

Bilby/Greater Bilby (*Macrotis lagotis*)

Like the Golden Bandicoot, the Bilby (*Macrotis lagotis*) was also once widespread across the Northern Territory, but its populations have declined dramatically following European settlement. In the Northern Territory, the Bilby is now generally reported regularly from the western deserts region (through to Western Australia north to the Pilbara and Kimberley regions), although other sightings occur occasionally. There are historical records within the Project Area (e.g. i) immediately east of fauna Site 16; ii) approx. 10 km north of the proposed mining area; and iii) along the Stuart Highway approx. 25 km north of the proposed access road), and the most recent of these is reportedly 1969.

The species occupies three major vegetation types, open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas (Southgate 1990b).

Diggings/scratchings, thought to have been made by a Bilby, were detected in recently burnt spinifex/acacia grassland during the GHD 2013 fauna survey (Section 5.5.3). The species is considered likely to still be present in this part of the Northern Territory, albeit possibly in small numbers.

Fox predation was the primary factor associated with regional declines of the species (Abbott 2001), although feral cats have been known to prey on bilbies, too. Clearing of habitat for grazing and as a result of fire are also potential threats (Southgate 1990a).

Malleefowl (*Leipoa ocellata*)

The distribution of the Malleefowl (*Leipoa ocellata*) was formerly more extensive, extending over a large proportion of mainland southern Australia, including the south-western region of the Northern Territory (Benshemesh 2000). The distribution has contracted substantially in all states in which the species occurs (Benshemesh 2000) but, for the most part, these changes appear to have had a much greater impact on the area of occupancy than the extent of occurrence. The Malleefowl has not been recorded in the Northern Territory since the early 1960s (DLRM threatened species information sheet, 2014). The most recent record in the vicinity of the Project Area is from 1930. The species is considered highly unlikely to be present in this part of the Northern Territory.

Grey Falcon (*Falco hypoleucos*)

The Grey Falcon (*Falco hypoleucos*) occurs in most of the drier parts of Australia, including much if not all of the Northern Territory. Its distribution is centred on inland drainage systems where there is an average annual rainfall of less than 500 mm. Its main habitat is timbered lowland plains, particularly acacia shrublands that are crossed by tree-lined watercourses. It is generally scarce wherever it is found.

The Grey Falcon hunts far out into tussock grassland and open woodland. It nests in old nests made by other birds, usually nests in the tallest trees along watercourses, particularly River Red Gum *Eucalyptus camaldulensis* (Higgins 1993).

The main prey of the Grey Falcon is granivorous parrots and pigeons, and mammals. It also occasionally feeds on carrion, including dead lambs (Higgins 1993).

There are numerous records of this species in the vicinity of the Project Area, most recently in 1967 (but the age of that date is likely to reflect absence of dedicated surveys). This species was detected during the GHD 2013 fauna survey (Section 5.5.3).

Threats to the Grey Falcon include overgrazing and habitat clearance.

Red Goshawk (*Erythroriorchis radiatus*)

The Red Goshawk (*Erythroriorchis radiatus*) is endemic to Australia and is dispersed across coastal and sub-coastal areas from western Kimberley (WA) to northeastern NSW. The Red Goshawk inhabits coastal and subcoastal tall, open forests and woodlands, tropical savannas with tree-lined waterways and the edges of rainforests. It is well known to occur in the northern part of the NT, and there are three widely-spaced, recent confirmed sightings in central Australia (DotE 2015). However, no breeding has been recorded in central Australia and these records are thought to be of dispersive individuals (Czechura 2005, pers. comm., in DotE 2015). This species is generally scarce wherever it is found.

There are no historical records of this species within 50 km of the Project Area, and the species was not detected within the Project area during the GHD 2013 fauna survey. The species is considered highly unlikely to be present in the Project Area.

Night Parrot (*Pezoporus occidentalis*)

The distribution of the Night Parrot (*Pezoporus occidentalis*) is very poorly understood, owing to the scarcity of confirmed records (i.e. there are only 24 or so specimens in museum collections). Little is known also of the biology of the species. It is thought to be restricted to remote parts of the arid zone where there is dense, low vegetation, such as areas with *Triodia* (spinifex). It hides in the vegetation during the day and becomes active at night. Like a quail, the parrot spends most of its time on the ground, running between shelter when possible or making short, low flights, quickly diving back into the vegetation.

The majority of confirmed records were obtained during the late 19th century (Higgins 1999). Until recently, persistence of the Night Parrot anywhere in Australia was uncertain; records surfaced occasionally (e.g. Boulia, Qld, in 1990; Pilbara, WA, in 2005), but typically with some degree of uncertainty. In 2006, a dead bird was found in south-western Qld, and then in May 2013, live birds were photographed in the wild (location undisclosed, but probably in south-western Queensland) for the first time, providing proof of the species' persistence.

There are a handful of records of the Night Parrot in the vicinity of the Project Area, the closest being along the Stuart Highway approx. 25 km north of the proposed access road. The most recent record identified in the DLRM database is from 1930.

Given the nature of the habitat used by this species (hummock grassland and chenopod shrubland), and the widespread availability of this habitat across much of arid Australia, including within the Project Area, it is possible that the species uses habitats within the Project Area as an extremely rare and nomadic, transient visitor, in response to suitable conditions.

Princess Parrot (*Polytelis alexandrae*)

The Princess Parrot (*Polytelis alexandrae*) is confined to arid regions of Western Australia, the Northern Territory, and South Australia (Higgins 1999). It inhabits sand dunes and sand flats across the arid zone of Australia, occurring mainly in open savanna woodlands and shrublands that usually consist of scattered stands of *Eucalyptus*, *Casuarina* or *Allocasuarina* trees, an understorey of shrubs, and a ground cover dominated by *Triodia* species (Allen 1987; Baxter and Henderson 2000; Ford and Sedgwick 1967; Forshaw and Cooper 2002; Garnett 1993; Johnstone and Storr 1998; Parker 1971; Pianka and Pianka 1970).

The DLRM database contains no historical records of this species within 50 km of the Project Area. However, it is a highly nomadic species that is difficult to detect. Therefore, it may occur very occasionally within the Project Area in suitable habitats.

Threats to the species may include habitat degradation and reduced availability of food, the introduction of new and unsuitable fire regimes, and introduction of grazing animals such as sheep, rabbits and camels.

Great desert skink (*Liopholis kintorei*)

The Great desert skink (*Liopholis kintorei*) occupies a range of vegetation types, with its main habitat being sandplain and adjacent swales. Vegetation usually consists of hummock grassland (*Triodia basedowii*, *T. pungens* and *T. schinzii*), with some scattered shrubs and occasional trees (e.g. *Acacia* spp., *Eucalyptus* spp., *Hakea* spp., *Grevillea* spp. and *Allocasuarina decaisneana*) (Cogger *et al.* 1993; McAlpin 2001).

The DLRM database has no historical records of this species within 50 km of the Project Area, but there is suitable habitat within the Project Area. The species is likely to be rare, if present.

Threats to the species include intense large-scale fires, predation by foxes and cats, and rabbits digging up burrow systems.

5.5.2 Near-threatened and data deficient species identified for the Project Area

In addition to the identified threatened species, eleven others are listed as near-threatened (NT) or data deficient (DD) under the TPWC Act (Table 5-10). Near-threatened species are those that do not currently qualify for higher categories of threat (CR, EN, VU), but that are close to qualifying and may qualify in the near future. Data-deficient species are those for which there is currently inadequate information to make an assessment of extinction risk (DD is therefore not a category of threat).

The NT and DD species identified are shown in Table 5-10. None of these is listed as threatened under the EPBC Act. Four of these species were detected by GHD during the survey in April 2013.

The three mammals (Kultarr *Antechinomys laniger*, Spectacled Hare-wallaby *Lagorchestes conspicillatus* and Northern Nailtail Wallaby *Onychogalea unguifera*) have the potential to occur in the Project Area. These species could occur anywhere in open woodland or shrubland, which includes most of the Project Area. The Nailtail Wallaby has not been recorded in the area since 1969, while the other two species have been recorded more recently.

The four birds (Bush Stone-curlew *Burhinus grallarius*, Yellow-rumped Mannikin *Lonchura flaviprymna*, Emu *Dromaius novaehollandiae*, and Australian Bustard *Ardeotis australis*) are either known to occur or have the potential to occur within the Project Area. The Bush Stone-curlew is likely to occur within the Project Area, and was recorded relatively recently in the DLRM database (2001). The Yellow-rumped Mannikin is restricted to more northerly parts of the NT, and is unlikely to occur in the Project Area as anything more than a vagrant.

Both of the other two were recorded during the baseline fauna survey by GHD in April 2013.

The Australian bustard is widespread, although generally scarce in the Northern Territory. It is more common in the north of Australia, occurring in loose aggregations, particularly during the breeding season when they exhibit a unique 'exploded' lek mating system, where the males occupy display arenas that females visit for mating purposes. The species' strongholds in the Northern Territory include the Barkly Tableland, Daly River region, the Victoria River District and the Tanami Desert. The Australian bustard typically occurs in open habitats, preferring grasslands, low shrublands, grassy woodlands and other structurally similar but artificial habitats such as croplands and airfields. This species responds favourably to fire and is often located in recently burnt habitats, including woodlands.

Threats to the Australian bustard include impacts such as fluctuations in rainfall, altered fire regimes, predation by exotic species, habitat alteration, pesticides, grazing and hunting pressure (e.g. traditional hunting with access to modern weapons on a species with a low reproductive rate).

The Emu is extremely widespread across continental Australia. It occurs across most of the Northern Territory but is scarce in the driest desert regions (Marchant and Higgins 1990). Emus can move large distances in response to a decline in food or water resources. They are probably less sedentary in the south of the Northern Territory than in the north. Threats to the Emu are thought to be primarily associated with changing fire regimes (i.e. the occurrence of too frequent and extensive fires).

Both reptiles (Woma Python *Aspidites ramsayi* and King Brown Snake *Pseudechis australis*) were detected during the baseline fauna survey by GHD in April 2013, and are likely to be widespread but sparse across the region.

The two frogs (Ornate Burrowing Frog *Platyplectrum ornatus* and Giant Frog *Litoria australis*) are generally very common in areas where they occur. However, both species tend to be restricted to more northerly parts of the NT, although their true distribution remains uncertain. Both species are burrowing frogs, and in arid areas, they are highly seasonal in their activity, so only recorded if conditions and season are suitable. Neither species was recorded during the baseline fauna survey by GHD in April 2013. The Giant Frog may occur within the Project Area, but the Ornate Burrowing Frog is likely to be replaced in this part of the NT by a closely-related species, Spencer's Burrowing Frog (*Platyplectrum spenceri*).

Table 5-10 Near-threatened and Data Deficient fauna species identified for the Project Area

Common Name	Scientific Name	TPWC	Source	Most recent (DLRM)	Likelihood of occurrence within the study area
MAMMALS					
Kultarr	<i>Antechinomys laniger</i>	NT	DLRM	2001	Possible – could occur anywhere in open woodland or shrubland, which includes most of the Project Area. Recorded in the area relatively recently (2001), but not detected during GHD survey.
Spectacled Hare-wallaby	<i>Lagorchestes conspicillatus</i>	NT	DLRM	1995	Possible – could occur anywhere in open woodland or shrubland, which includes most of the Project Area. Recorded in the area relatively recently (1995), but not detected during GHD survey.
Northern Nailtail Wallaby	<i>Onychogalea unguifera</i>	NT	DLRM	1969	Unlikely – could occur anywhere in open woodland or shrubland, which includes most of the Project Area, but not recorded in the area for more than 40 years.
BIRDS					
Emu	<i>Dromaius novaehollandiae</i>	NT	DLRM, GHD	2006 (2013 GHD)	Present – Characteristic feathers found during GHD survey. Wide ranging and nomadic species that is likely to occur within most habitats of the Project Area.
Australian Bustard	<i>Ardeotis australis</i>	NT	DLRM, GHD	2001 (2013 GHD)	Present – observed during GHD survey. Occupies a wide range of habitats, but prefers grasslands, low shrublands, and open grassy woodlands. Likely to occur at least occasionally within most habitats of the Project Area.
Bush Stone-curlew	<i>Burhinus grallarius</i>	NT	DLRM	2001	Possible – Not recorded during GHD survey, but suitable habitat occurs across much of the Project Area. Species likely to occur within the Project Area.
Yellow-rumped Mannikin	<i>Lonchura flaviprymna</i>	NT	DLRM	1901	Unlikely – restricted to more northerly parts of the Northern Territory. Unlikely to occur in the Project Area as anything more than a vagrant.
REPTILES					
Woma Python	<i>Aspidites ramsayi</i>	NT	DLRM, GHD	2009 (2013 GHD)	Present – observed during baseline GHD survey in April 2013. Likely to be widespread but sparse across the entire Project Area.

Common Name	Scientific Name	TPWC	Source	Most recent (DLRM)	Likelihood of occurrence within the study area
King Brown Snake	<i>Pseudechis australis</i>	NT	DLRM, GHD	1986 (2013 GHD)	Present – observed during baseline GHD survey in April 2013. Likely to be widespread but sparse across the entire Project Area.
AMPHIBIANS					
Ornate Burrowing Frog	<i>Platyplectrum ornatus</i>	DD	DLRM	1978	Unlikely – tends to be restricted to more northerly parts of the Northern Territory, and likely to be replaced in this region by closely-related species, Spencer's Burrowing Frog (<i>Platyplectrum spenceri</i>) (not listed as threatened or near threatened).
Giant Frog	<i>Litoria australis</i>	DD	DLRM	2009	Possible – tends to be restricted to more northerly parts of the Northern Territory, but true distribution remains uncertain. Highly seasonal in its activity, so only recorded if conditions and season are suitable (warm and wet).

Key to Tables:

EPBC Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

TPWC = *Territory Parks and Wildlife Conservation Act 2006*;

DLRM The Department of Land Resource Management (DLRM) fauna records (not predictions) database

PMST Information sourced from the EPBC Protected Matters Search Tool

GHD = detected during fauna survey.

VU = Vulnerable; EN = Endangered; CR = Critically Endangered; EX = Extinct; EW = Extinct in the wild; RX = Regionally Extinct; NT = Near Threatened; DD = Data Deficient.

Likelihood of occurrence of fauna is assessed on a 4-tier scale:

- 1: **Present** – observed during baseline survey;
- 2: **Possible** - suitable habitat occurs within the study area, and site is within species' normal range;
- 3: **Unlikely** - suitable habitat does not occur within the study area, or suitable habitat present but substantially modified or degraded. Species not recorded for over 30 years;
- 4: **Highly unlikely** – no suitable habitat within the study area and site is outside species' normal range.

5.5.3 Threatened species observations during the fauna survey

Seven threatened species were detected or potentially detected during the baseline fauna survey in April 2013. These include five species (three birds and two reptiles) that were confirmed as present (i.e. observed) and two species (both mammals) that were not observed, but were considered likely to be present on the basis of indirect signs observed (burrows, diggings and scratchings). The seven species are discussed below.

Brush-tailed mulgara (Dasycercus blythi)

An active burrow observed at Site 16 had the right size and shape characteristics to be that of a Brush-tailed mulgara (*Dasycercus blythi*) (Figure 5-22). A motion-detecting surveillance camera was set up to monitor fauna activity at this burrow over the course of five days. No mulgara was photographed during that time. Elliot traps and cage near to the burrow also failed to capture this species.

Our confidence in the identification of the mulgara burrow was relatively high – the burrow was fresh and active, and showed the characteristic signs (e.g. 'ramp' at burrow entrance) of a burrow of this species (as experienced by GHD zoologists in the Pilbara region in Western Australia, where live animals have been captured). Failure to detect a live animal at the burrow thereafter (remote sensing camera) may be explained by the species' known sensitivity to disturbance, and the likelihood that mulgaras have numerous burrow entrances that would be used preferentially in response to disturbance.

The Brush-tailed Mulgara is considered to be present within the Project Area.

Figure 5-22 Active burrow (Mulgara) at site 16, as monitored by the motion-detecting camera (Camera 1; M2)



Bilby (Macrotis lagotis)

During incidental daytime searches outside the 16 formal fauna sampling sites, soil diggings and scratchings were observed in a relatively localised area adjacent to the existing north-south gas pipeline, approximately 6 km north of the access road) (Figure 4-1). According to one of GHD's team members who has extensive prior experience working with bilbies in fenced, predator-free enclosures, these diggings had the characteristics of those made by a Bilby (*Macrotis lagotis*) (J. Kuiper, GHD Ecologist; pers. comm.; Formerly with Australian Wildlife Conservancy)(also Triggs 2004 and Moseby *et al.* 2011). This determination was made on the following basis:

- Some scratchings appeared to be targeting shallow roots, and were scattered in patches around grasses and low vegetation with overburden/spoil evenly (randomly) distributed around the digging
- Some scratchings appeared to be targeting termites, and were linear in places indicating that the animal was scratching along a sub-soil termite tunnel (still with the spoil in random directions around the digging)
- Scratchings had a 'sharp' edge to the scrape. Rabbits have a softer edge due to the fur of the rabbit covering over the claw. Bilbies have little or no fur over their claws
- Some scratchings had two or three obvious claws marks
- The weather conditions at the time (dry with some wind) could have deteriorated any tracks/prints. The distinctive 'pig foot' toe mark (like a "V" shape) of the Bilby is the key difference between Rabbit and Bilby prints, as the two species have a similar gait pattern, but are often undetectable in soft, dry, sandy soils
- This observation was made at a location that is within 10 km of numerous historical Bilby records (DLRM database), and within the same habitat type, according to vegetation community (Acacia tall sparse shrubland/Acacia sparse shrubland + Triodia [spinifex sp.] low open hummock grassland) (Figure 4-1).

Following the discovery of the diggings, this area was extensively searched at night for two nights using strong headtorches. No Bilbies were seen.

Given that the Acacia/spinifex habitat type is known to be suitable for the Bilby (there are numerous historical records), and that this habitat type is widespread across the Project Area, particularly along the access road (Figure 4-1), the conclusion is made that the Bilby is likely to occur within the Project Area. It is likely to be relatively sparse, however, given that it is rarely recorded.

Grey Falcon (*Falco hypoleucos*)

The Grey Falcon was observed fleetingly during the baseline fauna survey by GHD in April 2013. At a cattle watering dam at a track intersection 1.2 km west of Site 7, one bird flew over two observers on the morning of 13 April in good light. The bird flew on a swift and direct course and was not seen to alight or return, so follow up observations were not made.

The Grey Falcon is widespread across inland Australia, but generally sparse and rare. Its habitat tends to be tree-scattered plains and desert watercourses (Higgins 1993, Slater et al 2003), which matches habitats that occur within the Project Area.

Emu (*Dromaius novaehollandiae*)

Feathers of an Emu (*Dromaius novaehollandiae*) were observed in a barbed-wire fence at Site 15, although no birds were observed there or at any other site. Emus are likely to be sparse across the entire Project Area.

Australian bustard (*Ardeotis australis*)

The Australian bustard (*Ardeotis australis*) was recorded on four occasions during the survey. A total of 11 birds was recorded, although it is possible or even likely that the same individuals were seen on multiple occasions, since observations tended to occur within the same general location (approximately 3 km north-west of Site 9) on successive days. The Australian bustard is likely to occur in small groups across the entire Project Area.

Woma Python (*Aspidites ramsayi*)

One Woma Python (*Aspidites ramsayi*) was detected within the Project Area during the fauna survey in April 2013. This location is approximately 6.8 km south-west of Site 16.

The Woma Python occupies a broad variety of arid habitats and is likely to be widespread but sparse across the Project Area.

King Brown Snake (*Pseudechis australis*)

Two King Brown Snakes (*Pseudechis australis*) were detected within the Project Area during the fauna survey in April 2013. Both were observed on the road while driving between sites, rather than being captured in traps. One large individual was detected very near Site 9, and another smaller individual was seen east of Site 2.

The King Brown Snake occupies a broad variety of arid habitats and is likely to be widespread across the Project Area.

5.6 Migratory species

Seven species (all birds) predicted or known to occur within the Project Area are listed as Migratory under the EPBC Act (Table 5-11). Of these, the Rainbow Bee-eater (*Merops ornatus*) is the only one that is known to occur historically (NT DLRM Database), and this species was detected during the baseline fauna survey by GHD in April 2013.

Each of these Migratory species occupies a very broad area that includes much if not all of the Australian mainland, and none is linked strongly to habitats in the Project Area that are likely to be impacted by the project.

Table 5-11 EPBC Act-listed Migratory fauna species identified for the Project Area (50 km buffer)

Common Name	Scientific Name	Migratory	Source
Fork-tailed Swift	<i>Apus pacificus</i>	Mi	PMST
Great Egret	<i>Ardea alba</i>	Mi	PMST
Cattle Egret	<i>Ardea ibis</i>	Mi	PMST
Oriental Plover	<i>Charadrius veredus</i>	Mi	PMST
Australian Painted Snipe	<i>Rostratula australis</i>	Mi	PMST
Oriental Pratincole	<i>Glareola maldivarum</i>	Mi	PMST
Rainbow Bee-eater	<i>Merops ornatus</i>	Mi	DLRM, PMST, GHD

5.7 Feral / pest animals

Twelve non-native fauna species are identified for the Project Area (Table 5-12). Ten of these are mammals, one is a bird and one is a reptile. An account of each species is provided below.

The Rock Dove and the Asian House Gecko tend to occur in locations that have human development (houses, buildings, etc). These species are unlikely to impact on the natural environment in the Project Area. In contrast, all of the mammals are known to invade natural environments, and are generally considered to be responsible for major impacts on Australia's natural environment. Of the ten mammals identified, seven have been recorded previously on the DLRM database, and four of those (Cat, European Rabbit, Donkey and Cattle) were detected during the baseline survey by GHD in April 2013. Cattle are present as an agricultural asset, but all others are present as feral animals.

Despite the diversity and confirmed presence of non-native fauna (particularly mammals), the Project Area does not appear to be unusually or excessively overrun by feral animals, compared with other parts of the NT or Australia. That said, the non-native fauna that occurs at the site is likely to have had, and to continue to have, an adverse impact on the area's ecology.

Table 5-12 Non-native fauna species identified for the Project Area

Common name	Scientific name	DLRM	PMST	GHD
Mammals				
Cat	<i>Felis catus</i>	X	X	X
European Rabbit	<i>Oryctolagus cuniculus</i>	X		X
Donkey	<i>Equus asinus</i>	X		X
Dog (domestic)	<i>Canis lupus familiaris</i>		X	
House Mouse	<i>Mus musculus</i>	X	X	
Red Fox	<i>Vulpes vulpes</i>		X	
Horse	<i>Equus caballus</i>	X		
Pig	<i>Sus scrofa</i>	X		
Cattle	<i>Bos taurus</i>	X	X	X
Camel	<i>Camelus dromedarius</i>		X	
Birds				
Rock Dove	<i>Columba livia</i>	X	X	
Reptiles				
Asian House Gecko	<i>Hemidactylus frenatus</i>	X	X	

Cat (*Felis catus*)

Feral cats occupy all Northern Territory habitats, ranging from rainforest to desert. Their occupation of arid regions has apparently been facilitated by their ability to survive without drinking. Available data indicate that populations fluctuate markedly in time and space. Predation by feral cats is considered to have had a major deleterious influence on fauna in arid Australia (particularly small mammal communities) and is appropriately listed as a key threatening process under the EPBC Act.

The fauna survey resulted in six records of the cat across the Project Area (see Appendix D).

European Rabbit (*Oryctolagus cuniculus*)

Rabbits compete with domestic stock for food, damage soils contributing to erosion, and cause profound damage to native plants. In the arid areas of Australia, including the southern Northern Territory, rabbits overgraze pasture plants and reduce trees and shrubs by killing mature plants and suppressing the recruitment of seedlings.

Rabbits have a deleterious impact on many native fauna either directly through competition for food or shelter, or indirectly through environmental modification. The result is loss of biodiversity. Rabbits have been linked to the decline of species like the greater bilby (*Macrotis lagotis*) in the Northern Territory.

Rabbits are patchily distributed in arid areas south of a line extending east-west across the Territory 100 km north of the tropic of Capricorn. A few isolated populations have been recorded further north.

Competition and land degradation by rabbits is listed as a key threatening process under the EPBC Act.

No rabbits were seen during the fauna survey, but rabbit scat was seen at one location (Site 6).

Donkey (Equus asinus)

In Australia, donkeys pose a significant threat to the natural environment. They have been associated with increased erosion of soil and waterways, spread of weeds, trampling of native vegetation, consumption of native seedlings leading to reduced biodiversity, sedimentation of waterways and water bodies, destruction of infrastructure, and competition with native species and domestic cattle for resources.

One donkey was seen during the GHD fauna survey, near the location where harp trap 2 was placed (Figure 4-1).

Dog (domestic) (Canis lupus familiaris)

Feral domestic dogs pose a predatory threat to fauna. However, because the Project Area already supports the closely-related Dingo, the impact of dogs on native fauna is unlikely to be severe.

The Dingo was observed during the GHD survey (Appendix D), but feral dogs were not knowingly seen. It is acknowledged, however, that identification of some dogs/dingoes is near impossible without genetic analysis.

House mouse (Mus musculus)

Despite their distribution throughout Australia, often in great abundance, house mice are not currently considered to be a major threat to biodiversity in the Northern Territory. Nevertheless, there have been some concerns about the impacts of house mice seed predation on native vegetation. In some locations house mice prey on young birds.

This species was not detected by GHD, but is likely to be present at varying levels of abundance depending on rainfall, with plagues potentially occurring following good rainfall, followed by relatively low numbers in dry years (Menkhorst and Knight 2011). Impacts from this species are likely to be low generally, except when their numbers are high.

Red fox (Vulpes vulpes)

The red fox was introduced to mainland Australia in the 1860s. It is now widespread and common south of the Tropic of Capricorn and is found in most habitats from wet forest to desert (Menkhorst and Knight 2011). Foxes are opportunistic omnivores, but are predominantly carnivorous. The red fox is responsible for local extinction of many populations of small to medium-sized mammals (Saunders *et al.* 2010). Historical accounts detail how the arrival of foxes in many areas coincided with the local demise of native fauna. Fox control measures include trapping, shooting, den fumigation and exclusion fencing; baiting using the toxin 1080 is the most commonly employed method.

The fox was not detected during the GHD survey, however they appear to be highly cryptic and difficult to detect where dingos occur and also appear to have a more northerly distribution than previously thought, persisting up into the northern Tanami (R. Paltridge *pers. comm.*). There are no historical records (DLRM database) within 50 km of the Project Area.

Horse (*Equus caballus*)

As with donkeys, horses can pose a significant threat to the natural environment. They have been associated with increased erosion of soil and waterways, spread of weeds, trampling of native vegetation, consumption of native seedlings leading to reduced biodiversity, sedimentation of waterways and water bodies, destruction of infrastructure, and competition with native species and domestic cattle for resources.

In central Australia, feral horses overgraze large areas because they can travel up to 50 kilometres from water in search of food. This can force native wildlife from its favoured habitats.

No horses were seen during the GHD survey.

Pig (*Sus scrofa*)

Feral pigs are large omnivorous mammals with powerful bodies and coarse hairy coats. Their thick necks, wedge-shaped heads and mobile snouts are used in feeding to uproot the ground and find prey or plant material. Feral pigs require water daily and for this reason are generally located close to a permanent water source (<http://parksandwildlife.nt.gov.au/wildlife/exotic>).

Predation, habitat destruction, competition and disease transmission by feral pigs is listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Feral pigs are particularly destructive to the natural environment because they engage in 'rooting' behaviour to locate food. This rooting disrupts the seed bank, disturbs surface vegetation, alters soil composition, increases the growth of weeds, disperses the seeds of exotic plants, and destroys habitat utilised by native species. In addition, pigs are omnivorous, meaning that they eat a wide and varied diet including small animals and invertebrates. This reduces the availability of food for native species. Their rooting behaviour also increases soil erosion and increases siltation of rivers.

No pigs were seen during the GHD survey.

Cattle (*Bos taurus/indicus*)

In Australia, cattle negatively affect the natural environment by contributing to land degradation through trampling, soil compaction and erosion, increased nutrient loading, spread of weeds, and sedimentation of waterways. Feral cattle may be present within the study area, although it is more likely that widely ranging domesticated cattle would be encountered across the study area depending on conditions and available pasture.

Cattle seen within the Project Area are agricultural stock rather than feral animals.

Camel (*Camelus dromedarius*)

According to the DLRM website (<http://www.lrm.nt.gov.au/feral/camel>), feral camels have demonstrable environmental, economic and cultural impacts. In central Australia, camels feed on more than 80% of the available plant species. Serious impacts of camels on vegetation are evident in situations where camels occur at densities greater than 2 animals per km², which is the case throughout much of the Northern Territory. Feral camels severely defoliate and suppress the recruitment of some shrub and tree species, with such impacts being greatly exacerbated in drier years. Feral camels have a noticeable impact on fragile salt lake ecosystems and foul waterholes, which are important sites for Aboriginal people and for native fauna. Feral camels are also likely to destabilise dune crests thereby contributing to erosion.

The Camel was not detected during the GHD survey, and there are no historical records (DLRM database) within 50 km of the Project Area.

Rock Dove (Columba livia)

The Rock Dove (feral pigeon) is generally considered to be a public nuisance and is not considered to have a significant impact on biodiversity. However, they are primarily seed-eaters, and compete with native birds for food (<http://parksandwildlife.nt.gov.au/wildlife/exotic>).

Feral pigeons were not seen in the Project Area during the GHD survey.

Asian house gecko (Hemidactylus frenatus)

The Asian house gecko occurs in tropical and temperate regions worldwide. It is native to South-East Asia and has been introduced to several locations through the movement of cargo. The Asian house gecko has invaded widely in Australia, but is largely restricted to human-altered landscapes. Possible impacts on native fauna include competition with native gecko species and the spread of parasites.

A recent paper by Vanderduys and Kutt (2013) suggests that the Asian house gecko will continue to spread through suitable habitats in northern Australia. However, that 'suitable habitat' is likely to be confined to areas close to infrastructure where there is artificial lighting and modified plant communities.

Asian House Geckos were not seen in the Project Area during the GHD survey.

6. Discussion

6.1 How well do the results represent the fauna of the Project Area?

The numbers of fauna species detected during the fauna survey in April 2013 was moderate. A total of 116 species were detected, including 24 mammals, 58 birds, 34 reptiles and no amphibians. The species accumulation curves presented in section 5.4.4 show that additional survey effort in the area would likely result in gradual accumulation of additional species.

Compared with the 249 species that have been recorded in the Mount Peake area historically (DLRM database), 116 species appears low. It does, however, provide a reasonably representative snapshot of the resident species in this area. For the most part, the long list of additional species is likely to comprise very rare residents, seasonal fauna (e.g. migrants, frogs) and vagrants. The fact that the GHD survey in April 2013 resulted in the detection of 18 species that were not historically recorded on the DLRM database within the search area suggests that the fauna assemblage in this area is not entirely known and is likely to be very dynamic. Species are likely to move into and out of the area, or become active and inactive (and therefore vary in detectability), with changing conditions.

Species' accumulation curves (using actual observations and the order observed) through time suggested that the survey detected the majority of species (for each species group) susceptible to the sampling techniques and present at the time of survey. However, smoothed curves and extrapolated (Bootstrap) curves showed that this was not necessarily the case for all species groups or in all habitats. In all cases, comparison of the actual data with the Bootstrap predicted curves showed that our survey resulted in fewer than expected fauna species. Additional sampling effort is the only way to generate a fuller understanding of the fauna present, including the occurrence of rare and threatened species.

When results are categorised by fauna group, it is evident that not all groups are equally represented. The GHD survey resulted in the detection of 68% of mammal species recorded historically in the area (24 of 35 species), 43% of birds (58 of 135), 49% of reptiles (34 of 70) and 0% of frogs (0 of 9 species). Thus, according to historical information, the mammal results are highly representative of the area, the reptile and bird results are adequate, while the frogs were missed altogether. Results for birds and frogs are not surprising, given that both groups respond greatly to seasonal/environmental conditions (i.e. temperature, rainfall, time of year) and the corresponding resources (e.g. plants flowering, water availability, invertebrate abundance). Birds are highly mobile, and move vast distances in response to conditions. Frogs are highly seasonal, and become inactive when conditions are unsuitable. The results for reptiles are likely due to a number of factors: i) some species are generally sparse across the landscape and were only likely to be detected by chance; ii) some species are habitat specialists (e.g. rock specialists) and occur in habitats not well represented in the Mount Peake area and therefore not sampled; and iii) some species are cryptic and difficult to catch.

6.2 Effects of environmental conditions on the results

The weather during the survey was generally warm and dry, and followed a long, hot and dry summer. Given this, it is not surprising that the results of this survey did not match or even approach the species numbers known to occur or have occurred in this area over many decades. Many fauna species that occupy central Australian habitats are nomadic, opportunistic, and often irruptive. Therefore, rapid changes in environmental conditions can result in rapid changes in species presence and abundance.

Also reflecting the dry conditions and time of year, no amphibians were found during this survey. This does not indicate that amphibians are absent from this landscape. In dry conditions, arid-zone frogs tend to secrete themselves away in deep hollows or rock crevices/cracks, or they burrow into the ground and await the next rain. With changed environmental conditions (i.e. humidity and rain), amphibians are likely to be detected (possibly in large numbers), along with other vertebrate species that respond to rainfall and moisture, and the vegetative growth that rainfall brings.

6.3 Fauna diversity patterns

The eight vegetation communities identified during the GHD flora survey (GHD 2015) provide five main habitat types for fauna. However, the boundaries of habitat types tended to be indistinct, and the prevailing patterns in fauna distribution among habitats were generally very weak. While the MDS and Cluster analyses presented graphs that suggested clear patterns, the statistical basis of every test was weak. This suggests that species tended not to be habitat specialists, but occurred within multiple habitats.

The prevailing pattern in fauna distribution (all species) among habitats was that riparian and Corymbia woodland habitats had the most similar fauna assemblages, which differed from spinifex, and from rocky and mulga habitats which shared characteristics in their fauna.

For mammals, mulga habitat differed from others the most, while riparian and woodland habitats, and rocky and spinifex habitats, shared characteristics in their fauna. Birds comprised half of all species, so not surprisingly, the bird fauna patterns matched the patterns for all species. Reptiles differed from other taxonomic groups: spinifex and woodland habitats shared characteristics, while riparian habitats differed, as did rocky and mulga habitats.

The minor differences in fauna among sites were not driven simply by numbers of species – sites that grouped together varied widely in species richness. These differences are more likely to be due to subtle differences in the types and/or abundance of fauna that occur at the sites. This offers an explanation for the observation that 38% of species detected at sites (i.e. not including incidental observations) were detected in one habitat type only, and that only eleven species were ubiquitous, being found across all habitat types.

Fauna diversity was highest in the mulga habitat, for all species and for each taxonomic group (mammals, birds, reptiles). Spinifex habitat had the lowest diversity, while rocky, Corymbia woodland and riparian habitats had intermediate diversity. When numbers of sites per habitat are considered, the relative fauna richness appears to be a result of survey effort (i.e. number of sites sampled). Sampling of more sites in all habitats is likely to result in the detection of more species.

Patterns in fauna richness among sites/habitats are clouded by the observation that many of the sites had an understorey of spinifex (*Triodia* spp.). Spinifex grass tussocks provide habitat and shelter for a diverse range of small ground-dwelling fauna, particularly mammals and reptiles. Site locations among habitats were selected at least partly on the basis of the broadscale vegetation mapping available prior to the survey, and on landscape features of note (e.g. rocks, waterway, species of dominant trees). However, on-ground observations during the survey showed that most of the habitats supported spinifex tussocks in their ground-cover to some degree. Thus, even though only two sites were located in the formally recognised spinifex habitat, that habitat was less distinct from other habitats than expected, and the fauna patterns appear to reflect that. High species richness in the Mulga habitat, therefore, may not reflect the presence of Mulga trees/shrubs so much as the presence of spinifex tussocks and a higher survey effort (i.e. more sites).

The surprisingly low species richness detected in the spinifex habitat is likely to reflect the relatively open, recently burned nature of that habitat. Typically, that habitat was treeless, and much of it was recently burned, which means that there was a high proportion of bare ground and exfoliated shrubs. Less ground cover and absence of trees and dense shrubs greatly reduces shelter and other opportunities for fauna, particularly small ground-dwelling fauna. Cool temperatures at night may also have contributed to fewer small nocturnal animals (e.g. geckoes) than expected.

As is typical of most fauna surveys, birds were the most diverse of the species groups. The high mobility of most species of birds means they tend to occupy far greater distributional ranges and move relatively freely between numerous habitats than less mobile species, such as the many species of small reptiles and some of the mammals.

6.4 Threatened species

Three threatened and four near-threatened fauna species were detected during the survey (Table 6-1). The records of the two species of EPBC Act-listed mammal remain uncertain, because indirect evidence was seen, rather than the animals themselves. Other threatened species are considered likely to occur in the Project Area, but are probably restricted to specific habitats (e.g. rocky ridges), and may be rarely seen in the area that was sampled for this assessment.

All of the threatened and near-threatened species detected are species that have broad distributions across Australia. The narrowest distributions are those of the two mammal species. The distributional range of both species has declined in recent decades, most likely in response to a combination of predation by feral cats, habitat disturbance and degradation due to grazing, weed invasion, and changes in the use of fire across the landscape.

Five of these seven species are ground-dwelling species (reptiles, non-volant mammals, flightless birds) that have limited mobility across the landscape. These species are perhaps most at risk from localised habitat changes that may result from construction and operation of a mine in the Project Area.

Given the survey effort during this assessment, failure to detect a live Bilby or a live mulgara suggests that both species are not in large populations in the Project Area. It is noted, however, that arid fauna typically have breeding strategies that allow them to respond rapidly to improving conditions. Thus, future population sizes may differ greatly from current population sizes.

Table 6-1 Threatened fauna species identified for the Project Area (50 km buffer)

Common Name	Scientific Name	EPBC	TPWC
MAMMALS			
Brush-tailed Mulgara	<i>Dasycercus blythi</i>	VU	VU
Bilby (= Greater Bilby)	<i>Macrotis lagotis</i>	VU	VU
BIRDS			
Grey Falcon	<i>Falco hypoleucos</i>		VU
Emu	<i>Dromaius novaehollandiae</i>		NT
Australian Bustard	<i>Ardeotis australis</i>		NT
REPTILES			
Woma Python	<i>Aspidites ramsayi</i>		NT
King Brown Snake	<i>Pseudechis australis</i>		NT

6.5 Introduced species

Four introduced fauna species were detected during the baseline survey by GHD in April 2013. These were all mammals: Cat, European Rabbit, Donkey and Cattle. Cattle are present as an agricultural asset, but all others are present as feral animals.

Despite the diversity and confirmed presence of non-native fauna (particularly mammals), the Project Area did not appear to be unusually or excessively overrun by feral animals, as determined by the results of this assessment. That said, the non-native fauna that occurs at the site (particularly the Cat) is likely to have had, and to continue to have, an adverse impact on the area's ecology. The removal or control of feral animals would be expected to result in positive changes to fauna habitat and fauna communities, particularly if done in association with weed control, grazing control and appropriate fire management.

6.6 Implications for Legislation

6.6.1 Environment Protection and Biodiversity Conservation Act 1999

The MNES relevant to fauna at the Mount Peake project are: i) Listed threatened species and ecological communities; and ii) Migratory species protected under international agreements. The EPBC Protected Matters Search Tool indicates that eight threatened fauna species and seven migratory species are known to occur or considered to have a chance of occurring in the search area (Project Area plus a 50 km buffer) (Appendix A).

A referral under the EPBC Act was submitted to the Commonwealth Department of the Environment (DotE; Department of Sustainability, Environment, Water, Population and Communities DSEWPaC at the time) in October 2013. In November 2013, the Commonwealth Minister for the Environment determined that the action (Project) is a "controlled action" requiring formal assessment and approval under the EPBC Act.

The environmental assessment approach to be used will be to assess the project at the level of Environmental Impact Statement (EIS) under the Northern Territory *Environmental Assessment Act 1982*. This will be done under the NT/Commonwealth bilateral environmental assessment process.

The threatened fauna species of concern to DotE are:

- Black-footed Rock-wallaby (MacDonnell Ranges race) (*Petrogale lateralis*);
- Greater Bilby (*Macrotis lagotis*);
- Red Goshawk (*Erythrotriorchis radiatus*);
- Great Desert Skink (*Liopholis kintorei*);
- Southern Marsupial Mole (*Notoryctes typhlops*);
- Princess Parrot (*Polytelis alexandrae*); and
- Mulgara (*Dasycercus cristicauda* and *Dasycercus blythi*) (Note: the mulgara within the Project area is actually the Brush-tailed Mulgara, *Dasycercus blythi* – see Section 5.5.1).

Potential impacts on these species are assessed in detail.

6.6.2 Territory Parks and Wildlife Conservation Act 2006

Three species identified for this project are listed as threatened under the TPWC Act, and a further four are listed as near-threatened. Critical habitat for these species does not appear to be present within the Project Area, but mitigation measures (section 7.1), are likely to be required to effectively reduce impacts on these species to an acceptably low level.

6.6.3 Northern Territory Environment Protection Authority Act 2012

A Notice of Intent for the development of the Mount Peake Project was submitted to the Northern Territory Minister for Mines and Energy under the Northern Territory *Mining Management Act 2001* in June 2013. The Notice of Intent was subsequently referred to the Northern Territory Environment Protection Authority to determine whether formal assessment of the project will occur under the Northern Territory *Environment Protection Authority Act 2012*. The Project is being formally assessed under the *Environment Protection Authority Act*.

7. Potential Impacts on Fauna

7.1 Environmental risks

A description of the proposed project is provided in Section 1.1. The Project Terms of Reference identify the following environmental risks for the mine site Project Area (edited to exclude components of the project that are no longer relevant):

- Waste rock dump (WRD) and Tailings Storage Facility (TSF);
- Potential for acidic and/or metalliferous drainage from the WRD, TSF and other mine infrastructure;
- Handling, storage and transport of product;
- Product transport to the railhead;
- Potential for product concentrate spills from traffic and rail transport accidents, and wind and water erosion of product stockpiles;
- Handling, storage and transport of reagents and/or hazardous materials; and
- Closure and rehabilitation.

7.2 Potential sources of impact

This impacts section has a strong focus on threatened species identified for the Project area.

Construction and operation of infrastructure has the potential to result in a broad range of categories of impacts on native terrestrial fauna or sites of biological significance. The following list includes potential impacts that were identified in the NT EPA Terms of Reference, and others that are thought to be possible as a result of the assessment results:

- Clearing of breeding and/foraging habitat through clearing of vegetation
- Habitat fragmentation and creation of barriers to fauna movement
- Altered hydrology
- Water quality impacts
- Erosion and sedimentation impacting on waterways
- Soil compaction
- Groundwater contamination or lowering;
- Impacts on surface and groundwater systems;
- Waste material – industrial;
- Waste material – domestic;
- Noise disturbance;
- Dust generated by mining and processing activities;
- Visual disturbance (including artificial lights at night);
- Wildfire, inadvertently started by mine construction or operation;
- Risks associated with transport and traffic (including aeroplanes) during construction and operation;
- Introduction and/or spread of weeds and pest animals;

- Poisoning of fauna from drinking contaminated water; and
- Inappropriate/ineffective rehabilitation.

Potential impacts are described in more detail below.

7.2.1 Clearing of breeding and/or foraging habitat

For most fauna, clearing of native vegetation amounts to clearing of breeding and/or foraging habitat. Clearing of habitat, or high impact disturbance to habitat, could result in:

- Killing/injuring fauna
- Displacement of fauna
- Disruption to nesting/roosting/foraging and/or behaviour
- Reduction of area of fauna habitat locally and/or regionally
- Fragmentation of remaining habitat
- Erosion and sedimentation impacts, including degradation of surface water quality
- Increasing likelihood of weed establishment in cleared areas.

The fauna habitats affected by clearing comprise eight distinct vegetation communities (GHD 2015) which are presented in Table 7-1, along with extent of clearing proposed.

Table 7-1 TNG Mount Peake project fauna habitat and vegetation communities and proposed clearing area for each community

Fauna habitat	Corresponding vegetation community	Area (ha)	% of total area proposed to be cleared
Mulga woodland	Mulga shrubland on sandy red earths (VT 2)	420.25	41.68
	Tall Acacia shrubland on stony quartz plains (VT 8)	10.00	0.99
Riparian woodland	Riparian woodland along watercourses and drainage channels (VT 3)	2.90	0.29
	Floodplains dominated by <i>Eucalyptus victrix</i> (VT 5).	0	0
Rocky rises	Low open Eucalyptus woodland on limestone ridges (VT 1).	8.35	0.83
Spinifex grassland	Triodia grassland on sand plains (VT 6)	558.58	55.40
	Low Acacia shrubland on rocky slopes (VT 7)	3.50	0.35
Corymbia woodland	Low Corymbia open woodland on plains with red earths (VT 4)	4.61	0.46
TOTAL		1008.19	100

This table shows clearly that the two habitat types expected to be most impacted are mulga woodland (~41% of area) and spinifex grassland (~55% of area). In accordance with the likelihood of occurrence assessment presented in Table 5-9, these habitats in the Project area have the potential to support the following threatened species:

- Mulga woodland – Greater Bilby, Princess Parrot and Grey Falcon
- Spinifex grassland – Greater Bilby, Brush-tailed Mulgara, Night Parrot, Princess Parrot, Grey Falcon and Great Desert Skink.

In addition to the clearing areas included in Table 7-1 the Project would result in approximately 30 ha of clearing within the borefield area and associated pipeline. Although this area was not assessed during the field survey a review of geological and topographic information as well as aerial imagery suggests that vegetation would be comprised primarily of Triodia Grassland on sandy plains (VT 6), Mulga shrubland on sandy red earths (VT 2), Low Corymbia woodland on loamy alluvial plains (VT 4) as well as a small amount of Riparian Woodland along water courses (VT 3).

7.2.2 Habitat fragmentation and creation of barriers to fauna movement

Clearing of natural habitat, particularly through construction of linear infrastructure (e.g. access road, haul roads, and pipelines) can result in:

- Habitat fragmentation and creation of barriers to fauna movement, particularly for small ground-dwelling fauna
- Introduction and/or spread of exotic plants (weeds)
- Increased use of the area by non-native predators (e.g. cats, foxes), by creation of access tracks into new areas.

For this project, clearing of vegetation will form islands of cleared habitat in the vicinity of the mine area (TSF, WRD, pit, process plant) and the mine camp (accommodation area). However, the main potential cause of habitat fragmentation will be from construction of the access road (approximately 25 m wide and up to 100 km long). Note that similar linear clearing has already occurred in this area historically (e.g. existing Amadeus gas pipeline). The width of the access road, frequency of vehicle movements, and timing of vehicle movements will influence the impact of the access road as a barrier. Wider roads present greater barriers than narrower roads, as the risks to wildlife crossing the road are greater, particularly for small fauna. More frequent vehicle movements increase the risk of roadkill. Nighttime rather than daytime vehicle movements increase the risk of roadkill, as many of the threatened species at risk of vehicle collision are nocturnal.

Habitat fragmentation is most likely to impact on ground-dwelling fauna, and particularly small fauna that tend not to cover large areas in their normal activities (e.g. foraging, breeding). For this project, habitat fragmentation is of greatest concern for Greater Bilby, Brush-tailed Mulgara and Great Desert Skink. These species are most likely to be found in open sandy habitats dominated by spinifex grassland and low sparse shrubs. Larger fauna (e.g. Black-footed Rock-wallaby) and highly mobile fauna (e.g. Princess Parrot, Night Parrot, Grey Falcon) are less likely to be impacted by habitat fragmentation on the scale that would result from this project.

7.2.3 Altered hydrology

Vegetation in riparian zones and floodplain areas are likely to be at least partially dependent on surface water flows. The construction of linear infrastructure such as access roads and pipelines has the potential to interfere with natural surface water flows by blocking or disrupting the movement of water across the landscape. These potential impacts are likely to be most significant where the proposed access road crosses the Hanson River and in areas within the borefield area adjacent to the Hanson River, immediately west of the Stuart Highway.

Additionally the proposed mining operations may impact surface water flows through changes to areas of inundation, concentration of flows and/or disruption to sheet flow regimes. Changes to flow pathways may result in changes to the flow regime experienced by downstream receptors. Flow pathways include drainage channels, distributed channels and sheet flow areas. The key receptors that are vulnerable to changes in environmental flows are vegetation communities that are at least partially dependent on surface water flows including sheet flow (i.e. Mulga shrubland) and the riparian vegetation within drainage channels and Mud Hut Swamp.

Approximately 37% of the Project area is comprised of floodplains and plains that would be subject to seasonal inundation or surface water flows. A reduction in surface water flows has the potential to result in the death of understorey species and also overstorey mulga shrubs during low rainfall periods and may in the long term lead to alterations to community composition.

Engineering controls that assist in maintaining surface water flows have been incorporated into road designs to ameliorate any potential risks to vegetation and flora due to changes in flows. Given the relatively small variation in relief across the Project area, these practices would also provide other benefits such as erosion control. Design features that recognise the need to maintain existing surface water flows include the installation of at-grade flood ways where the access road crosses a water course and culverts to maintain flows under the access road where the drainage line is well defined.

The key groundwater receptors that are vulnerable to changes in environmental flows are the recharge zones and floodout zones located downstream of the Project area.

Fauna that rely on riparian habitats and that may be impacted by altered hydrology in and downstream of the Project area include the Common Brushtail Possum.

7.2.4 Water quality impacts

'Water quality' encompasses many attributes and may be impacted in numerous ways. These are addressed in other sections as follows:

- Changes in turbidity as a result of erosion and sedimentation – see section 7.2.5
- Changes in water chemistry as a result of contaminated run-off – see section 7.2.7;
- Changes in hydroperiod as a result of altered hydrology – see section 7.2.3
- Changes in hydroperiod as a result of lowering of the water table – see section 7.2.7
- Contamination of surface and groundwater systems – see section 7.2.8.

Impacts on water quality can in turn lead to:

- Impacts on vegetation that receive poor quality water, in turn leading to changes in available habitat for fauna
- Contamination of ephemeral waterways and subsequently groundwater in the broader area from uncontrolled release resulting in impacts on ecosystem health and/or public water supply.

These impacts are most likely to affect aquatic fauna rather than terrestrial fauna, but there is a chance of localised or cumulative effects in terrestrial fauna (e.g. fauna that drink or bath in contaminated water frequently).

7.2.5 Erosion and sedimentation impacting on waterways

Soils will be stripped in areas where new structures are to be constructed, with material stockpiled and used for rehabilitation. Soil quality may also be affected during construction and operations as a result of discharge of contaminants via seepage or spills, or from dust deposition.

There is potential for the Project to result in erosion and sedimentation of soils in areas that have been stripped of vegetation. Depleted soil quality can in turn impact future plant germination. Soil erosion has the potential to impact Murray Creek and the downstream Mud Hut Swamp through the release of sediment from site during flow events.

Soil protection measures and techniques would be implemented during construction and operation of the mine site.

Erosion and sedimentation impacts are most likely to affect aquatic fauna rather than terrestrial fauna.

7.2.6 Soil compaction

Soil compaction is expected to occur only in areas that are disturbed already as a direct consequence of the project (e.g. areas cleared of vegetation to form the access road or to create an accommodation area, or areas used for the WRD). Impacts of soil compaction alone are not expected. Therefore, soil compaction is not expected to have a direct impact on fauna.

7.2.7 Contamination or lowering of the water table

Water supply for the Project will be drawn from the Hanson River palaeovalley, approximately 25 km northeast of the mine site.

Maximum predicted groundwater drawdown is modelled as being up to 12 m below current groundwater levels (which are 10 – 12 m below ground level) at the operating bores in the centre of the borefield. The 1 m drawdown contour extends to around 6 km south of the borefield (GHD 2015a).

A draw down of 12 m below current groundwater levels is likely to result in the following impacts on fauna:

- Decline in availability of water to ecosystems including riparian vegetation resulting in loss of habitat for species relying on riparian habitat
- Shorter hydroperiod in waterbodies that may provide water for fauna.

Pit modelling indicates that groundwater drawdown will not impact any groundwater dependent ecosystems or wetlands.

After decommissioning, the mine void will act as a sink with a shallow lake forming.

7.2.8 Contamination of surface and groundwater systems

Potential sources of contaminants to surface and groundwater include:

- Runoff from areas cleared of vegetation
- Sediment runoff from soil stockpiles
- Runoff from hardstand areas, including roads, processing areas and site facilities
- Potential for Acidic and/or Metalliferous Drainage (AMD) from the waste rock dump, tailings storage facility and other mine infrastructure, to contaminate shared water resources

- Spills and runoff containing hazardous substances or elevated sediment concentrations
- Waste treatment areas (including the water treatment plant, wastewater treatment plant; oily water treatment plant and landfill facilities)
- Overtopping of tailings storage facility
- Leakage or spillage of hydrocarbon products from vehicles, wash down areas and workshops
- Spills/leaks from refuelling bays and fuel, oil and grease storages
- Contamination leaks from storages or pipelines and spills during handling of contaminants, chemicals and toxicants.

There are several risks associated with the construction and operation of the mine that could lead to contamination of surface and groundwater. These include contamination of waterways or groundwater caused by embankment failure or overtopping and subsequent uncontrolled release from storage ponds. There is also a contamination risk associated with 'First flush' surge of stored oxidation products generated in mine storage facilities (WRD, ROM Pad etc) over extended dry periods which may result in discharges into waterways.

There are a number of sensitive riparian habitats within close proximity to the development footprint, including Bloodwood Creek, Murray Creek and the Hanson River. These areas are all sensitive receptors for adverse impacts on water quality potentially arising from the Project. Vegetation and flora reliant on surface flows and groundwater uptake may also be impacted by surface water and groundwater contamination. In turn, common and threatened herbivorous species (including the Black-footed Rock-wallaby and Common Brushtail Possum) may be impacted over time by grazing/browsing on contaminated vegetation. Changes in water quality may also directly affect threatened fauna (e.g. Black-footed Rock-wallaby and Princess Parrot) that drink from such water sources.

Potential water quality impacts may be associated with runoff from disturbed areas (including areas cleared of their vegetation, construction lay-down areas and access roads). Concentrated and/or altered water movement within the construction footprint could increase the potential for sediment mobilisation and transport. Negative effects on aquatic habitats may include increases in stream sediment load, changes in channel form and changes in stream hydrology. Infrastructure that impinges on the stream channel may also cause increases in sediment input and consequent declines in water quality and stream habitat integrity (Davies and Nelson 1994).

7.2.9 Waste Materials – industrial waste

The Project will generate waste rock from the mine and tailings from the process plant. Both of these waste streams are benign and do not pose a contamination risk.

These waste materials on their own are not expected to result in direct impacts to fauna. However, potential impacts associated with the waste include:

- Collisions with fauna from vehicles used to transport waste rock
- Clearing of breeding and/or foraging habitat to create the TSF and WRD
- Dust as a result of increased traffic and specifically due to haulage of waste rock
- Increase in noise
- Spread of weeds.

7.2.10 Waste Materials – domestic waste and refuse

Unless it is managed appropriately, domestic refuse and waste (particularly around the accommodation area) is likely to attract non-native pest animals, particularly the Black Rat (*Rattus rattus*). This in turn is likely to attract their predators, which include the non-native Red Fox (*Vulpes vulpes*) and Cat (*Felix catus*) and the native Dingo (*Canis lupus*), and lead to increases in the local populations of predators. This is likely to have a detrimental impact on threatened fauna, particularly small fauna that spend considerable time on or near the ground (e.g., Night Parrot, Black-footed Rock-wallaby, Greater Bilby, Brush-tailed Mulgara, Great Desert Skink).

Two pump stations will be installed to collect sewage and wastewater for treatment in a Sewage Treatment Plant. One station will service the mine with a second station servicing the accommodation area. Treated waste water will be used around the site for landscaping purposes. Solids will be collected and disposed of offsite by a licensed waste transporter.

7.2.11 Noise generated by mining and processing activities

Disturbance to fauna associated with generation of unexpected and/or excessive noise from mining and processing activities during construction can result in:

- Displacement of fauna
- Disruption to nesting/roosting/foraging behaviour.

Displacement of fauna into sub-optimal habitats could increase their susceptibility to predation and competition.

FHA (2004) and Kaseloo (2005) reviewed literature on bird responses to intense noise levels and found that responses varied greatly. Approximately 60% of the 43 species studied exhibited population declines adjacent to roads, with the declines directly related to levels of traffic (Kaseloo 2005). Both studies reported that susceptible species exhibited declining populations in areas with greater than 50 dB(A). However, declines varied among years, with interaction with and between habitat quality and population density playing significant roles in determining the nature and extent of declines. Many bird (and other faunal classes) species remained unaffected by or persisted with high population densities in areas with high noise levels e.g. near roads, mines or military testing/training grounds, airports (FHA 2004; Kaseloo 2005).

It is likely that fauna in the immediate vicinity of the mine site would be most affected by Project noise that may encourage them to move to other nearby habitats. The majority of the threatened species that do or may occur within the Project area (Brush-tailed Mulgara, Greater Bilby, Common Brushtail Possum, Grey Falcon, Princess Parrot, Night Parrot and Great Desert Skink) use habitats that occur some distance from the mine site (generally >10 km) and are unlikely to be affected by construction or operational noise. Increased vehicle noise along the access road may have localised and isolated low-level impacts. However, most of the species are nocturnal, and those that are not are highly mobile, and their activity patterns are unlikely to be adversely impacted by activity in the project area at night.

Most of the area covered by the Project is not typically suitable habitat for the Black-footed Rock-wallaby, but there are rocky outcrops scattered throughout the area that are likely to be suitable. The species is known to occur in nearby rocky ranges and may occasionally move through the Project area to access different patches of suitable habitat. Noise generated by the mine is likely to preclude rock-wallaby movements through the mine site.

7.2.12 Dust generated by mining and processing activities

Dust is a potential problem for projects in regions that experience extended dry periods (Central Australia exhibits an arid and unpredictable climate and regularly experiences extended periods without rain). Drilling, blasting, excavation, movement of vehicles and handling of materials results in dispersion of particulates and dust, particularly from the mine site, and consequent soil, surface/groundwater contamination.

The following activities are identified as potentially the main generators of dust:

- Tracking of dust from vehicle movements on unsealed roads
- Wind erosion from the WRD, TSF, long-term ore stockpiles and disturbed areas
- Emissions from crushing and grinding in the process plant
- Concentrate loss from haulage on the access road.

Research and knowledge with respect to the effects on wildlife of dust are mostly restricted to effects on concentrated populations of domestic animals such as chickens in restricted environments or more general studies on the effects of infrastructure such as roads and mines on adjacent fauna populations (Collins and Algers 1986; Spellerberg 1998). Effects can range from significantly decreased fitness of individuals (Brown *et al.* 1997) to increased incidence of infectious diseases as a result of exposure to particulate emissions, leading to injury and death (Newman and Schreiber 1988).

The Northern Territory does not have specific air quality legislation. The standards for New South Wales Department of Environment and Conservation (DEC 2005) are broadly applicable, so are referenced here. DEC (2005) has no applicable criterion for fauna, but sets a dust criterion of $50\mu\text{g}/\text{m}^3$ TSP for human exposure. Small birds/mammals have higher rates of inhalation per unit body mass than humans so are likely to have lower dust tolerance thresholds (Newman and Schreiber 1988).

Other potential impacts of dust on fauna can include: i) degradation/loss of fauna habitat from detrimental impacts of dust deposition on flora species and vegetation communities; and ii) degradation/loss of water source for fauna resulting from degradation of surface water quality due to dust deposition/sedimentation.

It is likely that a range of non-threatened taxa that exist within the vicinity of the mine site could be adversely impacted by dust generated by mine operations. This would include birds, small ground-dwelling mammals and possibly reptiles (although a lack of data on the effects of dust on reptiles does not allow any solid conclusions to be drawn).

However, the majority of the threatened species identified for the Project area (Brush-tailed Mulgara, Greater Bilby, Common Brushtail Possum, Grey Falcon, Red Goshawk, Princess Parrot, Night Parrot and Great Desert Skink) either do not or would not regularly occur in the vicinity of the mine site, and hence would only ever be subjected to very low dust levels mainly from vehicle movements along unsealed roads.

There is habitat for the Black-footed Rock-wallaby within 2 km of the mine site, and this species may be exposed to higher levels of dust.

7.2.13 Visual disturbance during construction and operation - lighting

Light plays a critical role in ecology. It determines activity levels of diurnal and nocturnal fauna, it assists predators in their hunting success, and some light sources attract invertebrate fauna that are then preyed on by other fauna.

The study of the effects of artificial light on fauna is in its infancy and viewed as a new focus for research in ecology, and a pressing conservation challenge (Longcore and Rich 2004). Recorded responses from fauna subjected to artificial light vary widely among species. Mining will occur in two 12 hour shifts, 7 days a week. This has the potential to negatively impact on fauna, and on specific species of fauna. Predicting or defining precise impacts on fauna is near impossible. Therefore, a valid approach will be to implement measures to minimise and mitigate impacts that have been recorded elsewhere for other fauna.

Localised disturbance to nocturnal fauna associated with generation of light in mining and processing areas can cause the following impacts:

- Local displacement of fauna (i.e. nocturnal fauna move away from brightly lit areas)
- Increased susceptibility of fauna to predation (e.g. prey species find it harder to remain concealed in brightly lit areas)
- Disruption to nesting/roosting behaviour (e.g. bright lights may awaken diurnal species)
- Alteration to small mammal activity rhythms (e.g. Rotics *et al.* 2011)
- Disorientation of bats (e.g. Stone *et al.* 2009; Polak 2011)
- Alteration of bird calling behaviour (e.g. Kepempenaers *et al.* 2010; Longcore 2010)
- Disorientation of migrating birds (e.g. Longcore *et al.* 2008)
- Alteration to breeding behaviour of amphibians (e.g. Baker and Richardson 2005) and attraction and disorientation of amphibians (Buchanan 2006)
- Attraction of and enhanced mortality of insects (e.g. Yoon *et al.* 2010; Ferreira and Scheffrahn 2011; Fox 2012).

Fauna in the immediate vicinity of the mine site would be most exposed to artificial lighting that could impact 'normal' nocturnal behaviours (e.g. bats, migratory birds). The majority of the threatened species that do or may occur within the Project Area (Brush-tailed Mulgaras, Greater Bilby, Common Brushtail Possum, Grey Falcon, Red Goshawk, Princess Parrot, Night Parrot and Great Desert Skink) tend to occur some distance (>10 km) from the mine site and would be unlikely to be affected by operational lighting. Lighting could have some localised and isolated low-level impacts however, it is unknown whether artificial lighting has any adverse impacts on these species. It is entirely possible that mulgara could be attracted to lighting in an attempt to prey on insects, although it is unknown what the long-term effects of this would be.

Most of the area covered by the Project is generally unsuitable habitat for the Black-footed Rock-wallaby, but there are rocky outcrops scattered throughout the area that are likely to be suitable. The species is known to occur in nearby rocky ranges and may occasionally move through the Project area to access different patches of suitable habitat. It is possible that light emitted from the mine site could impact on nocturnal movements of rock-wallabies and could reduce dispersal activities in the immediate vicinity of the mine. Rock-wallabies occurring at distances of 2 km or more from the mine site are unlikely to be adversely impacted by artificial lighting, provided that lights are not directed towards their habitat, although the distance and buffering by the elevation and rocky habitat would diminish the penetration of the 'brightness' of the majority of lights that would be used for illumination purposes.

7.2.14 Wildfire, as a consequence of mining activities

Wildfire has an influential role in arid zone ecology, and is a necessary ecological process in some habitats. Fire can benefit some disturbance-tolerant species, but can have detrimental impacts on other types of fauna and fauna habitat, if it occurs at the wrong time of year, or in habitats that don't respond well to fire, or with excessive heat.

The impacts of too frequent, hot and extensive fires are well documented in the arid zone of central Australia. A number of the threatened species recorded within the study area are adversely affected by too frequent and extensive fires. For example, large-scale, intense wildfires that tend to occur in areas where patch burning has not occurred can devastate or fragment local populations of Great Desert Skink (Woinarski *et. al.* 2007). Wildfire within Black-footed Rock-wallaby habitat can also have a major impact as it burns food plants such as SpeARBush and fig rendering habitats unsuitable for periods of time (Dr J. Read *pers. comm.*).

Potential impacts of fire on fauna include:

- Killing/injuring fauna
- Displacement of fauna
- Disruption to nesting/roosting/foraging habitats and/or behaviour
- Reduction of area of fauna habitat locally and/or regionally
- Habitat fragmentation
- Subsequent erosion and sedimentation resulting from loss of vegetation
- Degradation of surface water quality due to erosion of soils and landforms.

For the Mount Peake Project, vehicles, machinery, hot works, switchgear, transformers, HV power and personnel provide potential ignition sources that could lead to fire.

It is expected that all of the threatened species that do or may occur within the Project area would be affected by fire (both positive and negative impacts). Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (as distinct from small-patch burning) of Great Desert Skink and Black-footed Rock-wallaby habitat could be detrimental to those species as the fire could remove important shelter and food resources. Burning of rocky habitat is unlikely to be beneficial for many species and should be avoided. Continued persistence of the Black-footed Rock-wallaby in the area will depend on prevention of wildfire in the surrounding rocky habitats.

There is limited information regarding the response to fire for mulgara. Woinarski (2007) mentions that changes to fire regimes may have been a factor in historic declines. Extensive frequent fire may reduce ground-layer vegetation cover which could increase the likelihood of predation by cats/foxes (Dr R. Paltridge *pers. comm.*).

7.2.15 Risks associated with traffic during construction and operation

There is substantial literature and reviews on the effect of roads and vehicle traffic on adjacent biota (Forman and Alexander 1998; Forman and Deblinger 2000; Johnston and Johnston 2004; Lugo and Gucinski 2000; Pagotto *et al.* 2001; Trombulak and Frissell 2000; Walker and Everett 1987) and more recently the topic of road ecology has been considered a research discipline in itself (Coffin 2007). The history of the development of road ecology (Forman 1998) is well described in this publication. Creation and use of new roads and tracks through fauna habitats can lead to increased collisions with fauna, particularly at night, when nocturnal fauna can become dazed by a vehicle's bright lights.

There can be both biotic and abiotic effects of traffic on ecosystems (Coffin 2007) including:

- Direct mortality and injury (Erritzoe *et al.* 2003)
- Breeding failure caused by loss of naïve young fauna, or adults with dependent offspring
- The introduction of chemical pollutants, including toxic contaminants (Forman 2003)
- The dispersal of chemical pollutants and dust
- Noise effects (Bayne *et al.* 2008), particularly those that disrupt breeding behaviour
- Barriers to movement (Shepard *et al.* 2008)
- The creation of new habitat types, especially in agricultural landscapes (Bellamy *et al.* 2000)
- The creation of corridors and conduits of species movement or invasion (von der Lippe and Kowarik 2008)
- Fragmentation and edge effects (Hawbaker *et al.* 2006)
- Indirect effects of habitat degradation via vehicle spread of exotic plant species into relatively undisturbed habitat, which might change the quality and extent of habitat.

It is possible that several of the species that occur within the Project area could occasionally be struck and killed by vehicles moving in the area (e.g. Brush-tailed Mulgara, Greater Bilby, Common Brushtail Possum, Black-footed Rock-wallaby and Great Desert Skink). Some of the threatened species that do or may occur in the Project area are nocturnal and would only be affected by vehicles travelling at night. Mitigation options could involve the implementation of speed limits and a reduction in vehicle travel at night.

There are also some benefits in the construction of new roads, such as granivorous birds/herbivorous mammals feeding in road verges, as seeding grasses may be encouraged in these microhabitats due to changes in hydrology and accumulation of water in verges encouraging graminoid growth. However this could be counteracted by the increased probability for vehicle strike of birds, mammals, reptiles, especially if feeding/basking (reptiles) animals are flushed by passing traffic.

7.2.16 Introduction and/or spread of exotic plants and animals

Exotic plants (Weeds)

The establishment or spread of weeds can alter the ecological balance of arid zone ecology. Weed dominated habitats are generally less favourable for fauna than weed-free habitats. In particular, Buffel Grass (*Cenchrus ciliaris*), which is favoured by pastoralists, is a serious ecological pest in central Australia and its spread into rocky habitats of the study area should be prevented.

Transport of materials, vehicle movements and inappropriate waste management allows for introduction of new weeds and spread of existing weeds. These can cause:

- Local decline in habitat quality
- Displacement of fauna from habitats as habitat quality deteriorates
- Invasion of fauna species that are attracted to the weed species (e.g. cattle with buffel grass)
- Impacts on conservation significant fauna (i.e. threatened species)
- Changes in fuel load, resulting in changes to fire frequency and intensity.

Non-native animals

Creation of new roads and tracks and inappropriate management of waste (garbage) potentially allows the introduction or spread of pest animal species. This can cause:

- Increased predation pressure (particularly on threatened species) by opening up of new areas to feral predators (e.g. Cat, Red Fox)
- Increased competition (particularly on threatened species) by natural areas becoming invaded by aggressive and dominating pest species (e.g. House Mouse, Black Rat)
- Large-scale decline in habitat quality as natural areas are trampled and grazed increasingly by non-native species that have the potential to alter ecological processes (e.g. cattle, camel, goat).

Despite the diversity and confirmed presence of non-native fauna (particularly mammals), the Project Area does not appear to be unusually or excessively overrun by feral animals, compared with other parts of the NT or Australia. That said, the non-native fauna that occurs at the site is likely to have had, and to continue to have, an adverse impact on the area's ecology.

As stated in section 7.2.10, it will be important that on-site domestic waste (particularly food waste) is contained within a predator-proof fence to prevent access (access to easily obtain food resources could allow predators to increase in abundance).

7.2.17 Poisoning of fauna from drinking contaminated water

Tailings dams at mine sites typically contain water that, if consumed or absorbed, can be harmful to fauna. Effects can be immediate or cumulative. Consumption of contaminated water can cause:

- Killing/harming fauna
- Disruption to breeding success
- Knock-on effects, by attracting predators/scavengers to ill/dead fauna.

Bird numbers and use of tailings dams tend to increase with the size of the dam, and the provision of microhabitat features associated at the dam, such as shallow flats, trees in the water or at the water's edge, islands, or other vegetation overhanging the water.

The tailings dam at Mount Peake will contain benign silts and sands. No hazardous substances are expected to be stored in the dam.

The tailings dam will contain a 'slurry' rather than standing water. It is unlikely that the majority of the threatened species that do or could occur with the Project area (Black-footed Rock-wallaby, Brush-tailed Mulgara, Greater Bilby, Common Brushtail Possum and Great Desert Skink and to a lesser extent, Princess Parrot, Night Parrot, Grey Falcon and Red Goshawk) would access liquid contained within the tailings dam.

7.2.18 Inappropriate/Ineffective rehabilitation

The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. As discussed in section 7.2.16, weed dominated habitats are generally less favourable for fauna than weed-free habitats.

Transport of materials, vehicle movements and use of contaminated soil allows for introduction of new weeds and spread of existing weeds. These can cause:

- Local decline in habitat quality
- Displacement of fauna from habitats as habitat quality deteriorates
- Invasion of fauna species that are attracted to the weed species (e.g. cattle with buffel grass)
- Impacts on conservation significant fauna (i.e. threatened species)
- Changes in fuel load, resulting in changes to fire frequency and intensity (e.g. buffel grass tends to burn hotter than native grasses in this area, such that invasion of buffel grass in rocky habitats used by Black-footed Rock-wallaby may lead to more intense fires that impact on the wallabies).

If the condition of existing habitats declines, then inappropriate or ineffective rehabilitation has the potential to impact on all threatened fauna species.

8. Management and mitigation measures and proposed monitoring

The Terms of Reference for this Project call for the establishment of “mechanisms to determine the long-term impact of environmental impacts associated with key environmental issues (monitoring and reporting)”.

Mitigation measures will be required to reduce or eliminate impacts of mining and processing activities on fauna (particularly threatened species) and their habitat. This section provides guidance on the types of mitigation and monitoring that can be considered for the construction and operation phases of the project.

8.1 Mitigating against habitat clearing and fragmentation

This section provides recommendations for mitigation actions that will serve to reduce the following impacts:

- Clearing of breeding and/or foraging habitat (section 7.2.1)
- Habitat fragmentation and creation of barriers to fauna movement (section 7.2.2).

Consideration has been given to the location of infrastructure so that it avoids impacting threatened species' breeding and foraging habitats as far as practicable. Additional avoidance actions that can be taken to minimise impacts of clearing and fragmentation on threatened species include:

- Subtle realignments and sitings of all infrastructure (including the access road and fences) to minimise loss of key breeding and feeding habitat
- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. set down areas for construction)
- Clearly marking out areas of land to be cleared and areas to be retained (No-Go areas), so that impacts do not extend any further than necessary into important habitat
- Close monitoring of habitat clearing to ensure compliance with areas marked for clearing and no intrusion of any kind on areas outside the clearing zone
- Progressive incremental clearing of land as needed, rather than large-scale clearing in advance
- Minimising the clearing width associated with the access road. This will reduce the risks to fauna that move across the road
- Limiting construction and clearing to times of the year when fauna are least vulnerable (e.g. avoiding breeding period). Preferably, clearing would occur in autumn when young animals are mobile and less dependent on parents and when reptiles are still active and have a chance to escape
- Restricting vehicle movements to daylight hours only, thereby reducing the risk to nocturnal fauna that cross cleared areas at night. If that is not possible, then implementing slower speed limits for vehicles moving at night, to reduce the likelihood of roadkill
- Using strict fire-prevention management protocols at all times to prevent wildfire during clearing activities

- Undertaking pre-clearing fauna surveys prior to mine construction, with qualified ecologists on site to assist/translocate animals that are found during the clearing process and that require assistance in getting to safety
- Using strict vehicle hygiene protocols to prevent new weed incursion and spread, including a vehicle wash down facility on site
- Progressive reinstatement of cleared land as activities are completed, to reconnect habitat fragments (which forms part of the Closure and Rehabilitation Plan)
- Rehabilitation of edges that abut threatened species' habitat, to remove weed species and maximise regeneration of native vegetation
- Ongoing pest-animal control in all areas and particularly for predators and their prey (e.g. control of cats, foxes and non-native rats in particular).

8.2 Mitigating against impacts on surface and ground water

This section provides recommendations for mitigation actions that will serve to reduce the impacts on fauna and their habitat as a result of the following impacts:

- Altered hydrology (section 7.2.3)
- Water quality impacts (section 7.2.4)
- Erosion and Sedimentation impacting on waterways (section 7.2.5)
- Contamination or lowering of the water table (section 7.2.7)
- Impacts on surface and groundwater systems (section 7.2.8).

A Drainage, Erosion and Sediment Control Plan and a Water Management Plan (which encompasses surface and ground water) will be developed to document measures to ameliorate potential impacts on fauna and their habitat as a result of deleterious changes to all attributes of groundwater and surface water availability and quality.

Specific mitigation measures in the Plan will include:

- Incorporating engineered controls into design of all roads to maintain existing surface water flows, thereby ameliorating potential risks to habitat due to changes in flow. Given the relatively small variation in relief across the Project area, these controls will provide other benefits also, such as erosion control
- Avoiding where possible, or minimising, draw-down of the water table in areas where Groundwater Dependent Ecosystems (GDEs) exist, such as along waterways where River Red Gums occupy the riparian zone
- Implementing standard management controls and engineering specifications for drainage from on-site facilities
- Implementing standard management controls and protocols for minimising the risks of hydrocarbon spills
- Complete avoidance of spills or leaks of contaminated water or other substances
- Monitoring hydrogeological changes, and adapting the mitigation as necessary if discrepancies are detected.

8.3 Mitigating against soil compaction

No mitigation measures are proposed to reduce the impacts of soil compaction during construction or operation. Areas of compacted soil will be effectively rehabilitated as part of the mine closure process.

Areas of soil compaction will be minimised through other mitigation efforts, including:

- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. set down areas for construction)
- Clearly marking out areas of land to be cleared and areas to be retained (No-Go areas), so that impacts do not extend any further than necessary into important habitat
- Minimising the width of the access road.

8.4 Management of Waste Materials – industrial waste

A waste rock dump (WRD) will contain waste rock from mining operations. There are no specific strategies to manage placement in the dump as the waste rock is benign.

8.5 Management of Waste Materials – domestic waste and refuse

Domestic waste and refuse (particularly around the accommodation area) must be managed effectively so that it does not attract non-native pest animals, particularly the Black Rat (*Rattus rattus*), which in turn is likely to attract predators including the non-native Red Fox (*Vulpes vulpes*) and Cat (*Felix catus*) and the native Dingo (*Canis lupus*). Inappropriate waste management looms as one of the greatest sources of potential ecological impact from this project, and strict and appropriate waste management will be critical to keeping ecological impacts minimal. Mitigation efforts will include:

- Fencing, sufficient to keep predatory fauna out. On-site garbage/waste must be held in a securely fenced compound (i.e. the fence will need to prevent the entry of cats, foxes and dingos) to prevent the scavenging of waste material and potential population increases in both feral and native predators.

8.6 Mitigating noise generated by mining and processing activities

The primary mitigation efforts to minimise impacts on fauna from noise will be to:

- Implement standard noise minimisation measures to reduce noise wherever possible
- Avoid or minimise high-impact noises to daylight hours only (i.e. avoid excessively loud noises at night, when the majority of relevant threatened species are likely to be active).

8.7 Mitigating dust generated by mining and processing activities

The following actions are recommended to mitigate the impacts of dust on threatened fauna and their habitat:

- Defined haul routes to be used wherever it is necessary for vehicles to traverse unsealed surfaces or unformed roads
- Vehicular speeds would be limited to 25 km/h on areas of unconsolidated or unsealed soil associated with the project

- Prompt mitigation of excessive visible dust emissions, which may be a combination of:
 - o stabilisation of surface silt content through application of localised water sprays, or the use of appropriate chemical dust suppressants (suitable for roads which are traversed less frequently)
 - o control of mechanically induced dust emissions (from clearing, excavation, loading, dumping filling and levelling activities) by application of water sprays
 - o awareness of operational areas more frequently exposed to higher winds and the predominant wind directions in these areas at various times of the year. Temporary wind barriers may be employed where necessary
 - o review of daily weather updates from BoM or a private meteorology service provider, to give warning of likely strong winds to assist with daily management of wind-blown dust from unconsolidated soil surfaces and material stockpiles.
- Use sediment traps near waterways along roads, to trap accumulated dust before it enters waterways
- Progressively reinstate cleared land as activities are completed (which forms part of the Closure and Rehabilitation Plan) to minimise dust-generating areas
- Cover concentrate loads to prevent dust generation and product loss.

8.8 Mitigating visual disturbance during construction and operation - lighting

Mitigation action to reduce the impact on fauna of artificial lighting predominately involves turning off all unnecessary lights at night, when nocturnal fauna are active. However, this may not always be practical or safe; these steps should be taken where it is safe to do so.

Potentially negative impacts of artificial light can be mitigated by:

- Limiting artificial light to areas where it is essential
- Turning off lights when not required
- Avoiding the flood of light into natural habitats and limiting the escape of light into surrounding areas of fauna habitat (i.e. using shields/deflectors)
- Ensuring that artificial lighting is not directed upwards or laterally (i.e. should be directed towards the ground)
- Using lower (i.e. closer to the ground) rather than higher lighting installations
- Using lower wavelengths of light wherever possible i.e. red/yellow lights
- Using light intensities that are as low as possible without reducing safety or efficiency
- Avoiding painting large structures bright or reflective colours and minimise use of bright or reflective construction materials and finishes for large structures.

8.9 Mitigating against unplanned wildfire

There is potential for increased wildfire in the Project area if appropriate mitigation measures are not implemented. All of the threatened species that do or may occur within the Project area would be affected by fire. Fire ecology is complex. Avoiding fire altogether would be an ideal aim for rock-wallaby habitat, but less desirable for sandplain habitats, where small and cool patch burns are likely to promote habitat for some species (e.g. bilby). Minimising impacts on fauna from unplanned wildfire will involve:

- Development and implementation of a Fire Management Plan
- Careful planning of where high-risk activities can take place
- Maintenance of fire breaks around high-risk areas/activities
- Active fire management, and the use of small-scale, cool-season control burns.

8.10 Mitigating the risks associated with traffic during construction and operation

Impacts of traffic are not often considered in Recovery Plans and did not feature in recent reviews of the conservation status of the threatened species considered here. Traffic has the potential to impact on threatened species within the Project area.

To minimise and mitigate potential impacts the following actions are recommended:

- Keep the proposed road network to a minimum
- Develop and implement a Traffic Management Plan
- Upgrade high-use areas to be safer for vehicles and fauna (e.g. no blind curves, wider shrub-free verges)
- Fencing of the access road
- Provide road safety and awareness training to all staff and contractors with respect to safe driving in areas where native wildlife is prevalent
- Apply reduced speed limits for vehicles travelling at night
- Implement fatigue management measures for vehicle operators
- Monitor and document roadkill (location and time of day) of threatened species within the Project Area, to determine high-risk periods or locations.

8.11 Mitigating the introduction and/or spread of exotic plants and animals

Complete avoidance of exacerbating the introduction or spread of exotic (non-native) plants and animals should be the Project aim.

Exotic plants (Weeds)

Minimising impacts on fauna from the introduction or spread of weeds will include:

- Development of a Weed Management Plan to document mitigation measures to control existing exotic plants, and to stem the spread of others
- Cleaning vehicles (washdown) that are new to the site, to prevent the introduction of new weeds
- Keeping vehicles to established tracks and roads, and limiting their use off-road
- Annual weed monitoring and mapping, particularly along transport routes
- Weed control activities as required and in consultation/partnership with local landowners as necessary.

Non-native animals

Minimising impacts on native fauna from the introduction or spread of non-native fauna will include:

- Sound waste (garbage) management to prevent invasion/colonisation by Black Rat (*Rattus rattus*). On-site garbage waste will need to be held in a securely fenced compound to prevent artificial population increases in native and non-native predators (i.e. the fence will need to prevent the entry of cats, foxes and dingos). This is particularly important for protection of the Black-footed Rock-wallaby population near the Mine Site
- Investigate innovative passive baiting and trapping methods such as the newly developed 'Feral Cat Grooming Trap' (see <http://www.ecologicalhorizons.com/initiatives> for more information). This trap incorporates four rangefinder sensors, a programmable audiolure, a camera that photographs all activations, a solar-charged battery and an electric motor-tensioned spring (which fires sealed doses of toxic gel at 60 m/s). The sensors ensure that animals smaller or larger than a cat or fox do not activate the trap which holds 20 measured doses and can operate without intervention for several months. Field tests confirm that cats walking past at a distance of within 4m will be sprayed, meaning the Grooming Traps will provide a long-term tool to control trap- or bait-shy cats in areas of high conservation value
- Implement a pest eradication/control program, targeting foxes, cats and rabbits across the Project Area, and non-native rats and mice in Mine Site and accommodation areas
- Monitor populations of feral fauna species, and increase eradication/control efforts as required.

8.12 Mitigating the effects of poisoning fauna with tailings dam water

The tailings dam will not contain any hazardous or toxic substances and there is no opportunity for fauna accessing the dam to be poisoned. In addition, an underdrainage system will be installed to recover water from the tailings for reuse in the process plant. There is not expected to be a significant amount of standing water in the dam.

8.13 Mitigating against inappropriate/ineffective rehabilitation

A Rehabilitation Strategy and a Mine Closure Plan have been developed and will be progressively refined as a component of the Mine Management Plan.

Progressive rehabilitation should be guided by the following principles:

- Areas not required for ongoing operations will be progressively rehabilitated with native vegetation species that replace the fauna habitat that was cleared
- Locate and design landforms to be rehabilitated to optimise blending with the surrounding and pre-mine topography
- Topsoil will be stripped (and stockpiled for later re-use) in a designated area, to prevent erosion or run-off
- Minimise duration of stockpiling of vegetation and topsoil
- Minimise soil erosion, particularly on the batters of the waste rock stockpile;
- Annual monitoring of rehabilitated areas
- If monitoring identifies that completion criteria are not being met, then additional rehabilitation and monitoring will be completed until such criteria are met.

9. Risk assessment of impacts on fauna

This section provides a risk assessment that evaluates individual sources of potential impact for each threatened species. Risk is evaluated before and after mitigation measures are applied. Residual risk is the risk that remains after mitigation, and represents the ecological impact that is likely to result from the project.

Species considered in the risk assessment are identified in Section 9.1.

Risk assessment methods are presented in Section 9.2.

Individual risk assessments for species (as individuals or groups) are presented in Section 9.3.

9.1 Species considered

All species identified for assessment in the project-specific TOR have been considered for this risk assessment, along with a small number of additional species listed as threatened under the EPBC Act and/or TPWC Act that are known or considered likely to occur within the project area (as a result of the fauna survey).

Species listed as Near Threatened or Data Deficient under the TPWC Act, and known or considered likely to occur within the project area (Table 5-10), are not included specifically in this risk assessment. It is assumed that the implementation of all standard and species-specific or habitat-specific mitigation measures will reduce the risk of impacts on those species to an acceptably low level.

Table 9-1 presents a matrix of species by habitat, and shows the habitats where each species would be most likely to occur within the Project area.

Table 9-1 Matrix of habitat association of threatened species that may occur within the Project area.

Species	Mulga woodland	Riparian woodland	Rocky Rises	Spinifex grassland/sandplain	Corymbia woodland
Black-footed Rock-wallaby			Yes		
Greater Bilby	Yes			Yes	
Brush-tailed Mulgara				Yes	
Night Parrot			Yes	Yes	
Princess Parrot	Yes			Yes	Yes
Great Desert Skink				Yes	
Common Brushtail Possum		Yes			
Red Goshawk	Yes	Yes	Yes	Yes	Yes
Southern Marsupial Mole				Yes	
Grey Falcon	Yes	Yes	Yes	Yes	Yes

Species that occupy similar habitats or that are predicted to be similarly vulnerable to impacts are grouped for the purposes of the risk assessment. These species are likely to encounter similar impacts and be impacted in similar ways (unless stated), and mitigation efforts are likely to reduce the risks in similar ways. This approach avoids unnecessary repetition of information. Risk assessments are presented as follows:

- Fauna in rocky habitat (Black-footed Rock-wallaby (MacDonnell Ranges race), *Petrogale lateralis*)
- Ground-dwelling sandplain fauna with limited mobility (Greater Bilby, *Macrotis lagotis*; Brush-tailed Mulgara, *Dasycercus blythi*; Great Desert Skink, *Liopholis kintorei*; Southern Marsupial Mole, *Notoryctes typhlops*)
- Arid-zone avifauna with high mobility (Night Parrot, *Pezoporus occidentalis*; Red Goshawk, *Erythrorhynchus radiatus*; Princess Parrot, *Polytelis alexandrae*; Grey Falcon, *Falco hypoleucos*)
- Fauna in riparian habitat (Common Brushtail Possum (Southern N.T.), *Trichosurus vulpecula vulpecula*).

The assessment is risk averse in that most of the species were not recorded during the study. For the purposes of the risk assessment, each species is regarded as having a “population” in the Project area until it is demonstrated that no population exists.

9.2 Risk assessment method

Levels of risk, possible mitigation of risk and determination of residual risk to threatened species (and the fauna community as a whole) were determined using standard qualitative risk assessment procedures (Table 9-2) (A/NZS 4360:2004).

Assessments of risk are conducted assuming implementation of proposed mitigation for potential impacts. Where risks are high, additional mitigation is proposed to reduce residual risk to lowest practicable risk outcomes. The questions asked in each case were what was the likelihood of source of impact (e.g. land clearing) having a deleterious consequence on a threatened species, and what was the severity of the consequence if it occurred? Levels of likelihood and severity of consequences are defined in Table 9-3 and Table 9-4 respectively.

Table 9-2 Qualitative risk analysis matrix

		Severity of Consequence				
		Critical (5)	Major (4)	Significant (3)	Moderate (2)	Minor (1)
Likelihood of Consequence	Almost Certain (5)	Extreme	High	High	Medium	Medium
	Likely (4)	High	High	Medium	Medium	Low
	Possible (3)	High	Medium	Medium	Low	Low
	Unlikely (2)	Medium	Medium	Low	Low	Very Low
	Rare (1)	Medium	Low	Low	Very Low	Very Low

Table 9-3 Definitions of level of likelihood

Level of Likelihood	Definitions
Almost certain	The event is expected to occur in most circumstances (The event is likely to occur in the next 12 months)
Likely	The event will probably occur in most circumstances (The event is likely to occur in the next 1 – 2 years).
Possible	The event might occur at some time (The event is likely to occur in the next 2 – 5 years).
Unlikely	The event could occur at some time (The event is likely to occur in the next 5 – 10 years).
Rare	The event may occur only in exceptional circumstances (The event is not likely to in the next 10 years).

Table 9-4 Definitions of level of consequence

Levels of Consequence	Definitions
Critical	Extensive long term environmental harm and/or harm that is extremely widespread. Impacts unlikely to be reversible within 10 years.
Major	Major or widespread, unplanned environmental impact on or off the site. Significant resources required to respond and rehabilitate.
Significant	Significant, unplanned environmental impact contained within the site or minor impact that is off the site.
Moderate	Moderate, unplanned localised environmental impact contained on-site or with negligible off-site impact.
Minor	Minor environmental impact. Any impacts are contained on-site and short term in nature.

9.3 Risk assessments - threatened species

Risk assessments for species (as individuals or groups) are presented in Table 9-5 to Table 9-8.

Table 9-5 Project Risk Assessment – Black-footed Rock-wallaby (MacDonnell Ranges Race) (*Petrogale lateralis*)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference
Clearing of habitat	2	1	Very Low	A loss of 8.35 ha of potentially suitable (low quality) rocky habitat, and additional loss of habitats that may be used rarely by dispersing individuals to access other rocky areas. The loss of rocky habitat equates to 0.83% of the vegetation proposed to be cleared as a result of the project. Removal of habitat is considered to be unlikely to result in impacts on the local population of Black-footed Rock-wallaby, and to have a minor impact if it does.	– Minimise impact via actions in Section 8.1; – Produce and apply dedicated Biodiversity Management Plan (BMP) and ensure appropriate construction, weed, weed hygiene, fire and rehabilitation management aspects are covered in an attempt to minimise and mitigate clearing effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.1 and 8.1
Habitat fragmentation	2	1	Very Low	The project is not expected to result in further isolation of any population of Black-footed Rock-wallaby. Habitat fragmentation is considered unlikely to occur, and to have a minor impact on the Black-footed Rock-wallaby if it does.	– Further minimise potential for impact via actions in Section 8.1.	Very Low	Sections 7.2.2 and 8.1
Altered hydrology	1	1	Very Low	Altered hydrology as a result of the Project is not expected to impact on any population of Black-footed Rock-wallaby in its core habitat (rocky rises). Altered hydrology may impact on non-rocky habitats that are used occasionally for dispersal or foraging. Hydrology impacts on this species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	3	2	Low	Deleterious changes in water quality as a result of the Project could impact on the Black-footed Rock-wallaby when it comes to affected watercourses or waterbodies to drink. Without mitigation, impacts of this nature on this species are possible , and would have a moderate impact if they occurred.	– Minimise impact via actions in Section 8.2; – Produce and apply dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid contamination or deleterious changes in water quality.	Very Low	Sections 7.2.4 and 8.2
Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on any population of Black-footed Rock-wallaby. Impacts on this species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction is not expected to impact on any population of Black-footed Rock-wallaby. Impacts on this species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.3.	Very Low	Sections 7.2.6 and 8.3

Lowering or contamination of water table	1	1	Very Low	Because the Black-footed Rock-wallaby occupies rocky hills and slopes, it does not rely on groundwater dependent ecosystems or habitats. Therefore, lowering or contamination of the water table would have minor impacts on the Black-footed Rock-wallaby population, and it would be a rare event.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.7 and 8.2
Impacts on surface or groundwater systems	3	2	Low	Impacts on surface or groundwater systems as a result of the Project could impact on the Black-footed Rock-wallaby if individuals come to contaminated watercourses or waterbodies to drink. Without mitigation, impacts of this nature on this species are possible , and would have a moderate impact if they occurred.	– Minimise impact via actions in Section 8.2; – Produce and apply dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid impacts on surface or groundwater systems.	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	1	1	Very Low	Because the Black-footed Rock-wallaby occupies rocky hills and slopes, it is unlikely to encounter waste materials that result from the project. Therefore, impacts of this nature on this species would be rare , and would have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.4.	Very Low	Sections 7.2.9 and 8.4
Waste material – domestic	3	3	Medium	Domestic waste products (in the form of garbage/refuse) themselves will not impact on the Black-footed Rock-wallaby, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and their predators (cats, foxes and dingoes), which might then prey more heavily on Rock-wallabies. Without mitigation, such impacts are possible and the severity could be significant . Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.5; – Produce and apply a dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Very Low	Sections 7.2.10 and 8.5
Noise	3	1	Low	Rocky outcrops scattered throughout the area are likely to be suitable for the Black-footed Rock-wallaby. The species is known to occur in nearby rocky ranges and may occasionally move through the Project area to access different patches of suitable habitat. Noise generated by the mine is likely to preclude rock-wallaby movements through the Mine Site, however particularly noisy activities would likely occur during daylight hours when rock-wallabies (generally nocturnal) tend to be sheltering, and noise would be somewhat buffered and deflected by their rocky, elevated habitat. Fauna can habituate to predictable noises with time (this includes the Black-footed Rock-wallaby, which occurs in the rocky hills in central Alice Springs. Therefore, some of the noise impacts may be short-term impacts. Without mitigation, impacts from noise are possible but the severity would be minor . Mitigation and management can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.6; – The implementation of noise controls as defined in a Noise Management Plan – likely to include the avoidance of loud noise at night when rock-wallabies are active; – Produce and apply dedicated BMP and ensure appropriate noise controls are in place in an attempt to minimize and mitigate noise effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.11 and 8.6

Dust	3	1	Low	There is habitat for the Black-footed Rock-wallaby within 2 km of the Mine Site, and this species may be exposed to higher levels of dust. Without mitigation, impacts from dust are possible but the severity is expected to be minor . Mitigation and management can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.7; – Produce and apply dedicated BMP and ensure appropriate dust controls are in place in an attempt to minimize and mitigate dust effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small effect on any transitory rock-wallabies moving through the mine site footprint. Light emitted from the proposed mine is unlikely to impact on rock-wallaby populations >2 km from the proposed mine site. Impacts from lighting are unlikely and the severity is likely to be minor .	– Further minimise potential for impact via actions in Section 8.8; – Avoiding unnecessary lighting at night when rock-wallabies are active and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood of impacts; – Produce and apply dedicated BMP and ensure appropriate lighting controls are in place in an attempt to minimize and mitigate artificial light effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.13 and 8.8
Unplanned Wildfire	3	4	Medium	Wildfire within Black-footed Rock-wallaby habitat can have a major impact as it burns food plants rendering habitats unsuitable for periods of time. Continued persistence of the Black-footed Rock-wallaby in the area will depend on prevention of wildfire in the surrounding rocky habitats of the study area and surrounds. It is possible that extensive unplanned wildfire as a result of mine activities could have a major impact. Mitigation can be used to reduce the likelihood (to unlikely) but a major impact could still result.	– Minimise likelihood of impact via actions in Section 8.9; – Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place in an attempt to minimize and mitigate the potential impacts on the Black-footed Rock-wallaby population of the area; – A Bushfire Management Plan will be required to manage the risk.	Medium	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	1	1	Very Low	Because the Black-footed Rock-wallaby occupies rocky hills and slopes, and occasionally disperses across lower ground to reach other rocky slopes, it would be rarely encountered on roads or tracks. Therefore, mortality from collisions with vehicles would be rare and would have a minor impact on the local Black-footed Rock-wallaby population.	– Further minimise potential for impact via actions in Section 8.10; – Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP.	Very Low	Sections 7.2.15 and 8.10

Exotic plants and animals	4	4	High	Without efforts to minimize its likelihood, the introduction of exotic plants and animals as a result of mine activities is likely to occur and could have a major impact on the survival of the Black-footed Rock-wallaby population. An increase in the incidence of cats, foxes and dingos (e.g., through inadequate management of garbage) could result in increased rock-wallaby predation, particularly of more vulnerable juveniles. An increase in the incidence of weeds, particularly Buffel Grass, could have major implications for rock-wallaby habitat. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	– Minimise impact via actions in Section 8.11 – Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimise and mitigate the potential 'High' impacts of exotic plants and animals on the Black-footed Rock-wallaby population of the area; – Construct a predator-proof compound to contain food waste; – As part of BMP incorporate a monitoring program for weeds and pest animals.	Low	Sections 7.2.16 and 8.11
Poisoning of fauna from drinking contaminated water	1	1	Very Low	There is a low likelihood that rock-wallabies would descend from their rocky habitats to drink from tailings facilities. Impacts of this nature on this species are likely to be rare , and would have a minor impact on a population if they occurred.	– Further minimise potential for impact via actions in Section 8.12; – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than rock-wallabies.	Very low	Sections 7.2.17 and 8.12
Inappropriate/ineffective rehabilitation	4	4	High	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Weeds are likely to invade unless mitigation efforts are undertaken, and could have a major impact. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.13; – Produce and apply dedicated BMP and ensure appropriate construction, weed, weed hygiene, fire and rehabilitation management aspects are covered to minimize and mitigate clearing effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.18 and 8.13

Table 9-6 Project Risk Assessment – Sandplain ground-dwelling fauna (Greater Bilby, Brush-tailed Mulgara, Great Desert Skink, Southern Marsupial Mole)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference
Clearing of habitat	4	2	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential breeding, foraging and dispersal habitat for the Greater Bilby, Brush-tailed Mulgara, Great Desert Skink and Southern Marsupial Mole, equating to 97.1% of the vegetation proposed to be cleared as a result of the project. (Table 7-1). This comprises the loss of 558.58 ha of Spinifex grassland (55.4% of cleared area) and 420.25 ha of Mulga woodland (41.7% of cleared area). Most of this loss is associated with construction of the haul road. Without mitigation, removal of habitat is likely to impact on the populations of Greater Bilby, Brush-tailed Mulgara, Great Desert Skink and Southern Marsupial Mole that occur in the Project area. Impacts have the potential to be moderate . Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor .	- Minimise impact via actions in Section 8.1; - Implement clearing during autumn when breeding has ended. Avoid clearing during the winter/spring months when some animals (particularly reptiles) are inactive in burrows or breeding; - Have a qualified ecologist on-site during the clearing to capture and translocate animals encountered during the clearing process; - Produce and apply a dedicated BMP and ensure appropriate construction management results in minimizing clearing effects on the threatened species populations of the area.	Low	Sections 7.2.1 and 8.1
Habitat fragmentation	4	2	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential habitat for the Greater Bilby, Brush-tailed Mulgara, Great Desert Skink and Southern Marsupial Mole. Much of the habitat loss is associated with construction of the haul road, which will fragment the habitat for small ground-dwelling fauna, and increase the risk of injury or death of fauna that cross the haul road at inopportune times. Without mitigation, impacts on fauna are likely , and have the potential to be moderate . Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor .	- Further minimise impact via actions in Section 8.1; - Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene, fire, dust and rehabilitation management result in minimizing fragmentation effects and edge effects (ie unintentional widening of corridors through weed invasion or subsequent death of retained vegetation along edges); - Implement strict vehicle hygiene protocols to prevent new weed incursion and spread, including a vehicle wash down facility on site; - Limit vehicle speeds and restrict vehicle movements to daylight hours only, to allow fauna (particularly nocturnal species) to cross corridors of cleared habitat more safely, thereby reducing the impact of habitat fragmentation.	Low	Sections 7.2.2 and 8.1

Altered hydrology	1	1	Very Low	Altered hydrology as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Hydrology impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	1	1	Very Low	Deleterious changes in water quality as a result of the Project are unlikely to impact on sandplain ground-dwelling fauna. Water quality impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.4 and 8.2
Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Erosion and sedimentation impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Soil compaction impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.3.	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	1	1	Very Low	Lowering or contamination of the water table as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Water table impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.7 and 8.2
Impacts on surface or groundwater systems	1	1	Very Low	Changes to surface or groundwater systems as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	3	3	Medium	Industrial waste material on its own is not expected to result in direct impacts on sandplain fauna. However, the need to dump and transport waste materials has the potential to contribute to other impacts, namely: – Injury and death of fauna as a result of increase in waste-carrying transport and resulting collisions with wildlife; – Clearing of breeding and/or foraging habitat to create space to store/pile waste products; – Dust as a result of increased traffic and specifically due to haulage of waste rock; and – Spread and invasion of weeds. All of these could indirectly impact on sandplain fauna, and collectively, significant impacts are possible without mitigation. These impacts are addressed in turn in other sections of this risk assessment. Mitigation and management can reduce the risks to be possible and minor, or lower.	– Minimise potential for impact resulting from injury and death of fauna from vehicle collisions via actions in Section 8.10; – Minimise potential for impact resulting from clearing of habitat via actions in Section 8.1; – Minimise potential for impact resulting from dust via actions in Section 8.7; – Minimise potential for impact resulting from weed invasion via actions in Section 8.11; – Further minimise potential for impact via actions in Section 8.4.	Low	Sections 7.2.9, 8.1, 8.4, 8.7, 8.10, 8.11.

Waste material – domestic	3	5	High	Domestic waste products (in the form of garbage/refuse) themselves will not impact on sandplain fauna, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and the vermin attracting their predators (cats, foxes and dingoes). Larger numbers of predators would greatly increase the risk of predation on ground-dwelling sandplain fauna, possibly to the point of localized extinction. Without mitigation, such impacts are possible and the severity could be critical . Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	– Minimise impact via actions in Section 8.5; – Produce and apply dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Low	Sections 7.2.10 and 8.5
Noise	3	1	Low	Noise generated by the mine is likely to preclude movements of some sandplain fauna through the Mine Site, however particularly noisy activities would likely occur during daylight hours when most of the fauna (mostly nocturnal) tend to be sheltering. Most fauna can habituate to predictable noises with time. Therefore, some of the noise impacts may be short-term impacts. Without mitigation, impacts from noise are possible but the severity would be minor . Management and mitigation can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.6; – The implementation of noise controls as defined in a Noise Management Plan (possibly as part of the BMP) – likely to include the avoidance of loud noise at night when most sandplain fauna are active.	Very Low	Sections 7.2.11 and 8.6
Dust	2	1	Very Low	Sandplain fauna live in dusty habitats, and many of them dig burrows in dusty ground. Consequently, these species are likely to be adapted to coping with dusty conditions. Additional impacts on those species from dust as a result of this project are considered unlikely and are expected to be minor if they occur.	– Further minimise potential for impacts via actions in Section 8.7; – Produce and apply dedicated BMP and ensure appropriate dust controls are in place to minimize and mitigate dust effects on sandplain fauna populations of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small and localized effect on nocturnal threatened sandplain fauna (e.g. Crest-tailed Mulgara, Greater Bilby). Impacts from lighting are unlikely and the severity is likely to be minor .	– Further minimise potential for impact via actions in Section 8.8; – Avoiding unnecessary lighting at night when sandplain fauna would be most affected and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood and severity of impacts; – Produce and apply dedicated BMP and ensure appropriate lighting controls are in place to minimize artificial light effects on the fauna populations of the area.	Very Low	Sections 7.2.13 and 8.8

Unplanned Wildfire	3	4	Medium	It is possible that extensive unplanned wildfire as a result of mine activities could have a major impact on populations of sandplain fauna, particularly those that are less mobile or that are territorial or tend to remain within discrete areas (rather than being nomadic across a larger area). Species at greatest risk may be Great Desert Skink and Brush-tailed Mulgara. These species are likely to rely on the habitats within a relatively small area, and would be more vulnerable if their habitat is burnt out. Mitigation can be used to reduce the likelihood (to unlikely) but a major impact could still result.	- Minimise likelihood of impact via actions in Section 8.9; - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place to minimize and mitigate the potential for impacts on sandplain fauna, including the Great Desert Skink and Brush-tailed Mulgara; - A separate Bushfire Management Plan will be required to manage this risk.	Medium	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	4	2	Medium	Without mitigation, impacts on sandplain fauna from collisions with vehicles due to increased traffic (particularly along the haul road) are likely , and could have a moderate impact on species such as the Crest-tailed Mulgara and Great Desert Skink. Vehicle movements during dawn, dusk and nighttime would result in the highest risk to fauna. Management and mitigation efforts can be implemented to reduce the risk to unlikely and minor .	- Minimise likelihood and severity of impact via actions in Section 8.10; - Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP. - Restrict vehicle movements (particularly along the haul road) to be during daylight hours only – this would greatly reduce the chance of vehicle strike with species such as Great Desert Skink and Brush-tailed Mulgara, which are predominantly nocturnal; - Limit vehicle speeds, particularly during dawn, dusk and nighttime (if vehicle movements required during those times). - Produce and apply a Weed Hygiene Procedure and provision of on-site wash down facilities, to minimize the risk of weed invasion which could indirectly impact on sandplain fauna.	Very Low	Sections 7.2.15 and 8.10
Exotic plants and animals	4	4	High	Without adequate management and mitigation, the introduction of exotic plants and animals as a result of mine activities is likely to result in impacts on sandplain fauna, and those impacts have the potential to be major . Changes to habitats as a result of weed invasion are of concern, but the primary concern is any action that results in an increase in numbers of cats, foxes and dingos, which would then be likely to prey more heavily on sandplain fauna. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	- Minimise likelihood and severity of impact via actions in Section 8.11; - Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential 'High' impacts of exotic plants and animals on sandplain fauna populations of the area; - Construct a predator-proof compound to contain food waste; - As part of BMP incorporate a monitoring program for weeds and pest animals.	Low	Sections 7.2.16 and 8.11

Poisoning of fauna from drinking contaminated water	1	1	Very Low	Poisoning of sandplain fauna as a result of the Project is not expected occur. Such an impact on these species would be rare , and have a minor impact if it occurred.	– Further minimise potential for impact via actions in Section 8.12; – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Very low	Sections 7.2.17 and 8.12
Inappropriate/ineffective rehabilitation	4	4	High	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed-dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Unless rehabilitation is appropriate and effective, impacts are likely to occur and have the potential to be major . Mitigation efforts should reduce the likelihood of impacts to be unlikely, and reduce the scale of the impact to be localized such that it is minor. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.13; – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene and rehabilitation management aspects minimize and mitigate impacts on sandplain fauna populations of the area.	Very Low	Sections 7.2.18 and 8.13

Table 9-7 Project Risk Assessment – Arid zone avifauna with high mobility (Night Parrot, Red Goshawk, Princess Parrot, Grey Falcon)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference
Clearing of habitat	2	1	Very Low	All habitats cleared as a result of the project incorporate potential breeding, foraging and dispersal habitat for this group of species. The Grey Falcon and Princess Parrot are likely to use all habitat types in the Project area, perhaps favouring the open spinifex habitats. The Night Parrot is also likely to favour spinifex sandplain habitat. The Red Goshawk is likely to favour the taller trees in riparian habitat and Corymbia woodland. However, given the way these species tend to use their habitats, the impacts of the proposed clearing are expected to be minimal for these species. These species tend to forage over broad areas, relying less on any particular patch. Thus, these species can tolerate small scale removal of habitat patches, so long as high quality and accessible patches occur elsewhere in the locality. It is acknowledged that any removal of habitat results in incremental degradation of habitat for these species. The degradation may be immeasurably small, but it contributes nonetheless. The proposed clearing of habitat is unlikely to have a measurable impact on these highly-mobile bird species, and is therefore expected to be minor.	– Further minimise potential for impact via actions in Section 8.1.	Very Low	Sections 7.2.1 and 8.1
Habitat fragmentation	2	1	Very Low	Habitat clearing resulting from the project will fragment potential habitat for this group of species, but cleared areas are unlikely to disrupt movement by these species. These species are highly mobile and, as birds, they can easily move from one habitat patch to another. Therefore, fragmentation impacts from the proposed clearing are unlikely to have a measurable impact on these species, and are therefore expected to be minor.	– Further minimise potential for impact via actions in Section 8.1.	Very Low	Sections 7.2.2 and 8.1

Altered hydrology	1	1	Very Low	In general, altered hydrology as a result of the Project is not expected to have a measurable impact on this group of highly mobile avifauna. Small-scale impacts may result if altered hydrology results in the death of large trees (eg, groundwater-dependent trees in riparian habitats), which may provide favoured roost or nest sites for all species except the Night Parrot. Hydrology impacts on this group of highly mobile bird species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	3	1	Low	Deleterious changes in water quality as a result of the Project could impact on this group of highly mobile avifauna when very small numbers of individuals come to watercourses or waterbodies to drink. Impacts of this nature on this species are possible , but would have a minor impact if they occurred. Management and mitigation can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.2; – Produce and apply a dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid contamination or deleterious changes in water quality.	Very Low	Sections 7.2.4 and 8.2
Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on this group of highly mobile avifauna. Erosion and sedimentation impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction as a result of the Project is not expected to impact on this group of highly mobile avifauna. Soil compaction impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.3.	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	1	1	Very Low	Lowering or contamination of the water table as a result of the Project is not expected to impact on this group of highly mobile avifauna. Small-scale impacts may result if altered hydrology results in the death of large trees (eg, groundwater-dependent trees in riparian habitats), which may provide favoured roost or nest sites for all species except the Night Parrot. Water table impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.7 and 8.2
Impacts on surface or groundwater systems	1	1	Very Low	Changes to surface or groundwater systems as a result of the Project are not expected to impact on this group of highly mobile avifauna. Small-scale impacts may result if altered hydrology results in the death of large trees (eg, groundwater-dependent trees in riparian habitats), which may provide favoured roost or nest sites for all species except the Night Parrot. Impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2.	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	1	1	Very Low	Industrial waste material is not expected to result in measurable direct or indirect impacts on this group of highly mobile avifauna. Impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.10.	Very Low	Sections 7.2.9 and 8.10

Waste material – domestic	3	5	High	Domestic waste products (in the form of garbage/refuse) themselves will not impact on highly mobile avifauna, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and the vermin attracting their predators (cats, foxes and dingoes). Larger numbers of predators could greatly increase the risk of predation on the Night Parrot (which spends the majority of its time at or near the ground), possibly to the point of localized extinction. The other species are expected to be impacted less. Without mitigation, impacts (particularly on Night Parrot) are considered possible and the severity (if a population of Night Parrots occurs in or uses the Project area) could be critical . Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	- Minimise impact via actions in Section 8.5; - Produce and apply dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Low	Sections 7.2.10 and 8.5
Noise	2	1	Very Low	Impacts from noise are possible but the severity for mobile avifauna is expected to be minor . Most fauna can habituate to predictable noises with time.	Further minimise the potential for impact via actions in Section 8.6.	Very Low	Sections 7.2.11 and 8.6
Dust	2	1	Very Low	These species of highly mobile avifauna are likely to be adapted to coping with dusty conditions. Activities that generate large quantities of dust are likely to drive these species out of local areas at least for the short term, but are likely to push them into adjacent non-dusty areas rather than drive them out of the entire Project area. Measurable impacts from dust as a result of this project are considered unlikely and are expected to be minor if they occur.	- Further minimise potential for impacts via actions in Section 8.7; - Produce and apply dedicated BMP and ensure appropriate dust controls are in place to minimize and mitigate dust effects on mobile avifauna populations of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small and localized effect on nocturnal fauna. For this group of mobile avifauna, this is the Night Parrot. Impacts from lighting are considered unlikely and the severity is expected to be minor .	- Further minimise potential for impact via actions in Section 8.8; - Avoiding unnecessary lighting at night when fauna would be most affected and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood and severity of impacts; - Produce and apply dedicated BMP and ensure appropriate lighting controls are in place to minimize artificial light effects on the fauna populations of the area.	Very Low	Sections 7.2.13 and 8.8

Unplanned Wildfire	3	3	Medium	Extensive unplanned wildfire as a result of mine activities has the potential to have a major impact on fauna populations that rely on the habitats that burn, and/or that cannot escape the fire. Grey Falcon, Red Goshawk and Princess Parrot are likely to be able to escape the fire and seek alternative non-burned habitats, but there is a small chance of impact on those species if the fire occurs during the nesting season and any species has a nest near the ground within the area that burns. The likelihood of impact from fire on the Night Parrot is higher. This species appears to spend most of its time on or near the ground, sheltering in spinifex habitat by day and foraging in spinifex habitat by night, and nesting in large clumps of spinifex. Thus, fire in spinifex habitat has the potential to greatly disrupt the success of the Night Parrot. It is possible that extensive unplanned wildfire as a result of mine activities could have a significant impact on the Night Parrot, if it occurs within the Project area. Mitigation can be used to reduce the likelihood (to unlikely) but a significant impact could still result.	– Minimise likelihood of impact via actions in Section 8.9; – Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place to minimize the potential for impacts on fauna; – A separate Bushfire Management Plan will be required to manage this risk.	Low	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	2	2	Low	This group of highly-mobile avifauna comprises species that are generally sparse/rare and that occur in small numbers. Therefore, collisions with vehicles due to increased traffic (particularly along the haul road) are unlikely, but there could be a moderate impact if such collisions occur. Management and mitigation efforts will serve to greatly reduce the risk such that the likelihood is rare.	– Minimise likelihood and severity of impact via actions in Section 8.10; – Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP. – Limit vehicle speeds, particularly during dawn, dusk and nighttime (if vehicle movements required during those times). – Produce and apply a Weed Hygiene Procedure and provision of on-site wash down facilities, to minimize the risk of weed invasion which could indirectly impact on fauna.	Very Low	Sections 7.2.15 and 8.10
Exotic plants and animals	3	4	Medium	Without adequate management and mitigation, it is possible that the introduction of exotic plants and animals as a result of mine activities could result in direct impacts on two species (Night Parrot and Princess Parrot) and indirect impacts on the other species (Grey Falcon and Red Goshawk). Impacts of increased numbers of non-native predators (cats, foxes) on the Night Parrot have the potential to be major. Impacts of predators and weeds on other species are expected to be less. Management and mitigation efforts will serve to greatly reduce the risk posed by increases in exotic plants and animals such that the likelihood is unlikely and the severity is minor.	– Minimise likelihood and severity of impact via actions in Section 8.11; – Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential impacts of exotic plants and animals on fauna populations of the area; – Construct a predator-proof compound to contain food waste; – As part of BMP incorporate a monitoring program for weeds and pest animals.	Very Low	Sections 7.2.16 and 8.11

Poisoning of fauna from drinking contaminated water	3	1	Low	Poisoning of avifauna as a result of the Project is possible , if birds come to drink at contaminated sources. This is likely to involve small numbers of individuals if it occurs. Such an impact on these species is expected to be minor if it occurred. Management and mitigation efforts can reduce the likelihood to rare .	– Further minimise potential for impact via actions in Section 8.12; – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Very low	Sections 7.2.17 and 8.12
Inappropriate/ineffective rehabilitation	3	1	Low	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed-dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Impacts from inappropriate or ineffective rehabilitation are possible , but would be expected to have no more than a minor impact on these mobile avifauna. Management and mitigation efforts can reduce the likelihood to rare .	– Minimise impact via actions in Section 8.13; – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene and rehabilitation management aspects minimize and mitigate impacts on fauna populations of the area.	Very Low	Sections 7.2.18 and 8.13

Table 9-8 Project Risk Assessment – Fauna in riparian habitat (Common Brushtail Possum (Southern NT))

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference
Clearing of habitat	2	1	Very Low	A loss of 2.9 ha of potentially suitable riparian habitat, which equates to 0.29% of the vegetation proposed to be cleared as a result of the project. Removal of habitat is considered to be unlikely to result in impacts on the local population of Common Brushtail Possum, and to have a minor impact if it does.	– Further minimise potential for impact via actions in Section 8.1.	Very Low	Sections 7.2.1 and 8.1
Habitat fragmentation	3	2	Low	Due to the linear nature of riparian habitat along watercourses, removal of habitat has the potential to disrupt habitat continuity for the Common Brushtail Possum, and has the potential to fragment the population and isolate sub-populations. It is possible that the resulting impact could be moderate , if individuals cannot bridge the gap. Management and mitigation efforts can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.1; – Produce and apply a dedicated BMP and ensure appropriate construction management aspects are covered to minimize and mitigate fragmenting effects on riparian habitat. This may involve creating additional treed habitat to link isolated habitat patches.	Very Low	Sections 7.2.2 and 8.1
Altered hydrology	3	3	Medium	Altered hydrology as a result of the Project is most likely to impact on watercourses and riparian habitat. Therefore, without mitigation, impacts on the Common Brushtail Possum are possible , and have the potential to be significant if the altered hydrology results in broadscale death of large hollow-bearing trees along watercourses, and that tree death results in loss or fragmentation of habitat. Management and mitigation efforts can reduce the likelihood to unlikely and the severity to minor .	– Minimise potential for impact via actions in Section 8.2; – Produce and apply a dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid deleterious changes in local hydrology.	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	3	1	Low	Deleterious changes in water quality as a result of the Project could impact on the Common Brushtail Possum when it comes to affected watercourses or waterbodies to drink. Impacts of this nature on this species are possible , and would have a minor impact if they occurred. Management and mitigation efforts can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.2; – Produce and apply a dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid contamination or deleterious changes in water quality.	Very Low	Sections 7.2.4 and 8.2

Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on the Common Brushtail Possum. Gradual, long-term changes (eg, sediments smothering and killing trees, erosion destabilizing trees) may cause impacts over time if erosion and sedimentation are severe. Management and mitigation efforts will reduce the likelihood of this. Generally, impacts of this nature on this species would be expected to be rare and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2;	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction is not expected to impact on Common Brushtail Possum. Impacts on this species would be rare , and minor if they occurred.	– Further minimise potential for impact via actions in Section 8.3;	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	3	3	Medium	Lowering or contamination of water table as a result of the Project is most likely to impact on watercourses and riparian habitat. Therefore, without mitigation, impacts on the Common Brushtail Possum are possible , and have the potential to be significant if changes to the water table result in broadscale death of large hollow-bearing trees along watercourses, and that tree death results in loss or fragmentation of habitat. Management and mitigation efforts can reduce the likelihood to unlikely and the severity to minor .	– Minimise potential for impact via actions in Section 8.2; – Produce and apply a dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid deleterious changes to the water table.	Very Low	Sections 7.2.7 and 8.2
Impacts on surface or groundwater systems	3	3	Medium	Deleterious changes to the surface or groundwater systems as a result of the Project are most likely to impact on watercourses and riparian habitat. Therefore, without mitigation, impacts on the Common Brushtail Possum are possible , and have the potential to be significant if changes to the water table result in broadscale death of large hollow-bearing trees along watercourses, and that tree death results in loss or fragmentation of habitat. Management and mitigation efforts can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.2; – Produce and apply a dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid impacts on surface or groundwater systems.	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	2	1	Very Low	Direct and indirect impacts from generation, storage, handling, and transportation of industrial waste materials are not expected to impact on Common Brushtail Possum. Impacts on this species would be unlikely , and minor if they occurred.	– Further minimise potential for impact via actions in Section 8.4;	Very Low	Sections 7.2.9 and 8.4

Waste material – domestic	3	1	Low	Domestic waste products (in the form of garbage/refuse) themselves will not impact on the Common Brushtail Possum, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and their predators (cats, foxes and dingoes), which might then prey more heavily on all small fauna, including possums. However, the Common Brushtail Possum is partially arboreal and seeks refuge in trees, thereby reducing the risk. Without mitigation, impacts on this species are possible and the severity could be minor . Management and mitigation efforts can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.5; – Produce and apply a dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Very Low	Sections 7.2.10 and 8.5
Noise	3	1	Low	Noise generated by the mine is likely to preclude movements of some fauna through the Mine Site, however particularly noisy activities would likely occur during daylight hours when nocturnal fauna (including Common Brushtail Possum) tend to be sheltering. Most fauna can habituate to predictable noises with time. Therefore, some of the noise impacts may be short-term impacts. Without mitigation, impacts from noise are possible but the severity would be minor . Management and mitigation can reduce the likelihood to unlikely .	– Minimise impact via actions in Section 8.6; – The implementation of noise controls as defined in a Noise Management Plan (possibly as part of the BMP) – likely to include the avoidance of loud noise at night when many fauna are active.	Very Low	Sections 7.2.11 and 8.6
Dust	2	1	Very Low	Most desert fauna (including Common Brushtail Possum) are likely to be adapted to coping with dusty conditions. Activities that generate large quantities of dust may drive small numbers of individuals out of local areas at least for the short term, but are likely to push them into adjacent non-dusty areas rather than drive them out of the entire Project area. Measurable impacts from dust as a result of this project are considered unlikely and are expected to be minor if they occur.	– Further minimise potential for impacts via actions in Section 8.7; – Produce and apply a dedicated BMP and ensure appropriate dust controls are in place to minimize and mitigate dust effects on fauna populations of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small effect on Common Brushtail Possums that use riparian habitats near the mine site footprint. Impacts from lighting are unlikely and the severity is expected to be minor .	– Further minimise potential for impact via actions in Section 8.8 – Avoiding unnecessary lighting at night when possums are active and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood of impacts; – Produce and apply a dedicated BMP and ensure appropriate lighting controls are in place to minimize artificial light effects on the Common Brushtail Possums in the area.	Very Low	Sections 7.2.13 and 8.8

Unplanned Wildfire	3	3	Medium	It is possible that extensive unplanned wildfire as a result of mine activities could have a significant impact on the Common Brushtail Possum, particularly if it burns large hollow-bearing trees in riparian habitat. Mitigation can be used to reduce the likelihood (to unlikely) but a significant impact could still result.	– Minimise likelihood of impact via actions in Section 8.9; – Produce and apply a dedicated BMP and ensure appropriate wildfire controls are in place to minimize the potential impacts on fauna in the area; – A Bushfire Management Plan will be required to manage the risk.	Medium	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	2	1	Very Low	Because the Common Brushtail Possum occupies large trees in riparian habitats, it would be rarely encountered on roads or tracks, except where those roads cross waterways. Therefore, mortality from collisions with vehicles would be unlikely and would have a minor impact on the local Common Brushtail Possum population. Mitigation can reduce the likelihood to rare .	– Further minimise potential for impact via actions in Section 8.10; – Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP; – Limit vehicle speeds in all locations where roads cross waterways.	Very Low	Sections 7.2.15 and 8.10
Exotic plants and animals	3	1	Low	Without adequate management and mitigation, it is possible that the introduction of exotic plants and animals as a result of mine activities could impact on the Common Brushtail Possum. Impacts of predators and weeds on the possums are expected to be minor . Mitigation can reduce the likelihood to unlikely .	– Minimise likelihood and severity of impact via actions in Section 8.11; – Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential impacts of exotic plants and animals on fauna populations of the area; – Construct a predator-proof compound to contain food waste; – As part of BMP incorporate a monitoring program for weeds and pest animals.	Very Low	Sections 7.2.16 and 8.11
Poisoning of fauna from drinking contaminated water	3	2	Low	Poisoning of riparian fauna (Common Brushtail Possum) as a result of the Project is possible , if individuals come to drink at contaminated sources. Such an impact is expected to be moderate if it occurred. Management and mitigation efforts can reduce the likelihood to rare and the severity to minor .	– Further minimise potential for impact via actions in 8.12; – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Very low	Sections 7.2.17 and 8.12

Inappropriate/ineffective rehabilitation	4	2	Medium	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Weeds are likely to invade unless mitigation efforts are undertaken, but would not be expected to have any more than a moderate impact on the Common Brushtail Possum. Management and mitigation efforts can reduce the likelihood to unlikely and the severity to minor.	– Minimise impact via actions in Section 8.13; – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene and rehabilitation management aspects minimize and mitigate impacts on fauna populations of the area.	Very Low	Sections 7.2.18 and 8.13

9.4 Evaluation of impact significance under the EPBC Act

A 'real chance or probability' of a significant impact from a particular source is defined as there being an extreme or high risk of a population (or the fauna community) experiencing a significant consequence as defined in the guidelines (e.g. lead to a long-term decrease in the size of a population).

9.4.1 Definitions and criteria for determining significant impacts

Evaluation of the significance of potential impacts is based on the Commonwealth's *Significant Impacts Guidelines: Matters of National Environmental Significance* (the guidelines) for *endangered* or *vulnerable* species, as appropriate (note that no species of concern for this project is listed as *critically endangered*). Criteria for determining significant impacts for each category are shown below.

Significant impact criteria – endangered species

An action is likely to have a significant impact on an *endangered* species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of a population
- Reduce the area of occupancy of the species
- Fragment an existing population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of a population
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat
- Introduce disease that may cause the species to decline or
- Interfere with the recovery of the species.

Significant impact criteria – vulnerable species

An action is likely to have a significant impact on a *vulnerable* species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of an important population of a species
- Reduce the area of occupancy of an important population
- Fragment an existing important population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of an important population
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
- Introduce disease that may cause the species to decline or
- Interfere substantially with the recovery of the species.

Definitions for threatened species impacts

Assessment under the guidelines requires use of three definitions. These are for population, important population, and habitat critical to the survival of a species:

- A *population* of a species is defined under the EPBC Act as an occurrence of the species in a particular area. Occurrences include but are not limited to:
 - A geographically distinct regional population, or collection of local populations or;
 - A population, or collection of local populations, that occurs within a particular bioregion.
- An *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:
 - Key source populations either for breeding or dispersal;
 - Populations that are necessary for maintaining genetic diversity, and/or;
 - Populations that are near the limit of the species range.
- *Habitat critical to the survival of a species* refers to areas that are necessary:
 - For activities such as foraging, breeding, roosting, or dispersal;
 - For the long-term maintenance of the species (including the maintenance of species essential to the survival of the species or an ecological community, such as pollinators);
 - To maintain genetic diversity and long-term evolutionary development, or for the reintroduction of populations or recovery of the species.

Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species as habitat critical for that species, and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.

9.5 Impact significance for each EPBC Act-listed species

In the sections below, significant impact criteria are assessed for each EPBC Act-listed species against the likely risks and consequences **before mitigation**, as determined in sections 9.2 and 9.3 above. Actions are included if the risk of their impact is determined to be Medium or higher before mitigation (i.e. actions that are assessed to have Low or Very Low risk of impact are not considered).

9.5.1 Black-footed Rock-wallaby (Vulnerable)

The Black-footed Rock-wallaby is known to occur near the mine site, and is likely to use all potentially suitable rocky habitat in the region. Given the biology of the species and the fact that it comprises a set of discrete sub-populations that rely on occasional genetic mixing, all populations contribute to the persistence of the species, and all populations should be considered to be important populations.

Habitat that provides foraging resources and shelter from predators and exposure would be considered critical habitat. For this project, that includes all rocky habitats within and surrounding the Project area. Other habitats are likely to be used for dispersal and occasional foraging by this species, but are not likely to be considered critical habitat.

Potential impacts that pose the highest risk to the Black-footed Rock-wallaby are:

- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 9-9 EPBC risk assessment for Black-footed Rock-wallaby (vulnerable) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of an important population of a species	Possible	Major	Medium	- predation by increased numbers of non-native predators; - habitat deterioration through weed invasion; and - impacts of wildfire.
Reduce the area of occupancy of an important population	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of the Black-footed Rock-wallaby.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of the Black-footed Rock-wallaby.
Adversely affect habitat critical to the survival of a species	Likely	Minor	Low	- habitat deterioration through weed invasion; and - impacts of wildfire.
Disrupt the breeding cycle of an important population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of the Black-footed Rock-wallaby.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Possible	Significant	Medium	- habitat deterioration through weed invasion; and - impacts of wildfire.
Result in invasive species that are harmful to the species becoming established	Possible	Major	Medium	- Project results in increased numbers of non-native predators; - Project results in habitat deterioration through weed invasion.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into the Black-footed Rock-wallaby population.
Interfere substantially with the recovery of the species	Possible	Major	Medium	- Increased predation could affect recruitment; - Habitat deterioration could affect population's dispersal ability.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.2 Greater Bilby (Vulnerable)

The Greater Bilby may occur within the Project area. The local population is likely to be considered an important population because it is necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of the bilby, because it would support activities such as foraging, breeding and dispersal and would be necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Greater Bilby are:

- Impacts from habitat clearing
- Impacts from habitat fragmentation
- Impacts associated with management of industrial waste material
- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with vehicle movements (e.g. collisions)
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 9-10 EPBC risk assessment for Greater Bilby (vulnerable) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of an important population of a species	Possible	Critical	High	- predation by increased numbers of non-native predators; - collisions with vehicles; - habitat deterioration through weed invasion; and - impacts of wildfire.
Reduce the area of occupancy of an important population	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Likely	Minor	Low	- habitat clearing; - habitat deterioration through weed invasion; and - impacts of wildfire.
Disrupt the breeding cycle of an important population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Possible	Significant	Medium	- habitat deterioration through weed invasion; and - impacts of wildfire.
Result in invasive species that are harmful to the species becoming established	Possible	Critical	High	- Project results in increased numbers of non-native predators; - Project results in habitat deterioration through weed invasion.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere substantially with the recovery of the species	Possible	Major	Medium	- Increased predation could affect recruitment; - Habitat deterioration could affect population's dispersal ability.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.3 Brush-tailed Mulgara (Vulnerable)

The Brush-tailed Mulgara occurs within the Project area. The local population is likely to be considered an important population because it is necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of this species, because it would support activities such as foraging, breeding and dispersal and is necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Brush-tailed Mulgara are:

- Impacts from habitat clearing
- Impacts from habitat fragmentation
- Impacts associated with management of industrial waste material
- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with vehicle movements (e.g. collisions)
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 9-11 EPBC risk assessment for Brush-tailed Mulgara (Vulnerable) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of an important population of a species	Possible	Critical	High	- predation by increased numbers of non-native predators; - collisions with vehicles; - habitat deterioration through weed invasion; and - impacts of wildfire.
Reduce the area of occupancy of an important population	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Likely	Minor	Low	- habitat clearing; - habitat deterioration through weed invasion; and - impacts of wildfire.
Disrupt the breeding cycle of an important population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Possible	Significant	Medium	- habitat deterioration through weed invasion; and - impacts of wildfire.

Result in invasive species that are harmful to the species becoming established	Possible	Critical	High	- Project results in increased numbers of non-native predators; - Project results in habitat deterioration through weed invasion.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere substantially with the recovery of the species	Possible	Major	Medium	- Increased predation could affect recruitment; - Habitat deterioration could affect population's dispersal ability.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.4 Southern Marsupial Mole (Endangered)

The Southern Marsupial Mole may occur within the Project area, although habitats within the area are not ideal. If it occurs there, the local population is likely to be considered an important population because it would be necessary for maintaining genetic diversity. Most of the Project area is unlikely to be considered habitat critical to the survival of this species.

Potential impacts that pose the highest risk to the Southern Marsupial Mole are:

- Impacts from habitat clearing
- Impacts associated with management of industrial waste material
- Impacts of unplanned wildfire
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 9-12 EPBC risk assessment for Southern Marsupial Mole (Endangered) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of a population	Unlikely	Moderate	Low	- predation by increased numbers of non-native predators; - habitat deterioration through weed invasion; and - impacts of wildfire.
Reduce the area of occupancy of the species	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Unlikely	Minor	Very Low	Habitats within the Project area are unlikely to be considered critical habitat for this species.
Disrupt the breeding cycle of a population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Minor	Very Low	Habitats within the Project area are marginal for this species.
Result in invasive species that are harmful to an endangered species becoming established	Possible	Major	Medium	- Project results in increased numbers of non-native predators; - Project results in habitat deterioration through weed invasion.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere with the recovery of the species	Unlikely	Significant	Low	- Increased predation could affect recruitment; - Habitat deterioration could affect population's dispersal ability.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.5 Red Goshawk (Vulnerable)

The Red Goshawk may occur within the Project area, although the stronghold for the species tends to be further north, and there are no breeding records of this species in Central Australia. Therefore, if this species occurs in the Project area, then the local population is unlikely to be considered an important population because it would not be necessary for maintaining genetic diversity.

Most of the Project area is unlikely to be considered habitat critical to the survival of this species – the species prefers tall wooded and forested habitats, so may occupy only the riparian and Corymbia woodlands in the Project area.

None of the potential impacts identified for the project pose a medium or high risk to the Red Goshawk.

Table 9-13 EPBC risk assessment for Red Goshawk (Vulnerable) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Minor	Very Low	Local population unlikely to be considered 'important population'. Impacts are not expected to result in long-term decrease in population size of this species.
Reduce the area of occupancy of an important population	Unlikely	Minor	Very Low	Local population unlikely to be considered 'important population'. Impacts are not expected to reduce the area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Unlikely	Minor	Very Low	Habitat within the Project area unlikely to be considered 'critical habitat'.

Disrupt the breeding cycle of an important population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Minor	Very Low	Most of the habitat within the Project area unlikely to be favoured habitat.
Result in invasive species that are harmful to the species becoming established	Unlikely	Minor	Very Low	Species not likely to be affected by invasive species.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere substantially with the recovery of the species	Unlikely	Minor	Very Low	Project unlikely to influence the recovery of this species.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.6 Princess Parrot (Vulnerable)

The Princess Parrot is likely to occur within the Project area, but is probably sparse. The local population is likely to be considered an important population because it is necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of this species, because it is likely to support activities such as foraging, breeding and dispersal and is necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Princess Parrot are:

- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with invasion by exotic plants and animals, particularly predators.

Table 9-14 EPBC risk assessment for Princess Parrot (Vulnerable) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Minor	Very Low	- predation by increased numbers of non-native predators; - habitat deterioration through weed invasion; and - impacts of wildfire.
Reduce the area of occupancy of an important population	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Likely	Minor	Low	Habitats that would be impacted within the Project area are well represented in the broader landscape.
Disrupt the breeding cycle of an important population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Minor	Very Low	Habitats that would be impacted within the Project area are well represented in the broader landscape.
Result in invasive species that are harmful to the species becoming established	Possible	Major	Medium	- project results in increased numbers of non-native predators.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere substantially with the recovery of the species	Unlikely	Minor	Very Low	Project unlikely to influence the recovery of this species.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.7 Night Parrot (Endangered)

The Night Parrot may occur within the Project area, but is likely to be sparse and rare. The local population would be considered an important population because it would be necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of this species, because it would support activities such as foraging, breeding and dispersal and is necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Night Parrot are:

- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with invasion by exotic plants and animals, particularly predators.

Table 9-15 EPBC risk assessment for Night Parrot (Endangered) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of a population	Possible	Critical	High	- predation by increased numbers of non-native predators; - impacts of wildfire.
Reduce the area of occupancy of the species	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Likely	Minor	Low	- habitat clearing; - habitat deterioration through weed invasion; and - impacts of wildfire.
Disrupt the breeding cycle of a population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Minor	Very Low	Habitats that would be impacted within the Project area are well represented in the broader landscape.

Result in invasive species that are harmful to an endangered species becoming established	Possible	Critical	High	- Project results in increased numbers of non-native predators; - Project results in habitat deterioration through weed invasion.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere with the recovery of the species	Unlikely	Minor	Very Low	Project unlikely to influence the recovery of this species.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

9.5.8 Great Desert Skink (Vulnerable)

The Great Desert Skink is likely to occur within the Project area. The local population is likely to be considered an important population because it would be necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of this species, because it would support activities such as foraging, breeding and dispersal and is necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Great Desert Skink are:

- Impacts from habitat clearing
- Impacts from habitat fragmentation
- Impacts associated with management of industrial waste material
- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with vehicle movements (e.g. collisions/roadkill)
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 9-16 EPBC risk assessment for Great Desert Skink (Vulnerable) before mitigation

Criterion	Likelihood	Severity	Risk	Main contributing impacts
Lead to a long-term decrease in the size of an important population of a species	Possible	Critical	High	- predation by increased numbers of non-native predators; - collisions with vehicles; - habitat deterioration through weed invasion; and - impacts of wildfire.
Reduce the area of occupancy of an important population	Unlikely	Minor	Very Low	Impacts are not expected to result in a reduced area of occupancy of this species.
Fragment an existing population into two or more populations	Unlikely	Minor	Very Low	Impacts are not expected to fragment any population of this species.
Adversely affect habitat critical to the survival of a species	Likely	Minor	Low	- habitat clearing; - habitat deterioration through weed invasion; and - impacts of wildfire.

Disrupt the breeding cycle of an important population	Unlikely	Minor	Very Low	Impacts are not expected to disrupt the breeding cycle of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Possible	Significant	Medium	- habitat deterioration through weed invasion; and - impacts of wildfire.
Result in invasive species that are harmful to the species becoming established	Possible	Critical	High	- Project results in increased numbers of non-native predators; - Project results in habitat deterioration through weed invasion.
Introduce disease that may cause the species to decline	Rare	Major	Low	Impacts are not expected to introduce diseases into a population of this species.
Interfere substantially with the recovery of the species	Possible	Moderate	Low	- Increased predation could affect recruitment; - Habitat deterioration could affect population's dispersal ability.

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk is unlikely to be significant according to EPBC Act significant impact guidelines.

10. Conclusion

The Project area has the potential to support a range of threatened fauna species, including eight listed as *vulnerable* or *endangered* under the EPBC Act. These species are likely to occupy the full range of available fauna habitats within the Project area, but the sandplain spinifex habitat has the potential to support more threatened species than other habitats. The threatened fauna relevant to the Project can be categorised as follows:

- Fauna in rocky habitat (Black-footed Rock-wallaby (MacDonnell Ranges race), *Petrogale lateralis*)
- Ground-dwelling sandplain fauna with limited mobility (Greater Bilby, *Macrotis lagotis*; Brush-tailed Mulgara, *Dasyercus blythi*; Great Desert Skink, *Liopholis kintorei*; Southern Marsupial Mole, *Notoryctes typhlops*)
- Arid-zone avifauna with high mobility (Night Parrot, *Pezoporus occidentalis*; Red Goshawk, *Erythroriorchis radiatus*; Princess Parrot, *Polytelis alexandrae*; Grey Falcon, *Falco hypoleucos*)
- Fauna in riparian habitat (Common Brushtail Possum (Southern NT), *Trichosurus vulpecula vulpecula*).

The Project poses a range of potential impacts on some of these threatened fauna species. Before mitigation, a small number of impacts have the potential to be medium or high risk. The main sources of impact on fauna are expected to be from:

- Clearing of vegetation, particularly for the 100 km access road
- Unplanned wildfire, inadvertently started by mine construction or operation
- Collisions between fauna and traffic during construction and operation, particularly in spinifex sandplain habitat and particularly at night
- Introduction and/or spread of weeds (particularly through inadequate site reinstatement)
- Increase in population size of native and non-native predators (particularly through inadequate management of garbage/waste, which could attract vermin, and subsequently their predators such as cats and foxes).

The extent and severity of impact that this Project has on fauna depends entirely on the level of management and mitigation effort given. There is potential for all impacts and risks to be reduced to an acceptable level (i.e. not significant) through the use of effective and appropriate management and mitigation. Inadequate management and mitigation has the potential to lead to irreversible long-term impacts on some threatened fauna species. Monitoring will be required to measure the effectiveness of mitigation and to identify where changes in effort may be required.

11. References

- Abbott, I. (2001). The Bilby *Macrotis lagotis* (Marsupialia: Peramelidae) in south-western Australia: original range limits, subsequent decline, and presumed regional extinction. Records of the Western Australian Museum. 20:271-305. In: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=282.
- Allen, R.J. (1987). Alexandra's Parrots in the Great Victoria Desert. South Australian Ornithologist. 30:75.
- Baker, B., and Richardson, J. (2006). The effect of artificial light on male breeding-season behaviour in green frogs, *Rana clematans melanota*. Canadian Journal of zoology 84: 1528-1532.
- Baxter, C. & R. Henderson (2000). A literature summary of the Princess Parrot *Polytelis alexandrae* and a suspected recent breeding event in South Australia. South Australian Ornithologist. 33:93-108.
- Benshemesh, J. (2000). National Recovery Plan for the Malleefowl. (National Parks and Wildlife South Australia, Adelaide.).
- Benshemesh, J. (2004). Marsupial mole recovery plan. (Northern Territory Department of Natural Resources, Environment and the Arts, Alice Springs.).
- Buchanan, B.W., (2006). Observed and potential effects of artificial night lighting on anuran amphibians. In C. Rich & T. Longcore (eds), Ecological Consequences of Artificial Night Lighting. Island Press: 192-220.
- Christidis, L. and Boles, W. E. (2008). Systematics and Taxonomy of Australian Birds. Melbourne. CSIRO Publishing.
- Churchill, S. (2008). Australian Bats. Jacana Books, Allen & Unwin; Sydney.
- Cogger, H.G., E.E. Cameron, R.A. Sadler & P. Eggler (1993). The Action Plan for Australian Reptiles. [Online]. Canberra, ACT: Australian Nature Conservation Agency. Available from: <http://www.environment.gov.au/biodiversity/threatened/action/reptiles/index.html>.
- Corben, C. (2013). AnalookW for bat call analysis using ZCA. Version 3.9f, 22 March 2013.
- DECC NSW. (2005). Approved Methods for the Modelling and Assessment of Air pollutants in New South Wales. Department of Environment and Conservation, 59–61 Goulburn Street, Sydney, NSW. DEC 2005/361, August 2005.
- Department of Land Resource Management (2013). Burt Plain Bioregion. Viewed online 22nd April 2013: <<http://lrm.nt.gov.au/herbarium/nature/bioregional/burtplain>>.
- Department of Natural Resources, Environment and the Arts (cited as DNREA) (2006a). Threatened Species Information Sheet. Brush-tailed Mulgara (Mulgara), *Dasycercus blythi*. December 2006.
- Department of Natural Resources, Environment and the Arts (cited as DNREA) (2006b). Threatened Species Information Sheet. Crest-tailed Mulgara (Ampurta), *Dasycercus cristicauda*. December 2006.
- Department of Natural Resources, Environment, The Arts and Sport (cited as NRETAS) (2009a). Sites of conservation significance: Mud Hut Swamp. Northern Territory Government. <http://lrm.nt.gov.au/__data/assets/pdf_file/0009/13896/45_mudhut.pdf>.

- Department of Natural Resources, Environment, The Arts and Sport (cited as NRETAS) (2009b). Sites of conservation significance: Anmatyerr North, Northern Territory Government. <http://www.nretas.nt.gov.au/__data/assets/pdf_file/0008/13895/46_anmatyerr.pdf>.
- Department of Natural Resources, Environment, The Arts and Sport (cited as NRETAS) (2009c). Sites of Conservation Significance: Wood Duck Swamp. Northern Territory Government. www.lrm.nt.gov.au/__data/assets/pdf_file/0007/147/woodduck.pdf.
- Department of Natural Resources, Environment, The Arts and Sport (cited as NRETAS) (2010). Land Clearing Guidelines.: Northern Territory Planning Scheme. Northern Territory Department of Natural Resources, Environment, the Arts and Sport.
- Department of the Environment (cited as DotE) (2014). *Dasycercus cristicauda* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed 19 March 2014.
- DotE (Department of the Environment) (2015). *Erythroriorchis radiatus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Oct 2015.
- Evans, M.C. (1986). The Diet of the Brushtail Possum in Central Australia. Bachelor of Natural Resources thesis. (University of New England, Armidale).
- Federal Highway Administration (FHA). (2004). Noise effects on wildlife. US Department of Transportation. # FHWA-HEP-06-016.
- Ferreira, M. and Scheffrahn, R. (2011). Light attraction and subsequent colonizing behaviours of alates and dealates of the West Indian drywood termite (Isoptera: Kalotermeitidae). Florida Entomologist 94:131-136.
- Ford, J. & E.H. Sedgwick (1967). Bird distribution in the Nullarbor Plain and Great Victoria Desert region, Western Australia. Emu. 67:99-124.
- Forman, R.T.T. & Alexander, L. E. (1998). Roads and their major ecological effects. Annu. Rev. Ecol. Syst, 29: 207-231.
- Forman, R. T. T., and R. D. Deblinger. (2000). The ecological road-effect zone of a Massachusetts (USA) suburban highway. Conservation Bi-ology 14: 36–46.
- Forshaw, J.M. & W.T. Cooper (2002). Australian Parrots, 3rd edition. Robina, Queensland: Alexander Editions.
- Fox, R. (2012). The decline of moths in Great Britain: a review of possible causes. Insect Conservation and Diversity Online publication date 20-Jan-2012.
- Friend, J. A. (1990). Status of bandicoots in Western Australia. In: Seebeck, J., P. Brown, R. Wallis & C. Kemper, eds. Bandicoots and Bilbies. Pages: 73-84. Sydney: Surrey Beatty & Sons. In: http://www.environment.gov.au/cgi-in/sprat/public/publicspecies.pl?taxon_id=282.
- Garnett, S.T., ed. (1993). Threatened and Extinct Birds of Australia. Royal Australasian Ornithologists Union Report 82 2nd (corrected) Edition. Melbourne: Royal Australian Ornithology Union and Canberra: Australian National Parks and Wildlife Service.
- GHD (2015). Mount Peake EIS: Flora and Vegetation Survey. Prepared for TNG Limited.
- GHD (2015a). Mount Peake Groundwater and Surface Water Assessment. Prepared for TNG Limited.
- Higgins, P.J. (ed.) (1993). Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings. (Oxford University Press, Melbourne.)

- Higgins, P.J. (ed.) (1999). Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbirds. (Oxford University Press, Melbourne.)
- Johnstone, R.E. & G.M. Storr (1998). Handbook of Western Australian Birds. Vol. 1: Non-passerines (Emu to Dollarbird). Perth, Western Australia: West Australian Museum.
- Kaseloo, P. (2005). Synthesis of Noise Effects on Wildlife Populations. Road Ecology Center. UC Davis: Road Ecology Center. Retrieved from: <http://escholarship.org/uc/item/9fz3s9x0>
- Kempenaers, B., Borgstrom, P., Loas, P., Schlicht, E., and Valcu, M. (2010). Artificial night lighting affects dawn song, extra pair success and lay time in song birds. *Current Biology* 20: 1735-1739.
- Kerle, J.A., Foulkes, J.N., Kimber, R.G., and Papenfus, D. (1992). The decline of the brushtail possum, *Trichosurus vulpecula* (Kerr 1798), in arid Australia. *Rangelands Journal* 14, 107-127.
- Loncore, T., Rich, C., and Gauthreaux, S. (2008). Height, guy wires, and steady burning lights increase hazard of communication towers to nocturnal migrants: a review and meta-analysis. *The Auk* 125: 485-492.
- Longcore, T., and Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and the Environment* 2, 191-198.
- Loncore, T. (2010). Sensory Ecology: night lights alter reproductive behaviour of blue tits. *Current Biology* 20:893-895.
- Lugo, A. E., and H. Gucinski. (2000). Function, effects, and management of forest roads. *Forest Ecology and Management* 133: 167-286.
- Marchant, S. & P.J.Higgins, eds. (1990). The Handbook of Australian, New Zealand and Antarctic Birds, Volume 1 Part a - Rattites to Petrels. Melbourne, Victoria: Oxford University Press.
- Masters, P., Dickman, C. R. and Crowther, M. (2003). Effects of cover reduction on mulgara *Dasyurus cristicauda* (Marsupialia: Dasyuridae), rodent and invertebrate populations in central Australia: implications for land management. *Austral Ecology* 28: 658-665.
- Maxwell, S., Burbidge, A. A. and Morris, K. (1996). The 1996 Action Plan For Australian Marsupials and Monotremes. Project Number 500. Wildlife Australia, Canberra.
- McAlpin, S. (2001). A recovery plan for the Great Desert Skink (*Egernia kintorei*) 2001-2011. [Online]. Alice Springs: Arid Lands Environment Centre. Available from: <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/great-desert-skink/index.html>.
- Menkhorst, P. and Knight, F. (2011). A Field Guide to the Mammals of Australia (third edition). Oxford University Press.
- Milne, D.J. (2002). Key to the Bat Calls of the Top End of the Northern Territory. Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.
- Moseby K, Nano T and Southgate R. (2011). Tales in the sand; a guide to identifying Australian arid-zone fauna spoor and other signs. Ecological Horizons, South Australia.
- Newman, J.R. and Schreiber, R.K. (1988). Air pollution and wildlife toxicology: an overlooked problem. *Environmental Toxicology and Chemistry* 7:381-390.
- Northern Territory Environment Protection Authority (cited as NT EPA) (2013). Guidelines for assessment of impacts on terrestrial biodiversity. Northern Territory Environment Protection Authority; April 2013, Version 1.2

- Parker, S.A. (1971). Critical notes on the status of some central Australian birds. *Emu*. 71:99-102.
- Pavey, C (2006). Threatened Species of the Northern Territory: Information Sheet for Black-footed Rock Wallaby, *Petrogale lateralis*. Northern Territory Parks and Wildlife Commission.
- Pavey, C. R., Nano, C. E. M., Cooper, S. J. B., Cole, A. and McDonald, P., J. (2011). Habitat use, population dynamics and species identification of mulgara, *Dasycercus blythi* and *D. cristicauda*, in a zone of sympatry in central Australia. *Australian Journal of Zoology* 59: 156–169.
- Pennay, M., Law, B. and Reinhold, L. (2004). Bat Calls of New South Wales. Department of Environment and Conservation, Hurstville.
- Pianka, H.D. & E.R. Pianka (1970). Bird censuses from desert localities in Western Australia. *Emu*. 70:17-22.
- Polak, T., Korine, C., Yair, S., and Holderied, W. (2011). Differential effects of artificial lighting on flight and foraging behaviour of two sympatric bat species in a desert. *Journal of Zoology*, Online publication date: 1-Mar-2011.
- Reardon, T., Adams, M., McKenzie, N. and Jenkins, P. (2008). A new species of Australian freetail bat *Mormopterus eleryi* sp. nov. (Chiroptera: Molossidae) and a taxonomic reappraisal of *M. norfolkensis* (Gray). *Zootaxa* 1875: 1-31.
- Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). Key to the bat calls of south-east Queensland and north-east New South Wales. Department of Natural Resources and Mines, Brisbane.
- Ryan, P. & Shanks, B. (1996) Tailings dams. *The Bird Observer*, July, 1996, 7–10.
- Saunders GR, Gentle MN, and Dickman DR (2010). The impacts and management of foxes *Vulpes vulpes* in Australia. *Mammal Review* 40(3):181–211.
- Slater P, Slater P and R Slater (2003). *The Slater Field Guide to Australian Birds*. New Holland Australia.
- Southgate, R. I. (1990a). Habitats and diet of the greater bilby *Macrotis lagotis* Reid (Marsupialia: Peramelidae). In: Seebeck, J.H., P.R. Brown, R.L. Wallis & C.M. Kemper, eds. *Bandicoots and Bilbies*. Page(s) 303-309. Surrey Beatty & Sons: Chipping Norton, NSW. In: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=282.
- Southgate, R. I. (1990b). Distribution and abundance of the greater bilby *Macrotis lagotis* Reid (Marsupialia: Peramelidae). In: Seebeck, J., H., Brown, P., R., Wallis, R., L. and Kemper, C., M., eds. *Bandicoots and Bilbies*. Page(s) 293-302. Surrey Beatty & Sons: Chipping Norton, NSW. In: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=282 TNG Limited 2012. Mount Peake Project; Pre-Feasibility Study, October 2012.
- Southgate, R., Palmer, C., Adams, M., Masters, P., Triggs, B., and Woinarski, J. (1996). Population and habitat characteristics of the Golden Bandicoot (*Isodon auratus*) on Marchinbar Island, Northern Territory. *Wildlife Research* 23, 647-664.
- Stone, E., Jones, G., and Hams, S. (2009). Street lighting disturbs communing bats. *Current Biology* 19:1123-1127.
- Triggs, B. (2004). Tracks, scats and other traces; A field guide to Australian Mammals. Revised edition. Oxford University Press, Melbourne.
- Trombulak, S. C., and C. A. Frissell. (2000). Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14: 18–30.

Vanderduys EP and Kutt AS (2013). Is the Asian house gecko, *Hemidactylus frenatus*, really a threat to Australia's biodiversity? *Australian Journal of Zoology* 60(6) 361-367

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition). New Holland; Sydney.

Woinarski, J.C.Z. (2004). In a land with few possums, even the common are rare: ecology, conservation and management of possums in the Northern Territory. In *The biology of Australian possums and gliding possums* (eds R. Goldingay and S. Jackson). pp.51-62 (Surrey Beatty & Sons, Sydney.).

Woinarski, J., Pavey, C., Kerrigan, R., Cowie, I. and Ward, S. (2007). *Lost From Our Landscape: Threatened Species of the Northern Territory*. Northern Territory Government, Palmerston, NT.

Woolley, P. (2008). *Dasycercus blythi*. In: IUCN 2011. *IUCN Red List of Threatened Species*. Version 2011.1. <www.iucnredlist.org>. Accessed: 15 May 2012.

Yoon, T.J., Kim, D.G., Kim, S. Y., Jo, S.I., Bae, Y.J. (2010). Light attraction flight of the giant water bug, *Lethocerus deyrolli* (Hemiptera: Belostomatidae), an endangered wetland insect in East Asia. *Aquatic Insects* 32:195-203.

12. Acknowledgements

GHD thanks the following individuals or groups for their contributions to the project:

- TNG staff at the Project site for providing descriptions and locations of some of the fauna species observed around the study area and immediate surrounds;
- The Northern Territory Department of Land Resource Management (DLRM) for access to their fauna records database results for the study area;
- The Northern Territory Environment Protection Authority (NT EPA) for guidance on survey methods and assessment requirements; and
- Stirling Station for providing descriptions and locations of some of the fauna species observed around the study area and immediate surrounds.

The contents and views expressed within this report are entirely those of GHD and should not be considered to reflect the views of the parties listed above.

Appendices

Appendix A - Results of the EPBC protected matters search



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 14/02/14 13:08:37

[Summary](#)

[Details](#)

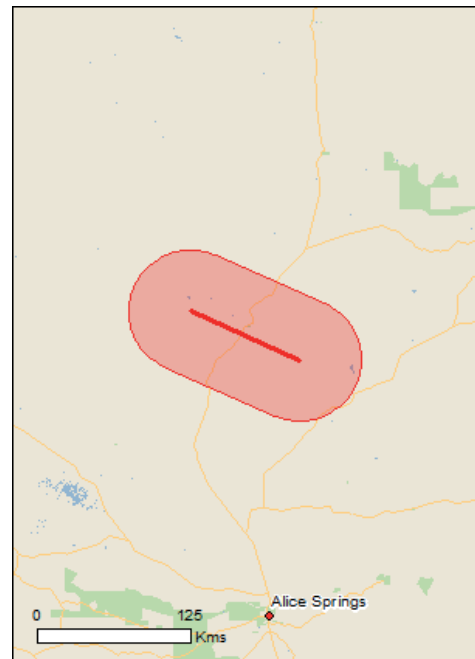
[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)



This map may contain data which are
©Commonwealth of Australia
(Geoscience Australia), ©PSMA 2010

[Coordinates](#)

Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	8
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As [heritage values](#) of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	7
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	1
State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Erythrorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Notoryctes typhlops Itjaritjari, Southern Marsupial Mole, Yitjarritjarri [296]	Endangered	Species or species habitat likely to occur within area
Petrogale lateralis MacDonnell Ranges race Waru, Black-footed Rock-wallaby (MacDonnell Ranges race) [66649]	Vulnerable	Species or species habitat known to occur within area
Plants		
Eleocharis papillosa Dwarf Desert Spike-rush [2519]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Liopholis kintorei Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within

Name	Threatened	Type of Presence area

Extra Information

Places on the RNE	[Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Historic		
Barrow Creek Telegraph Station - OTL Site	NT	Registered

State and Territory Reserves	[Resource Information]

Name	State
Barrow Creek Telegraph Station	NT
Central Mount Stuart	NT

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit, 2001.

Name	Status	Type of Presence
Birds		

Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area

Mammals

Bos taurus		
Domestic Cattle [16]		Species or species habitat likely to occur within area

Camelus dromedarius		
Dromedary, Camel [7]		Species or species habitat likely to occur within area

Canis lupus familiaris		
Domestic Dog [82654]		Species or species habitat likely to occur within area

Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area

Mus musculus		
House Mouse [120]		Species or species habitat likely to occur within area

Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area

Plants

Name	Status	Type of Presence
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Coordinates

-21.642048 133.296748,-21.968456 134.09875,-21.968456 134.09875

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [Department of Environment, Climate Change and Water, New South Wales](#)
- [Department of Sustainability and Environment, Victoria](#)
- [Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [Department of Environment and Natural Resources, South Australia](#)
- [Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts](#)
- [Environmental and Resource Management, Queensland](#)
- [Department of Environment and Conservation, Western Australia](#)
- [Department of the Environment, Climate Change, Energy and Water](#)
- [Birds Australia](#)
- [Australian Bird and Bat Banding Scheme](#)
- [Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [Museum Victoria](#)
- [Australian Museum](#)
- [SA Museum](#)
- [Queensland Museum](#)
- [Online Zoological Collections of Australian Museums](#)
- [Queensland Herbarium](#)
- [National Herbarium of NSW](#)
- [Royal Botanic Gardens and National Herbarium of Victoria](#)
- [Tasmanian Herbarium](#)
- [State Herbarium of South Australia](#)
- [Northern Territory Herbarium](#)
- [Western Australian Herbarium](#)
- [Australian National Herbarium, Atherton and Canberra](#)
- [University of New England](#)
- [Ocean Biogeographic Information System](#)
- [Australian Government, Department of Defence](#)
- [State Forests of NSW](#)
- [Geoscience Australia](#)
- [CSIRO](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

Appendix B - List of fauna species for the Project Area recorded during the current and previous surveys

GHD = Detected during this assessment: Fauna survey by GHD, April 2013.

DLRM = recorded on the DLRM Database.

PMST = Identified by the Protected Matters Search Tool.

EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

TRWC = Northern Territory *Territory Parks and Wildlife Conservation Act 2006*.

VU = Vulnerable;	EN = Endangered;	CR = Critically Endangered;

EX = Extinct;	LC = Least concern;	RX = Regionally extinct;

NT = Near threatened;	EW = Extinct in the wild;	DD = Data deficient;

Mi = Migratory;	Ma = Marine;	Invasive = non-native.

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Mammals						
Echidna	<i>Tachyglossus aculeatus</i>		X			LC
Brush-tailed Mulgara	<i>Dasycercus blythi</i>	x	X		VU	VU
Crest-tailed Mulgara	<i>Dasycercus cristicauda</i>			X	VU	VU
Kowari	<i>Dasyuroides byrnei</i>		X		VU	RX
Western Quoll	<i>Dasyurus geoffroii</i>		X		VU	RX
Fat-tailed Antechinus	<i>Pseudantechinus macdonnellensis</i>		X			LC
Hairy-nosed Free-tailed Bat	<i>Mormopterus eleryi</i>	x				LC
Red-tailed Phascogale	<i>Phascogale calura</i>		X		EN	RX
Inland Broad-nosed Bat	<i>Scotorepens balstoni</i>	x				LC
Inland Forest Bat	<i>Vespadelus baverstocki</i>	x				LC
Kultarr	<i>Antechinomys laniger</i>		X			NT
White-striped Free-tailed Bat	<i>Tadarida australis</i>	x				LC
Fat-tailed Dunnart	<i>Sminthopsis crassicaudata</i>	x				LC
Yellow-bellied Sheath-tail Bat	<i>Saccolaimus flaviventris</i>	x				LC
Stripe-faced Dunnart	<i>Sminthopsis macroura</i>		X			LC
Lesser Hairy-footed Dunnart	<i>Sminthopsis youngsoni</i>	x	X			LC
Pig-footed Bandicoot	<i>Chaeropus ecaudatus</i>		X		EX	EX
Golden Bandicoot	<i>Isodon auratus</i>		X		VU	EN
Finlayson's Cave Bat	<i>Vespadelus finlaysoni</i>	x				LC
Bilby	<i>Macrotis lagotis</i>	x?	X	X	VU	VU
Lesser Bilby	<i>Macrotis leucura</i>		X		EX	EX
Common Brushtail Possum (Southern N.T.)	<i>Trichosurus vulpecula vulpecula</i>		X			EN
Burrowing Bettong	<i>Bettongia lesueur</i>		X		EX	RX
Spectacled Hare-wallaby	<i>Lagorchestes conspicillatus</i>		X			NT
Mala	<i>Lagorchestes hirsutus</i>		X		EN	EW
Common Wallaroo	<i>Macropus robustus</i>		X			LC
Red Kangaroo	<i>Macropus rufus</i>	x	X			LC
Northern Nailtail Wallaby	<i>Onychogalea unguifera</i>		X			NT
Black-footed Rock-wallaby	<i>Petrogale lateralis</i>		X	X	VU	NT
Southern Marsupial Mole	<i>Notoryctes typhlops</i>		X	X	EN	VU
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>	x				LC
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	x				LC
Chocolate Wattled Bat	<i>Chalinolobus morio</i>	x				LC
Inland Free-tailed Bat	<i>Mormopterus sp.3</i>	x				LC
Little Broad-nosed Bat	<i>Scotorepens greyii</i>	x	X			LC
Spinifex Hopping-mouse	<i>Notomys alexis</i>	x	X			LC
Long-tailed Hopping-mouse	<i>Notomys longicaudatus</i>		X		EX	EX
Desert Mouse	<i>Pseudomys desertor</i>	x	X			LC
Sandy Inland Mouse	<i>Pseudomys hermannsburgensis</i>	x	X			LC
Dingo	<i>Canis lupus</i>	x	X			LC

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Dog	<i>Canis lupus familiaris</i>			X	Invasive	Non-native
House Mouse	<i>Mus musculus</i>		X	X	Invasive	Non-native
Fox	<i>Vulpes vulpes</i>			X	Invasive	Non-native
Cat	<i>Felis catus</i>	x	X	X	Invasive	Non-native
Rabbit	<i>Oryctolagus cuniculus</i>	x	X		Invasive	Non-native
Donkey	<i>Equus asinus</i>	x	X		Invasive	Non-native
Horse	<i>Equus caballus</i>		X		Invasive	Non-native
Pig	<i>Sus scrofa</i>		X		Invasive	Non-native
Cattle	<i>Bos taurus/indicus</i>	x	X	X	Invasive	Non-native
Camel	<i>Camelus dromedarius</i>			X	Invasive	Non-native
Birds						
Emu	<i>Dromaius novaehollandiae</i>	x	X			NT
Malleefowl	<i>Leipoa ocellata</i>		X		VU	CR
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>		X			LC
Australian Wood Duck	<i>Chenonetta jubata</i>		X			LC
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>		X			LC
Grey Teal	<i>Anas gracilis</i>		X			LC
Pacific Black Duck	<i>Anas superciliosa</i>		X			LC
Hardhead	<i>Aythya australis</i>		X			LC
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>		X			LC
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	x	X			LC
Common Bronzewing	<i>Phaps chalcoptera</i>	x	X			LC
Crested Pigeon	<i>Ocyphaps lophotes</i>	x	X			LC
Spinifex Pigeon	<i>Geophaps plumifera</i>		X			LC
Diamond Dove	<i>Geopelia cuneata</i>		X			LC
Peaceful Dove	<i>Geopelia striata</i>	x	X			LC
Tawny Frogmouth	<i>Podargus strigoides</i>		X			LC
Spotted Nightjar	<i>Eurostopodus argus</i>	x	X			LC
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>	x				LC
Fork-tailed Swift	<i>Apus pacificus</i>			X	Mi / Ma	LC
Australasian Darter	<i>Anhinga novaehollandiae</i>		X			LC
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>		X			LC
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>		X			LC
Pied Cormorant	<i>Phalacrocorax varius</i>		X			LC
Australian Pelican	<i>Pelecanus conspicillatus</i>		X			LC
White-necked Heron	<i>Ardea pacifica</i>		X			LC
Eastern Great Egret	<i>Ardea modesta</i>		X			LC
Great Egret	<i>Ardea alba</i>			X	Mi / Ma	LC
Intermediate Egret	<i>Ardea intermedia</i>		X			LC
Cattle Egret	<i>Ardea ibis</i>			X	Mi / Ma	LC
White-faced Heron	<i>Egretta novaehollandiae</i>		X			LC
Glossy Ibis	<i>Plegadis falcinellus</i>		X			LC

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Royal Spoonbill	<i>Platalea regia</i>		X			LC
Yellow-billed Spoonbill	<i>Platalea flavipes</i>		X			LC
Black-shouldered Kite	<i>Elanus axillaris</i>	x	X			LC
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>	x	X			LC
Whistling Kite	<i>Haliastur sphenurus</i>	x	X			LC
Black Kite	<i>Milvus migrans</i>	x	X			LC
Brown Goshawk	<i>Accipiter fasciatus</i>		X			LC
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>		X			LC
Spotted Harrier	<i>Circus assimilis</i>		X			LC
Red Goshawk	<i>Erythrotriorchis radiatus</i>			X	VU	VU
Wedge-tailed Eagle	<i>Aquila audax</i>	x	X			LC
Little Eagle	<i>Hieraaetus morphnoides</i>		X			LC
Nankeen Kestrel	<i>Falco cenchroides</i>		X			LC
Brown Falcon	<i>Falco berigora</i>	x	X			LC
Australian Hobby	<i>Falco longipennis</i>		X			LC
Grey Falcon	<i>Falco hypoleucos</i>	x	X			VU
Peregrine Falcon	<i>Falco peregrinus</i>		X			LC
Brolga	<i>Grus rubicunda</i>		X			LC
Black-tailed Native-hen	<i>Tribonyx ventralis</i>		X			LC
Eurasian Coot	<i>Fulica atra</i>		X			LC
Australian Bustard	<i>Ardeotis australis</i>	x	X			NT
Bush Stone-curlew	<i>Burhinus grallarius</i>		X			NT
Black-winged Stilt	<i>Himantopus himantopus</i>		X			LC
Oriental Plover	<i>Charadrius veredus</i>			X	Mi / Ma	LC
Black-fronted Dotterel	<i>Elseya melanops</i>	x	X			LC
Red-kneed Dotterel	<i>Erythronyx cinctus</i>		X			LC
Banded Lapwing	<i>Vanellus tricolor</i>		X			LC
Masked Lapwing	<i>Vanellus miles</i>		X			LC
Australian Painted Snipe	<i>Rostratula australis</i>			X	EN / Mi / Ma	VU
Common Greenshank	<i>Tringa nebularia</i>		X			LC
Little Button-quail	<i>Turnix velox</i>		X			LC
Oriental Pratincole	<i>Glareola maldivarum</i>			X	Mi / Ma	LC
Australian Pratincole	<i>Stiltia isabella</i>		X			LC
Gull-billed Tern	<i>Gelochelidon nilotica</i>		X			LC
Whiskered Tern	<i>Chlidonias hybrida</i>		X			LC
Major Mitchell's Cockatoo	<i>Lophochroa leadbeateri</i>	x	X			LC
Galah	<i>Eolophus roseicapilla</i>	x	X			LC
Little Corella	<i>Cacatua sanguinea</i>		X			LC
Cockatiel	<i>Nymphicus hollandicus</i>		X			LC
Princess Parrot	<i>Polytelis alexandrae</i>			X	VU	VU
Australian Ringneck	<i>Barnardius zonarius</i>	x	X			LC
Mulga Parrot	<i>Psephotus varius</i>	x	X			LC
Budgerigar	<i>Melopsittacus undulatus</i>	x	X			LC

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Night Parrot	<i>Pezoporus occidentalis</i>		X		EN	CR
Horsfield's Bronze-Cuckoo	<i>Chalcites basal</i>		X			LC
Pallid Cuckoo	<i>Cacomantis pallidus</i>	x	X			LC
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>		X			Not evaluated
Southern Boobook	<i>Ninox novaeseelandiae</i>	x	X			LC
Eastern Barn Owl	<i>Tyto javanica</i>	x	X			LC
Red-backed Kingfisher	<i>Todiramphus pyrrhopygius</i>		X			LC
Rainbow Bee-eater	<i>Merops ornatus</i>	x	X	X	Mi / Ma	LC
Western Bowerbird	<i>Ptilonorhynchus guttatus</i>		X			LC
Splendid Fairy-wren	<i>Malurus splendens</i>	x	X			LC
White-winged Fairy-wren	<i>Malurus leucopterus</i>	x	X			LC
Variegated Fairy-wren	<i>Malurus lamberti</i>		X			LC
Dusky Grasswren	<i>Amytornis purnelli</i>		X			LC
Weebill	<i>Smicrornis brevirostris</i>	x	X			LC
Western Gerygone	<i>Gerygone fusca</i>		X			LC
Slaty-backed Thornbill	<i>Acanthiza robustirostris</i>	x	X			LC
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>	x	X			LC
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>		X			LC
Inland Thornbill	<i>Acanthiza apicalis</i>	x	X			LC
Southern Whiteface	<i>Aphelocephala leucopsis</i>		X			LC
Banded Whiteface	<i>Aphelocephala nigrincta</i>		X			LC
Red-browed Pardalote	<i>Pardalotus rubricatus</i>		X			LC
Striated Pardalote	<i>Pardalotus striatus</i>		X			LC
Pied Honeyeater	<i>Certhionyx variegatus</i>		X			LC
Singing Honeyeater	<i>Lichenostomus virescens</i>	x	X			LC
Grey-headed Honeyeater	<i>Lichenostomus keartlandi</i>		X			LC
Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>	x	X			LC
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>	x	X			LC
White-fronted Honeyeater	<i>Purnella albifrons</i>		X			LC
Yellow-throated Miner	<i>Manorina flavigula</i>	x	X			LC
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>	x	X			LC
Grey Honeyeater	<i>Conopophila whitei</i>	x				LC
Crimson Chat	<i>Epthianura tricolor</i>		X			LC
Orange Chat	<i>Epthianura aurifrons</i>		X			LC
Black Honeyeater	<i>Sugomel niger</i>		X			LC
Brown Honeyeater	<i>Lichmera indistincta</i>	x	X			LC
Black-chinned Honeyeater	<i>Melithreptus gularis</i>	x	X			LC
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	x	X			LC
White-browed Babbler	<i>Pomatostomus superciliosus</i>	x	X			LC
Ground Cuckoo-shrike	<i>Coracina maxima</i>		X			LC
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>		X			LC
White-winged Triller	<i>Lalage sueurii</i>	x	X			LC

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Rufous Whistler	<i>Pachycephala rufiventris</i>	x	X			LC
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	x	X			LC
Crested Bellbird	<i>Oreoica gutturalis</i>	x	X			LC
Masked Woodswallow	<i>Artamus personatus</i>		X			LC
Black-faced Woodswallow	<i>Artamus cinereus</i>	x	X			LC
Little Woodswallow	<i>Artamus minor</i>		X			LC
Grey Butcherbird	<i>Cracticus torquatus</i>	x	X			LC
Pied Butcherbird	<i>Cracticus nigrogularis</i>	x	X			LC
Australian Magpie	<i>Cracticus tibicen</i>	x	X			LC
Grey Fantail	<i>Rhipidura fuliginosa</i>	x				LC
Willie Wagtail	<i>Rhipidura leucophrys</i>	x	X			LC
Australian Raven	<i>Corvus coronoides</i>		X			LC
Little Crow	<i>Corvus bennetti</i>		X			LC
Torresian Crow	<i>Corvus orru</i>	x	X			LC
Magpie-lark	<i>Grallina cyanoleuca</i>	x	X			LC
Jacky Winter	<i>Microeca fascians</i>		X			LC
Red-capped Robin	<i>Petroica goodenovii</i>	x	X			LC
Hooded Robin (Mainland)	<i>Melanodryas cucullata picata/westralensis</i>	x	X			LC
Rufous Songlark	<i>Cincloramphus mathewsi</i>		X			LC
Brown Songlark	<i>Cincloramphus cruralis</i>		X			LC
Spinifexbird	<i>Eremiornis carteri</i>	x	X			LC
White-backed Swallow	<i>Cheramoeca leucosterna</i>		X			LC
Fairy Martin	<i>Petrochelidon ariel</i>		X			LC
Tree Martin	<i>Petrochelidon nigricans</i>		X			LC
Mistletoebird	<i>Dicaeum hirundinaceum</i>	x	X			LC
Zebra Finch	<i>Taeniopygia guttata</i>	x	X			LC
Painted Finch	<i>Emblema pictum</i>		X			LC
Yellow-rumped Mannikin	<i>Lonchura flaviprymna</i>		X			NT
Australasian Pipit	<i>Anthus novaeseelandiae</i>		X			LC
Rock Dove	<i>Columba livia</i>		X	X	Invasive	Non-native
Reptiles						
Clawless Gecko	<i>Crenadactylus ocellatus</i>		X			LC
Fat-tailed Gecko	<i>Diplodactylus conspicillatus</i>		X			LC
Centralian Dtella	<i>Gehyra montium</i>		X			LC
Northern Spotted Rock Dtella	<i>Gehyra nana</i>		X			LC
Purplish Dtella	<i>Gehyra purpurascens</i>		X			LC
Tree Dtella	<i>Gehyra variegata</i>	x	X			LC
Bynoe's Gecko	<i>Heteronotia binoei</i>	x	X			LC
Beaded Gecko	<i>Lucasium damaeum</i>		X			LC
Crowned Gecko	<i>Lucasium stenodactylum</i>	x	X			LC
Centralian Knob-tailed Gecko	<i>Nephurus amya</i>		X			LC
Three-lined Knob-tailed Gecko	<i>Nephurus levis</i>		X			LC
Marbled Velvet Gecko	<i>Oedura marmorata</i>		X			LC

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Beaked Gecko	<i>Rhynchoedura ornata</i>	x	X			LC
Northern Spiny-tailed Gecko	<i>Strophurus ciliaris</i>	x	X			LC
Rusty-topped Delma	<i>Delma borea</i>		X			LC
Sharp-snouted Delma	<i>Delma nasuta</i>		X			LC
Black-necked Snake-lizard	<i>Delma tincta</i>		X			LC
Burton's Legless Lizard	<i>Lialis burtonis</i>		X			LC
Western Hooded Scaly-foot	<i>Pygopus nigriceps</i>		X			LC
Striped Rainbow Skink	<i>Carlia munda</i>	x	X			LC
Three-Spined Rainbow Skink	<i>Carlia triacantha</i>	x	X			LC
Inland Snake-Eyed Skink	<i>Cryptoblepharus australis</i>	x				LC
Carnaby's Snake-Eyed Skink	<i>Cryptoblepharus carnabyi</i>		X			LC
Aboreal Snake-Eyed Skink	<i>Cryptoblepharus plagiocephalus</i>		X			LC
Lively Ctenotus	<i>Ctenotus alacer</i>		X			LC
Brook's Ctenotus	<i>Ctenotus brooksi</i>		X			LC
Grand Ctenotus	<i>Ctenotus grandis</i>	x				LC
Greer's Ctenotus	<i>Ctenotus greeri</i>	x	X			LC
Helen's Ctenotus	<i>Ctenotus helenae</i>	x	X			LC
Leonhard's Ctenotus	<i>Ctenotus leonhardii</i>	x	X			LC
Leopard Ctenotus	<i>Ctenotus pantherinus</i>	x	X			LC
Robust Ctenotus	<i>Ctenotus robustus</i>	x	X			LC
Rock Ctenotus	<i>Ctenotus saxatilis</i>		X			LC
Schomburgk's Ctenotus	<i>Ctenotus schomburgkii</i>	x	X			LC
Slender Blue-tongued Lizard	<i>Cyclodomorphus melanops</i>		X			LC
Great Desert Skink	<i>Liopholis kintorei</i>			X	VU	VU
Striated Egernia	<i>Liopholis striata</i>		X			LC
Narrow-Banded Sand Swimmer	<i>Eremiascincus fasciolatus</i>		X			LC
Broad-Banded Sand Swimmer	<i>Eremiascincus richardsonii</i>		X			LC
Two-toed Lerista	<i>Lerista bipes</i>	x				LC
Frost's Lerista	<i>Lerista frosti</i>		X			LC
Sand Lerista	<i>Lerista labialis</i>	x	X			LC
Yellow-Tailed Lerista	<i>Lerista xanthura</i>		X			LC
Grey's Menetia	<i>Menetia greyii</i>	x	X			LC
Red-Tailed Snake-Eyed Skink	<i>Morethia ruficauda</i>	x	X			LC
Centralian Blue-Tongued Lizard	<i>Tiliqua multifasciata</i>	x	X			LC
Ring-tailed Dragon	<i>Ctenophorus caudicinctus</i>		X			LC
Clay's Dragon	<i>Ctenophorus clayi</i>	x				LC
Military Dragon	<i>Ctenophorus isolepis</i>	x	X			LC
Central Netted Dragon	<i>Ctenophorus nuchalis</i>	x	X			LC
Gilbert's Dragon	<i>Lophognathus gilberti</i>	x	X			LC
Long-nosed Water Dragon	<i>Lophognathus longirostris</i>		X			LC
Thorny Devil	<i>Moloch horridus</i>	x	X			LC
Dwarf Bearded Dragon	<i>Pogona minor</i>	x	X			LC
Central Bearded Dragon	<i>Pogona vitticeps</i>		X			LC

Common Name	Scientific Name	GHD	DLRM	PMST	EPBC	TPWC
Ridge-tailed Monitor	<i>Varanus acanthurus</i>	x	X			LC
Rusty Desert Monitor	<i>Varanus eremius</i>	x	X			LC
Pygmy Mulga Monitor	<i>Varanus gilleni</i>		X			LC
Sand Goanna	<i>Varanus gouldii</i>	x	X			LC
Black-tailed Monitor	<i>Varanus tristis</i>		X			LC
Northern Blind Snake	<i>Ramphotyphlops diversus</i>		X			LC
Children's Python	<i>Antaresia childreni</i>		X			LC
Stimson's Python	<i>Antaresia stimsoni</i>		X			LC
Black-headed Python	<i>Aspidites melanocephalus</i>		X			LC
Woma Python	<i>Aspidites ramsayi</i>	x	X			NT
Desert Death Adder	<i>Acanthophis pyrrhus</i>	x	X			LC
Northern Shovel-nosed Snake	<i>Brachyuropsis roperi</i>		X			LC
Half-girdled Snake	<i>Brachyuropsis semifasciatus</i>		X			LC
Yellow-faced Whip Snake	<i>Demansia psammophis</i>	x	X			LC
Orange-naped Snake	<i>Furina ornata</i>		X			LC
Mulga Snake	<i>Pseudechis australis</i>	x	X			NT
Ringed Brown Snake	<i>Pseudonaja modesta</i>		X			LC
Western Brown Snake	<i>Pseudonaja nuchalis</i>		X			LC
Little Spotted Snake	<i>Suta punctata</i>	x	X			LC
Asian House Gecko	<i>Hemidactylus frenatus</i>		X	X	Invasive	Non-native
Frogs						
Northern Burrowing Frog	<i>Neobatrachus aquilonius</i>		X			LC
Sudell's Frog	<i>Neobatrachus sudelli</i>		X			LC
Desert Spadefoot Toad	<i>Notaden nichollsi</i>		X			LC
Ornate Burrowing Frog	<i>Platyplectrum ornatus</i>		X			DD
Spencer's Frog	<i>Platyplectrum spenceri</i>		X			LC
Giant Frog	<i>Litoria australis</i>		X			DD
Knife-footed Frog	<i>Litoria cultripes</i>		X			LC
Main's Frog	<i>Litoria maini</i>		X			LC
Red Tree-frog	<i>Litoria rubella</i>		X			LC

Appendix C - Fauna species (numbers of individuals per species) recorded during the fauna survey

* = non-native species

P = present

	Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Incidental/ spotlighting	Total
Common name	Scientific name																		
Mammals																			
Brush-tailed Mulgara	<i>Dasycercus blythi</i>																1		1
Hairy-nosed Free-tailed Bat	<i>Mormopterus eleryi</i>	1	1		1		1	1			1				1	1	1	1	10
Inland Broad-nosed Bat	<i>Scotorepens balstoni</i>	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	15
Inland Forest Bat	<i>Vespadelus baverstocki</i>	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	15
White-striped Free-tailed Bat	<i>Tadarida australis</i>			1		1		1									1	1	5
Fat-tailed Dunnart	<i>Sminthopsis crassicaudata</i>		1	2			2					2						3	10
Yellow-bellied Sheathtail Bat	<i>Saccolaimus flaviventris</i>			1		1		1							1			1	5
Lesser Hairy-footed Dunnart	<i>Sminthopsis youngsoni</i>						1		3										4
Finlayson's Cave Bat	<i>Vespadelus finlaysoni</i>										1				1	1	1	1	5
Bilby	<i>Macrotis lagotis</i>																	1	1
Red Kangaroo	<i>Macropus rufus</i>																	6	6
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>	1	1	1	1	1	1	1	1		1	1			1		1	3	15
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	1	1	1	1	1	1	1	1	1	1	1			1	1	1	2	16
Chocolate Wattled Bat	<i>Chalinolobus morio</i>															1	1	1	3
Inland Free-tailed Bat	<i>Mormopterus sp.3</i>				1	1				1		1							4
Little Broad-nosed Bat	<i>Scotorepens greyii</i>		1	1	1	1	1	1	1	1	1	1			1	1		1	13
Spinifex Hopping-mouse	<i>Notomys alexis</i>	25							2	6					1	1		4	77
Desert Mouse	<i>Pseudomys desertor</i>									3									3
Sandy Inland Mouse	<i>Pseudomys hermannsburgensis</i>									2					1		1		4
Dingo	<i>Canis lupus</i>																	10	10
Cat*	<i>Felis catus</i>				1													6	7
Rabbit*	<i>Oryctolagus cuniculus</i>						1												1
Donkey*	<i>Equus asinus</i>																	1	1
Cattle*	<i>Bos taurus/indicus</i>																	P	P
Birds																			
Emu	<i>Dromaius novaehollandiae</i>															1			1
Hoary-headed Grebe	<i>Poliocephalus poliocephalus</i>																	4	4
Common Bronzewing	<i>Phaps chalcoptera</i>			4			1					1		1				2	9
Crested Pigeon	<i>Ocyphaps lophotes</i>			6				2	2				1			2		12	25
Peaceful Dove	<i>Geopelia striata</i>																	1	1
Spotted Nightjar	<i>Eurostopodus argus</i>										1							8	9
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>																	1	1
Black-shouldered Kite	<i>Elanus axillaris</i>																	1	1
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>							1										2	3
Whistling Kite	<i>Haliastur sphenurus</i>								1								1		2
Black Kite	<i>Milvus migrans</i>																	1	1
Wedge-tailed eagle	<i>Aquila audax</i>																	1	1
Brown Falcon	<i>Falco berigora</i>						2	1				1				1	1	3	9
Grey Falcon	<i>Falco hypoleucos</i>																	1	1
Australian Bustard	<i>Ardeotis australis</i>																	8	8
Black-fronted Dotterel	<i>Elsayornis melanops</i>																	1	1
Major Mitchell's Cockatoo	<i>Lophochroa leadbeateri</i>		1	10			3	5										4	23
Galah	<i>Eolophus roseicapilla</i>					6		2										11	19
Australian Ringneck	<i>Barnardius zonarius</i>			6		4	2	6	4			1	1	1		2		5	32
Mulga Parrot	<i>Psephotus varius</i>																	1	1
Budgerigar	<i>Melopsittacus undulatus</i>				1			4	6				4	2		4			21
Pallid Cuckoo	<i>Cacomantis pallidus</i>							1										1	2
Southern Boobook	<i>Ninox novaeseelandiae</i>	1																3	4

	Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Incidental/ spotlighting	Total
Common name	Scientific name																		
Eastern Barn Owl	<i>Tyto javanica</i>										1							3	4
Rainbow Bee-eater	<i>Merops ornatus</i>								1										1
Splendid Fairy-wren	<i>Malurus splendens</i>			7	3							1					1	7	19
White-winged Fairy-wren	<i>Malurus leucopterus</i>							2					1			1		3	7
Weebill	<i>Smicrornis brevirostris</i>				3	5		1											9
Slaty-backed Thornbill	<i>Acanthiza robustirostris</i>																	1	1
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>							1										2	3
Inland Thornbill	<i>Acanthiza apicalis</i>			6		1												5	12
Singing Honeyeater	<i>Lichenostomus virescens</i>	6	3	4		1	4	8	5	2	1	1				1	1	3	40
Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>	1	4			1	1												7
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>								1		1		3					4	9
Yellow-throated Miner	<i>Manorina flavigula</i>								1		1		2					1	5
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>			2		1		1	4				1					1	10
Grey Honeyeater	<i>Conopophila whitei</i>			3															3
Brown Honeyeater	<i>Lichmera indistincta</i>								1								1	1	3
Black-chinned Honeyeater	<i>Melithreptus gularis</i>				2													2	4
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>								1			1	1					5	8
White-browed Babbler	<i>Pomatostomus superciliosus</i>	1			5					3									9
White-winged Triller	<i>Lalage sueurii</i>												1						1
Rufous Whistler	<i>Pachycephala rufiventris</i>			4	3	2	2	2	1			1	1	2	1			3	22
Grey Shrike-thrush	<i>Colluricincla harmonica</i>		1	1	1		1	1	1				1	1		1		1	10
Crested Bellbird	<i>Oreoica gutturalis</i>	2	3	3	2	2	1	4	4			2	1			1		3	28
Black-faced Woodswallow	<i>Artamus cinereus</i>	4							1	3							9	2	19
Grey Butcherbird	<i>Cracticus torquatus</i>		1	1	1		1	1										1	6
Pied Butcherbird	<i>Cracticus nigrogularis</i>		1	1		2		1	2									1	8
Australian Magpie	<i>Cracticus tibicen</i>					1												6	7
Grey Fantail	<i>Rhipidura fuliginosa</i>																	2	2
Willie Wagtail	<i>Rhipidura leucophrys</i>			2			2		3	1	2	1	3			1		6	21
Torresian Crow	<i>Corvus orru</i>			1					3	1	4	1	1				1	1	13
Magpie-lark	<i>Grallina cyanoleuca</i>																	4	4
Red-capped Robin	<i>Petroica goodenovii</i>			2															2
Hooded Robin (Mainland)	<i>Melanodryas cucullata picata/westralensis</i>	1										1							2
Spinifexbird	<i>Eremiornis carteri</i>															1			1
Mistletoebird	<i>Dicaeum hirundinaceum</i>												1						1
Zebra Finch	<i>Taeniopygia guttata</i>	5	1		15		3	4	5	1		1				18	3	8	64
Reptiles																			
Tree Dtella	<i>Gehyra variegata</i>												1	1					2
Bynoe's Gecko	<i>Heteronotia binoei</i>							1											1
Crowned Gecko	<i>Lucasium stenodactylum</i>						4												4
Beaked Gecko	<i>Rhynchoedura ornata</i>																	1	1
Northern Spiny-tailed Gecko	<i>Strophurus ciliaris</i>							1						1	1			9	12
Striped Rainbow Skink	<i>Carlia munda</i>				1	3						1	3					3	11
Desert Rainbow Skink	<i>Carlia triacantha</i>				1	4		4			1		1						11
Inland Snake-eyed Skink	<i>Cryptoblepharus australis</i>							1							1				2
Grand Ctenotus	<i>Ctenotus grandis</i>								1					1					2
Greer's Ctenotus	<i>Ctenotus greeri</i>	3	1	1					1	8		1		1			2	2	20
Clay-soil Ctenotus	<i>Ctenotus helenae</i>	1				1		2	1				3			4		2	14
Leonhard's Ctenotus	<i>Ctenotus leonhardii</i>					1												1	2
Leopard Ctenotus	<i>Ctenotus pantherinus</i>		2				3			2	1		1	1		1	9	1	21

[illegible]

Appendix D – Results of the remote surveillance cameras used during the fauna survey

Camera	Location	Start Date	End Date	# photos	# with animals	Spinifex hopping Mouse	Cat	Dingo	Torresian Crow	Sand Goanna	Others
1 (M2)	site 16	10/04/2013	15/04/2013	91	24	0	0	0	24	0	
2 (M3)	Between sites 8 and 9	11/04/2013	15/04/2013	103	24	0	0	21	0	3	
3 (M5)	b/w Site 09 and 16	10/04/2013	15/04/2013	9	0	0	0	0	0	0	
4 (M7)	site 01	13/04/2013	15/04/2013	396	311	299	6	0	0	0	6 Hooded Robin
5 (M8)	North of access road	12/04/2013	15/04/2013	147	107	68	0	11	0	26	1 Black-faced Woodswallow 1 Crested Bellbird

A selection of the notable images captured are presented below.

Spinifex Hopping-mouse, *Notomys alexis* (M8)
(screen grab from 10 sec video).



Spinifex Hopping-mouse, *Notomys alexis* (M7)
(Note: Date on camera not correct)



KeepGuard 01-01-2011 10:39:18

Hooded Robin, *Melanodryas cucullata* (M7)
(Note: Date on camera not correct)



KeepGuard 01-02-2011 03:28:45

Torresian Crow, *Corvus orru* (M2)



KeepGuard 04-11-2013 10:11:22

Dingo, *Canis lupus dingo* (M8)
(screen grab from 10 sec video).



Dingo, *Canis lupus dingo* (M3)
(Note: Date on camera not correct)



KeepGuard 04-13-2012 20:02:35

Sand Goanna, *Varanus gouldii* (M8)
(screen grab from 10 sec video).



Sand Goanna, *Varanus gouldii* (M3)
(Note: Date on camera not correct)



KeepGuard

04-13-2012 14:21:48

Cat, *Felis catus* (M7)
(Note: Date on camera not correct)



KeepGuard

01-02-2011 14:03:14

GHD

57 Orange Avenue
Mildura, Victoria 3500
T: (03) 5018 5200 F: (03) 5018 5201 E: milduramail@ghd.com.au

© GHD 2015

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

N:\AU\Mildura\Projects\61\2905710\WP\603375.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	C. Whitehead R. Retallick	A. Holmes		I. McCardle		26/11/2015

www.ghd.com





Appendix I

Air Quality Assessment Report





TNG Limited
Mount Peake Project
Air Quality Assessment Report

December 2015

Executive summary

Introduction

TNG Limited is proposing to develop the Mount Peake Project, approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway, consisting of:

- Mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Road haulage of the concentrate to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed Darwin Refinery located at Middle Arm, Darwin.

The mine will be an open pit truck and shovel operation with an initial throughput of 3 million tonnes per annum (Mtpa), increasing up to 6 Mtpa from year 5. Following beneficiation, approximately 1.8 Mtpa of magnetite concentrate will be produced at peak production. The life of the mine is expected to be 15 years.

Emissions

The main air emissions are expected to be from material transport, processing and wind erosion (dust), and the power plant (carbon monoxide, oxides of nitrogen and volatile organic carbons). Greenhouse gas emissions will also occur throughout the life of the mine.

Sensitive receptors

The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community. The accommodation village will be located approximately 5 km to the east of the mine.

Construction dust assessment

The construction dust assessment shows:

- Dust emissions during construction are not considered to be significant. For the construction phase of the Project
- Due to the separation distance between the Project site and the nearest sensitive receptor, the dust management measures would detail actions for typical dust control.

Operational dust assessment

Air dispersion and deposition modelling was undertaken using the US EPA approved CALPUFF dispersion model. Surface meteorological observations from a nearby Bureau of Meteorology Station were used to inform CALMET (the 3D meteorological model pre-processor to CALPUFF) in combination with upper air data synthesized using The Air Pollution Model (TAPM). Model development was for the year 1 July 2011 to 30 June 2012. CALPUFF was then used to simulate the dispersion characteristics and concentrations of pollutants generated by the proposed activities.

Mining Year 4 was chosen to represent the highest emissions year during operations. This year was chosen as it has one of the highest mining rates, and the pit depth is shallow such that wind erosion would be relatively high compared to other years.

The modelling shows:

- Predicted impacts at receptors are all lower than assessment criteria
- The highest predicted concentration impacts from the Project are predicted at the closest receptor (Mine Camp). Predicted concentrations at the camp range between 2.5% and 44% of the various assessment criteria
- Predicted concentrations at non-mining receptors range between 0.005% and 5% of the guidelines. These low impacts from the Project were expected due to the large separation distances
- Predicted dust deposition is below detection levels and is therefore undiscernible from background dust at the sensitive receptors
- There are limited anthropogenic dust sources in the area with the majority of dust in the area generated through emission processes that naturally occur in the environment such as wind erosion from open areas and bushfire smoke
- Dust emissions from the Project, regional background sources, or both have the potential to dominate in the area of the mine site (a scale of kilometres from the site); however further afield, where non-mining related receptors are located (tens of kilometres), background regional levels and their own local neighbourhood sources will dominate
- The range of any measurable dust impact (taken as 10% of the assessment criterion) is approximately 20 km from the mine site. That is, any location outside of a radius of 20 km from the mine site is unlikely to distinguish the Project dust contributions from other regional sources. As the closest major dust source to the Project is Anningie Station (30 km from the Project), cumulative impacts from the two sources are likely to be insignificant.

Power station

The power station assessment shows:

- The predicted concentrations at all receptors are below the assessment criteria for all assessed pollutants
- As there are limited anthropogenic sources of pollutants other than dust in the area, background levels are unlikely to be of any significance.

Greenhouse gases

- Total emissions for the life of mine are estimated at 3,212,358 t CO₂-e
- Average annual emissions are estimated at 178,000 t CO₂-e. This is approximately 1%, 0.3% and 0.001% of annual NT, Australia and global emissions respectively
- The following management measures will be implemented to avoid, mitigate and offset greenhouse gas emissions arising from the Project:
 - Commitment to energy efficiency within the site Environmental Management Plan
 - Monitoring of greenhouse gas emissions and reporting of Scope 1 and Scope 2 emissions as part of National Greenhouse and Energy Reporting Scheme
 - Continuous improvement in compliance and emissions reduction throughout the project life through assessment and review processes including legislative reporting requirements.

Glossary of acronyms and terms

Air NEPM	National Environment Protection (Ambient Air Quality) Measure
Air Toxics NEPM	National Environment Protection (Air Toxics) Measure
AWS	automatic weather station
BoM	Bureau of Meteorology
CALMET	3D meteorological model pre-processor to CALPUFF
CALPUFF	Model that simulates dispersion of air pollutants
CO	carbon monoxide
EPA (WA)	Environmental Protection Authority (WA)
CO ₂	Carbon dioxide
CO ₂ -e	Carbon dioxide equivalent emissions
EPP	Environmental Protection Policy (WA)
GHD	GHD Pty Ltd
GL	Gigalitres
Kwinana EPP	Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999
Mtpa	Million tonnes per annum
MW	megawatts
NEPM	National Environment Protection Measure
NO ₂	nitrogen dioxide
NOHSC	National Occupational Health and Safety Commission
NO _x	oxides of nitrogen
NSW DEC	NSW Department of Environment and Conservation
NT	Northern Territory
PJ	petajoules
PM ₁	particulate matter of less than 1 micron in aerodynamic diameter
PM _{2.5}	particulate matter of less than 2.5 microns in aerodynamic diameter
PM ₁₀	particulate matter of less than 10 microns in aerodynamic diameter
PAHs	polycyclic aromatic hydrocarbons
ROM	run of mine
SEPP-AQM	Victorian State Environment Protection Policy (Air Quality Management)
SO ₂	sulphur dioxide
STEL	short term exposure level
TAPM	The Air Pollution Model
TNG	TNG Limited (wholly owned subsidiary Enigma Mining Limited)
TSP	total suspended particulates
TWA	time weighted average
µm	micrometre
µg/m ³	micrograms per cubic metre
Vic EPA	Victorian EPA
VOC	volatile organic compounds

Table of contents

1.	Introduction.....	1
1.1	Background.....	1
1.2	Scope of work	1
1.3	Approach.....	3
1.4	Limitations	3
2.	Project description.....	4
2.1	Mount Peake Project area	4
2.2	Mine operations	4
2.3	Water and power requirements	5
2.4	Timing	5
3.	Operational emission sources.....	8
3.1	Mine operation dust sources.....	8
3.2	Power station sources.....	12
3.3	Greenhouse gas sources.....	13
4.	Assessment criteria.....	14
4.1	Criteria for dust sources.....	14
4.2	Criteria for power station sources.....	15
5.	Existing environment.....	16
5.1	Topography and land use	16
5.2	Meteorology	16
5.3	Existing emissions	18
5.4	Sensitive receptors	18
6.	Meteorological modelling	19
6.1	Meteorological model choice	19
6.2	Meteorological configuration.....	19
7.	Construction assessment.....	24
7.1	Heavy machinery and plant	24
7.2	Construction dust.....	24
7.3	Construction dust management framework.....	25
8.	Mine operational assessment	26
8.1	Model selection	26
8.2	Model Parameters.....	27
8.3	Dust modelling results.....	33
8.4	Discussion of results	40
9.	Power station operational assessment	41
9.1	Emission rates	41
9.2	Modelling results	41

9.3	Discussion of results	41
10.	Greenhouse gas assessment	44
10.1	Introduction	44
10.2	Boundary of assessment	45
10.3	Greenhouse gases.....	45
10.4	Emission scope.....	46
10.5	Calculation of GHG emissions.....	46
10.6	Management of greenhouse gas emissions.....	49
11.	Conclusions.....	51
11.1	Dust assessment	51
11.2	Power station	51
11.3	Greenhouse gas	52

Table index

Table 3-1	Potential dust sources from mine operations	8
Table 3-2	Emission estimate NPI emission factor equations.....	11
Table 3-3	NPI estimated emission for criteria pollutants per genset	12
Table 3-4	NPI estimated emission of VOCs, per genset	12
Table 4-1	Assessment levels for dust (in-air concentrations and deposition)	14
Table 4-2	Assessment criteria for stack emissions from gas fired power station	15
Table 5-1	Sensitive receptor locations.....	18
Table 6-1	CALMET model configurations	20
Table 6-2	TAPM model configurations.....	22
Table 6-3	Initial deep soil moisture content – Input into TAPM	23
Table 8-1	Predicted throughput for 20 operational years	27
Table 8-2	Modelled source configuration for the Mount Peake Project – Volume sources	28
Table 8-3	Modelled source configuration for the Mount Peake Project– Area sources.....	29
Table 8-4	Mining Year 4 emission rates	31
Table 8-5	Predicted concentrations at receptors	33
Table 9-1	Emission rates per genset	41
Table 9-2	Modelled power station source configuration	42
Table 9-3	Predicted concentrations at receptors, $\mu\text{g}/\text{m}^3$	43
Table 10-1	Greenhouse gases and 100 year global warming potentials	45
Table 10-2	Transport calculations.....	47
Table 10-3	Power plant greenhouse gas emissions	48
Table 10-4	Borefield calculations	48

Table 10-5	Summary of total emissions (life of mine).....	49

Figure index

Figure 1-1	Project location – Mount Peake Project Area	2
Figure 2-1	Mount Peake Project and sensitive receptor locations.....	6
Figure 2-2	Mine Site Detail - Mount Peake Project area.....	7
Figure 3-1	Dust lift off resulting from saltation of sand particles	9
Figure 5-1	Annual and seasonal wind roses for observed meteorological data at the Territory Grape Farm AWS.....	17
Figure 6-1	Terrain from model domain.....	20
Figure 6-2	Meteorological monitoring site location.....	21
Figure 8-1	Emission source locations	30
Figure 8-2	Predicted 99.9 percentile PM ₁₀ 1-hour concentrations	34
Figure 8-3	Predicted 24-hour maximum PM ₁₀ concentrations	35
Figure 8-4	Predicted annual PM ₁₀ concentrations	36
Figure 8-5	Predicted 99.9 percentile TSP 1-hour concentrations	37
Figure 8-6	Predicted 24-hour maximum TSP concentrations	38
Figure 8-7	Predicted monthly maximum dust deposition	39

Appendices

Appendix A – Dust emissions inventory summary

1. Introduction

TNG Limited (TNG), is proposing to develop the Mount Peake Project, located approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway (Figure 1-1), consisting of:

- Mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Road haulage of the concentrate to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed Darwin Refinery located at Middle Arm, Darwin.

1.1 Background

The mine will be an open pit truck and shovel operation with an initial throughput of 3 million tonnes per annum (Mtpa), increasing up to 6 Mtpa from year 5. Following beneficiation, approximately 1.8 Mtpa of magnetite concentrate will be produced at peak production. The life of the mine is expected to be 15 years.

The main air emissions are expected to be from material transport, processing and wind erosion (dust), and the power plant (carbon monoxide, oxides of nitrogen and volatile organic carbons). Greenhouse gas emissions will also occur throughout the life of the mine.

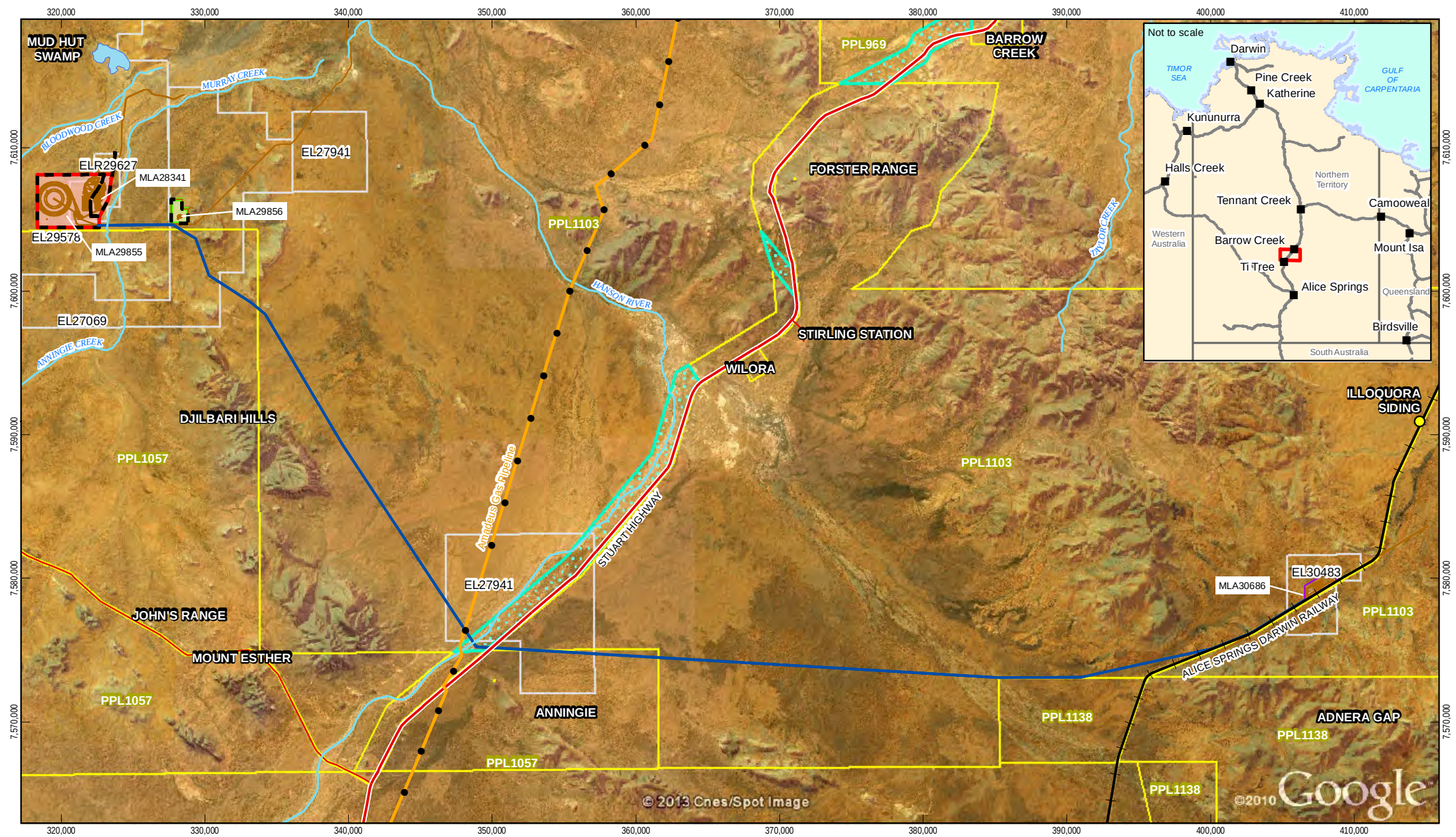
The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community. The accommodation village will be located approximately 5 km to the east of the mine.

1.2 Scope of work

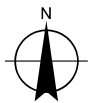
GHD Pty Ltd (GHD) was commissioned by TNG to prepare an environmental assessment for the Project. As part of this commission, GHD completed an air assessment.

This report assesses the potential air quality impacts from construction and operation of the Project. The report's scope is to:

- Assess the likely level of dust generation and other pollutants associated with construction of the Project
- Assess air quality impacts from the operation of the Project, including dispersion modelling and assessment against relevant air quality criteria
- Specify intended air quality management and mitigation measures during construction and operation of the Project to allow compliance with relevant air quality criteria
- Assessment of greenhouse gas emissions for the operation of the Project.



Paper Size A4
0 2.5 5 7.5 10
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53



LEGEND

Illoquora Siding	Amadeus Gas Pipeline	Crown Land
Principal Road	Mine Site Facilities	Camp Facilities
Minor Road	Mud Hut Swamp	Mount Peake Mineral Leases
Major Watercourses	Rail Siding Loading Facility	Cadastral Boundaries
Railway	Mount Peake Mining Area	Access Road



TNG Ltd
Mount Peake EIS

Project Location
Mount Peake Project Area

Job Number 61-29057
Revision A
Date 23 Oct 2015

G:\61\29057\11 GIS\Maps\MXD\6129057_001_Fig1\ProjectLocation.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

© 2015. Whilst every care has been taken to prepare this map, G.A, GE, GHD and TNG make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Data source: TNG - Gas / Slurry Pipeline Study Corridor, Camp Facilities, Transport Study Corridor, Mount Peake Mining Area, Mount Peake Granted Tenements (2015). Geoscience Australia - Waterways, mainland, placename, road (2008). Google Earth Pro - Imagery (Date extracted: 13/02/2014). Created by: RB

Figure 1-1

1.3 Approach

The approach adopted for the assessment of emissions to air from the Project is summarised in the following points. Each point is described in detail in the subsequent sections of the report:

- Outline of the Project, including layout, equipment and process flows (Section 2)
- Identification of emission sources and mitigation measures for the operational phase of the Project, including from mine operations and power station (Section 3)
- Identification of the appropriate air quality criteria and guidelines applicable to this air assessment (Section 4)
- Investigation of the existing environment, in terms of topography and land use, meteorology, background air quality and sensitive receptors (Section 5)
- Meteorological modelling, in order to synthesize site representative meteorology for use in dispersion modelling (Section 6)
- Assessment of predicted air quality impacts during construction including development of a management framework to inform task specific mitigation measures for use during construction (Section 7)
- Atmospheric dispersion and deposition modelling for the assessment of predicted air quality impacts during operation of the mine (Section 8) and power station (Section 9)
- Greenhouse gas assessment for the Project (Section 10)
- Conclusions drawn from the above assessment (Section 11).

1.4 Limitations

This report has been prepared by GHD for TNG Limited and may only be used and relied on by TNG Limited for the purpose agreed between GHD and the TNG Limited as set out in this report.

GHD otherwise disclaims responsibility to any person other than TNG Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope of work and limitations set out in the report.

GHD accepts no responsibility for the integrity of the software coding of the approved meteorological and air dispersion models (TAPM, CALMET and CALPUFF) used.

GHD has prepared this report on the basis of information provided by TNG Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

2. Project description

2.1 Mount Peake Project area

The Mount Peake Project is located approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway.

Mining, processing and associated infrastructure will occur at the mine site with accommodation facilities located 5 km to the east.

A transport corridor for site access and product haulage will run 100 km south-east and then east from the mine site to a new rail siding and load out facility near Adnera.

Existing infrastructure includes the Stuart Highway, Adelaide to Darwin Railway, the Amadeus Gas Pipeline, pastoral station tracks and wells for stock watering.

All Project components lie within the Stirling and Anningie perpetual pastoral leases aside from a portion of crown land adjacent to the Stuart Highway intersected by the transport corridor.

The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community.

Figure 2-1 shows the proposed Mount Peak Project site and the closest receptors.

2.2 Mine operations

The mine will be an open pit truck and shovel operation. Extracted ore will be transported by haul truck from the mine pit and stockpiled onsite at a run of mine (ROM) pad prior to processing. Mining will commence with a starter pit accessing high grade and low strip ratio ore to feed a beneficiation plant. The initial throughput of the beneficiation plant will be 3 Mtpa ramping up to 6 Mtpa in year 5. The life of the mine is expected to be 19 years inclusive of construction (2 years), mining (15 years) and closure (2 years).

Overburden and waste rock will be stored in a waste rock dump (WRD), as shown in Figure 2-2.

Extracted ore will undergo beneficiation, which involves crushing, grinding and magnetic separation to produce a concentrate. Ore will be loaded from the ROM pad to a primary crusher by front end loader. Approximately 1.8 Mtpa of concentrate will be produced at peak production.

Tailings will be stored in a tailings storage facility (TSF), as shown in Figure 2-2.

The magnetite concentrate will be transported by road haulage to a new rail siding and load out facility at Adnera. Up to 100 return truck movements will occur per day at peak production. To ensure safety for users of the Stuart Highway an underpass of the highway will be constructed.

Train loading will be via front end loader to a conveyor and loading bin located over the rail siding. Around one train movement per day is expected.

New facilities at the Mount Peake Project include:

- Open cut mine
- Waste rock dump (WRD) with up to 70 million tonne (Mt) capacity
- Run of mine (ROM) pad
- Four long term stockpiles of up to 4 Mt capacity each
- Process plant
- Tailings storage facility (TSF) with up to 63 Mt capacity

- Access road between the mine site and Adnera Loadout Facility including an underpass of Stuart Highway (for concentrate trucks) and intersections with Stuart Highway (for mine site access)
- Borefield and associated water pipeline
- Concentrate stockpiles
- Water treatment plant
- Sewage treatment plant
- Gas fired power station
- Explosives and detonator magazines
- Accommodation village
- Administrative buildings, laboratory, workshops and warehouses
- Gatehouse and weighbridge
- Fuel farm
- Concentrate loadout facility and rail siding at Adnera

Upon completion of the project, the site will be decommissioned and rehabilitated following an approved *Mine Closure Plan*.

2.3 Water and power requirements

Approximately 2,625 MLpa of make-up water will be required for mining, processing, dust suppression and potable use. Water will be obtained from a purpose built bore field.

At full production the power draw for the mine and process plant is estimated at 24 MW. Power during the first four years will be supplied from 16 x 1,400 kVA gas fired generating sets with an additional 12 generating sets added from year five. Emergency backup will be provided from 3 x 1,250 kVA diesel generators.

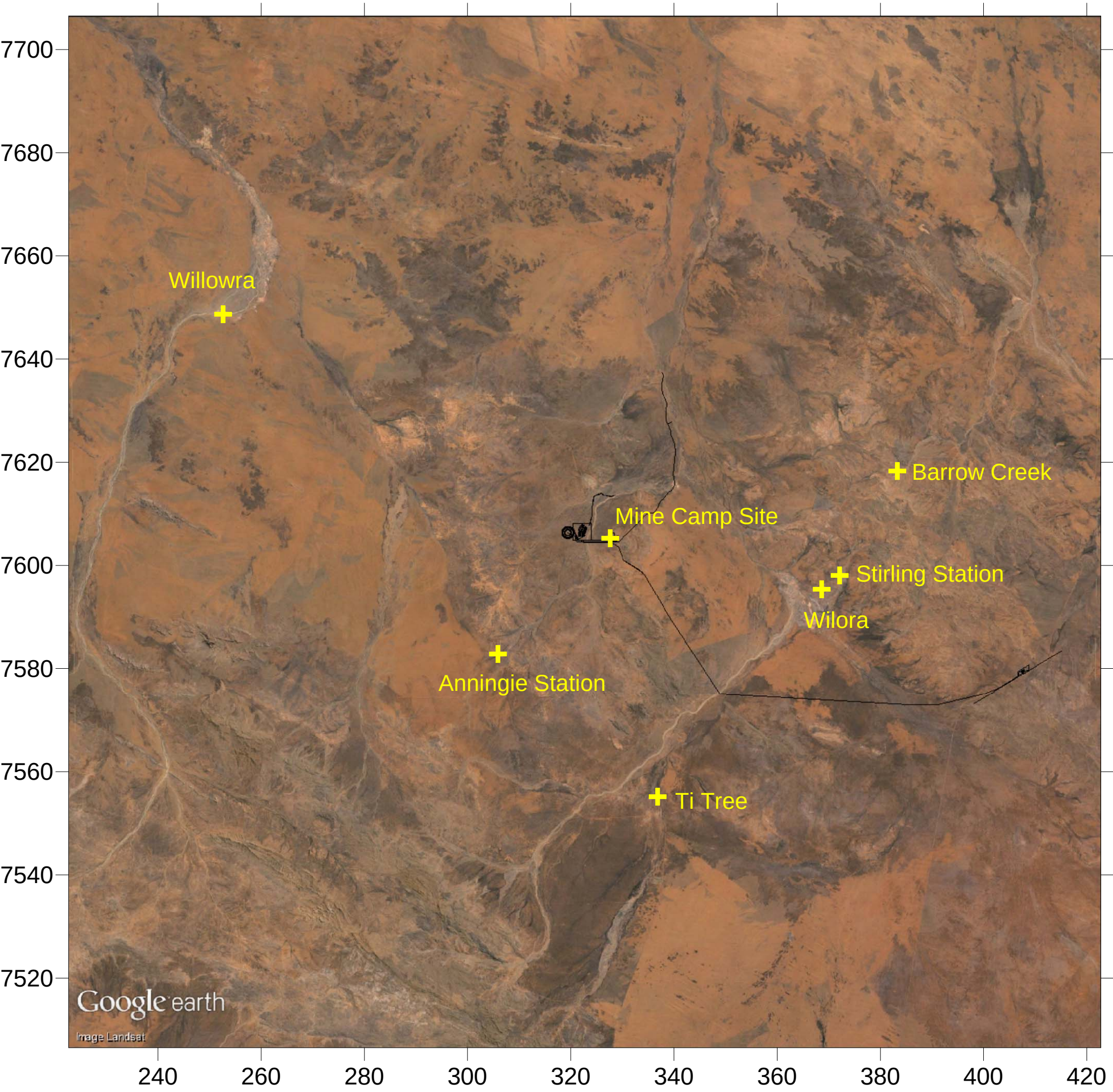
Gas will be provided from the Amadeus Gas Pipeline via a hot tap. Road train tankers will commute between the pipeline and the mine site along the access road.

Diesel generators will be used to power the borefield.

Power for construction will be provided by diesel powered generators until the power station is operable.

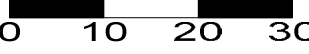
2.4 Timing

TNG proposes to commence construction in late 2016 with mining commencing in 2018.



- LEGEND**
-  Proposed mine layout
 -  Sensitive receptors

SCALE



Kilometres (at A3)

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20151028

COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.

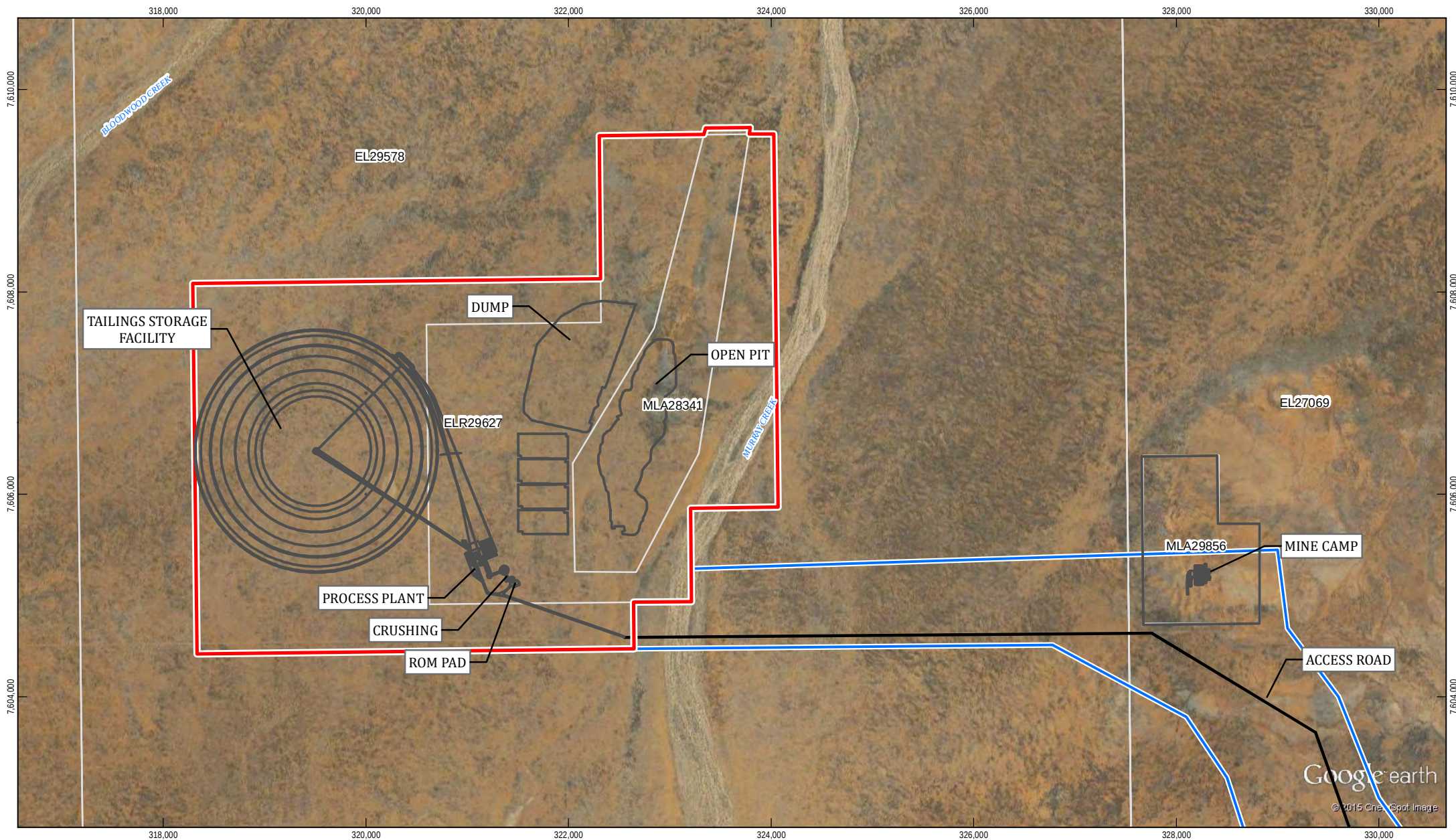


CLIENTS | PEOPLE | PERFORMANCE

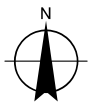
TNG Limited
Mount Peake Project

FIGURE 2-1
Proposed Mount Peake Project
and sensitive receptor locations

CREATED SW	CHECKED JF	APPROVED JF	DATE 28.10.15	FILE LOCATION G:/61/2905711/Technical/Surfer/Figure 2-1	DRAWING NO. Figure 2-1.srf	REVISION 0



Paper Size A4
0 0.5 1 1.5
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53



LEGEND

- Mine Site Facilities
- Mount Peake Granted Tenements
- Mount Peake Mining Area
- Access Road
- Transport Study Corridor



TNG Ltd
Mount Peake EIS

Mine Site Detail
Mount Peake Project Area

Job Number	61-29057
Revision	A
Date	26 Oct 2015

Figure 2-2

G:\61\29057\11 GIS\Maps\MXD\6129057_002_Fig2MineSiteDetail.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

© 2015. Whilst every care has been taken to prepare this map, TNG, GHD and GE make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Google: Imagery - 20150910; TNG Ltd: Mine site facilities, access road, mining area, Tenure - 20151021

3. Operational emission sources

3.1 Mine operation dust sources

The predominant mine operation dust sources include mechanical sources (trucking, conveying, dozing and grading) and wind erosion sources (cleared areas and stockpiles). The following sections detail the methods used to calculate emission rates for various sources. The calculated emission rates are summarised in Section 8.

Mine operations have the potential to generate particulate emissions from activities outlined in Table 3-1.

Table 3-1 Potential dust sources from mine operations

Source type	Source location
Wind erosion	Mine pit, long-term ore stockpiles, crushed ore stockpile, waste rock dump and tailings storage facility
Drilling of ore and waste rock	Mine pit
Blasting of ore and waste rock	Mine pit
Loading ore and waste rock into haul trucks using excavators/shovels or front end loaders	Mine pit
Hauling ore and waste rock	Haul roads from mine pit to the crushing plant, long-term ore stockpiles and waste rock dump
Unloading ore and waste rock from haul trucks	Crushing plant, long-term ore stockpiles and waste rock dump
Dozing of waste rock and long-term ore stockpiles	Waste rock dumps and long-term ore stockpiles
Ancillary vehicle movement	Mine roads
Grading haul roads	Haul roads
Primary crusher	Crushing plant
Ore handling and transfer	Crushing plant, crushed ore stockpile and crushed ore stockpile to processing plant

3.1.1 Wind erosion emissions

Shao *et al.*^[1] describes the process by which dust lift off occurs for three grain sizes:

- Large particles (>1000 µm) remain stationary or move along the ground (creep) as they are too aerodynamically heavy
- Sand particles (typically between 60 and 1000 µm) are easily lifted from the surface into saltation motion as they have small threshold velocities. This leads to sand drift
- Dust particles (typically <60 µm) are not lifted directly from the surface (under normal conditions) due to large threshold velocities which are present due to large inter-particle cohesive forces. However, when saltation occurs (by sand particles), dust particles are ejected from the surface due to sand grain impacts. This is termed saltation bombardment. In the atmosphere, turbulence and buoyancy keep the dust particles suspended for a period of time (determined by a number of factors) until deposition occurs, often many kilometres from the original source.

These movements are illustrated in Figure 3-1.

¹ Shao, Raupach and Leys, 1996. *A Model for Predicting Aeolian Sand Drift and Dust Entrainment on Scales from Paddock to Region*. Australian Journal of Soil Research, 34, pp. 309-342.

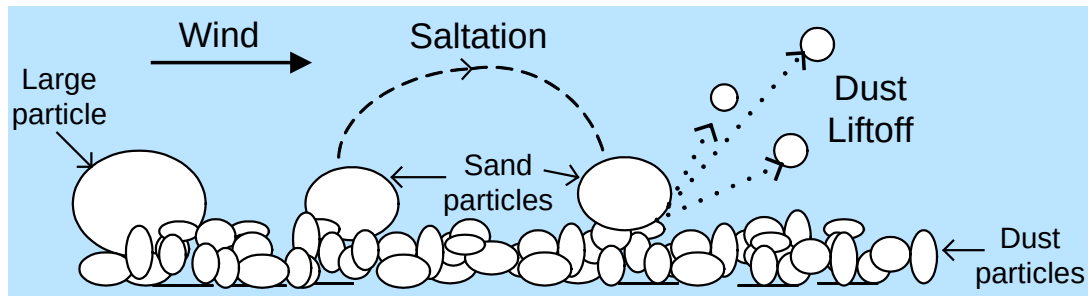


Figure 3-1 Dust lift off resulting from saltation of sand particles

An SKM study^[2] calculated stream wise dust flux ($Q(d)$) for a particle size as following Equation 3-1.

Equation 3-1

$$\begin{aligned}\tilde{Q}(d) &= \left(\frac{c_s \rho}{g} \right) \times u_*^3 \left[1 - \left(\frac{u_{*t}(d)}{u_*} \right)^2 \right] & (u_* \geq u_{*t}) \\ &= 0 & (u_* < u_{*t})\end{aligned}$$

Where u_{*t} is the threshold friction velocity, u_* is the frictional velocity, c_s is a coefficient of order 1, ρ is the air density and g is gravity.

In the SKM study, U was assumed to be directly proportional to u_* and the first term was simplified as constant of proportionality, which was determine when calibrating the model. However, Shao *et al.* indicate that Equation 3-1 is for estimating stream wise sand flux (i.e. $d = d_s$). Shao *et al.* go on to postulate that dust flux, $F(d_d, d_s)$, can be calculated using Equation 3-2.

Equation 3-2

$$\tilde{F}(d_d, d_s) = \frac{2}{3} \left(\frac{\rho_p}{\rho} \right) \left[\frac{\beta \gamma g}{\{u_{*t}(d_d)\}^2} \right] \tilde{Q}(d_s)$$

Where ρ_p and ρ are the density of the particle and air, β is a constant bombardment parameter and γ is a dimensionless constant empirically derived as 2.5. By substituting the stream wise sand flux (Equation 3-1) into the dust flux (Equation 3-2), GHD has derived Equation 3-3.

Equation 3-3

$$\begin{aligned}F(d_d, d_s) &= B \times u_* \left(\frac{u_*^2}{u_{*t}^2} - 1 \right) & (u_* \geq u_{*t}) \\ &= 0 & (u_* < u_{*t})\end{aligned}$$

Where:

- F is the average hourly dust flux (PM₁₀ or TSP) per active area for a given area. It has units of g/s/m²
- B is a dimensioned constant of proportionality that incorporates particle and air densities, a bombardment constant, source particle size distribution, gravity, ground cover, a degree of management effort and other empirical constants
- u_* is the average hourly surface friction velocity for the active area
- u_{*t} is the average hourly threshold friction velocity for dust lift off.

GHD has adopted the above methodology for a number of similar studies^[3].

² SKM (Sinclair Knight Merz), 2004. *Kwinana Residue Area Dust Emission Modelling: Final*. November 2004.

³ GHD, 2009. *Kwinana Residue Dust Emissions Study Report for Alcoa of Australia*. December 2009.

GHD, 2013. *Pinjarra Residue Dust Emissions Study Report for Alcoa of Australia*. February 2013.

GHD, 2014. *Project Shaheen Air Quality Assessment Report for Mubadala & DUBAL*. June 2014.

Calculation of u_{*}

u_{*} values are provided as output from the CALMET meteorological model (see Section 6 for more information on CALMET model development).

Calculation of $u_{*,t}$

Equation 3-4 below may be used to determine $u_{*,t}$. This is an adapted form of the u_{*} equation presented in Shao *et al.*

Equation 3-4

$$u_{*,t} = \frac{u_{*,t,dry}}{H(\omega)}$$

Where $u_{*,t,dry}$ is the average threshold friction velocity for the drying area when the drying area is dry and $H(\omega)$ is a measure of soil wetness where 0 is a wet soil and 1 is a dry soil. The following $u_{*,t,dry}$ values were adopted for this study:

- $u_{*,t,dry} = 0.3$ for tailings dam (majority of area is wet)
- $u_{*,t,dry} = 0.232$ for other areas.

It is noted that Shao *et al.* includes a ground cover, or management function within the denominator of Equation 3-4. As GHD has no means of calculating an hourly varying management of cover factor, it is assumed to be constant which is effectively incorporated into the calibration factor B of Equation 3-3. Incorporation of a valid management function, based on a continuous measure of management effort could be a future improvement to the model.

Calibration of B

In the absence of measured hourly dust concentration data for the typical site conditions, B values were adjusted to give the overall hourly emission rates in line with the National Pollutant Inventory (NPI) default emission values of 0.4 and 0.2 kg/ha/h for TSP and PM₁₀, respectively. The B values used for this assessment were:

- $B_{TSP} = 2.75 \times 10^{-4}$
- $B_{PM10} = 1.38 \times 10^{-4}$.

3.1.2 Mechanical emissions

Mechanical emission factors (EF) are calculated using a combination of process rates, ore properties and emission factors from the NPI estimation manual for mining^[4]. Table 3-2 shows NPI equations used within this study.

3.1.3 Control factors

Emission factors were multiplied by various ratios, depending on controls employed to reduce dust emission from various dust sources. Control factors are from the NPI manual for mining^[4]. The following control factors were used in this study for various activities:

- Hauling – 75% for level 2 watering (>2 litres/m²/h)
- Wind erosion from stockpiles – 50% for water sprays
- Unloading trucks – 70% for water sprays.

⁴ National Pollutant Inventory, 2012. *National Pollutant Inventory Emission Estimation Technique Manual for Mining – Version 3.1.*

Table 3-2 Emission estimate NPI emission factor equations

Equation ID	Equation	Constants used in this assessment				Dust sources
Equation 3-5 Blasting	$EF(kg/blast) = 344 * A^{0.8} * M^{-1.9} * D^{-1.8}$ Where A is the area blasted in m ² , M is % moisture content, and D is depth of blast holes (m).	A = 4043 m ² M = 5% D = 12 m				Blasting
Equation 3-6 Excavators/ shovels/ front end loaders	$EF(kg/t) = k \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}}$ Where: U is mean wind speed (m/s) and M is % moisture	k TSP = 0.74, k _{PM10} = 0.35 U =3.2 m/s M = 5% for low grade rock, 20 % for ore				Ore loading Waste rock loading
Equation 3-7 Wheel generated dust	$EF(kg/VKT) = \frac{0.4536}{1.6093} \times k \times \left(\frac{S_{(\%)}}{12}\right)^a \times \left(\frac{W_{(t)}}{3}\right)^b$ Where: s is % silt content, W is vehicle mass (tonnes) and k, a and b are empirical constants		TSP	PM ₁₀	S = 6% (road surface) W = 384 t for HV and 5 t for LV (inc. buses)	Hauling ore Hauling waste rock Light vehicle travel
		a	0.7	0.9		
		b	0.45	0.45		
		k	4.9	1.5		
Equation 3-8 Dumping	$EF_{TSP}(kg/t) = 0.012$ $EF_{PM10}(kg/t) = 0.0043$	-				Dumping ore Dumping waste rock
Equation 3-9 Dozing	$EF(kg/h) = a \times \frac{s^b_{(\%)}}{M^{1.4}_{(\%)}}$ Where: s is % silt content and M is % moisture content		TSP	PM ₁₀	s = 6% M = 5% (low grade rock)	Waste rock dozing
		a	2.6	0.34		
		b	1.2	1.5		
		c	1.3	1.4		
Equation 3-10 Grading	$EF(kg/VKT) = 0.0034 \times S^a$ Where: S is mean grader speed (km/h)		TSP	PM ₁₀	S = 10 km/h	Grading roads
		a	2.5	2.0		
Equation 3-11 Conveying	$EF_{TSP}(kg/t) = 0.005$ $EF_{PM10}(kg/t) = 0.002$	For high moisture content ores				Processing plant conveyors
Equation 3-12 Primary crushing	$EF_{TSP}(kg/t) = 0.01$ $EF_{PM10}(kg/t) = 0.004$	For high moisture content ores				Primary crushing
Equation 3-13 Secondary crushing	$EF_{TSP}(kg/t) = 0.03$ $EF_{PM10}(kg/t) = 0.012$	For high moisture content ores				Secondary crushing
Equation 3-14 Tertiary crushing	$EF_{TSP}(kg/t) = 0.03$ $EF_{PM10}(kg/t) = 0.01$	For high moisture content ores				Tertiary crushing

3.2 Power station sources

The primary pollutants from gas engines are oxides of nitrogen (NO_x) formed by high temperatures generated in the combustor and carbon monoxide (CO) and volatile organic compounds (VOC) which are formed predominantly by the incomplete combustion of fuel. Particulate matter less than 10 microns in aerodynamic diameter (PM₁₀) and sulphur dioxide (SO₂) are emitted in trace amounts as the gas turbines are fired using natural gas.

This assessment assumes the power station is at individual plant capacity, i.e. at 100% maximum capacity rating and not the estimated load. This conservative approach provides for increased loading if required.

Emissions and its constituents were estimated using emission factors from the NPI emissions estimation manual for combustion engines^[5].

Emissions were estimated using:

Equation 3-15

$$E_i = \frac{(FC \times EF_i \times 1000)}{(365 \times 24 \times 60 \times 60)}$$

Where: E_i = Emission rate of pollutant i (g/s)

FC = fuel consumption (m³/yr)

EF_i = Emission factor for pollutant i

Table 3-3 and Table 3-4 outline the estimated emissions of criteria pollutants. The tables include outputs for the operational power generation (gas) using total power plant generation of 1.8 PJ with 28 gensets (highest power output anticipated for the life of mine). Emissions from power generation at the borefield and the emergency generators are considered small in relation to the main site power station, and are not included in the modelling.

Table 3-3 NPI estimated emission for criteria pollutants per genset

Pollutant	Gas	
	EF _i (kg/m ³) ^[6]	E _i (g/s)
Carbon monoxide	0.005310	0.29
Oxides of nitrogen	0.068300	3.74

Table 3-4 NPI estimated emission of VOCs, per genset

Pollutant	EF _i (kg/m ³)	Gas	
		E _i (g/s)	% of VOCs
Total VOCs	0.00198	0.11	--
Acetaldehyde	0.00014	0.0077	7%
Benzene	0.0000074	0.00040	0.37%
Formaldehyde	0.00088	0.048	45%
Toluene	0.0000068	0.00037	0.34%
Xylene	0.0000031	0.00017	0.16%

⁵ National Pollutant Inventory 2008. *NPI Emissions Estimation Technique Manual (EET) for Combustion Engines*.

⁶ From Table 54 of *EET for Combustion Engines*

3.2.1 Upset conditions

Risk assessment of air quality impacts due to upset conditions did not identify any significant risk from plant failure or malfunction. Gas supply failure or engine malfunction would result in the partial or full shut down of power generation systems and cessation of emissions to air.

No further consideration of upset conditions has been made in this assessment.

3.2.2 Mitigation measures

Emissions from gas engines would be mitigated by tuning for optimum performance, efficiency and lowest emissions. This involves using lean burn technology, involving combustion of a lean air-fuel mixture, which has more air than is required for the stoichiometric combustion of the fuel. This results in lower peak combustion temperatures, which in turn reduces NO_x formation.

3.3 Greenhouse gas sources

Greenhouse gas sources are discussed in Section 10.5 of this document.

4. Assessment criteria

4.1 Criteria for dust sources

Air quality impacts are assessed by comparing monitoring results or model predictions with appropriate criteria. The impacts of emissions from mining in the Northern Territory are primarily assessed with reference to the *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM). Of the indicators prescribed in the Air NEPM, PM₁₀ and PM_{2.5}, are considered as the main air quality indicators for the Project (construction and operation), as shown in Table 4-1.

In addition, the WA Environmental Protection Authority (EPA) criteria for total suspended particulates (TSP)^[7], the Victoria Mining Protocol for Environmental Management (PEM) criteria for PM_{2.5} and PM₁₀^[8], and the Victorian Environment Protection Authority (Vic EPA) Design Criteria for PM₁₀^[9] are shown in Table 4-1.

Given that the NEPM criteria were designed as goals to guide the management of emissions to air sheds of significant population (and not to apply to individual emitters), the WA, NSW and Victorian criteria are more relevant to this situation. In particular, the Victorian Mining PEM criteria have been specifically developed for mining operations, where sources are mobile and area-based, and are therefore the more appropriate criteria to apply.

EPA Victoria specified PM₁₀ and PM_{2.5} criteria for non-point sources in mining operations are also shown in Table 4-1.

There are no specific criteria for dust deposition in the Northern Territory and the NSW Office of Environment and Heritage (NSW OEH) dust deposition standard provided in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*^[10] has been applied. NSW OEH impact assessment goals for an annual average dust deposition such that nuisance dust impacts could be avoided are provided in Table 4-1.

Table 4-1 Assessment levels for dust (in-air concentrations and deposition)

Pollutant	Averaging period	Max./99.9th %ile	Criterion	Source
TSP	24-hours	Maximum	90 µg/m ³	WA EPA
PM ₁₀	1-hour	99.9 th %ile	80 µg/m ³	SEPP-AQM
	24-hours	Maximum	50 µg/m ³	Air NEPM
	24-hours	Maximum	60 µg/m ³	Mining PEM
	Annual	Maximum	20 µg/m ³	Air NEPM ^[11]
Dust deposition	Annual	Maximum	2.0 g/m ² /month	NSW OEH

⁷ The *Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999* (Kwinana EPP) specifies a standard of 90 µg/m³ for least dust impacted areas (rural residential areas beyond the buffer area).

⁸ EPA Victoria, 2007. *Protocol for Environmental Management: Mining and Extractive Industries*, EPA Victoria Publication 1191, December 2007.

⁹ Established under the Victorian State Environment Protection Policy (Air Quality Management) (SEPP-AQM).

¹⁰ NSW OEH, 2005. *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. Sydney, August 2005.

¹¹ Proposed addition to the Air NEPM.

4.2 Criteria for power station sources

The proposed gas fired power station will generate the exhaust pollutants carbon monoxide (CO) and oxides of nitrogen, NO_x (as nitrogen dioxide, NO₂) and trace products of incomplete combustion. However, it is anticipated that CO and NO_x will be the most pertinent air pollutant and that the other emission constituents will not pose a significant issue. Criteria pollutants will be assessed against the Air NEPM and Vic EPA design criteria. Other trace pollutants will be assessed against Air Toxics NEPM and Vic EPA design criteria. Assessment criteria from the gas fired power station are outlined in Table 4-2.

Sulphur dioxide and particulate emissions were not modelled from the power station due to the negligible quantity of sulphur in the pipeline natural gas and negligible contribution of dust compared to other mine site activities.

Table 4-2 Assessment criteria for stack emissions from gas fired power station

Pollutant	Averaging period	Max./99.9 th %ile	Criterion	Source
Nitrogen dioxide	1-hour	Maximum	247 µg/m ³	Air NEPM
	1-hour	99.9 th %ile	190 µg/m ³	SEPP-AQM
	Annual	Maximum	62 µg/m ³	Air NEPM
Carbon monoxide	1-hour	99.9 th %ile	29,000 µg/m ³	SEPP-AQM
	8-hours	Maximum	11,254 µg/m ³	Air NEPM
Acetaldehyde	3-minutes	99.9 th %ile	76 µg/m ³	SEPP-AQM
Benzene	3-minutes	99.9 th %ile	53 µg/m ³	SEPP-AQM
	Annual	Maximum	10.5 µg/m ³	Air Toxics NEPM
Formaldehyde	3-minutes	99.9 th %ile	40 µg/m ³	SEPP-AQM
	24-hours	Maximum	53.6 µg/m ³	Air Toxics NEPM
Toluene	3-minutes	99.9 th %ile	650 µg/m ³	SEPP-AQM
	24-hours	Maximum	4114 µg/m ³	Air Toxics NEPM
	Annual	Maximum	411 µg/m ³	Air Toxics NEPM
Xylenes	3-minutes	99.9 th %ile	350 µg/m ³	SEPP-AQM
	24-hours	Maximum	1183 µg/m ³	Air Toxics NEPM
	Annual	Maximum	946 µg/m ³	Air Toxics NEPM

5. Existing environment

5.1 Topography and land use

5.1.1 Mount Peake Project area

The Mount Peake Project Area lies within the Burt Plain bioregion. Land use immediately adjacent to the Mount Peake Project Area is pastoral activities. Existing infrastructure includes the Stuart Highway, Adelaide to Darwin Railway, the Amadeus Gas Pipeline, pastoral station tracks and wells for stock watering.

The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community.

5.2 Meteorology

5.2.1 Temperature

Temperatures vary significantly, with mean daily maximum temperatures ranging from 22°C (August) to 37°C (January), and mean daily minimum temperatures from 8°C (July) to 24°C (January). Average annual evaporation for Barrow Creek totals around 2,980 mm, with average monthly evaporation exceeding rainfall in all months^[12].

5.2.2 Rainfall

The climate of the region is arid to semi-arid with a mean annual rainfall of approximately 320 mm recorded at Barrow Creek, approximately 65 km east of the mining area. The climate is characterised by hot, wet summers and warm, dry winters.

Rain tends to fall during heavy rain events between November and March, with little follow on rain. The highest annual rainfall for Barrow Creek of 1,153 mm was recorded in 2010. Annual rainfall is highly variable.

5.2.3 Wind

Annual and seasonal wind roses for the Territory Grape Farm AWS, based on hourly observations, are shown for 2 July 2011 to 30 June 2012 in Figure 5-1. The wind roses show graphically the frequency of occurrence of winds by direction and strength, from varying compass points. The length of the bar represents the frequency of occurrence of winds from that direction and the colour corresponds to the wind speed categories, as defined in the legend. Figure 5-1 shows a dominant south easterly wind direction throughout the year.

¹² Bureau of Meteorology (BoM), 2015. *Climate Statistics for Australian Locations - Monthly Climate Statistics - Summary Statistics – Barrow Creek*. http://www.bom.gov.au/climate/averages/tables/cw_015525.shtml. Accessed 5 May 2015.

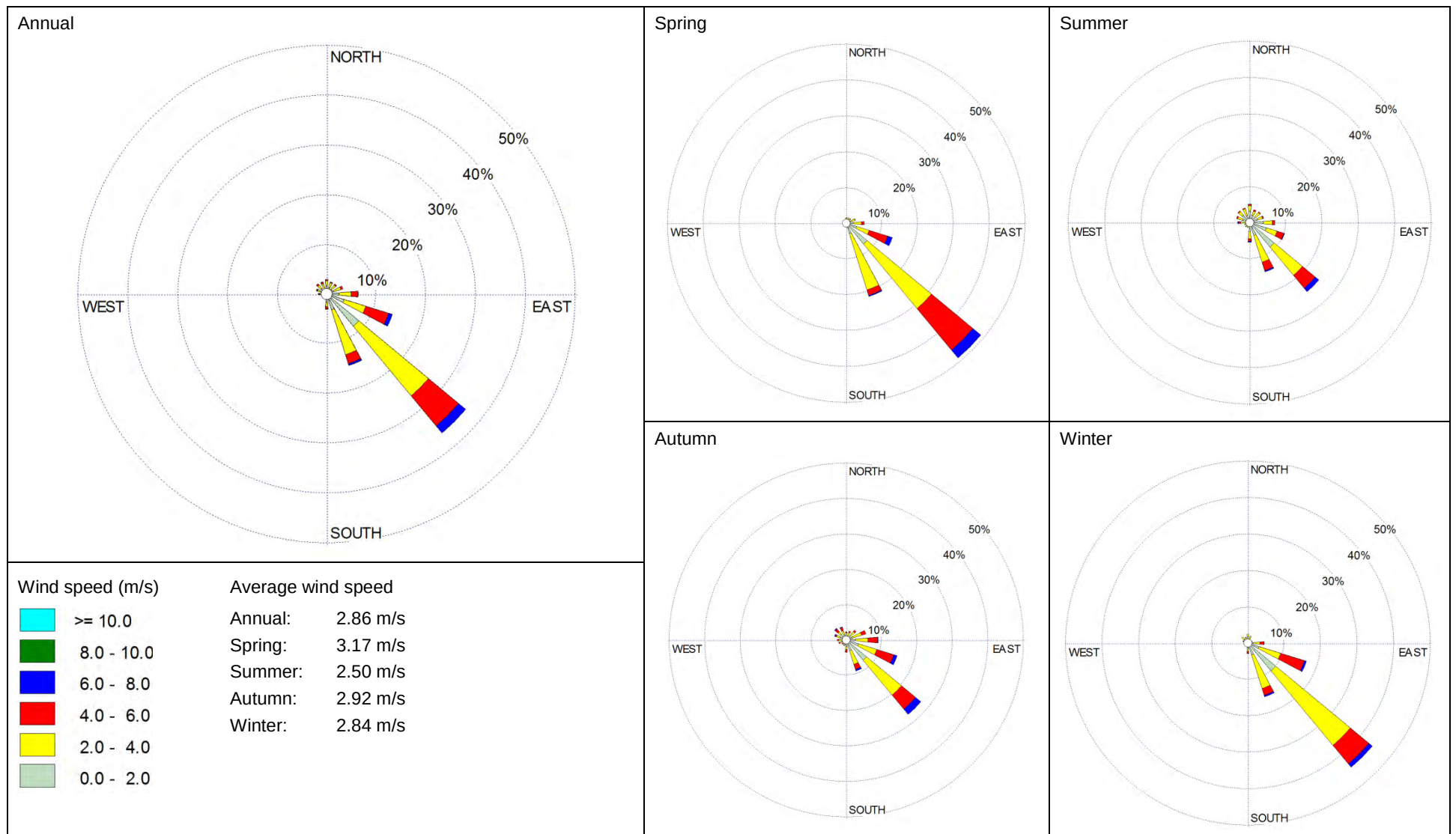


Figure 5-1 Annual and seasonal wind roses for observed meteorological data at the Territory Grape Farm AWS

5.3 Existing emissions

No previous air quality monitoring has been performed at or nearby the Mount Peake Project area.

There are no existing industrial air emissions within the Mount Peake Project area.

Dust emissions occur from wind erosion from exposed ground, station related vehicle traffic on unsealed roads and smoke emissions from seasonal bushfires in the region.

The nearest occupied residence is Anningie Station homestead (approximately five permanent residents) around 30 km from the mine site. Wilora community (approximately 120 residents) is around 20 km from the access road and 47 km from the mine site. Ti Tree (approximately 150 residents) is around 52 km from the mine site.

There are also two semi-permanently occupied Indigenous outstations (Patsy's and Walkabout) on the western side of Stuart Highway between Wilora and Barrow Creek.

5.4 Sensitive receptors

A number of sensitive receptors were identified in the Mount Peake region as listed in Table 5-1 and shown in Figure 2-1.

Whilst the majority of these receptors are unlikely to experience any impact during the construction or operation of the Project (due to the separation distance), they have been included in this assessment for completeness.

Table 5-1 Sensitive receptor locations

Name	Detail	Easting (m)	Northing (m)	Distance from Mount Peake (km)
Mine camp site	Mine accommodation village	327,657	7,605,251	5
Anningie Station	Pastoral lease homestead	305,913	7,582,817	30
Wilora	Aboriginal community	368,646	7,595,380	47
Stirling Station	Pastoral lease homestead	372,097	7,598,030	51
Ti Tree	Small town	336,844	7,555,160	52
Barrow Creek	Small town	383,314	7,618,267	62
Willowra	Aboriginal community	252,622	7,648,678	80

6. Meteorological modelling

6.1 Meteorological model choice

CALMET (v 5.8) is the 3D meteorological model pre-processor to the CALPUFF dispersion model (discussed in Section 8.1). CALMET includes a diagnostic wind field generator, with algorithms to generate slope flows, kinematic terrain effects (wind channelling), terrain blocking effects (stagnation) and also divergence minimisation (mass consistency) over spatially varying land uses and types. The latter can vary from industrial areas to barren land and even water bodies and ice.

CALMET also includes separate micrometeorological models to characterise both the overland and over water atmospheric boundary layers. The sub-models each formulate the evolution of spatially varying temperature profiles and the heights of the different mixed layers both over water and overland and the thermal internal boundary layer interface between them through a process of upwind spatial averaging. They also generate parameters that characterise the atmospheric stability within and above these layers.

This meteorological, micro-meteorological and land use information is passed to the CALPUFF dispersion model so that the manner in which emission plumes are transported and dispersed in the atmosphere can be determined^[13].

6.2 Meteorological configuration

6.2.1 CALMET settings

CALMET settings were as per the CALPUFF guidance document^[14] for *hybrid mode* using a combination of gridded meteorological data supplemented by surface data (one meteorological station located at the Territory Grape Farm AWS), except for the following:

- Kinematic effects were computed (IKINE = 1)
The nature of the terrain means that hills and valleys create flow divergence and convergence as the wind moves around the natural obstacles. A better representation of the vertical velocity was required to maintain mass consistency and to more accurately represent the situations of plume strike.
- The O'Brien procedure for vertical velocity adjustment was applied (IOBR = 1)
With kinematic effects included, the O'Brien procedure was applied so that domain mass consistency could be maintained at the top of the domain.

The TERRAD variable was set to a value of 10 km based on an inspection of the terrain elevations in the vicinity of the Project site.

Terrain and land use data were derived from 90 m resolution topography obtained from the AUSLIG data set. Aerial imagery was applied to confirm land use characteristics and modified where appropriate.

Figure 6-1 shows a summary of the terrain in the model domain.

Table 6-1 provides a summary of key parameters used in the CALMET model.

¹³ Refer to *A User's Guide for the CALMET Meteorological Model (Version 5)*, Earth Tech, Inc., January 2000.

¹⁴ Atmospheric Studies Group, 2011. *Generic Guidance and Optimum Model Setting for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for Modelling and Assessments of Air Pollutants in NSW, Australia'*. Prepared for NSW Office of Environment and Heritage, Sydney.

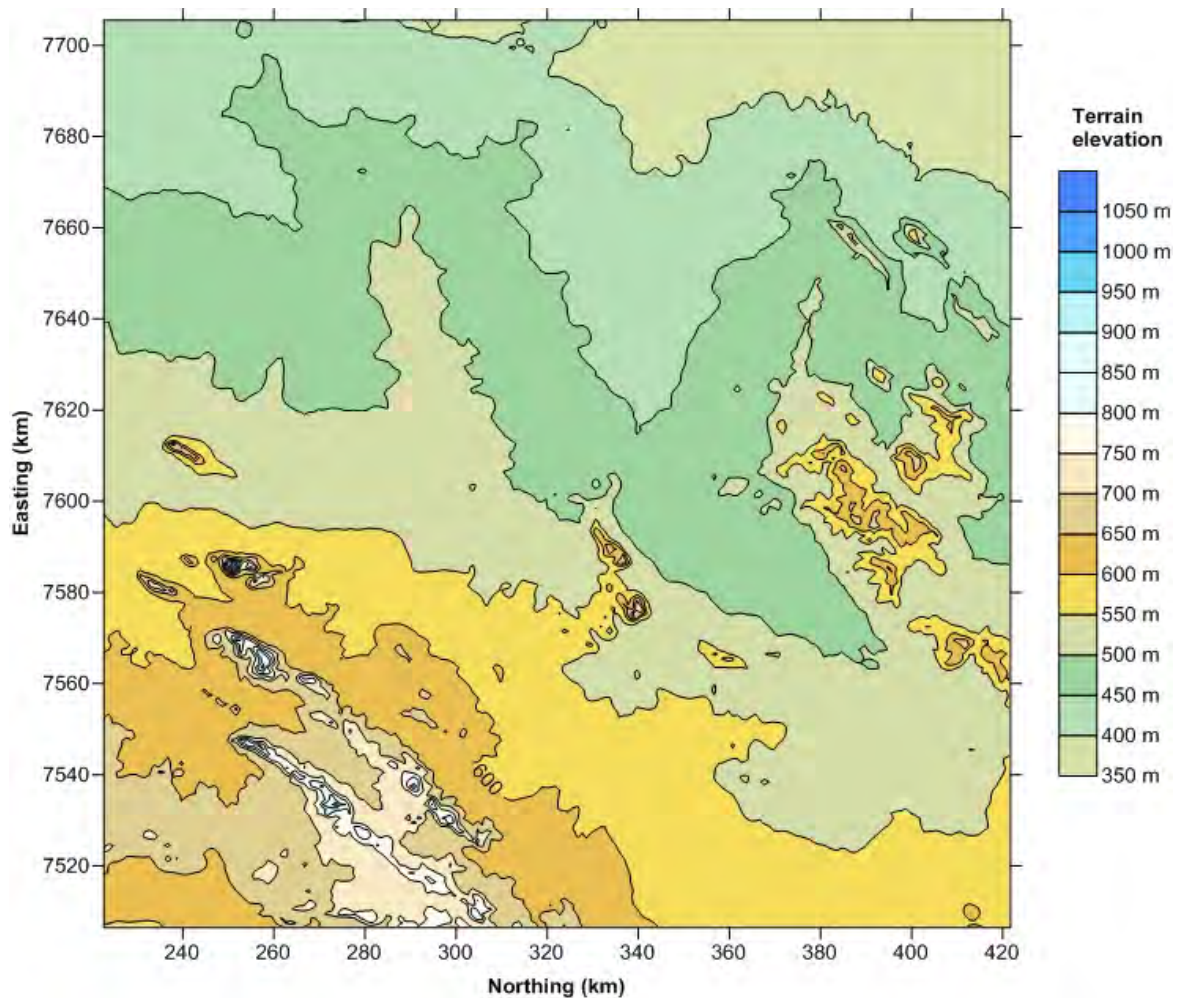


Figure 6-1 Terrain from model domain

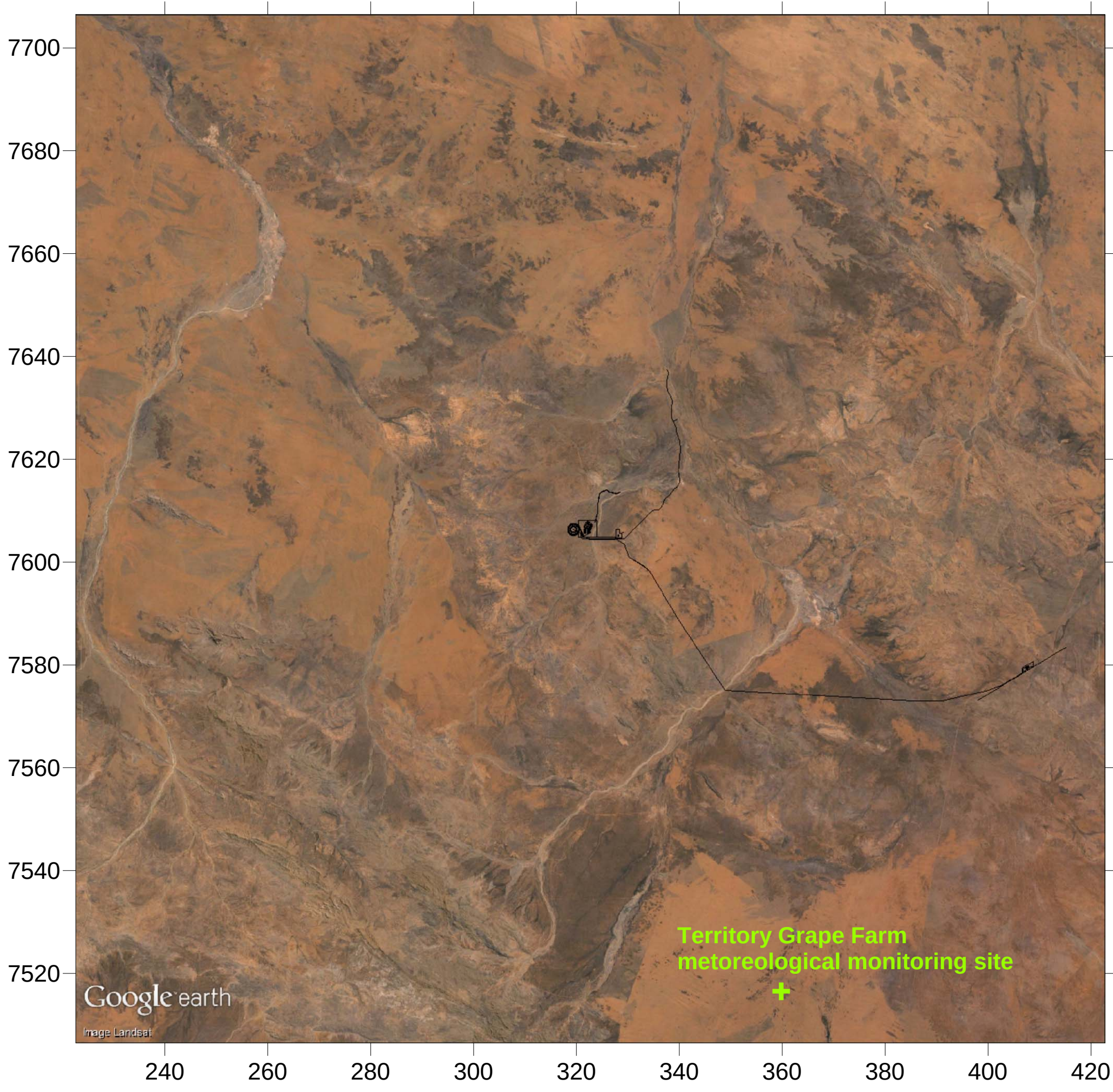
Table 6-1 CALMET model configurations

Parameter	Detail
Domain origin	UTM 53 coordinates 222.198 km east and 7506.005 km north
CALMET grid resolution	1000 m
No. CALMET grids	Easting = 200; Northing = 200
No. vertical levels	11
Vertical levels (m)	0, 20, 40, 61, 80, 100, 120, 180, 420, 700, 1500, 2500
CALMET setting for hybrid mode	TERRAD = 10 km Kinematic effects O'Brien corrections
Surface data	Refer to Section 6.2.2
Upper data	Refer to Section 6.2.3

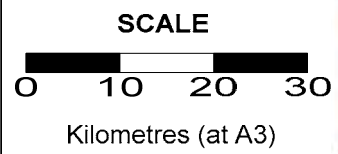
6.2.2 Surface data

The closest representative meteorological station to the Project site is Territory Grape Farm AWS, operated by the Bureau of Meteorology since 1987, as shown in Figure 6-2.

A review of meteorological data from the Territory Grape Farm AWS allowed for selection of an appropriate year long period to use in modelling. This year was chosen by choosing meteorological conditions that are most similar to typical meteorological patterns in the area. July 2011 through to June 2012 was chosen as the most appropriate time period.



- LEGEND**
- Proposed mine layout
 - Meteorological monitoring site



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datump of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20151028

COPYRIGHT
THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



CLIENTS | PEOPLE | PERFORMANCE

TNG Limited
Mount Peake Project

FIGURE 6-2
Meteorological monitoring site location

CREATED SW	CHECKED JF	APPROVED JF	DATE 28.10.15	FILE LOCATION G:/61/2905711/Technical/Surfer/Figure 6-2	DRAWING NO. Figure 6-2.srf	REVISION 0

The following hourly measured parameters were adopted for input into the CALMET model.

- Wind speed and direction
- Ambient temperature
- Relative humidity
- Pressure
- Precipitation.

In addition to this, ceilometer data from Alice Springs Airport AWS was included to provide ceiling height and cloud cover (in tenths).

6.2.3 Upper data

The 3D prognostic model The Air Pollution Model (TAPM) was used to synthesise upper data in the absence of suitable upper observations.

TAPM was configured using a nested model domain approach designed to capture:

- Broad scale synoptic flows
- Regional and broader scale sea and land breezes
- Regional and broader wind channelling around geographical features
- Influences of land use.

The nested grids were then configured with surface characteristics such as terrain elevation, surface roughness, vegetation type, soil type and monthly varying (initial) deep soil moisture content. The synoptic analysis for each month of the model year was used with the model settings shown in Table 6-2 for each of the Project areas.

Table 6-2 TAPM model configurations

Model parameter	Configuration
Three nested grids	10,000 m, 3000 m, and 1500 m resolution 81 x 81 grid points
Vertical levels	11 vertical levels, ranging up to 8000 m
Grids centred at	322198 m E and 7606005 N, Map Grid of Australia, Zone 53
Vegetation, terrain and land use	Datasets provided with the model Where required, adjustments made, with cross-reference to aerial imagery, in the immediate area of the mine site.
Deep soil volumetric moisture content for land areas	Adjusted as required, see below.
Air-sea temperature differences	Default values used
Surface vegetation and precipitation processes	Included (snow processes and non-hydrostatic process excluded)

Deep soil moisture content

Deep soil moisture content was varied to reflect actual rainfall during the year, as shown in Table 6-3. The wet season, based on meteorological records for the region, was determined by an experienced meteorologist to have begun on 15 December 2011 and to have finished on 30 April 2012.

During this period, the region experienced varied rainfall events, such that the initial deep soil moisture content was increased for periods of high rainfall to take into account the intake of moisture. Persistent rain was received from 16 December 2011 to 15 January 2012, 27 February to 10 March 2012 and 13 to 30 April 2012, as outlined in Table 6-3.

Initial deep soil moisture content was decreased to default during the periods with no rainfall,

Table 6-3 Initial deep soil moisture content – Input into TAPM

Period		Initial deep soil moisture content m ³ /m ³ (volume of water per volume of soil)	Modelled season
From	To		
1 July 2011	15 December 2011	0.15	Dry
16 December 2011	15 January 2012	0.40	Wet
16 January 2012	26 February 2012	0.15	Dry
27 February 2012	10 March 2012	0.40	Wet
11 March 2012	12 April 2012	0.15	Dry
13 April 2012	30 April 2012	0.40	Wet
1 May 2012	30 June 2012	0.15	Dry

Upper data from TAPM was then converted using CALTAPM to form data input files for use in the CALMET model.

7. Construction assessment

This section outlines assessment of air emissions likely to result during construction of the Mount Peake Project.

Potential air quality impacts during construction and site establishment for the Project will be emissions from heavy vehicle exhausts, dust generation from heavy equipment during earthworks and wind erosion from disturbed soil surfaces.

7.1 Heavy machinery and plant

Emissions from heavy vehicles would consist of products of combustion, including NO_x, SO₂, PM₁₀ and VOCs.

Vehicle emissions will arise from diesel powered equipment used during construction. Emissions from heavy equipment will be minimised by ensuring all vehicles on-site are well maintained and operated in an efficient manner.

Emissions from vehicles on-site are not considered to represent a significant source of emissions.

7.2 Construction dust

The impacts of dust emissions fall under two distinct categories, being health and amenity:

- Potential health impacts are attributable to the concentration of respirable particles in ambient air. Respirable particles of dust (PM₁₀) would have maximum impact under light winds and stable atmospheric conditions. These conditions most frequently occur overnight and very early in the morning
- The presence of total suspended particles (TSP), greater than 35 micron, is likely to affect amenity by way of reducing visibility (whilst in the air column) and by soiling of materials via dust deposition. Amenity impacts are most marked in high wind conditions, when larger particles may be displaced and transported a significant distance before being deposited and soiling surfaces. Mitigation of amenity related dust impacts would in turn act to reduce health impacts due to dust emissions.

The extent to which these emissions may impact on the surrounding sensitive land uses would depend upon a number of site-specific factors.

Dust emissions will arise during construction of the Project. The following construction activities involve the movement and placement of soil, rock etc. and can be the source of dust emissions:

- Mechanical disturbance: dust emissions resulting from the operation of construction equipment and vehicles
- Wind erosion: dust emissions from exposed and disturbed soil surfaces under high wind speeds during construction.

Extensive inventories^[15] for PM₁₀ and TSP emissions from earth moving machinery are commonly used to characterise the source dust emission rates from activities on-site during the construction phase. At this stage, the reference design has not specified the schedule of operations and the exact type and number of dozers, scrapers, trucks and other earthmoving equipment, so that it is not possible to characterise these sources.

¹⁵ NPI 2012 *Emission Estimation Technique Manual for mining* v3.0;
NPI US EPA (United States Environmental Protection Agency), 2001. *AP-42: Compilation of Air Pollutant Emission Factors* – Fifth Edition

Dust emissions during construction are not considered to represent a significant source of emissions. For the construction phase of the Project, a framework which includes a comprehensive range of mitigation measures for the management of dust emissions will be developed as a part of construction dust management measures.

7.3 Construction dust management framework

As the reference design has not specified the schedule of operations and the exact type and number of dozers, scrapers, trucks and other earthmoving equipment, it is not possible to characterise construction dust sources. A management framework has been developed and would be applied to ensure dust emissions are managed.

Dust emissions would be controlled by application of a dust management processes, defined as part of the site Environmental Management Plan. Using this approach, a staged dust management plan for dust mitigation and management measures would be influenced by the proximity of sensitive receptors. Due to the separation distance between the Project site and the nearest sensitive receptor, the dust management measures would detail actions for typical dust control.

7.3.1 Typical dust management and mitigation measures

Typical dust management measures are based on the principles found in the *Environmental Guidelines for Major Construction Sites*^[16]. From the identification of potential dust emission sources, appropriate dust management and mitigation measures for a typical level of control would include:

- All construction and maintenance equipment/vehicles to be operated and maintained to manufacturer's specifications in order to minimise exhaust emissions
- Defined haul routes to be used wherever it is necessary for vehicles to traverse unsealed surfaces or unformed roads
- Vehicular speeds would be limited to 25 km/h on areas of unconsolidated or unsealed soil associated with the project
- Prompt mitigation of excessive visible dust emissions, which may be a combination of:
 - Stabilisation of surface silt content through application of localised water sprays, or the use of appropriate chemical dust suppressants (suitable for roads which are traversed less frequently)
 - Control of mechanically induced dust emissions (from clearing, excavation, loading, dumping filling and levelling activities) by application of water sprays
 - Awareness of operational areas more frequently exposed to higher winds and the predominant wind directions in these areas at various times of the year. Temporary wind barriers may be employed where necessary
 - Review of daily weather updates from BoM or a private meteorology service provider, to give warning of likely strong winds to assist with daily management of wind-blown dust from unconsolidated soil surfaces and material stockpiles
 - All haulage vehicles are to have their loads covered while transporting material to or from the work area through off-site routes that may have sensitive receptors.

¹⁶ EPA Vic, 1996. *Best Practice Environmental Management - Environmental Guidelines for Major Construction Sites*. Melbourne, February 1996.

8. Mine operational assessment

8.1 Model selection

Due to the scale of the model domain, air dispersion and deposition modelling of emissions has been undertaken using the US EPA approved CALPUFF dispersion model (version 5.8.4). CALPUFF is an advanced Lagrangian, non-steady state air dispersion model. The model has been approved by the US EPA, *40 CFR Part 51 Guideline on Air Quality Models*^[17], as the preferred model for assessing long range transport of pollutants and on a case by case basis for certain near field applications involving complex meteorological conditions.

The CALPUFF dispersion model utilises the three dimensional wind fields from CALMET to simulate the dispersion of air pollutants to predict ground level concentrations across a Cartesian gridded domain. CALPUFF contains parameterisations for complex terrain effects, overwater transport, coastal interaction effects, variability in land use (the latter two being of paramount importance in this assessment) and their associated meteorological effects, building downwash, wet and dry removal, and simple chemical transformation. CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF contains algorithms that can remove near source effects such as building downwash, transitional plume rise, partial plume penetration, sub grid scale terrain interactions, as well as the long range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions.

Emission sources can be characterised as arbitrarily varying point, area, volume and lines or any combination of those sources within the modelling domain.

CALPUFF was used to simulate the dispersion characteristics and concentrations of pollutants generated by the proposed activities.

Key features of CALPUFF used to simulate dispersion and deposition in this assessment are:

- Emission sources (as detailed in Section 8.2.1), characterised as either volume or area sources, with initial release geometries representative of each activity
- The 1000 m resolution 3D winds and temperatures, the spatially varying micrometeorological fields used to characterise atmospheric turbulence and the geophysical data from CALMET were used to characterise transport and dispersion of the emissions to air
- Dispersion option micro meteorology
- Averaging time of 1 hour
- Wind speed profile ISC rural
- Calm condition is defined as wind speeds less than 0.5 m/s
- Terrain heights at sources determined from geophysical data
- Discrete receptor heights of 1.5 metres
- Computational grid size was 40 x 40 km
- Chemical transformation for pollutants was not modelled
- Dust deposition was calculated for receptor locations using dry flux settings.

¹⁷ US EPA, 2005. *40 CFR Part 51 Guideline on Air Quality Models*

- The plume element modelling method selected was 'puff'
- The model was configured to predict concentrations over the sampling grid for the year 1 July 2011 through 30 June 2012, with the meteorology described in Section 6
- The model run period was for 8760 hours (1 year)
- The CALPOST run period was also for 8760 (1 year) hours with output options only calculated for concentration with various averaging times to align with assessment criteria. A peak to mean ratio of 1.82 was used to convert 1 hour results to 3 minute results when assessing against VOCs.

The following section details the model configuration for each emission source.

8.2 Model Parameters

The end of Mining Year 4 was selected for modelling as the mine will still be shallow and will have one of its highest throughputs, resulting in the highest estimated emissions.

Mine operations will be 24-hour, split across two shifts (6 am – 6 pm and 6 pm – 6 am).

Table 8-1 shows the predicted throughput for the 15 operational mining years, with the selected modelling year in blue.

Table 8-1 Predicted throughput for 20 operational years

Mining year	Total ore mined	Total waste mined
1	5.80	5.84
2	4.62	7.02
3	3.79	7.85
4	5.31	6.26
5	6.12	5.37
6	5.65	5.93
7	5.87	5.98
8	6.23	5.62
9	6.57	5.27
10	8.39	0.55
11	6.83	0.26
12	4.30	0.18
13	4.44	0.05
14	2.26	0
15	1.60	0

8.2.1 Emission sources (Mining Year 4)

Table 8-2 and Table 8-3 show the source details for the volume and area sources. Stage 2 and Stage 3 of mining and stripping will be underway by the end of Mining Year 4. The pit locations of the modelled year are provided in Figure 8-1, as are the proposed tailings storage facility, waste rock dump, stockpile area and processing plant.

8.2.2 Emission rates (Mining Year 4)

Table 8-4 provides the predicted worst case emission rates of the mine during operation. Appendix A provides more detailed summaries of the modelled emissions estimates.

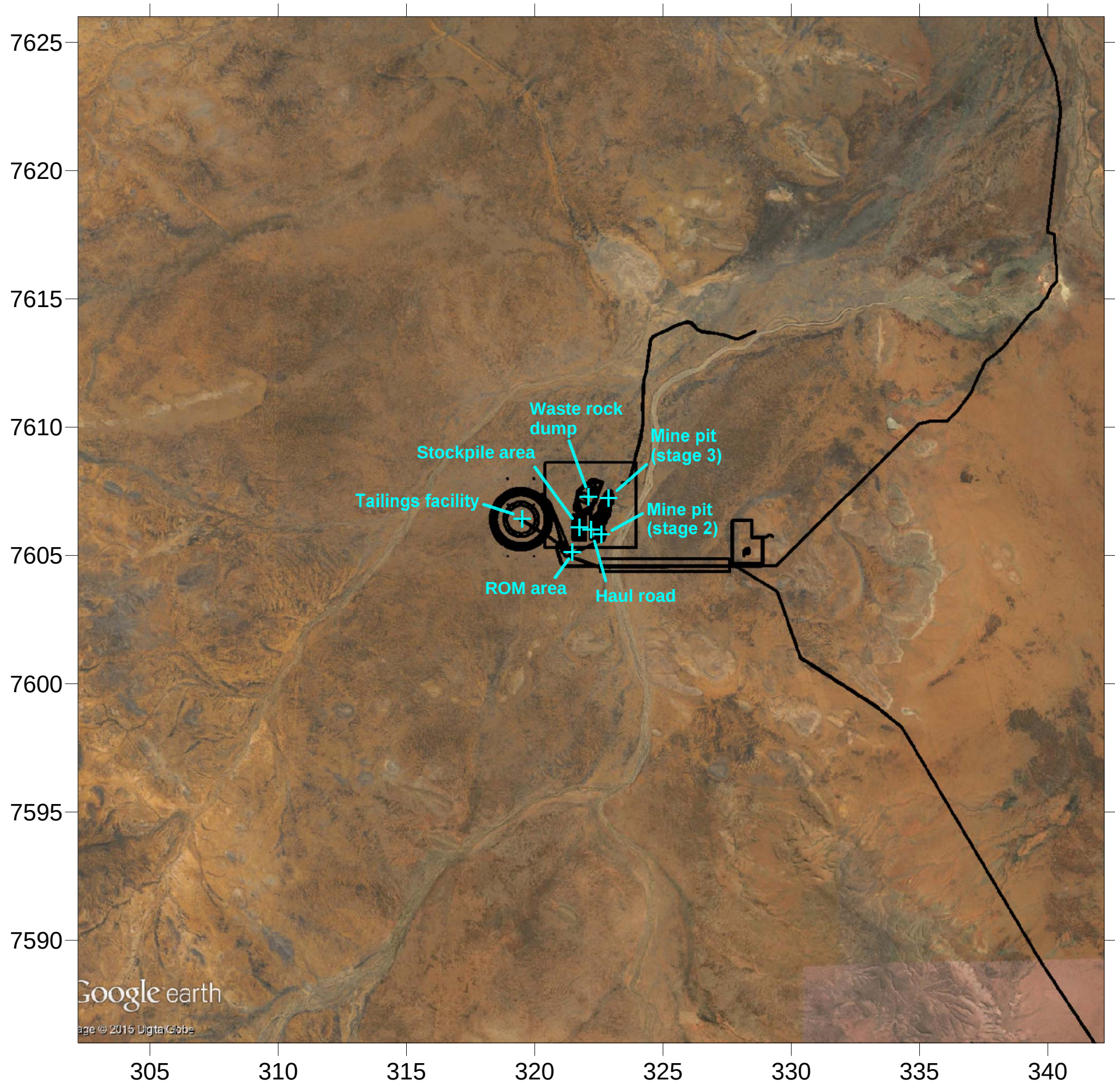
Table 8-2 Modelled source configuration for the Mount Peake Project – Volume sources

Source	Centroid x coordinate, km	Centroid y coordinate, km	Effective height, m	Base elevation, m	Initial sigma y, m	Initial sigma z, m
Loading ore – stage 2 (southern pit)	322.603	7605.822	12.0	481.3	2.5	3.0
Loading ore – stage 3 (northern pit)	322.879	7607.239	12.0	483.0	2.5	3.0
Waste rock dumping	322.099	7607.283	10.0	480.8	2.5	2.5
Unloading ore to stockpile	321.745	7606.096	10.0	482.4	2.5	2.5
Front end loading ore to primary crusher	321.462	7605.129	8.0	484.6	2.0	2.0
Primary crushing	321.462	7605.129	4.0	484.6	2.2	1.0
Conveyer to secondary crusher	321.462	7605.129	2.0	484.6	5.0	0.5
Secondary crushing	321.462	7605.129	4.0	484.6	2.2	1.0
Conveyer to tertiary crusher	321.462	7605.129	2.0	484.6	5.0	0.5
Tertiary crushing	321.462	7605.129	4.0	484.6	2.2	1.0

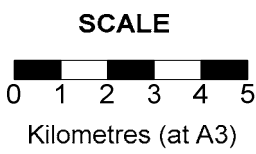
Table 8-3 Modelled source configuration for the Mount Peake Project– Area sources

Source	Corner x coordinates, km	Corner y coordinates, km	Effective height, m	Base elevation, m	Initial sigma z, m
Constant area sources					
Hauling waste –stage 2 (southern pit)	320.417, 320.417, 323.946, 323.946	7608.199, 7604.906, 7608.199, 7604.906	2.0	481.4	0.5
Hauling waste – stage 3 (northern pit)	320.417, 320.417, 323.946, 323.946	7608.199, 7604.906, 7608.199, 7604.906	2.0	481.4	0.5
Hauling ore – stage 2 (southern pit)	320.417, 320.417, 323.946, 323.946	7608.199, 7604.906, 7608.199, 7604.906	2.0	481.4	0.5
Hauling ore – stage 3 (northern pit)	320.417, 320.417, 323.946, 323.946	7608.199, 7604.906, 7608.199, 7604.906	2.0	481.4	0.5
Grading	320.417, 320.417, 323.946, 323.946	7608.199, 7604.906, 7608.199, 7604.906	2.0	481.4	0.5
Miscellaneous travel	320.417, 320.417, 323.946, 323.946	7608.199, 7604.906, 7608.199, 7604.906	0.5	481.4	0.13
Dozing waste rock	321.157, 321.157, 323.042, 323.042	7606.341, 7608.226, 7608.226, 7606.341	4.0	480.8	1.0
Variable area sources (wind erosion)^[18]					
Blasting – stage 2 (southern pit)	322.273, 322.273, 322.933, 322.933	7605.492, 7605.492, 7605.492, 7605.492	481.3	481.3	0.5
Blasting – stage 3 (northern pit)	320.417, 320.417, 323.946, 323.946	7608.199, 7604.908, 7608.199, 7604.906	483.0	483.0	0.5
Southern pit (stage 2)	322.273, 322.273, 322.933, 322.933	7605.492, 7605.492, 7605.492, 7605.492	481.3	481.3	0.5
Northern pit (stage 3)	320.417, 320.417, 323.946, 323.946	7608.199, 7604.908, 7608.199, 7604.906	483.0	483.0	0.5
Stockpile	321.075, 321.075, 322.414, 322.414	7605.426, 7606.765, 7606.765, 7605.426	482.4	482.4	0.5
Waste rock dump	321.157, 321.157, 323.042, 323.042	7606.341, 7608.226, 7608.226, 7606.341	480.8	480.8	0.5
Tailings storage facility	317.619, 317.619, 321.398, 321.398	7604.535, 7608.313, 7608.313, 7604.535	484.2	484.2	0.5

¹⁸ Rise velocities for each source assigned as 0 m/s, and hourly variable temperature taken as hourly variable ambient temperature.



- LEGEND**
-  Proposed mine layout
 -  Emission source locations



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150220

COPYRIGHT
THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



**TNG Limited
Mount Peake Project**

FIGURE 8-1
Emission source locations

CREATED	CHECKED	APPROVED	DATE	FILE LOCATION	DRAWING NO.	REVISION
SW	JF	JF	28.10.15	G:/61/2905711/Technical/Surfer/Figure 8-1	Figure 8-1.srf	0

Table 8-4 Mining Year 4 emission rates

Description of source	Total area ha	Average annual emissions, no control		Control factor TSP & PM ₁₀	Average annual emissions, with control			
		TSP	PM ₁₀		TSP		PM ₁₀	
		g/s	g/s		g/s	g/s/ha	g/s	g/s/ha
Mechanical sources								
Blasting – stage 2	0.4	0.5	0.3	1.00	0.5	1.35	0.3	0.70
Blasting – stage 3	0.4	0.5	0.3	1.00	0.5	1.35	0.3	0.70
Loading ore – stage 2	--	0.1	0.1	1.00	0.11	-	0.05	-
Loading ore – stage 3	--	0.1	0.1	1.00	0.11	-	0.05	-
Hauling waste rock – stage 2 ^{19]}	5.0	13.9	2.9	0.25	3.5	0.69	0.7	0.14
Hauling waste rock – stage 3 ^[19]	5.0	13.9	2.9	0.25	3.5	-	0.7	-
Hauling ore – stage 2 ^[19]	5.0	12.0	2.5	0.25	3.0	0.60	0.6	0.13
Hauling ore – stage 3 ^[19]	5.0	12.0	2.5	0.25	3.0	-	0.6	-
Roads – grading haul roads ^[19]	10.0	1.5	0.5	0.25	0.4	0.04	0.1	0.01
Roads – misc vehicle traffic ^[19]	109.6	2.3	0.7	0.25	0.6	0.005	0.2	0.002
Waste Rock Dumping	--	2.2	0.8	0.30	0.7	-	0.2	-
Unloading ore to stockpile	--	0.3	0.1	1.00	0.3	-	0.1	-
ROM – front end loading ore to primary crusher	--	0.1	0.0	1.00	0.07	-	0.03	-
ROM – Primary crushing	--	1.3	0.5	1.00	1.3	-	0.5	-
ROM – Conveyer to secondary crusher	--	0.7	0.3	1.00	0.7	-	0.3	-
ROM – Secondary Crushing	--	4.0	1.6	1.00	4.0	-	1.6	-
ROM – Conveyer to tertiary crusher	--	0.7	0.3	1.00	0.7	-	0.3	-
ROM – Tertiary Crushing	--	4.0	1.3	1.00	4.0	-	1.3	-
Dozing – Waste Rock	88.8	0.8	0.1	1.00	0.8	0.009	0.1	0.002
Wind erosion sources								

¹⁹ Emission rate was modelled as a generalised area source containing the road network. Emission rates were scaled accordingly to ensure that total emissions were equal to predicted emissions for the exposed surface areas.

Description of source	Total area ha	Average annual emissions, no control		Control factor TSP & PM ₁₀	Average annual emissions, with control			
		TSP	PM ₁₀		TSP		PM ₁₀	
		g/s	g/s		g/s	g/s/ha	g/s	g/s/ha
Southern pit (stage 2)	10.9	0.1	0.1	1.00	0.1	0.013	0.1	0.007
Northern pit (stage 3)	18.7	0.2	0.1	1.00	0.2	0.013	0.1	0.007
Stockpiles	44.8	0.6	0.3	0.65	0.4	0.009	0.2	0.004
Waste rock dump	88.8	1.2	0.6	0.65	0.8	0.009	0.4	0.004
Tailings storage facility	357.0	4.7	2.4	0.65	3.1	0.009	1.5	0.004

8.3 Dust modelling results

Table 8-5 shows predicted PM₁₀ and TSP concentrations at receptors.

Figure 8-2 through Figure 8-7 show contour plots of the 40 km grid centred over the mine site. The figures show (in order):

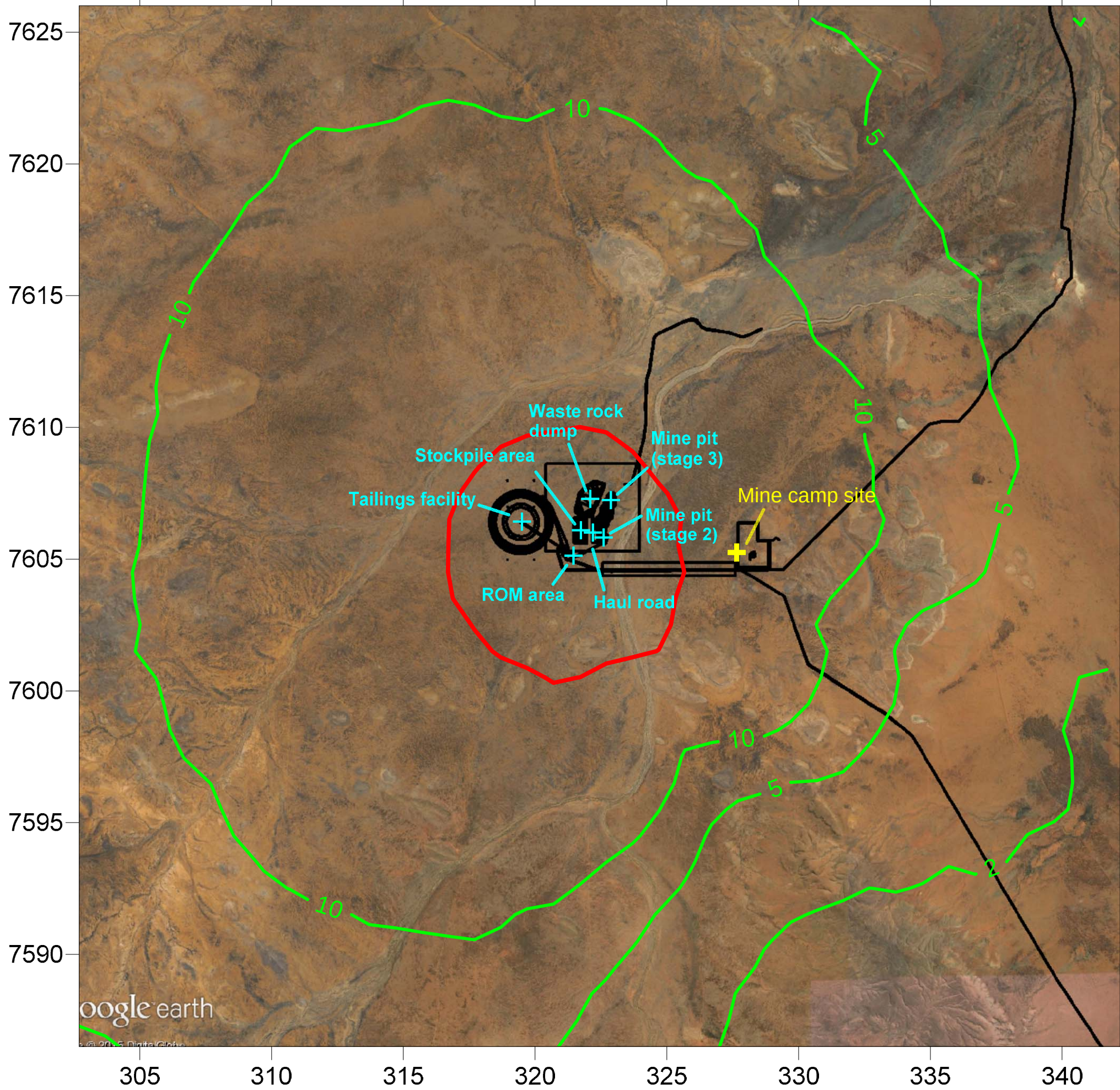
- 99.9th percentile 1-hour PM₁₀
- Maximum 24-hour PM₁₀
- Annual average PM₁₀
- 99.9th percentile 1-hour TSP
- Maximum 24-hour TSP.
- Maximum monthly dust deposition

Dust deposition is 2 g/m²/mth in the direct vicinity of the mine site and decreases to below detection levels beyond, as shown in Figure 8-7.

It is noted that the figures do not show all receptors, as many are a significant distance from the mine site.

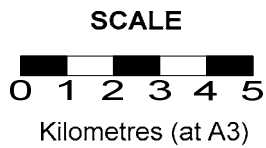
Table 8-5 Predicted concentrations at receptors

Receptor	PM ₁₀ µg/m ³			TSP µg/m ³	
Averaging period	Annual	24-hour	1-hour	24-hour	1-hour
Rank	Max	Max	99.9 %ile	Max	99.9 %ile
Guideline	20	50	80	90	- -
1. Anningie Station	0.04	1.2	4.3	3.3	11.7
2. Willowra	0.05	0.2	8.8	0.6	2.4
3. Wilora	0.004	0.1	0.4	0.3	1.1
4. Barrow Creek	0.001	0.05	0.1	0.1	0.4
5. Mine camp site	0.5	9.7	35	26.4	95.6
6. Stirling Station	0.004	0.01	0.3	0.3	0.8
7. Ti Tree	0.007	0.2	0.6	0.4	1.6



Guideline values:
Victorian SEPP-AQM 1-hour 99.9 percentile PM10 design criteria of 80 ug/m3

- LEGEND**
- Proposed mine layout
 - Emission source locations
 - Sensitive receptor
 - Predicted 1-hr 99.9 percentile PM10 concentrations
 - Victorian SEPP-AQM criteria (80 ug/m3)



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150910

COPYRIGHT

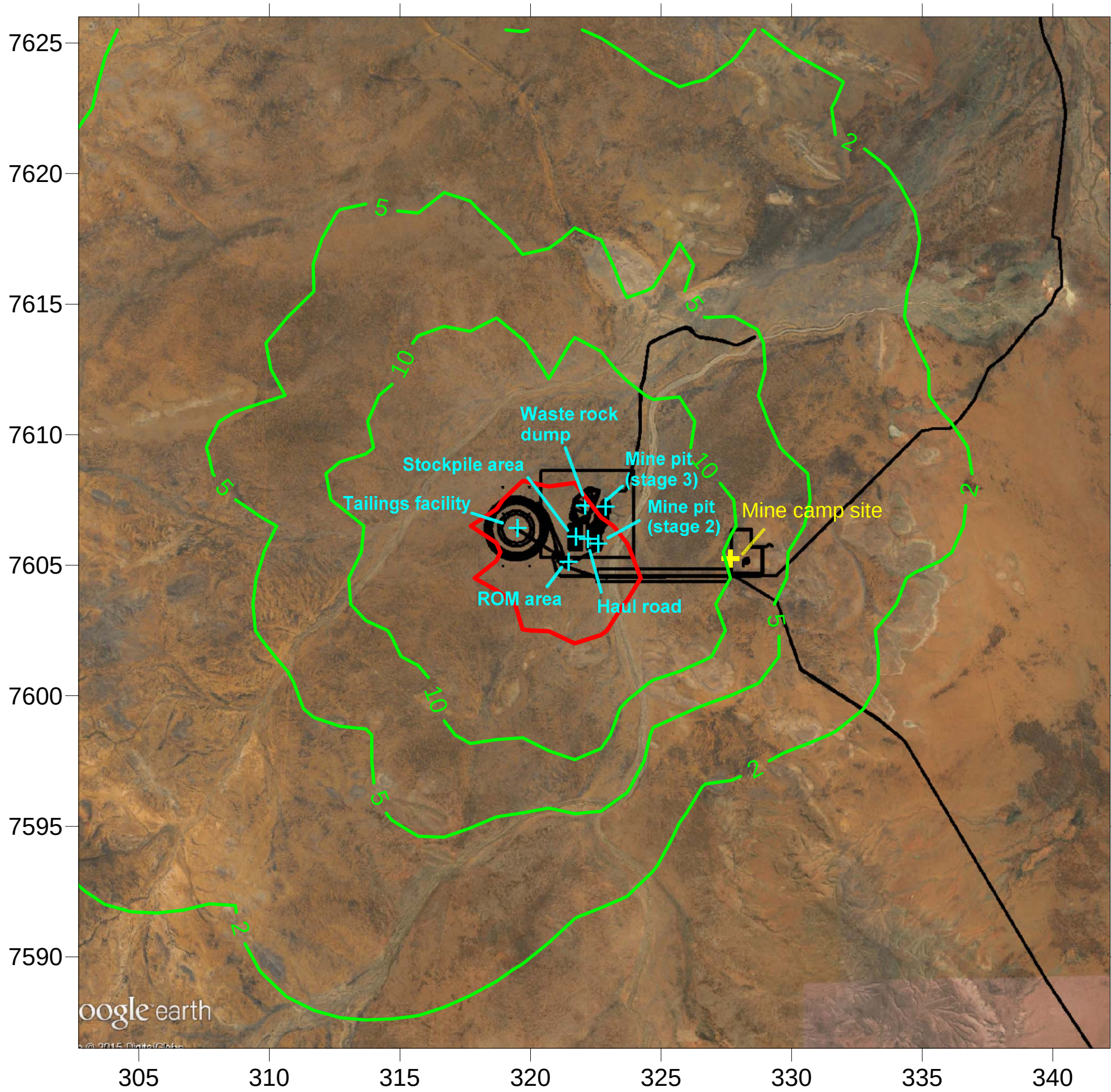
THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



TNG Limited
Mount Peake Project

FIGURE 8-2
Mining year 4
Predicted 99.9 percentile PM10 1-hour concentrations

CREATED	CHECKED	APPROVED	DATE	FILE LOCATION	DRAWING NO.	REVISION
SW	JF	JF	28.10.15	G:/61/2905711/Technical/Surfer/Figure 8-2	Figure 8-2.srf	0



Guideline values:
Air NEPM 24-hour maximum PM10 concentration of 50 ug/m3

LEGEND

- Proposed mine layout
- Emission source locations
- Sensitive receptor
- Predicted 24-hr maximum PM10 concentrations
- Air NEPM criteria (50 ug/m3)

SCALE

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150910

COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.

CREATED

SW

CHECKED

JF

APPROVED

JF

DATE

28.10.15

FILE LOCATION

G:/61/2905711/Technical/Surfer/Figure 8-3

DRAWING NO.

Figure 8-3.srf

REVISION

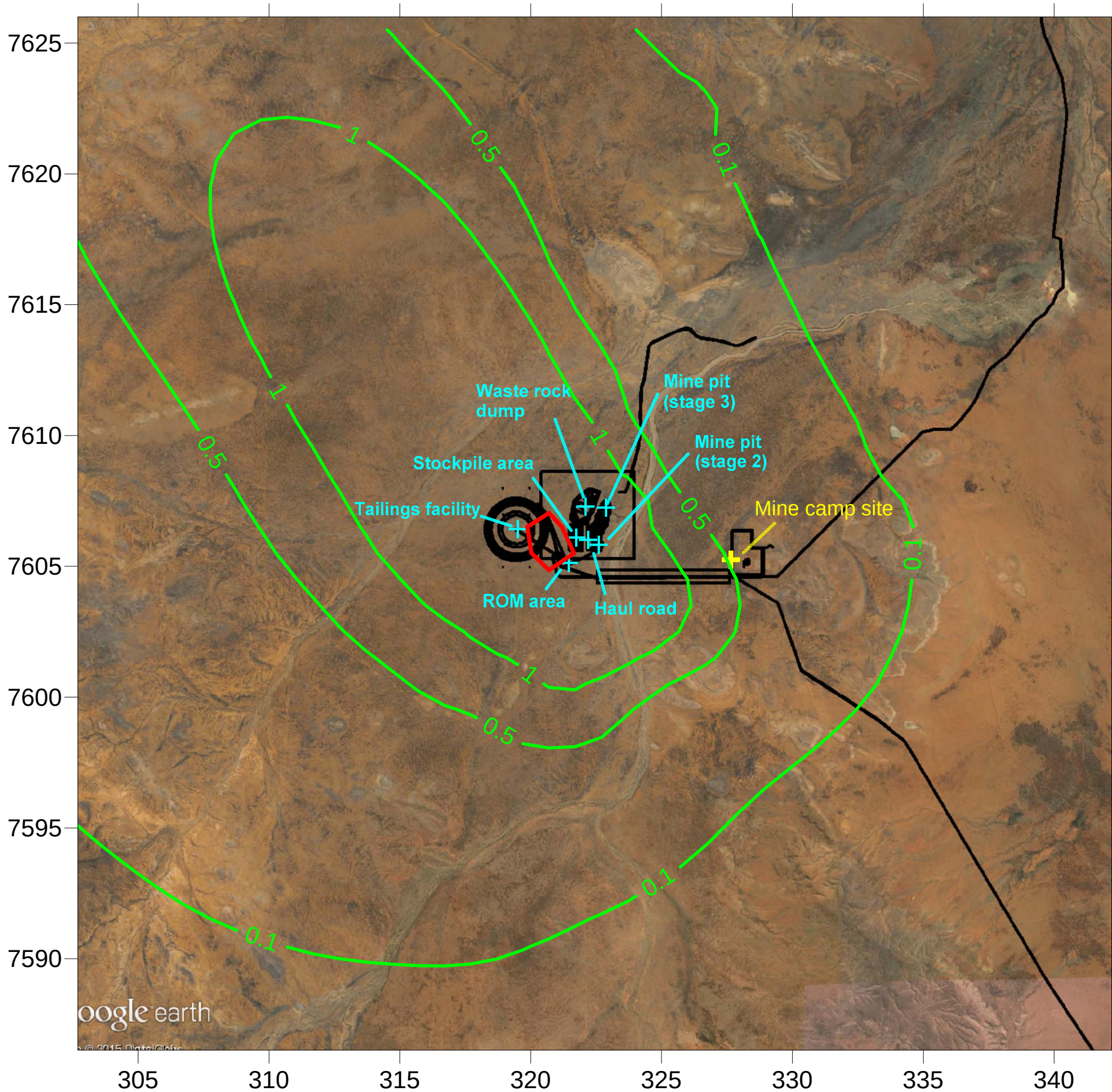
0

CLIENTS | PEOPLE | PERFORMANCE

TNG Limited

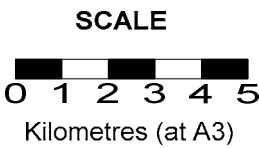
Mount Peake Project

FIGURE 8-3
Mining year 4
Predicted 24-hour maximum PM10 concentrations



Guideline values:
Proposed variation to the Air NEPM for an annual PM10 concentration of 20 ug/m3

- LEGEND**
- Proposed mine layout
 - Emission source locations
 - Sensitive receptor
 - Predicted annual PM10 concentrations
 - Proposed variation to Air NEPM (20 ug/m3)



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150910

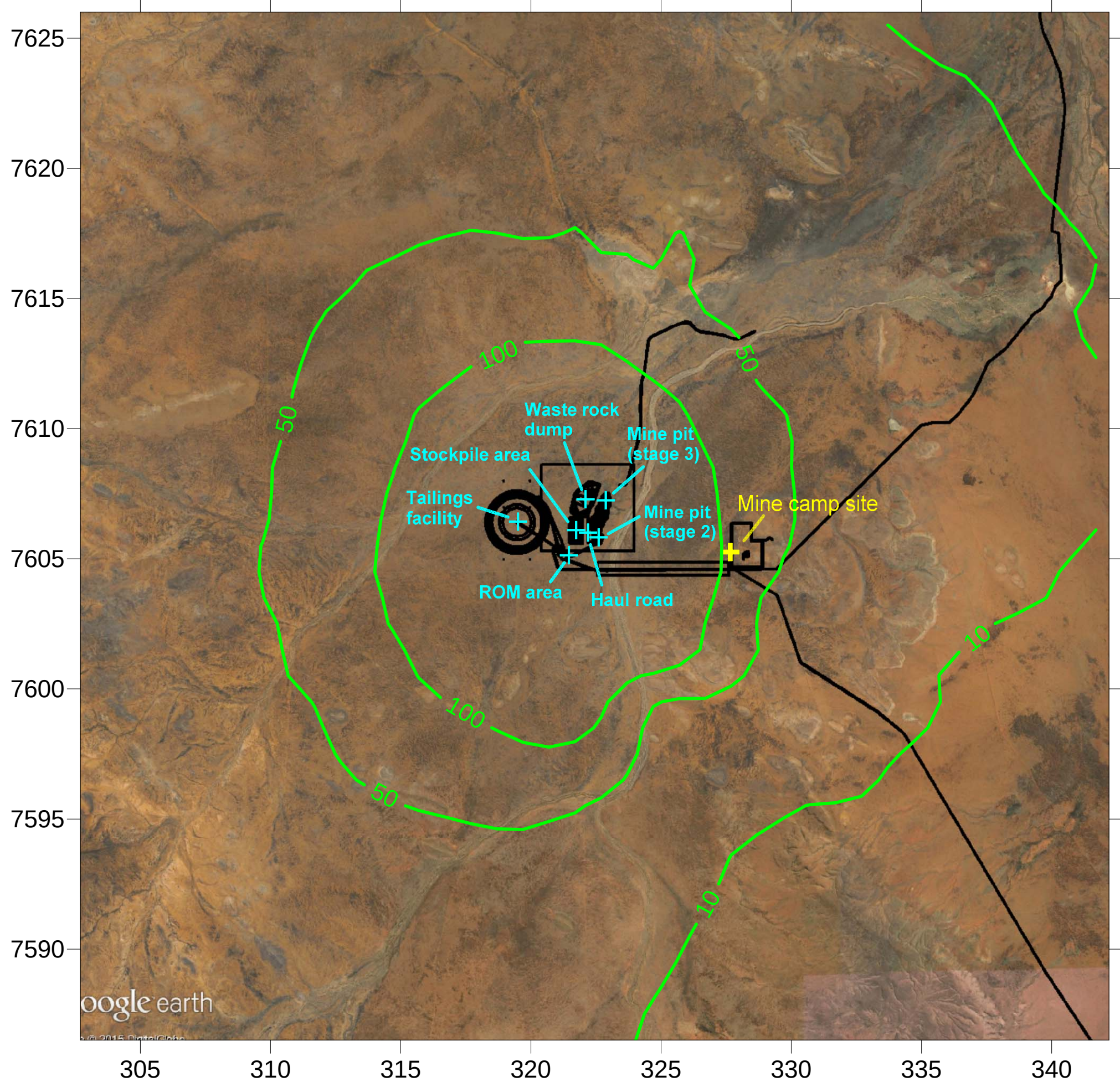
COPYRIGHT
THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



TNG Limited
Mount Peake Project

FIGURE 8-4
Mining year 4
Predicted annual PM10 concentrations

CREATED	CHECKED	APPROVED	DATE	FILE LOCATION	DRAWING NO.	REVISION
SW	JF	JF	28.10.15	G:/61/2905711/Technical/Surfer/Figure 8-4	Figure 8-4.srf	0

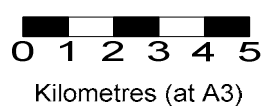


Guideline values:
Nil

LEGEND

- Proposed mine layout
- Emission source locations
- Sensitive receptor
- Predicted 1-hr 99.9 percentile TSP concentrations

SCALE



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150910

COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



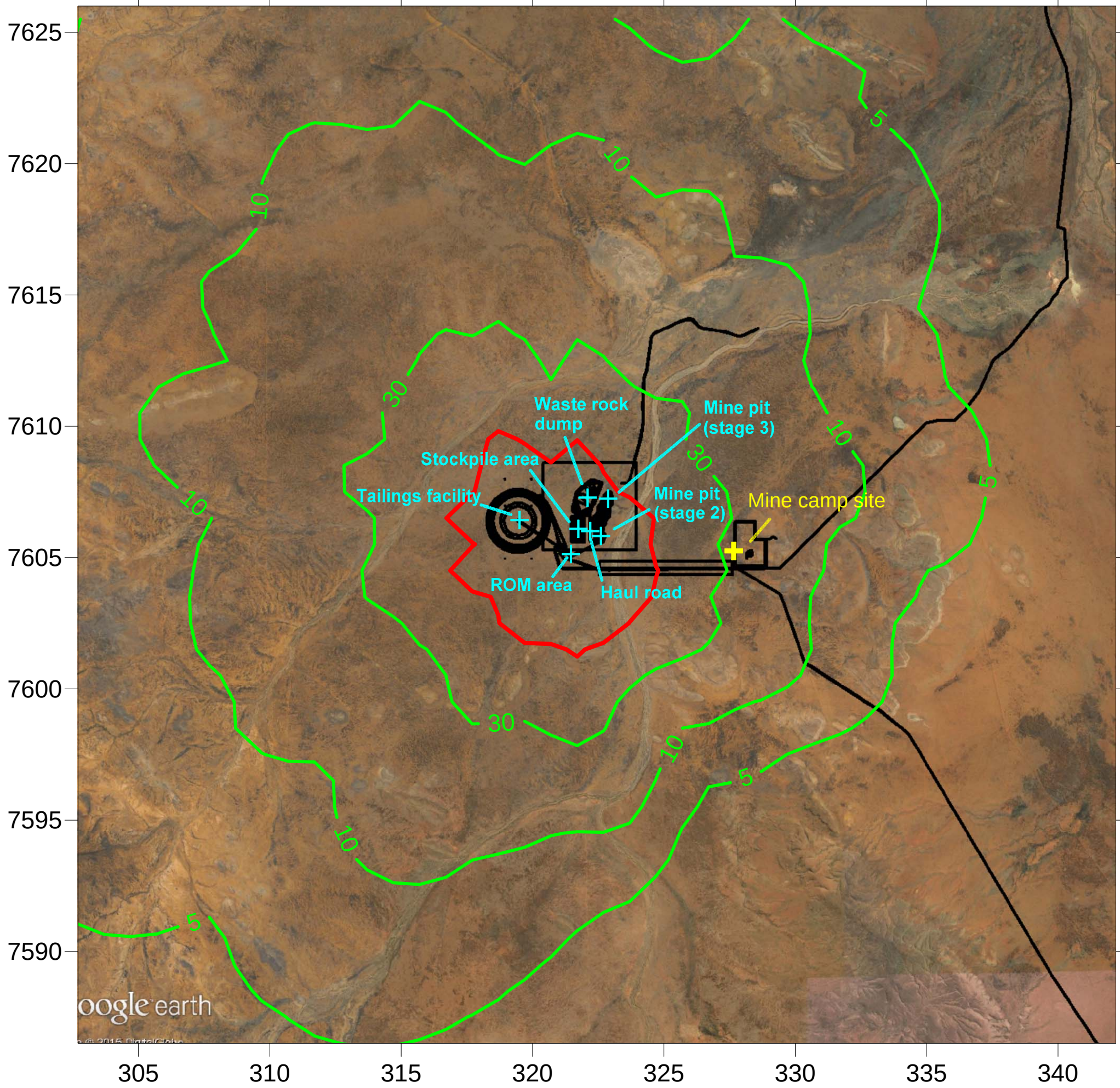
CLIENTS | PEOPLE | PERFORMANCE

TNG Limited
Mount Peake Project

FIGURE 8-5

Mining year 4
Predicted 99.9 percentile TSP 1-hour concentrations

CREATED	CHECKED	APPROVED	DATE	FILE LOCATION	DRAWING NO.	REVISION
SW	JF	JF	28.10.15	G:/61/2905711/Technical/Surfer/Figure 8-5	Figure 8-5.srf	0

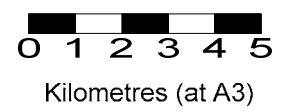


Guideline values:
Nil

LEGEND

- Proposed mine layout
- Emission source locations
- Sensitive receptor
- Predicted 24-hr max TSP concentrations
- Kwinana EPP criteria (90 ug/m3)

SCALE



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150910

COPYRIGHT

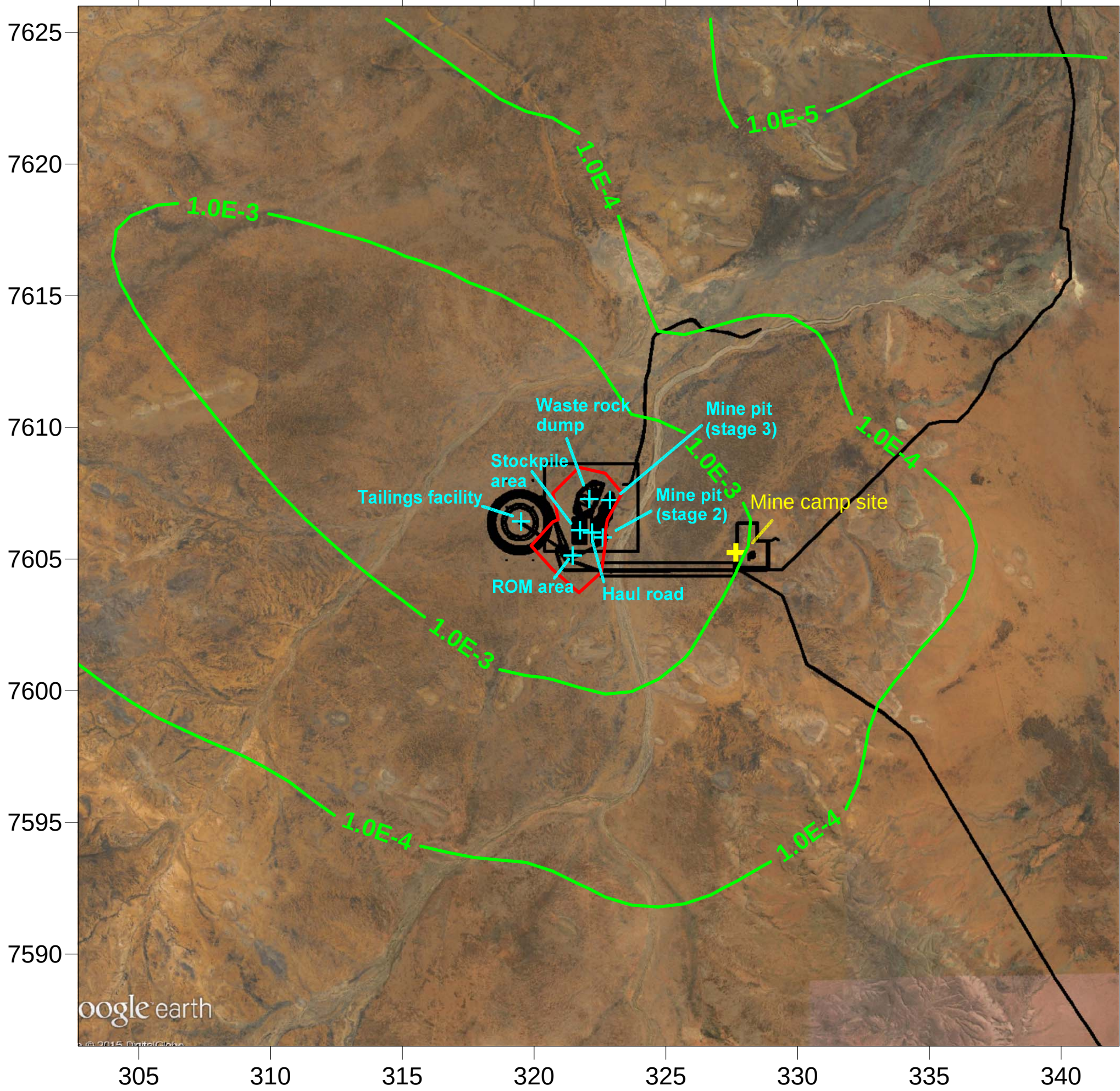
THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



**TNG Limited
Mount Peake Project**

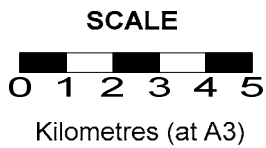
FIGURE 8-6
Mining year 4
Predicted 24-hour maximum TSP concentrations

CREATED	CHECKED	APPROVED	DATE	FILE LOCATION	DRAWING NO.	REVISION
SW	JF	JF	28.10.15	G:/61/2905711/Technical/Surfer/Figure 8-6	Figure 8-6.srf	0



Guideline values:
NSW OEH guideline for maximum annual average deposition of 2 g/m²/mth

- LEGEND**
- Proposed mine layout
 - Emission source locations
 - Sensitive receptor
 - Predicted max deposition (g/m²/mth)
 - NSW OEH guideline (2 g/m²/mth)



MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
Geocentric Datum of Australia (GDA)

GRID:
Map Grid of Australia 1994, Zone 53

DATA SOURCE:
GE_MGA53_20150910

COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.



TNG Limited
Mount Peake Project

FIGURE 8-7
Mining year 4
Predicted maximum deposition (g/m²/mth)

CREATED	CHECKED	APPROVED	DATE	FILE LOCATION	DRAWING NO.	REVISION
SW	JF	JF	25.11.15	G:/61/2905711/Technical/Surfer/Figure 8-7	Figure 8-7.srf	0

8.4 Discussion of results

8.4.1 Predicted dust concentrations

Predicted impacts at receptors are all lower than assessment criteria.

The highest predicted concentrations are predicted at the closest receptor (Mine Camp). Predicted concentrations at the Mine Camp during Mining Year 4 range between 2.5% and 44% of the various assessment criteria.

Predicted concentrations at non-mining receptors during Mining Year 4 range between 0.005% and 5% of the guidelines. These low impacts from the Project were expected due to the large separation distances.

It is noted that the second highest predicted concentrations occur at the furthest receptor (Willowra). This is a result of the predominant south easterly wind direction (Figure 5-1) directing emissions in a north westerly direction towards Willowra, and away from receptors south east of the mine site.

8.4.2 Predicted dust deposition

No dust deposition is predicted to occur at any of the sensitive receptors as a result of the Project. This is due to the large distance of sensitive receptors from sources. Large particles will be deposited closer to the sources than any of the receptor locations. Smaller particles will remain airborne further from the emission sources, but are less prone to deposition.

8.4.3 Consideration of cumulative impacts from regional background dust

There are limited anthropogenic dust sources in the area with the majority of dust in the area generated through emission processes that naturally occur in the environment such as wind erosion from open areas and bushfire smoke.

Dust emissions from the Project, regional background sources, or both have the potential to dominate in the neighbourhood of the mine site (a scale of kilometres from the site); however further afield, where the receptors are located (tens of kilometres), background regional and their own local neighbourhood sources will dominate.

8.4.4 Consideration of cumulative impacts from other sources

The plots show that the range of any measurable dust impact (taken as 10% of the assessment criterion) is approximately 20 km from the mine site. That is, any location outside of a radius of 20 km from the mine site is unlikely to distinguish the Project dust contributions from other regional sources. As the closest major dust source to the Project is Anningie Station (30 km from the Project), cumulative impacts from the two sources are likely to be insignificant.

9. Power station operational assessment

9.1 Emission rates

Worst case emissions from the power station were estimated by assuming that the 28, 1,400 kVA gas fired gen sets are operating at maximum capacity for the modelling year.

Table 9-1 provides the predicted emission rates for each pollutant for each location. Table 9-2 provides the model source configuration. As the proposed QSK60 Gas G-Drive Cummins Genset specifications were not provided and are not publicly available; stack height, radius, exit velocity and temperature for the gas gen sets are based on 2 MW Cummins Gensets, which were used in a similar study. It is anticipated that these parameters would be similar to the Cummins Genset.

Table 9-1 Emission rates per genset

Pollutant	Gas genset emission rate (g/s)
CO	0.19
NOx	2.49
Total VOC	0.072
Acetaldehyde	0.0051
Benzene	0.00027
Formaldehyde	0.032
Toluene	0.00025
Xylene	0.00011

9.2 Modelling results

Table 9-3 shows predicted concentrations at receptors for each species modelled. No exceedances are predicted.

9.3 Discussion of results

9.3.1 Predicted concentrations

The predicted concentrations at all receptors are below the assessment criteria for all assessed pollutants.

9.3.2 Consideration of cumulative impacts and background concentrations

As there are limited anthropogenic sources of pollutants other than dust in the area, background levels are unlikely to be of any significance.

Table 9-2 Modelled power station source configuration

Source	Centroid x coordinate, km	Centroid y coordinate, km	Stack height (m)	Stack radius (m)	Exit velocity (m/s)	Temp. (K)
Operational power generation						
GG01	321.04327	7605.4041	9.37	0.229	42	695
GG02	321.04483	7605.4009	9.37	0.229	42	695
GG03	321.04613	7605.3976	9.37	0.229	42	695
GG04	321.04717	7605.3946	9.37	0.229	42	695
GG05	321.04803	7605.3916	9.37	0.229	42	695
GG06	321.04951	7605.3888	9.37	0.229	42	695
GG07	321.05051	7605.3857	9.37	0.229	42	695
GG08	321.05156	7605.3825	9.37	0.229	42	695
GG09	321.05301	7605.3793	9.37	0.229	42	695
GG10	321.05430	7605.37567	9.37	0.229	42	695
GG11	321.05582	7605.3718	9.37	0.229	42	695
GG12	321.05724	7605.3684	9.37	0.229	42	695
GG13	321.05837	7605.3647	9.37	0.229	42	695
GG14	321.06005	7605.3604	9.37	0.229	42	695
GG15	321.06167	7605.3568	9.37	0.229	42	695
GG16	321.06284	7605.3539	9.37	0.229	42	695
GG17	321.06379	7605.3509	9.37	0.229	42	695
GG18	321.06476	7605.3477	9.37	0.229	42	695
GG19	321.06605	7605.3448	9.37	0.229	42	695
GG20	321.06716	7605.3419	9.37	0.229	42	695
GG21	321.06826	7605.3392	9.37	0.229	42	695
GG22	321.06934	7605.336	9.37	0.229	42	695
GG23	321.07048	7605.3333	9.37	0.229	42	695
GG24	321.07166	7605.3307	9.37	0.229	42	695
GG25	321.07254	7605.3278	9.37	0.229	42	695
GG26	321.07361	7605.3251	9.37	0.229	42	695
GG27	321.07471	7605.3221	9.37	0.229	42	695
GG28	321.07571	7605.3197	9.37	0.229	42	695

Table 9-3 Predicted concentrations at receptors, $\mu\text{g}/\text{m}^3$

Receptor	CO	NO ₂ ^[20]		Acetaldehyde	Benzene	Formaldehyde	Toluene			Xylene
Averaging period	8-hour	1-hour	Annual	3-min	3-min	3-min	3-min	24-hour	annual	3-min
Rank	Max	Max	- -	99.9%ile	99.9%ile	99.9%ile	99.9%ile	max	- -	99.9%ile
Guideline	11,254	247	62	76 $\mu\text{g}/\text{m}^3$	10.5 $\mu\text{g}/\text{m}^3$	40 $\mu\text{g}/\text{m}^3$	650 $\mu\text{g}/\text{m}^3$	4114 $\mu\text{g}/\text{m}^3$	411 $\mu\text{g}/\text{m}^3$	350 $\mu\text{g}/\text{m}^3$
1. Anningie Station	1.72	12.78	1.57	0.24	0.24	0.24	0.24	0.0008	0.000041	0.0054
2. Willowra	0.45	2.20	0.46	0.04	0.04	0.04	0.04	0.0002	0.000026	0.0009
3. Wilora	0.14	1.79	0.19	0.03	0.03	0.03	0.03	0.0001	0.000003	0.0008
4. Barrow Creek	0.14	1.47	0.17	0.03	0.03	0.03	0.03	0.0001	0.000002	0.0006
5. Mine camp site	1.02	20.00	1.49	0.37	0.37	0.37	0.37	0.0007	0.000021	0.0084
6. Stirling Station	0.17	1.91	0.21	0.04	0.04	0.04	0.04	0.0001	0.000003	0.0008
7. Ti Tree	1.57	6.48	1.43	0.12	0.12	0.12	0.12	0.0007	0.000020	0.0027

²⁰ Taken as 20% of NOx results

10. Greenhouse gas assessment

10.1 Introduction

The objective of the greenhouse gas assessment is to:

- Estimate the greenhouse gas emission for the construction and operations phases of the Project
- Detail the project lifecycle greenhouse gas emissions and the greenhouse gas efficiency of the project
- Identify measures to minimise greenhouse gas emissions.

10.1.1 Australian, Northern Territory and Global greenhouse gas emissions

The Commonwealth Department of the Environment (DotE) estimates annual greenhouse gas emissions for Australia. The latest estimates are for 2013^[21].

Australia's total greenhouse gas emissions for 2013 were estimated at 548.6 million tonnes of carbon dioxide equivalent (Mt CO₂-e)^[21] and the northern Territory's emissions for 2013 were estimated at 13.8 Mt CO₂-e. The major emission sources for the Northern Territory's emissions for 2013 were agriculture (primarily the burning of savannahs) and fuel combustion for stationary energy purposes^[21].

2012 global greenhouse gas emissions from Annex 1 countries to the Kyoto protocol were 15.1 gigatonnes of carbon dioxide equivalent (Gt CO₂-e)^[22].

10.1.2 Legislative framework

Key legislation relevant to the Project includes:

- *National Greenhouse and Energy Reporting Act 2007*. The National Greenhouse and Energy Reporting Scheme applies to Scope 1 and 2 emissions at facilities that emit over 25,000 t CO₂-e per year or consume more than 100 TJ of energy, or corporations that emit over 50,000 t CO₂-e per year or consume more than 200 TJ of energy. The Project will trigger both the facility and corporation thresholds. Participation will need to be determined based on actual annual greenhouse gas emissions and energy consumption
- *Carbon Credits (Carbon Farming Initiative) Act 2011*. The Carbon Farming Initiative was developed to give farmers, forest growers and landholders the ability to generate accredited domestic offsets for access to domestic voluntary and international carbon markets. It is unlikely that the Project will generate offsets at the mine site. Any claims relating to carbon neutrality for the Project (or part thereof) should give consideration to the use of offsets generated under the Carbon Farming Initiative and the requirements of the National Carbon Offset Standard (NCOS).

²¹ Commonwealth Department of Environment, 2013. *State and Territory Inventories 2013. Australia's National Greenhouse Accounts*. Commonwealth of Australia, May 2015.

²² United Nations Framework Convention on Climate Change, 2014. National greenhouse gas inventory data for the period 1990-2012.

10.2 Boundary of assessment

The following activities comprise the majority of greenhouse gas emissions from the Project:

- Fuel combustion - diesel (site vehicles)
- Fuel combustion – diesel (trains for concentrate export)
- Fuel combustion – natural gas (power generation)
- Fuel combustion – diesel (power generation).

Other smaller emissions include:

- Clearing of vegetation
- Use of explosives
- Wastewater treatment
- Embodied emissions associated with production of major construction materials, and transport of materials to site
- Employee transportation.

The smaller emissions listed above typically comprise approximately 20% of total emissions from mine sites^[23]. As this assessment has been undertaken at an early stage of project development, and quantities have not yet been estimated for some of the smaller emission sources, these emissions have not been estimated separately. Rather, total emissions are estimated for fuel combustion for vehicle use and power generation, and a 20% uplift is added to account for these additional sources.

10.3 Greenhouse gases

The greenhouse gases considered in this assessment are listed in Table 10-1 together with their global warming potential. Global warming potential is a relative measure of how much heat a greenhouse gas traps in the atmosphere compared to a similar mass of carbon dioxide.

Table 10-1 Greenhouse gases and 100 year global warming potentials

Greenhouse gas	Global warming potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	21
Nitrous oxide (N ₂ O)	310
Hydrofluorocarbons (HFCs)	140-11,700
Perfluorocarbons (PFCs)	6,500-9,200
Sulphur hexafluoride (SF ₆)	23,900

²³ As shown in the GHG assessment undertaken for the Mt Todd EIA: GHD, 2012. *Mt Todd Gold Project Greenhouse Gas Assessment Report* for Vista Gold Australia Pty Ltd.

10.4 Emission scope

Greenhouse gas emissions are separated into Scopes 1, 2 and 3 in accordance with the Greenhouse Gas Protocol:

- Scope 1 emissions are created directly by a person or business from sources that are owned or controlled by that person or business
- Scope 2 emissions arise from the generation of electricity, heating, cooling or steam that is purchased and consumed by a person or business. These are indirect emissions as they arise from sources not owned or controlled by the person or business who consumes the electricity
- All other emissions associated with the Project are defined as Scope 3, since they are produced outside the mine site, and TNG does not have operational control of the facilities from which they originate. For example, TNG will not own or operate vehicles used to transport raw materials to the site and emissions resulting from the combustion of fuels for this transportation are classified as Scope 3.

Scope 1 emissions will be produced by the combustion of fuels such as diesel at the mine site, and by vehicles, plant and equipment which TNG has operational control over. The site will also combust fuel (diesel and gas) for power generation. The direct combustion of these fuels is considered as Scope 1 emissions.

As the Project generates its own power, no Scope 2 emissions are included in this assessment.

The main Scope 3 emission is fuel combustion in diesel trains for the export of concentrate from site. All other scope 3 emissions associated with the Project have been accounted for by adding 20% to the emissions calculated from fuel combustion.

10.5 Calculation of GHG emissions

10.5.1 Calculation of GHG emissions from combustion of diesel in vehicles

Emissions from transport of products can be estimated using Equation 10-1:

Equation 10-1

$$E_{ij} = \frac{Q \times EF_j \times EC_i}{1000}$$

where:

E_j is the emission of carbon dioxide in CO₂-e tonnes

Q is the quantity of material being burned in kL for transport purposes

EF_j is the emission factor per tonne of material used measured in kg CO₂-e/GJ. The emission factor for diesel is 69.9 (combined emissions of CO₂, CH₄ and N₂O).

EC_j is the energy content factor in GJ/kL for diesel. The energy factor for diesel is 38.6.

Emissions have been separated into two categories:

- Scope 1: site vehicles
- Scope 3: trains for concentrate export

The total Scope 1 volume of diesel being consumed per annum is estimated as:

- 1,750 kL in total during the 2 year construction period
- 7,000 kL per annum during operational years 1-4
- 14,150 kL per annum during operational years 5-15.

The total Scope 3 volume of diesel being consumed per annum is estimated as:

- 10,000 kL per annum during operational years 1-4
- 20,000 kL per annum during operational years 5-15.

Table 10-2 shows the calculated emissions.

Table 10-2 Transport calculations

Factor	Unit	Mining years 1 – 4 (annual rate)	Mining years 5 – 15 (annual rate)	Total construction phase (2 years)
Scope 1: site vehicles				
Total fuel used	kL	7,000	14,150	1,750
Energy content factor for diesel	GJ/kL	38.6	38.6	38.6
Emissions factor	kg CO ₂ -e/GJ	69.9	69.9	70
Emissions	CO ₂ -e tonnes	18,887	38,179	4,722
Scope 3: trains for concentrate export				
Total fuel used	kL	10,000	20,000	-
Energy content factor for diesel	GJ/kL	38.6	38.6	-
Emissions factor	kg CO ₂ -e/GJ	69.9	69.9	-
Emissions	CO ₂ -e tonnes	26,981	53,963	-

10.5.2 Calculation of GHG emissions from gas consumption for electricity production

Emissions from the burning of gas at the power plant for electricity production can be estimated Equation 10-2:

Equation 10-2

$$E_{ij} = \frac{Q \times EF_j \times EC_i}{1000}$$

where:

E_j is the emission of carbon dioxide in CO₂-e tonnes

Q is the quantity of material being burned in m³

EF_j is the emission factor per tonne of material used measured in kg CO₂-e/GJ. The emission factor for diesel is 51.33 (combined emissions of CO₂, CH₄ and N₂O).

EC_j is the energy content factor in GJ/m³ for gas. The energy factor for natural gas is 3.93 x 10⁻²

The total volume of material being burned annually is estimated as:

- Zero during construction (non-operational)
- 32,224,080 m³ (1.2 PJ) per annum for operation years 1-4
- 48,336,120 m³ (1.8 PJ) per annum for operation years 5-15.

Table 10-3 shows the calculated emissions. These values assume that 100% of all gas fuel is consumed and that all 28 gas gensets are in continuous operation for the entire year.

Table 10-3 Power plant greenhouse gas emissions

Factor	Unit	Mining years 1 – 4 (annual rate)	Mining years 5 – 15 (annual rate)
Fuel amount (annual amount) ^[24]	m ³	32,224,080	48,336,120
Energy content factor for diesel	GJ/m ³	0.039	0.039
Emissions factor (gas)	kg CO ₂ -e/GJ	51.3	51.3
Emissions	CO ₂ -e tonnes	65,005	97,507

10.5.3 Calculation of GHG emissions from the burning of diesel for electricity production

Emissions from the burning of diesel for energy production can be estimated Equation 10-3:

Equation 10-3

$$E_{ij} = \frac{Q \times EF_j \times EC_i}{1000}$$

where:

E_j is the emission of carbon dioxide in CO₂-e tonnes

Q is the quantity of material being burned in kL

EF_j is the emission factor per tonne of material used measured in kg CO₂-e/GJ. The emission factor for diesel is 69.5 (combined emissions of CO₂, CH₄ and N₂O).

EC_j is the energy content factor in GJ/kL for diesel. The energy factor for diesel is 38.6.

The total volume of material being burned annually is estimated as:

- 1,750 kL in total during the 2 year construction period
- 515 kL per annum during years 1-4 (based on 235 L/day per bore, 6 bores)
- 858 kL per annum during years 5-15 (based on 235 L/day per bore, 10 bores).

Table 10-4 shows the calculated emissions. These values assume that 100% of all diesel fuel is consumed and that all diesel gensets are in continuous operation for the entire year.

Table 10-4 Borefield calculations

Factor	Unit	Mining years 1 – 4 (annual rate)	Mining years 5 – 15 (annual rate)	Total construction phase (2 years)
Total fuel used	kL	515	858	1,750
Energy content factor for diesel	GJ/kL	38.6	38.6	38.6
Emissions factor	kg CO ₂ -e/GJ	69.5	69.5	69.5
Emissions	CO ₂ -e tonnes	1,382	2,302	4,695

10.5.4 Total greenhouse gas emissions

Total greenhouse gas emissions for the life of mine cover two years of construction emissions and 15 years of operational emissions. Total emissions for the life of mine are estimated at 3,212,358 tonnes CO₂-e (Table 10-5).

Average annual emissions are estimated at 178,000 tonnes CO₂-e. This is approximately 1% of NT annual emissions, 0.03% of Australia's annual emissions and 0.001% of global emissions.

²⁴ Based on 330 L/hour diesel use for each 1MW unit.

Table 10-5 Summary of total emissions (life of mine)

Source	Total Emissions (tonnes CO ₂ -e)	Percentage of total
Fuel combustion - diesel (site vehicles)	500,235	16%
Fuel combustion – diesel (trains exporting product)	701,516	22%
Fuel combustion – natural gas (power generation)	1,332,595	41%
Fuel combustion – diesel (power generation)	35,540	1%
Other emissions	642,472	20%
All emissions	3,212,358	100%

10.6 Management of greenhouse gas emissions

10.6.1 Avoidance of impacts

Impacts of the Project on greenhouse gas emissions have been avoided or minimised where possible through the planning and design process.

The majority of emissions for the Project are from the combustion of natural gas to provide the Project with electricity. The power station is estimated to use 24.6 PJ of gas to produce 2500 GWh over the project life. The Scope 1 greenhouse gas intensity of the power station is estimated at 0.53 kg CO₂-e/kWh.

When compared with the greenhouse gas intensity of grid electricity in the Northern Territory (0.67 kg CO₂-e/kWh), the onsite power station significantly reduces emissions associated with electricity supply.

The consumption of diesel is a necessary requirement of the Project and currently accounts for approximately 23% of the greenhouse gas emissions. However, a reduction in the quantity of fuel consumed may be achievable through optimisation of operational activities and logistics. This optimisation will be undertaken during the detailed project design and planning stage.

A small reduction in fuel consumption may be achieved through the use of more efficient plant and vehicles. Modern vehicles are typically more fuel efficient than the older models. The use of more recent vehicles would need to be part of a wider fuel management strategy that incorporates project planning, logistics, driver education and maintenance as any fuel reduction due to more efficient models may be outweighed by poor management in other areas.

10.6.2 Mitigation of impacts

Fuel Replacement

The most significant greenhouse gas mitigation option for fuel related emissions is likely to be the use of biodiesel. Biodiesel blends (diesel that has a percentage of the fuel replaced with biodiesel) may reduce emissions; however, this is dependent on a number of factors including the origin of the biodiesel feedstock.

When sourced from appropriate feedstocks, the reduction in emissions is approximately equivalent to the percentage of biodiesel in the blend (for example diesel with 20% biodiesel will reduce greenhouse gas emissions by approximately 20%). Calculations to determine the reduction in greenhouse gas emissions when using biodiesel should consider the entire life cycle of the fuel.

There are other factors that require consideration prior to the use of biodiesel. There is debate over the suitability and / or the percentage of biodiesel that can be used in vehicles. Biodiesel may not be suitable for some vehicles without major modifications. Plant operators are also concerned that vehicle warranties may be void if biodiesel or biodiesel blends are used in vehicles.

Opportunities for the use of biodiesel on the Project will be further examined.

Energy Efficiency and Management

TNG is currently evaluating the potential use of solar power and storage battery systems at the mine site. If implemented this will have the effect of reducing reliance on fossil fuels.

Commitments to energy management will be developed as part of an energy efficiency assessment. Regular energy audits and reviews of mining operations may identify energy efficiency improvement opportunities which may be implemented to progressively improve operations and subsequent energy efficiency.

An energy efficiency review will be undertaken to identify initiatives and technologies leading to implementation of processes to ensure energy efficiency opportunities are integrated into operations.

A commitment to energy efficiency and management will be recognised via the site Environmental Management Plan. Appropriate management would be integrated into all activities and processes, and greenhouse gas emissions would be monitored. Through assessment and review, the Project will seek continuous improvement in compliance and emissions reduction.

10.6.3 Offsets

The feasibility of generating carbon offsets at the project site under the Carbon Farming Initiative is likely to be limited.

10.6.4 Monitoring and reporting

There are a number of legislative requirements for measuring, monitoring and reporting greenhouse gas emissions and energy consumption that are applicable to the Project.

Scope 1 and 2 emissions will be measured or estimated as part of the National Greenhouse and Energy Reporting Scheme. The technical guidelines for the National Greenhouse and Energy Reporting Scheme outline the methods used for measuring and reporting these emissions. Measuring and monitoring Scope 1 emissions will be required as part of the carbon pricing mechanism.

The legislative measuring and reporting requirements will be used to assist in the identification of greenhouse gas reduction opportunities and track performance throughout the project life.

10.6.5 Summary

In summary, the following management measures will be implemented to avoid, mitigate and offset greenhouse gas emissions arising from the Project:

- Commitment to energy efficiency within the site Environmental Management Plan
- Monitoring of greenhouse gas emissions and reporting of Scope 1 and Scope 2 emissions as part of National Greenhouse and Energy Reporting Scheme
- Continuous improvement in compliance and emissions reduction throughout the project life through assessment and review processes including legislative reporting requirements.

11. Conclusions

11.1 Dust assessment

11.1.1 Construction dust

- Dust emissions during construction do not represent a significant source of emissions
- Due to the separation distance between the Project site and the nearest sensitive receptor, the dust management measures would detail actions for typical dust control.

11.1.2 Operational dust

Predicted dust concentrations

- Predicted impacts at receptors are all lower than assessment criteria
- The highest predicted concentration impacts from the Project are predicted at the closest receptor (Mine campsite). Predicted concentrations at the campsite range between 2.5% and 44% of the various assessment criteria
- Predicted concentrations at non-mining receptors range between 0.005% and 5% of the guidelines. These low impacts from the Project were expected due to the large separation distances.
- Predicted dust deposition is below detection levels and is therefore undiscernible from background dust at the sensitive receptors. This is due to the large distance of sensitive receptors from sources. Large particles will be deposited closer to the sources than any of the receptor locations. Smaller particles will remain airborne further from the emission sources, but are less prone to deposition.

Consideration of cumulative impacts from regional background dust

- There are limited anthropogenic dust sources in the area with the majority of dust in the area generated through emission processes that naturally occur in the environment such as wind erosion from open areas and bushfire smoke
- Dust emissions from the Project, regional background sources, or both have the potential to dominate in the neighbourhood of the mine site (a scale of kilometres from the site); however further afield, where the receptors are located (tens of kilometres), background regional and their own local neighbourhood sources will dominate.

Consideration of cumulative impacts from other sources

- The range of any measurable dust impact (taken as 10% of the assessment criterion) is approximately 20 km from the mine site. That is, any location outside of a radius of 20 km from the mine site is unlikely to distinguish the Project dust contributions from other regional sources. As the closest major dust source to the Project is Anningie Station (30 km from the Project), cumulative impacts from the two sources are likely to be insignificant.

11.2 Power station

- The predicted concentrations at all receptors are below the assessment criteria for all assessed pollutants
- As there are limited anthropogenic sources of pollutants other than dust in the area, background levels are unlikely to be of any significance.

11.3 Greenhouse gas

- Total emissions for the life of mine are estimated at 3,212,358 t CO₂-e
- Average annual emissions are estimated at 178,000 t CO₂-e. This is approximately 1%, 0.03% and 0.001% of annual NT, Australia and global emissions respectively
- The following management measures will be implemented to avoid, mitigate and offset greenhouse gas emissions arising from the Project:
 - Commitment to energy efficiency within the site Environmental Management Plan
 - Monitoring of greenhouse gas emissions and reporting of Scope 1 and Scope 2 emissions as part of National Greenhouse and Energy Reporting Scheme
 - Continuous improvement in compliance and emissions reduction throughout the project life through assessment and review processes including legislative reporting requirements.

Appendices

Appendix A – Dust emissions inventory summary

Emission rates and parameters

Mechanical Emission Factors ¹		
Excav., shov. & FEL	Ore	Waste rock
EF TSP (kg/t)	0.0005	0.0005
EF PM10 (kg/t)	0.0003	0.0003
Bulldozers	Ore	Waste rock
EF TSP (kg/hr)	2.21	2.75
EF PM10 (kg/hr)	0.40	0.52
Trucks (unloading)	Ore	Waste rock
EF TSP (kg/t)	0.0120	0.0120
EF PM10 (kg/t)	0.0043	0.0043
Drilling	Ore	Waste rock
EF TSP (kg/hole)	0.59	-
EF PM10 (kg/hole)	0.31	-
Blasting	Ore	Waste rock
EF TSP (kg/blast)	141.69	-
EF PM10 (kg/blast)	73.68	-
Grader	Ore	Waste rock
EF TSP (kg/VKT)	1.08	
EF PM10 (kg/VKT)	0.34	

Crushing emission factors ¹	
Primary	
EF TSP (kg/t)	0.01
EF PM10 (kg/t)	0.00
Secondary	
EF TSP (kg/t)	0.03
EF PM10 (kg/t)	0.01
Tertiary	
EF TSP (kg/t)	0.03
EF PM10 (kg/t)	0.01
Conveying, transfer etc.	
EF TSP (kg/t)	0.01
EF PM10 (kg/t)	0.00
Screening	
EF TSP (kg/t)	0.08
EF PM10 (kg/t)	0.06

Constants		
Parameter	Ore	Waste rock
Mean wind speed (m/s)	3.2	
Moisture (%)	5.0	5.0
Silt (%)	5.0	6.0
Mean grader speed (km/hr) - haul roads	10	
Area of blasting (m2)	4043	-
Depth of blasting (m)	12	-
Holes per blast	80	-

Haul road parameters	
Vehicle gross mass (haul truck) (t)	384
Vehicle gross mass (ancillary vehicles) (t)	5
Moisture (%)	3
Silt content (%)	6
Haul Road width (m)	30

Haul road distances		
	Pit to ROM	Pit to WRD
Daily haul rate (tpd)	18970	16091
Return distance (m)	3333	3360
Payload (t)	140	140
Truck trips	100	115
VKT (km)	333	386
Trucks per hour	4	5
Haul road area (ha)	5	5

Wheel generated dust ¹	
Haul trucks	
EF TSP (kg/VKT)	6.20
EF PM10 (kg/VKT)	1.30
Ancillary vehicles	
EF TSP (kg/VKT)	0.71
EF PM10 (kg/VKT)	0.23

1. NPI Mining 3.1 (2012)

Mining Year 4 Mine Details

Throughput		
Mining rate	Mtpa	t/day
Total (ore + waste rock)	11.57	35061
Ore	6.26	18970
Waste rock	5.31	16091

Operational times	
Days per year	330
Hours per day	24
Blasting hours per day	1

Density	
Ore density (dry) (t/bcm)	3.0
Waste rock density (dry) (t/bcm)	2.7

Moisture and silt content		
Product	Moisture (%)	Silt (%)
Ore	5.0	5.0
Waste rock	5.0	5.0
Haul roads	5.0	5.0

Mine areas					
	Area (ha)	East (m)	North (m)	Width (m)	Length(m)
Pit Stage 2	10.8758	322.60305	7605.82162	329.784778	329.7847783
Pit Stage 3	18.6579	322.87884	7607.23945	431.947914	431.9479135
Stockpile	44.8408	321.74469	7606.09566	669.632735	669.6327352
Waste Rock Dump	89	322.09933	7607.28325	942.590049	942.5900487
Tailings	357	319.50866	7606.42396	1889.44436	1889.444363

Roads			
	Area (ha)	Length (m)	Width (m)
Haul road	10	3333	30
Other roads (transport corridor)	110	99666	11

Fleet details				
Mine equipment fleet	Model	Number	Payload (t)	Weight (t)
Haul truck	Cat 793D	7	218	384
Face shovel / excavator	Cat 6018 & 6015	3	N/A	N/A
Front end loaders	2 Cat 980 H & 1Cat 966H	3	N/A	N/A
Water cart	Cat 777D WT	2	N/A	N/A
Dozer	Cat D9T	2	N/A	N/A
Wheeled Dozer	834	1	N/A	N/A
Grader	Cat 16M	1	N/A	N/A
Drill	Cat MD5125	2	N/A	N/A
Roller	Cat CS74	1	N/A	N/A
Fuel truck	Cat 777G FT	1	N/A	N/A
Light vehicles	not provided	10	N/A	N/A
Busses	not provided	4	N/A	N/A

Source Type	Description of Source	AUSPLUME ID (Area or Volume Source)	Model Run Source On/Off	Emission Regime	Total Area (ha)	Avg annual emissions (uncontrolled)		Overall Control Factor		Control Factor Breakdown						Avg annual emissions (controlled)			
						TSP g/s	PM10 g/s	TSP	PM10	Pit Retention	Water	Wind Breaks	Equipment	Re-veg	TSP g/s	TSP g/s/ha	PM10 g/s	PM10 g/s/ha	
Mech	Blasting - Stage 2 (Southern Pit)	BlastS (A)	On	B	0.4	0.5	0.3	1.00	1.00						0.5	1.352	0.3	0.703	
Mech	Blasting - Stage 3 (Northern Pit)	BlastN (A)	On	B	0.4	0.5	0.3	1.00	1.00						0.5	1.352	0.3	0.703	
Mech	Loading ore - Stage 2 (Southern Pit)	LoadS (V)	On	A		0.1	0.1	1.00	1.00						0.11		0.05		
Mech	Loading ore - Stage 3 (Northern Pit)	LoadN (V)	On	A		0.1	0.1	1.00	1.00						0.11		0.05		
Mech	Hauling Waste Rock - Stage2 (Southern Pit)	WHaulS (A)	On	A	5.0	13.9	2.9	0.25	0.25	0.75					3.5	0.688	0.7	0.144	
Mech	Hauling Waste Rock - Stage 3 (Northern Pit)	WHualN (A)	On	A	5.0	13.9	2.9	0.25	0.25	0.75					3.5		0.7		
Mech	Hauling Ore - Stage 2 (Southern Pit)	OHaulS (A)	On	A	5.0	12.0	2.5	0.25	0.25	0.75					3.0	0.598	0.6	0.125	
Mech	Hauling Ore - Stage 3 (Northern Pit)	OHaulN (A)	On	A	5.0	12.0	2.5	0.25	0.25	0.75					3.0		0.6		
Mech	Roads - grading haul roads	Grade (A)	On	A	10.0	1.5	0.5	0.25	0.25	0.75					0.4	0.037	0.1	0.012	
Mech	Roads - misc vehicle traffic	MiscVT (A)	On	A	109.6	2.3	0.7	0.25	0.25	0.75					0.6	0.005	0.2	0.002	
Mech	Waste Rock Dumping	Wdump (V)	On	A		2.2	0.8	0.30	0.30	0.7					0.7		0.2		
Mech	Unloading ore to stockpile	Stock (V)	On	A		0.3	0.1	1.00	1.00	0.7					0.3		0.1		
Mech	ROM - Front end loading Ore to Prim Crush	R-Ld (V)	On	A		0.1	0.0	1.00	1.00						0.07		0.03		
Mech	ROM - Primary Crushing	R-PC (V)	On	A		1.3	0.5	1.00	1.00						1.3		0.5		
Mech	ROM - Conveyer (PC - SC)	R-P2S (V)	On	A		0.7	0.3	1.00	1.00						0.7		0.3		
Mech	ROM - Secondary Crushing	R-SC (V)	On	A		4.0	1.6	1.00	1.00						4.0		1.6		
Mech	ROM - Conveyer (SC-HPGRStockpile)	R-C2S (V)	On	A		0.7	0.3	1.00	1.00						0.7		0.3		
Mech	ROM - Tertiary Crushing	R-TC (V)	On	A		4.0	1.3	1.00	1.00						4.0		1.3		
Mech	Dozing - Waste Rock	Doz-W (A)	On	A	88.8	0.8	0.1	1.00	1.00						0.8	0.009	0.1	0.002	
Wind	Wind Erosion - Stage 2 (Southern Pit)	WE-PS (A)	On	C	10.9	0.1	0.1	1	1						0.1	0.013	0.1	0.007	
Wind	Wind Erosion - Stage 3 (Northern Pit)	WE-PN (A)	On	C	18.7	0.2	0.1	1	1						0.2	0.013	0.1	0.007	
Wind	Wind Erosion - Stockpile	WE-S (A)	On	C	44.8	0.6	0.3	0.65	0.65	0.5					0.4	0.009	0.2	0.004	
Wind	Wind Erosion - Waste Rock	WE-WR (A)	On	C	88.8	1.2	0.6	0.65	0.65	0.5					0.8	0.009	0.4	0.004	
Wind	Wind Erosion - Tailings	WE-T (A)	On	C	357.0	4.7	2.4	0.65	0.65	0.5					3.1	0.009	1.5	0.004	

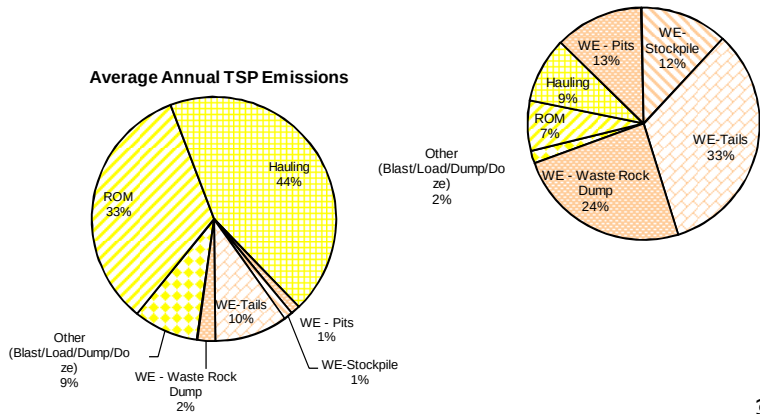
Total dust produced from mining activities in modelled year (includes wind erosion)*	TSP	1599 Tonnes
	PM10	621 Tonnes

Total Emissions	32.1		10.5	
Total Mech Emissions	32.1	100%	8.2	78%
Total Wind Emissions	4.6	14%	2.3	22%

Breakdown of dust emission regimes	
A	Continuous constant
B	Pit - 1 hr / 3 days
C	Calculated hourly

Control Factor Key	
Pit Retention	On = 50% (TSP) or 5% (PM10) reduction
Watering / water spray (W)	Hauling - level 2 watering (>2L/m2/hr) = 75% reduction
	Unloading Trucks - water sprays = 70% reduction
	Loading stockpiles - water sprays = 50% reduction
	conveying/misc transfer - water spray + chemicals = 90% reduction
	Wind erosion from stockpiles - water sprays = 50% reduction
Wind Breaks	Wind erosion from stockpiles - wind breaks = 30% reduction
Equipment	primary crusher - hooding with scrubbers = 75% reduction
Re-veg (RV)	wind erosion from stockpiles - re-veg = 99% reduction
Sprays (SS)	wind erosion surfaces - surface sprays = 90% reduction

99.9 Percentile Annual TSP Emissions



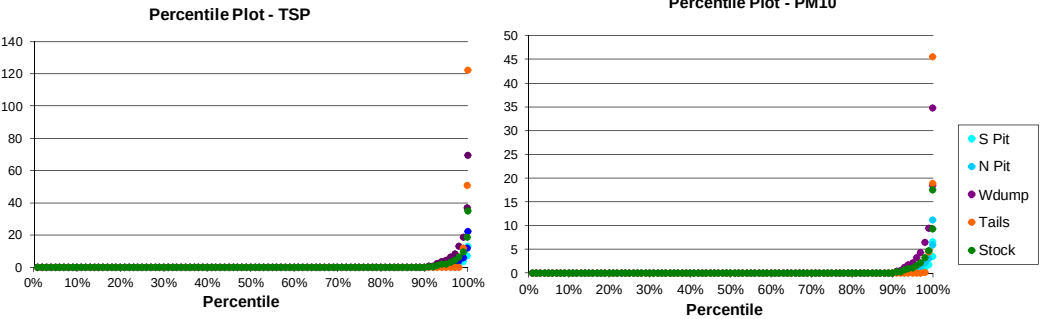
Note on Blasting
Blasting has been included in this spreadsheet to indicate the approximate dust emissions that will occur due to blasting. However, as a separate blasting investigation has been undertaken, blasting was not incorporated into the emissions model.
Blasting was estimated to have a blast area of 0.8 ha, which equates to one blast per day

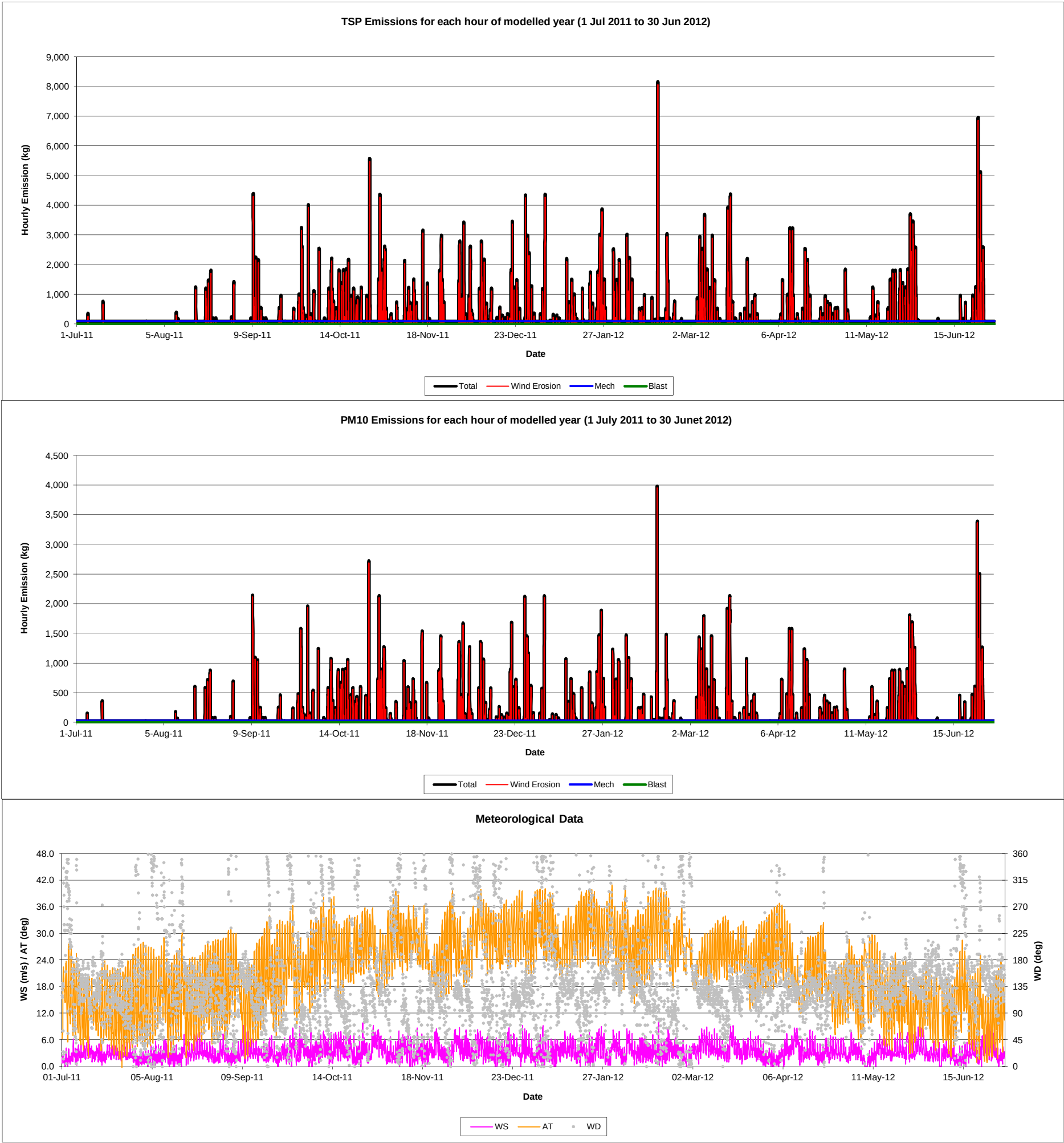
Wind Erosion Areas Breakdown with associated control factors							
	Total Area (ha)	Disturbed Controlled		Disturbed Uncontrolled		Undisturbed Areas [1]	
		% of Area	Controls	% of Area	Controls	% of Area	Controls
Pit - Stage 2	10.8758	0%	none	100%	none	0%	none
Pit - Stage 3	18.6579	0%	none	100%	none	0%	none
Stockpile	44.8408	70%	W	30%	none	0%	none
Waste Rock	88.8476	70%	W	30%	none	0%	none
Tailings	357	70%	W	30%	none	0%	none

[1] Undisturbed areas have dust emissions of background values (control factor = 0)							
Total area	520	ha	100%	Total disturbed area	520	ha	100%
Total disturbed	520	ha	100%	Area with controls	343	ha	66%
Total undisturbed	-	ha	0%	Area without controls	177	ha	34%

Average annual emissions from disturbed areas								
	Disturbed Controlled Areas (MANAGED)				Disturbed Uncontrolled Areas (ACTIVE)			
	area (ha)	% of area	ER (g/s)	% of ER	area (ha)	% of area	ER (g/s)	% of ER
Pit - Stage 2	0	0%	0.0	0%	10.8758	100%	0.1	100.0%
Pit - Stage 3	0	0%	0.0	0%	18.6579	100%	0.2	100.0%
Stockpile	31.38856	70%	0.2	0%	13.45224	30%	0.2	46.2%
Waste Rock	62.19332	70%	0.4	53.8%	26.65428	30%	0.4	46.2%
Tailings	249.9	70%	1.7	53.8%	107.1	30%	1.4	46.2%

Hourly calculated emissions statistics for 1 Jul 2011 to 30 Jun 2012								
	TSP Emissions (g/s)				PM10 Emissions (g/s)			
	Max	99.9 %ile	99 %ile	Ann avg	Max	99.9 %ile	99 %ile	Ann avg
Pit - Stage 2	13.1	7.0	3.5	5,161	6.5	3.5	1.8	2,581
Pit - Stage 3	22.4	11.9	6.1	8,854	11.2	6.0	3.0	4,427
Stockpile	35.0	18.7	9.5	13,831	17.5	9.3	4.7	4,427
Waste Rock	69.4	37.0	18.7	27,406	34.7	18.5	9.4	13,703
Tailings	122.1	50.7	12.1	11,911	45.5	18.9	4.5	4,440
Blasting - Stage 2	39.4	39.4	39.4	19,523	20.5	20.5	20.5	10,152
Blasting - Stage 3	39.4	39.4	39.4	19,523	20.5	20.5	20.5	10,152





GHD

GHD, 999 Hay Street, Perth, WA 6000

P.O. Box 3106, Perth WA 6832

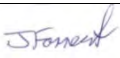
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

© GHD 2015

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\61\2905711\WP\149442_RevA.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	S Woods L Clayson	J Forrest		I McCardle		1/12/15

www.ghd.com





Appendix J

Noise and Vibration Assessment Report





TNG Limited

Mount Peake Project

Noise and Vibration Assessment Report

December 2015

Executive summary

Introduction

TNG Limited is proposing to develop the Mount Peake Project, located approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway, consisting of:

- Mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Road haulage of the concentrate to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed Darwin Refinery located at Middle Arm, Darwin.

The mine will be an open pit truck and shovel operation mining up to 8.4 million tonnes per annum (Mtpa) of ore. Following beneficiation, approximately 1.8 Mtpa of magnetite concentrate will be produced at peak production. The life of the mine is expected to be 15 years.

Noise sources

The main noise sources are expected to be from mine plant and equipment (excavators, haul trucks, dozers, graders etc.), the processing plant (crushers, ball mills and conveyors and drives etc.) and the power station (gas engines etc.).

Sensitive receptors

The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community. The accommodation village will be located approximately 5 km to the east of the mine.

Construction noise and vibration

The results of the construction assessment indicate that noise and vibration levels of the mine are expected to comply with nominated noise criteria at all times for noise and vibration sensitive receptors.

Construction noise is not expected to cause adverse impacts at noise receptors. However, in order to reduce the risk of noise impact, the mitigation measures outlined in Section 8 should be taken into consideration during construction.

Operational noise and vibration

The results of the operational assessment indicate that the operational noise and vibration impact of the Project is expected to comply with the nominated noise criteria at all times for noise and vibration sensitive receptors assessed under all weather conditions.

A mine site noise model predicts potential noise levels for a worst case mine operating scenario. The model predicted noise levels under varying meteorological conditions and has assumed that all machinery and plant on the mine site is operating continuously.

Predicted noise levels under worst case conditions (wind assisted conditions during temperature inversion) at the nearest noise sensitive receptor (the mine camp) is 34 dBA, which is below the noise criteria of 35 dBA.

The estimated increase in traffic noise levels due to the Project is not expected to be noticeable.

The nature and levels of vibration emitted by the mine will vary with the activities being undertaken on the site, however, due to the distances between the sources and receptors, vibration is unlikely to have a significant impact.

Available literature suggests that the impact of noise from the Project is unlikely to result in negative impacts to either livestock or native fauna. As such, no specific management measures, other than those proposed in regard to management of impacts to human receptors, are suggested.

Although not expected to cause adverse noise impacts, the mitigation measures detailed in the report should be taken into consideration for operation of the Project in order to reduce risk of noise impact.

Glossary of acronyms and terms

DECC	NSW Department of Environment and Climate Change
EPA	Environment Protection Authority
GHD	GHD Pty Ltd
ICNG	NSW <i>Interim Construction Noise Guideline</i>
GLpa	Gigalitre per annum
INP	NSW <i>Industrial Noise Policy</i>
Mt	Million tonne
Mtpa	Million tonnes per annum
MW	Megawatt
PPV	Peak particle velocity
RBL	Rating background level
ROM	Run of mine
RNP	NSW <i>Road Noise Policy</i>
SPL	Sound pressure level at the distance from the source (dB)
SWL	Sound power level of the source (dB)
TNG	TNG Limited
TSF	Tailings storage facility
VDV	Vibration dose value
WRD	Waste rock dump

Table of contents

1.	Introduction.....	1
1.1	Background.....	1
1.2	Scope of work	1
1.3	Approach.....	3
1.4	Limitations	3
2.	Project description.....	4
2.1	Project proposal	4
2.2	Mine operations	4
3.	Noise sources	9
3.1	Construction	9
3.2	Operational	9
4.	Noise criteria	10
4.1	Construction noise	10
4.2	Operational noise	11
4.3	Vibration criteria	13
4.4	Blasting	15
4.5	Road traffic noise	15
5.	Existing environment.....	16
5.1	Topography and land use	16
5.1	Existing noise	16
5.2	Meteorology	16
5.3	Sensitive receptors	17
6.	Construction noise and vibration assessment	18
6.1	Construction noise assessment.....	18
6.2	Construction vibration	19
7.	Operational noise assessment.....	22
7.1	Noise modelling methodology.....	22
7.2	Noise sources	22
7.3	Noise modelling scenarios	26
7.4	Noise modelling results.....	28
7.5	Road traffic noise assessment.....	29
8.	Mitigation and control measures	34
9.	Conclusions.....	35
9.1	Construction noise and vibration	35
9.2	Operational noise and vibration	35

Table index

Table 4-1	ICNG recommended standard hours for construction works.....	10
Table 4-2	ICNG construction noise criteria at residential receptors	10
Table 4-3	Construction noise goals $L_{Aeq(15-min)}$	11
Table 4-4	Project specific noise criteria	12
Table 4-5	Vibration dose value ranges and probabilities for adverse comment to intermittent vibration ($m/s^{1.75}$).....	13
Table 4-6	Guidance on the effects of vibration levels	14
Table 4-7	Guideline values for short term vibration on structures	14
Table 4-8	Recommended ANZECC 1990 blasting limits.....	15
Table 4-9	NSW road traffic noise criteria	15
Table 5-1	Receptor locations	17
Table 6-1	Predicted plant activity noise levels, dBA	19
Table 6-2	Typical vibration levels for construction equipment	20
Table 6-3	Predicted construction equipment vibration levels (mm/s PPV)	21
Table 7-1	Model settings.....	22
Table 7-2	Modelled noise sources – Mobile sources.....	23
Table 7-3	Modelled noise sources – Fixed sources.....	23
Table 7-4	Mobile sources - Estimated sound power levels, dB	24
Table 7-5	Mobile sources - Estimated sound power levels, dB	25
Table 7-6	Estimated internal sound pressure levels, dB	26
Table 7-7	Transmission loss of building materials, dB.....	26
Table 7-8	Predicted night $L_{Aeq(15-min)}$ noise levels, dBA.....	28

Figure index

Figure 1-1	Project location, Mount Peake Project area	2
Figure 2-1	Mine site detail, Mount Peake Project area	6
Figure 2-2	Layout of the processing facilities.....	7
Figure 2-3	Concentrate loadout facility, Adnera rail siding, proposed site layout	8
Figure 7-1	Predicted night $L_{Aeq (15-min)}$ noise levels under neutral meteorological conditions	30
Figure 7-2	Predicted night $L_{Aeq (15-min)}$ noise levels under temperature inversion conditions.....	31
Figure 7-3	Predicted night $L_{Aeq (15-min)}$ noise levels under dry season meteorological conditions	32
Figure 7-4	Predicted night $L_{Aeq (15-min)}$ noise levels under wet season meteorological conditions.....	33

Appendices

Appendix A – Noise terminology

1. Introduction

TNG Limited (TNG) is proposing to develop the Mount Peake Project (the Project), located approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway (Figure 1-1), consisting of:

- Mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Road haulage of the concentrate to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed Darwin Refinery located at Middle Arm, Darwin.

1.1 Background

The mine will be an open pit truck and shovel operation with an initial throughput of 3 million tonnes per annum (Mtpa), increasing up to 6 Mtpa from year 5. Following beneficiation, approximately 1.8 Mtpa of magnetite concentrate will be produced at peak production. The life of the mine is expected to be 15 years.

The main noise sources are expected to be from mine plant and equipment (excavators, haul trucks, dozers, graders etc.), the processing plant (crushers, ball mills and conveyors and drives etc.) and the power station (gas engines etc.).

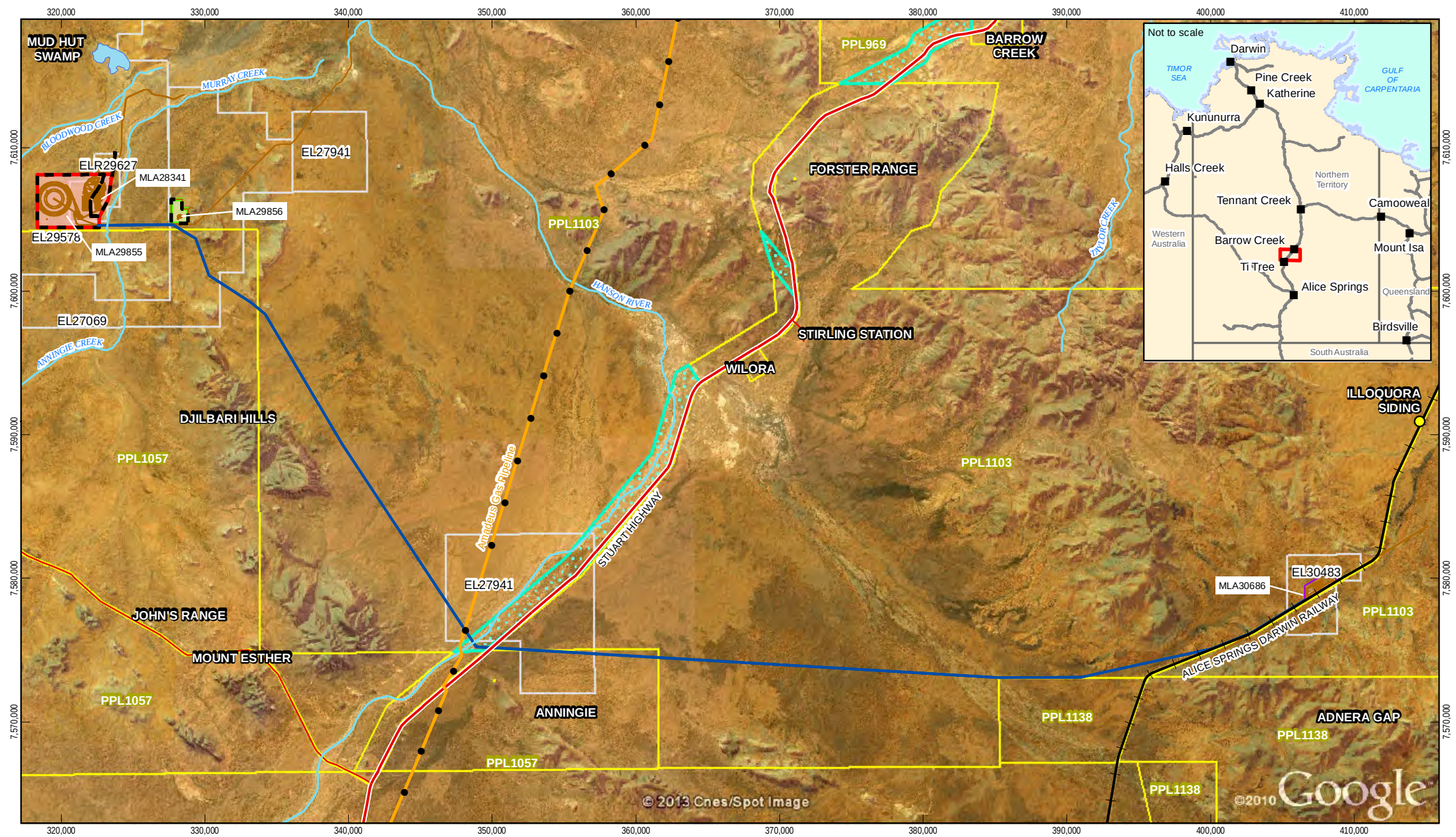
The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community. The accommodation village will be located approximately 5 km to the east of the mine.

1.2 Scope of work

GHD Pty Ltd (GHD) was commissioned by TNG to prepare an environmental assessment for the Project. As part of this commission, GHD completed a noise and vibration assessment.

This report assesses the potential noise and vibration impacts from construction and operation of the Project. The report's scope is to:

- Identify noise sensitive locations surrounding the Project
- Describe the existing noise environment at noise sensitive locations surrounding the Project
- Identify noise and vibration sources associated with construction and operation of the Project
- Develop an environmental noise model showing the impacts from the operation of the Project in isolation using noise modelling software
- Use the noise model to assess operational noise based on all plant operating on-site continuously
- Assess the potential noise impacts on nearby noise sensitive receptors and compare the impacts with assigned noise levels
- Identify opportunities for the attenuation of noise impacts from the Project on noise sensitive areas should predicted noise impacts exceed the relevant noise targets.

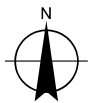


Paper Size A4

0 2.5 5 7.5 10

Kilometres

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



LEGEND

Illoquora Siding	Amadeus Gas Pipeline	Crown Land
Principal Road	Mine Site Facilities	Mount Peake Granted Tenements
Minor Road	Mud Hut Swamp	Mount Peake Mineral Leases
Major Watercourses	Rail Siding Loading Facility	Cadastral Boundaries
Railway	Mount Peake Mining Area	Access Road
	Camp Facilities	



TNG Ltd
Mount Peake EIS

Project Location
Mount Peake Project Area

Job Number	61-29057
Revision	A
Date	23 Oct 2015

Figure 1-1

G:\61\29057\11 GIS\Maps\MXD\6129057_001_Fig1ProjectLocation.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

© 2015. Whilst every care has been taken to prepare this map, G.A, GE, GHD and TNG make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Data source: TNG - Gas / Slurry Pipeline Study Corridor, Camp Facilities, Transport Study Corridor, Mount Peake Mining Area, Mount Peake Granted Tenements (2015). Geoscience Australia - Waterways, mainland, placename, road (2008). Google Earth Pro - Imagery (Date extracted: 13/02/2014). Created by: RB

1.3 Approach

The approach adopted by GHD for the assessment of noise and vibration impacts from the Project is summarised in the following points. Each point is described in detail in the subsequent sections of the report:

- Outline of the Project, including process description (Section 2)
- Anticipated construction, operational and road traffic noise sources (Section 3)
- Identification of the relevant noise criteria and guidelines applicable to this assessment (Section 4)
- Investigation of the existing noise environment, including identification of sensitive receptors (Section 5)
- Desktop assessment of construction noise and vibration (Section 6)
- Noise modelling for the assessment of predicted noise impacts during operation of the Project. Road traffic noise was addressed by desktop review (Section 7)
- Recommended mitigation and control measures (Section 8)
- Conclusions drawn from the above assessment (Section 9).

1.4 Limitations

This report has been prepared by GHD for TNG Limited and may only be used and relied on by TNG Limited for the purpose agreed between GHD and the TNG Limited as set out in this report.

GHD otherwise disclaims responsibility to any person other than TNG Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope of work and limitations set out in the report.

GHD accepts no responsibility for the integrity of the software coding of the approved noise model (CadnaA) used.

GHD has prepared this report on the basis of information provided by TNG Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

2. Project description

2.1 Project proposal

The Mount Peake Project is located approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway.

Mining, processing and associated infrastructure will occur at the mine site with accommodation facilities located 5 km to the east.

An access road for site access and product haulage will run 100 km south-east and then east from the mine site to a new rail siding and load out facility near Adnera.

Existing infrastructure includes the Stuart Highway, Adelaide to Darwin Railway, the Amadeus Gas Pipeline, pastoral station tracks and wells for stock watering.

All Project components lie within the Stirling and Anningie perpetual pastoral leases aside from a portion of crown land adjacent to the Stuart Highway that is intersected by the access road.

The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community. The accommodation village will be located approximately 5 km to the east of the mine. Figure 1-1 shows the proposed Mount Peak Project site and the closest receptors.

2.2 Mine operations

The mine will be an open pit truck and shovel operation. Extracted ore will be transported by haul truck from the mine pit to a run of mine (ROM) pad or to long-term stockpiles prior to processing. Mining will commence with a starter pit accessing high grade and low strip ratio ore to feed a beneficiation plant. The initial throughput of the beneficiation plant will be 3 Mtpa ramping up to 6 Mtpa in year 5. The life of the mine is expected to be 19 years inclusive of construction (2 years), mining (15 years) and closure (2 years).

Overburden and waste rock will be stored in a waste rock dump (WRD), as shown in Figure 2-1.

Extracted ore will undergo beneficiation, which involves crushing, grinding and magnetic separation to produce a concentrate (Figure 2-2). Ore will be loaded from the ROM pad to a primary crusher by front end loader. Approximately 1.8 Mtpa of concentrate will be produced at peak production.

Tailings will be stored in a tailings storage facility (TSF), as shown in Figure 2-1.

The magnetite concentrate will be transported by road haulage to a new rail siding and load out facility at Adnera (Figure 2-3). Up to 100 return truck movements will occur per day at peak production. To ensure safety for users of the Stuart Highway an underpass of the highway will be constructed.

Train loading will be via front end loader to a conveyor and loading bin located over the rail siding. Around one train movement per day is expected.

New facilities at the Mount Peake Project include:

- Open cut mine
- Waste rock dump (WRD) with up to 70 million tonne (Mt) capacity
- Run of mine (ROM) pad
- Four long term stockpiles of up to 4 Mt capacity each

- Process plant
- Tailings storage facility (TSF) with up to 63 Mt capacity
- Access road between the mine site and Adnera Loadout Facility including an underpass of Stuart Highway (for concentrate trucks) and intersections with Stuart Highway (for mine site access)
- Borefield and associated water pipeline
- Concentrate stockpiles
- Water treatment plant
- Sewage treatment plant
- Gas fired power station
- Explosives and detonator magazines
- Accommodation village
- Administrative buildings, laboratory, workshops and warehouses
- Gatehouse and weighbridge
- Fuel farm
- Concentrate loadout facility and rail siding at Adnera.

Upon completion of the project, the site will be decommissioned and rehabilitated following an approved *Mine Closure Plan*.

2.2.1 Water and power requirements

Approximately 2,625 MLpa of make-up water will be required for mining, processing, dust suppression and potable use. Water will be obtained from a purpose built bore field.

At full production the power draw for the mine and process plant is estimated at 24 MW. Power during the first four years will be supplied from 16 x 1,400 kVA gas fired generating sets with an additional 12 generating sets added from year five. Emergency backup will be provided from 3 x 1,250 kVA diesel generators.

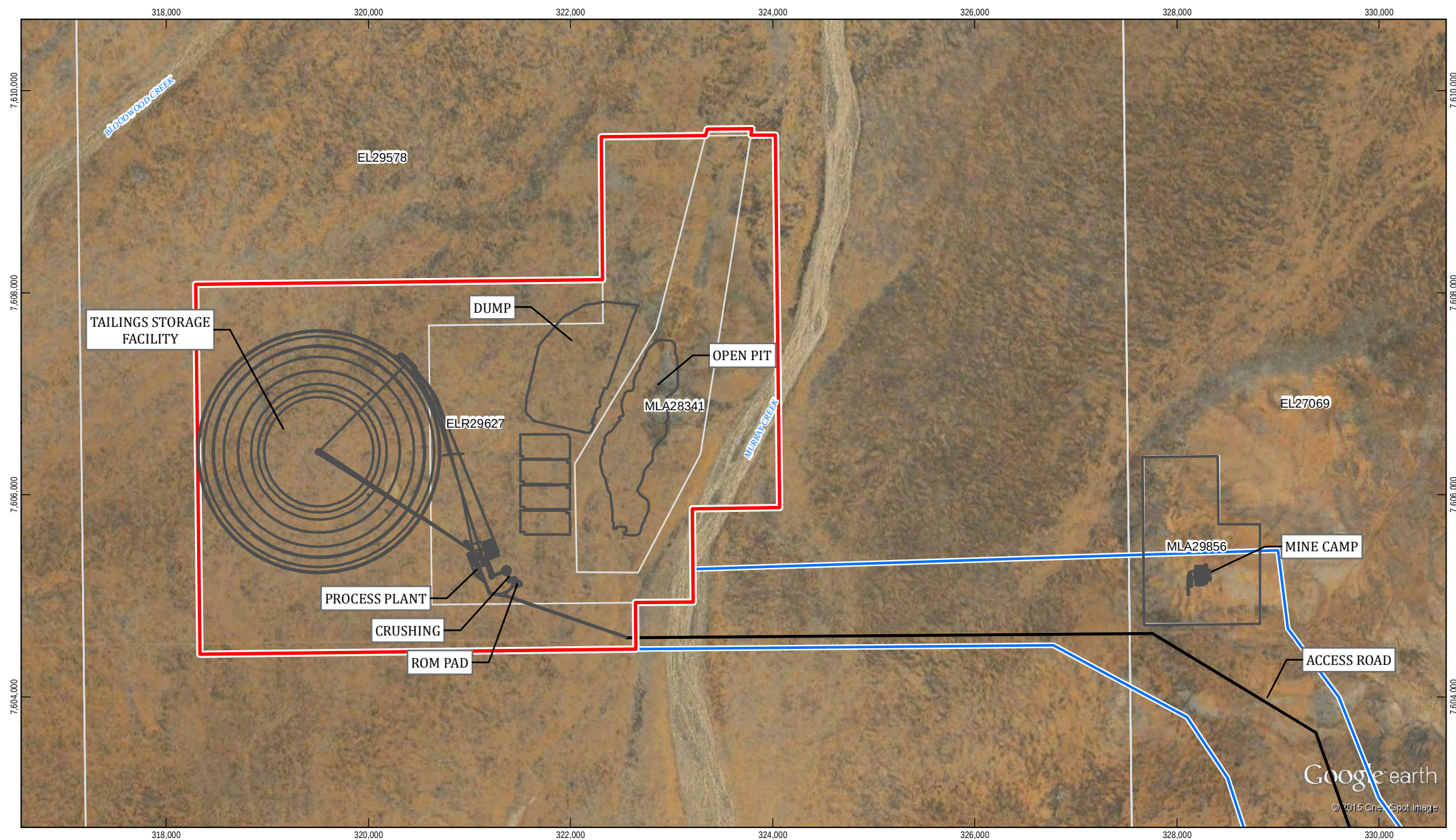
Gas will be provided from the Amadeus Gas Pipeline via a hot tap. Road train tankers will commute between the pipeline and the mine site along the access road.

Diesel generators will be used to power the borefield.

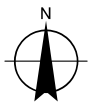
Power for construction will be provided by diesel powered generators until the power station is operable.

2.2.2 Timing

TNG proposes to commence construction in the late 2016 with mining commencing in 2018.



Paper Size A4
0 0.5 1 1.5
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53



LEGEND

- Mine Site Facilities
- Mount Peake Granted Tenements
- Mount Peake Mining Area
- Access Road
- Transport Study Corridor



TNG Ltd
Mount Peake EIS

Job Number 61-29057
Revision A
Date 26 Oct 2015

Mine Site Detail
Mount Peake Project Area

Figure 2-1

G:\61\29057\11 GIS\Maps\MXD\6129057_002_Fig2MineSiteDetail.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

© 2015. Whilst every care has been taken to prepare this map, TNG, GHD and GE make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Google: Imagery - 20150910; TNG Ltd: Mine site facilities, access road, mining area, Tenure - 20151021

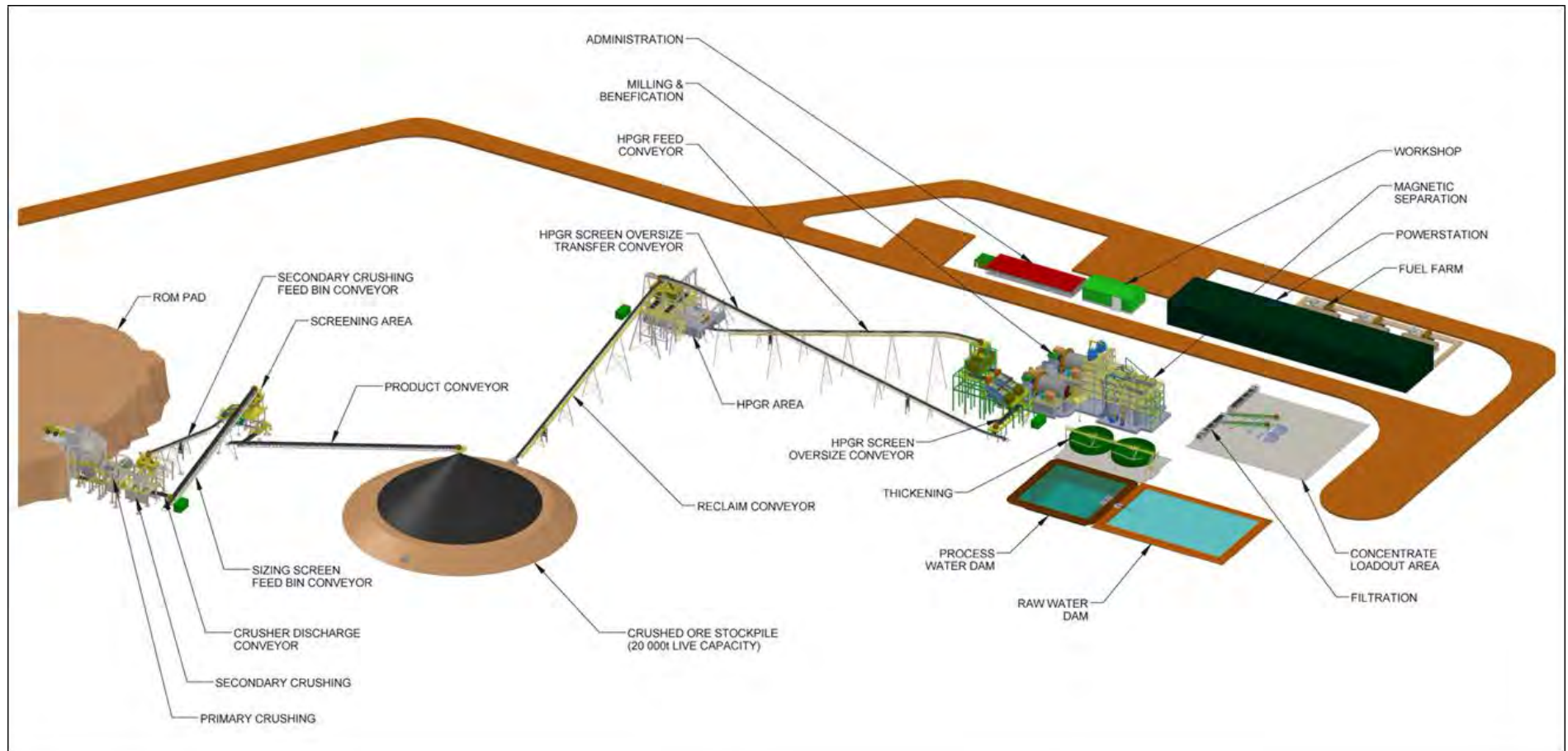


Figure 2-2 Layout of the processing facilities

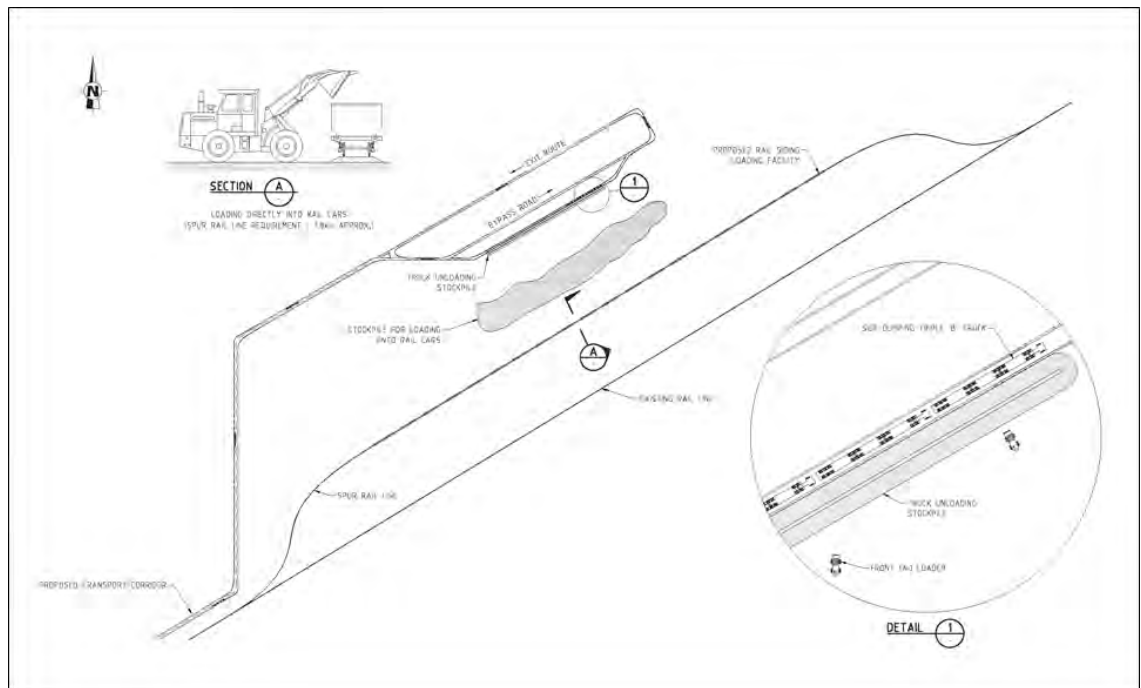


Figure 2-3 Concentrate loadout facility, Adnera rail siding, proposed site layout

3. Noise sources

3.1 Construction

Construction works are due to commence as soon as all relevant approvals and permits are obtained (second half of 2016) and is expected to occur over a 24 month period.

Construction activities expected to be undertaken include civil excavation and earthworks, building construction, equipment fabrication and installation, waste removal and materials transfer. Where possible, activities that could result in elevated noise levels will be scheduled during day time work hours.

An assessment of construction noise and vibration has been made in Section 6.

3.2 Operational

Noise sources resulting from Project operations are outlined below:

- Mine pit: Blast hole drills, blasting, shovels, dump trucks and water trucks
- Waste rock dumps: Dump trucks, dozers and water trucks
- Haul roads: Dump trucks, graders and water trucks
- Crushing plant (ROM pad): Wheel loader, primary (grizzly), secondary (jaw) and tertiary (cone) crushers, vibratory screens, apron feeders, conveyors and conveyor drives
- Crushed ore stockpile: Tripper conveyor and conveyor drive, apron feeder, conveyors and conveyor drives
- High pressure grinding rolls (HPGR) area: HPGRs, apron feeders, conveyors and conveyor drives
- Concentrators: Secondary ball mill and pumps (feed and sump), vibrating screen, ball mill and pumps (feed and sump), magnetic separator pumps (feed and sump), desliming pump (tails), finisher pumps (feed, sump and tails) and flotation pump (tails)
- Concentrate transfer: Front end loader to load road train and delivery to Adnera
- Tailing dewatering: Thickeners, tails pumps and agitated tails tanks
- Tailings storage facility: Slurry pumps and agitated slurry tanks
- Power station: Gas gensets, transformers and emergency diesel gensets
- Adnera loadout facility: Road trains will side dump concentrate to a stockpile adjacent to the rail siding. Train loading will occur directly by up to four front-end loaders. Around one train movement per day is expected. Generators on site will provide power.

An assessment of operational noise has been made in Section 7.

4. Noise criteria

4.1 Construction noise

In the absence of relevant Northern Territory guidelines or policies, construction noise is assessed with consideration to NSW Department of Environment and Climate Change (DECC) *Interim Construction Noise Guidelines* (ICNG)^[1]. The ICNG recommend standard hours for construction activity is detailed in Table 4-1.

Table 4-1 ICNG recommended standard hours for construction works

Work type	Recommended standard hours of work
Normal construction	Monday to Friday: 7.00 am to 6.00 pm Saturday: 8.00 am to 1.00 pm No work on Sundays or public holidays
Blasting	Monday to Friday: 9.00 am to 5.00 pm Saturday: 9.00 am to 1.00 pm No work on Sundays or public holidays

Extended working hours would be required on some week nights and potentially weekends, particularly for concrete pours during the hotter months, construction material delivery or to catch up on schedule delays. However, given the location of the mine site and the large distance between sources and receptors, this is not expected to be an issue.

The need for extended working hours will be determined during detailed design and during the construction period.

It is unlikely that blasting will be required during construction. This will be confirmed on finalisation of the relevant geotechnical studies.

The ICNG provides noise management for construction noise levels at residential receptors. These management levels are calculated based on the adopted rating background level (RBL) at nearby residential locations, as shown in Table 4-2.

Table 4-2 ICNG construction noise criteria at residential receptors

Time period	Management level L_{Aeq} (15-min)
Recommended standard hours	Noise affected level: RBL + 10 dBA Highly noise affected level: 75 dBA
Outside recommended standard hours	Noise affected level: RBL + 5 dBA

The above levels apply at the boundary of the most affected residences or within 30 m from the residence where the property boundary is more than 30 m from the residence.

The noise affected level represents the point above which there may be some community reaction to noise. Where the noise affected level is exceeded, all feasible and reasonable work practices to minimise noise should be applied and all potentially impacted residents should be informed of the nature of the works, expected noise levels, duration of works and a method of contact. The noise affected level is the background noise level plus 10 dBA during recommended standard hours and the background noise level plus 5 dBA outside of recommended standard hours.

¹ DECC. 2009. *Interim Construction Noise Guideline*. Department of Environment and Climate Change, NSW.

The highly noise affected level represents the point above which there may be strong community reaction to noise and is set at 75 dBA. Where noise is above this level, the relevant authority may require respite periods by restricting the hours when the noisy activities can occur, taking into account:

- Times identified by the community when they are less sensitive to noise (such as mid-morning or mid-afternoon for works near residences)
- Whether the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Based on the distance between the Project and the closest sensitive receptors (approximately 30 km), background monitoring was not completed for this assessment. The NSW *Industrial Noise Policy* (INP)^[2] states that where the background level (RBL) is found to be less than 30 dBA then it is set to 30 dBA. Therefore, construction noise goals were derived based on a RBL of 30 dBA, as shown in Table 4-3.

Table 4-3 Construction noise goals $L_{Aeq(15-min)}$

Within recommended standard hours	Outside recommended standard hours	
	Evening (6.00 pm to 10.00 pm)	Night (10.00 pm to 7.00 am)
40	35	35

4.1.1 NSW sleep disturbance criteria

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the analysis should include maximum noise levels and the extent and number of times the maximum exceeds the rating background levels. The INP application notes regarding sleep disturbance recommend that where the $L_{A1(1-min)}$ exceeds the $L_{A90(15-min)}$ by more than 15 dBA, more detailed analysis is required. Further guidance for sleep disturbance is provided in the *Road Noise Policy* (RNP)^[3] which concludes, based on the research to date, that:

- Maximum internal noise levels below 50-55 dBA are unlikely to awaken people from sleep
- One or two noise events per night, with maximum internal noise levels of 65–70 dBA, are not likely to affect health and wellbeing significantly

The sleep disturbance criteria has been set at 65 dBA based on the RNP recommended maximum internal noise levels of 55 dBA, and assuming a 10 dBA reduction in noise from outside to inside the building.

4.2 Operational noise

The *Waste Management and Pollution Control Act 1998* arose as the initial action in the development of a Strategy for Waste Management and Pollution Control in the Northern Territory which began in 1995.

The Act has no provision for the assessment criteria for noise and vibration. There are no other relevant Northern Territory guidelines and criteria for noise or vibration. Therefore, operational noise criteria applicable to site noise sources were determined with consideration to the NSW INP.

² EPA. 2000. *Industrial Noise Policy*. NSW Environment Protection Authority.

³ DECCW. 2011. *NSW Road Noise Policy*. Department of Environment, Climate Change and Water, NSW.

The policy is specifically aimed at assessing noise from industrial noise sources scheduled under the NSW *Protection of the Environment Operations Act 1997*. It is typically used as a guide by NSW Environment Protection Authority (EPA) officers for setting statutory limits in licences for these sources. The policy is designed for large and complex industrial sources and specifies substantial monitoring and assessment procedures. The INP is typically the preferred noise guideline in the absence of other noise policies and guidelines. The INP provides guidance on the assessment of operational noise impacts. The guidelines include intrusive and amenity criteria designed to protect receptors from noise significantly louder than the background level and to limit the total noise level from all sources near a sensitive receptor.

Intrusive noise limits set by the INP control the relative audibility of operational noise compared to the background level. The amenity criteria limit the total level of extraneous noise. Both sets of criteria are calculated and the more stringent of the two in each time period applies with consideration to the Application Notes pertaining to Section 2.4 of the INP. Table 2.2 in the INP provides modifications to the amenity criteria for existing levels of industrial noise.

Attended observations noted that existing levels of industrial noise in the area are not a significant contributor to the existing ambient noise level in the vicinity of the development. Therefore the amenity noise criteria do not require adjustment.

The amenity criteria are determined based on the overall acoustic characteristics of the receptor area and the existing level of noise excluding other noises that are uncharacteristic of the usual noise environment. Residential receptor areas are characterised into 'urban', 'suburban', 'rural' or other categories based on land uses, the existing level of noise from industry, commerce and road traffic. The nearest residential receptors to this development were classified as rural.

The NSW INP states that where the background level is found to be less than 30 dBA then it is set to 30 dBA. The project specific noise levels for the proposed mine at identified sensitive receptors are provided in Table 4-4.

Table 4-4 Project specific noise criteria

Criterion	Nearest residential receptor		
	Day 7.00 am to 6.00 pm	Evening 6.00 pm to 10.00 pm	Night 10.00 pm to 7.00 am
A: Rating background level ^[4]	-	-	-
B: Intrusiveness criteria (A + 5 dB)	35 L _{Aeq} (15-min)	35 L _{Aeq} (15-min)	35 L _{Aeq} (15-min)
C: Rural amenity criteria (INP Table 2.1)	50 L _{Aeq} (day)	45 L _{Aeq} (evening)	40 L _{Aeq} (night)
D: Amenity criteria (INP Table 2.2 adjusted)	-	-	-
Project specific noise level (INP Page 21)	35 L _{Aeq} (15-min)	35 L _{Aeq} (15-min)	35 L _{Aeq} (15-min)

(-) denotes not applicable since there is no existing industrial noise

The above levels apply at the boundary of the most affected residences or within 30 m from the residence where the property boundary is more than 30 m from the residence.

⁴ The NSW INP states where the rating background level is found to be less than 30 dBA, then it is set to 30 dBA.

4.2.1 Low frequency noise

The INP is considered to address noise sources with inherent dominant infrasound or (very) low frequency noise characteristics. The planned power station at the mine site has the potential to generate low frequency noise components below 200 Hz. The procedure for the initial screening to determine if a more detailed assessment is required is as follows:

- If the dB (linear) measurement exceeds the dBA measurement by more than 15 dB, a one third octave band measurement in the frequency range 20 to 200 Hz should be carried out.

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level. Table 4.1 in the INP sets out the corrections to be applied for tonal, impulsive, intermittent and low frequency noise. The corrections specified are to be added to the measured or predicted noise levels at the receiver before comparison with the criteria. Correction of 5 dB is to be applied if the difference between the measurements of C-weighted and A-weighted levels over the same period is 15 dB or more.

4.3 Vibration criteria

4.3.1 Human comfort vibration criteria

In the absence of any Northern Territory or Australian guidelines relating to human comfort criteria for vibration, criteria have been adopted with consideration to the *British Standard 6472 – 2008, Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting* (BS 6472-1:2008), which are recognised as the preferred standard for assessing the human comfort criteria for residential building types.

Typically, mine activities generate ground vibration of an intermittent nature. Under BS 6472-1:2008, intermittent vibration is assessed using the vibration dose value (VDV). Table 4-5 includes acceptable values of vibration dose for residential receptors for day and night periods.

Table 4-5 Vibration dose value ranges and probabilities for adverse comment to intermittent vibration (m/s^{1.75})

Location	Low probability of adverse comment ^[5]	Adverse comment possible	Adverse comment probable ^[6]
Residential buildings 16 hour day (7.00 am to 11.00 pm)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night (11.00 pm to 7.00 am)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

These values represent the best judgement available at the time the standard was published and may be used for both vertical and horizontal vibration, providing that they are correctly weighted. Because there is a range of values for each category, it is clear that the judgement can never be precise.

Whilst the assessment of response to vibration in BS 6472-1:2008 is based on VDV and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of peak particle velocity (PPV), since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage.

⁵ Below these ranges adverse comment is not expected.

⁶ Above these ranges adverse comment is very likely.

Humans are capable of detecting vibration at levels that are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in *British Standard 5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration* (BS 5228-2:2009) as shown in Table 4-6.

Table 4-6 Guidance on the effects of vibration levels

Approximate vibration level	Degree of perception
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.00 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10.00 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

4.3.2 Structural damage vibration criteria

There is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance limiting vibration is attained by reference to German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures* (DIN 4150-3).

Table 8 of DIN 4150-3 presents guideline values for the maximum absolute value of the velocity “...at the foundation of various types of building. Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible”.

Measured values exceeding those listed in Table 4-7 does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary.

Table 4-7 Guideline values for short term vibration on structures

Type of structure	Guideline values for velocity, (mm/s)		
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz ^[7]
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50
Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10

The vibration criteria presented in this standard exceed the human comfort criteria presented above. Therefore, as indicated above, the human comfort criteria should be the over-riding criteria for the assessment of any vibration.

⁷ Where frequencies are above 100 Hz the values given in this column may be used as minimum values.

4.4 Blasting

The Australian and New Zealand Environment and Conservation Council (ANZECC) *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (1990) are typically referred to when dealing with potential blasting noise and vibration. This guideline recommends the noise and vibration limits shown in Table 4-8.

Table 4-8 Recommended ANZECC 1990 blasting limits

Air blast overpressure	Ground vibration
115 dB(lin) peak	5 mm/s PPV
The level of 115 dB may be exceeded on up to 5% of the total number of blasts over a period of 12 months, but never over 120 dB(lin) peak	The level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months, but never over 10 mm/s

ANZECC guideline recommends that blasting should only be permitted during the following hours:

- Monday to Saturday, 9.00 am to 5.00 pm
- No blasting on Sundays or public holidays

The frequency of blasting should not take place more than once per day. This requirement does not apply to minor blasts such as clearing crushers, feed chutes, etc.

When considering a time to initiate the blast - weather conditions must be assessed. Generally the atmosphere is most stable early morning and late afternoon due to the absence of direct ground heating from the sun.

4.5 Road traffic noise

Stuart Highway is the only government controlled road potentially affected by the Project. It is not planned for redevelopment or upgrade. The developer is solely responsible for managing traffic noise impacts on sensitive receptors.

In the absence of NT road traffic noise criteria, road traffic noise targets for the above have been sourced from the NSW RNP.

The road traffic noise associated with the construction works and operation is sourced from the RNP. Recommended noise levels associated with land use developments are shown in Table 4-9. Where noise criteria levels are already exceeded, construction and operational traffic arising from the proposal should not lead to an increase of more than 2 dBA in existing noise levels.

Table 4-9 NSW road traffic noise criteria

Road category	Type of project / land use	Assessment criteria dBA	
		Day 7.00 am to 10.00 pm	Night 10.00 pm to 7.00 am
Local road	Existing residences affected by noise from new local road corridors Existing residences affected by noise from redevelopment of existing local roads Existing residences affected by additional traffic on existing local roads generated by land used developments	L _{Aeq} (1 hour) 55 dB (external)	L _{Aeq} (1 hour) 50 dB (external)

5. Existing environment

5.1 Topography and land use

The Mount Peake Project Area lies within the Burt Plain bioregion. Land use immediately adjacent to the Mount Peake Project Area is pastoral activities. Existing infrastructure includes the Stuart Highway, Adelaide to Darwin Railway, the Amadeus Gas Pipeline, pastoral station tracks and wells for stock watering.

The nearest non-mining sensitive receptor to the mine site is Anningie Station homestead approximately 30 km to the south-west of the mine site. The access road lies approximately 20 km to the south of the Wilora Aboriginal community.

5.1 Existing noise

The Mount Peake Project Area currently has few sources of noise and vibration. Noise is associated with operations on Anningie and Stirling stations, traffic noise on Stuart Highway and rail noise from the Alice Springs to Darwin railway.

The nearest occupied residence is Anningie Station homestead (approximately five permanent residents) around 30 km from the mine site. Wilora community (approximately 120 residents) is around 20 km from the access road.

5.2 Meteorology

The climate of the region is arid to semi-arid with a mean annual rainfall of approximately 320 mm recorded at Barrow Creek, approximately 65 km east of the mining area. The climate is characterised by hot, wet summers and warm, dry winters. Rain tends to fall during heavy rain events between November and March, with little follow on rain. The highest annual rainfall for Barrow Creek of 1,153 mm was recorded in 2010. Annual rainfall is highly variable.

Temperatures vary significantly, with mean daily maximum temperatures ranging from 22°C (August) to 37°C (January), and mean daily minimum temperatures from 8°C (July) to 24°C (January). Average annual evaporation for Barrow Creek totals around 2,980 mm, with average monthly evaporation exceeding rainfall in all months.

5.2.1 Wind climate

The INP states that wind effects need to be assessed where wind is a feature of the area. Based on analysis of meteorological data for the mine, wind is considered to be a feature where source to receiver wind speeds of 3 m/s or below occur for 30% of the time or more in any assessment period (day, evening, night) in any season. Therefore, the assessment of the level by which noise from the mine is increased as a result of wind effects has been included in the prediction modelling.

5.2.2 Atmospheric stability

As per the INP, assessment of impacts is confined to the night time noise assessment period (10.00 pm to 7.00 am), as this is the time likely to have the greatest impact - that is, when temperature inversions usually occur and disturbance to sleep is possible.

The INP states that an occurrence of 30% of the total nights during winter (June, July and August) is selected as representing a significant noise impact warranting further assessment.

Based on analysis of meteorological data for the mine, F class atmospheric conditions occur for more than 30% of the total winter nights. Therefore, the assessment of the level by which noise from the mine is increased as a result of inversion effects has been included in the prediction modelling.

5.3 Sensitive receptors

A number of receptors were identified in the Mount Peake region, based on reviewing aerial photographs, as listed in Table 5-1. The distance from the processing plant and the project specific noise level used for assessment is provided for each receptor.

Table 5-1 Receptor locations

Receptor name	Location (MGA 94)		Distance from process plant (km)	Project specific noise level L_{Aeq} (15 min)
	Easting (km)	Northing (km)		
Anningie Station	305.913	7582.817	30	35
Willowra	252.622	7648.678	80	35
Wilora	368.646	7595.380	47	35
Barrow Creek	383.314	7618.267	62	35
Mine camp site	327.657	7605.251	5	35
Stirling Station	372.097	7598.030	51	35
Ti Tree	336.844	7555.160	52	35

6. Construction noise and vibration assessment

6.1 Construction noise assessment

Construction noise impacts associated with the Project were estimated using the following distance attenuation relationship:

$$SPL = SWL - 20\log(d) + 10\log(Q) - 11$$

where: d = Distance between the source and receptor (m)
 Q = Directivity index (2 for a flat surface)
 SPL = Sound pressure level at the distance from the source (dB)
 SWL = Sound power level of the source (dB)

Typical noise levels produced by construction plant anticipated to be used on-site were sourced from *AS 2436 – 2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites* and GHD's internal database.

Propagation calculations take into account sound intensity losses due to spherical spreading, with additional minor losses such as atmospheric absorption, directivity and ground absorption ignored in the calculations. As a result, predicted received noise levels are expected to slightly overstate actual received levels and thus provide a measure of conservatism.

Received noise produced by anticipated activities, during the construction of the Project are shown in Table 6-1 for a variety of distances, with no noise barriers or acoustic shielding in place and with each plant item operating at full power. The sound pressure levels shown are maximum levels produced when machinery is operated under full load.

Other construction noise sources such as a concrete batching plant are expected to have similar sound power levels to the noise sources shown in Table 6-1. The magnitude of off-site noise impact associated with construction will be dependent upon a number of factors:

- The intensity and locations of construction activities
- The type of equipment used
- Existing local noise sources
- Intervening terrain
- The prevailing weather conditions.

Construction machinery will move about the Project site area, altering the directivity of the noise source with respect to individual receptors. During any given period the machinery items to be used in the Project area will operate at maximum sound power levels for only brief stages. At other times the machinery may produce lower sound levels while carrying out activities not requiring full power. It is unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Finally, certain construction machinery will be present for only brief periods during construction.

Due to the distance between the construction works and sensitive receptors it is unlikely that construction activities will be audible and cause nuisance to any sensitive receptors.

Table 6-1 Predicted plant activity noise levels, dBA

Plant	Estimated SWL, dBA	Estimated SPL, dBA at distance (m)						
		50	250	500	750	1000	3000	5000
Backhoe	104	62	48	42	39	36	26	22
Backhoe (with auger)	106	64	50	44	41	38	28	24
Bulldozer	108	66	52	46	43	40	30	26
Compactor	113	71	57	51	48	45	35	31
Compressor (silenced)	101	59	45	39	36	33	23	19
Concrete agitator truck	109	67	53	47	44	41	31	27
Concrete pump truck	108	66	52	46	43	40	30	26
Concrete saw	117	75	61	55	52	49	39	35
Concrete vibratory screed	115	73	59	53	50	47	37	33
Crane (mobile)	104	62	48	42	39	36	26	22
Excavator	107	65	51	45	42	39	29	25
Front end loader	113	71	57	51	48	45	35	31
Generator (diesel)	104	62	48	42	39	36	26	22
Grader	110	68	54	48	45	42	32	28
Hand tools (electric)	102	60	46	40	37	34	24	20
Hand tools (pneumatic)	116	74	60	54	51	48	38	34
Jack hammers	121	79	65	59	56	53	43	39
Piling (bored)	111	69	55	49	46	43	33	29
Rock breaker	118	76	62	56	53	50	40	36
Roller (vibratory)	108	66	52	46	43	40	30	26
Scraper	116	74	60	54	51	48	38	34
Truck (>20 tonnes)	107	65	51	45	42	39	29	25
Truck (dump)	117	75	61	55	52	49	39	35
Truck (water cart)	107	65	51	45	42	39	29	25
Vehicle (light commercial, 4WD)	106	64	50	44	41	38	28	24
Welder	105	63	49	43	40	37	27	23

6.1.1 Sleep disturbance

The Project criteria for night-time sleep disturbance of 65 dBA $L_{A1(1-min)}$ external to the dwelling is predicted to be met at all receptors. It should be noted that the maximum predicted noise level (L_{Amax}) summarised in Table 6-1 were used for the assessment of the sleep disturbance. $L_{A1(1-min)}$ is considered representative of L_{Amax} .

Given the intermittent, mobile and short term nature of construction noise, the estimates are considered conservative. Essentially, they represent the maximum possible distances over which an acoustic impact may be observable during quiet ambient conditions. If such impacts were to occur, they would likely be intermittent and infrequent.

6.2 Construction vibration

Vibration impacts discussed essentially focus on potential structural damage to properties in close vicinity of the Project area and/or potentially affected by construction activities. It is possible that construction vibration will be perceived at times by local sensitive receptors. However, the level of annoyance will depend on individuals.

6.2.1 Pile driving

Construction of the Project may require foundations for major and minor structures to be supported on piles. Impacts associated with pile driving techniques would not normally lead to structural damage when carried out further than 30 m from a vibration sensitive structure, such as a residential dwelling.

Project configuration is such that the minimum distance between the nearest residences and the site structures exceeds 1,000 m. As a result, vibration impacts from pile driving, should it occur on site, is not expected to be a concern from a structural damage point of view.

6.2.2 Blasting

Construction of the Project may require blasting as part of ground clearance and site preparation. Any blasting on site should be subject to a blasting noise and vibration control plan.

Such controls should be prepared with consideration to AS 2187.2:2006 *Explosives – Storage and Use – Part 2: Use of Explosives*.

6.2.3 General assessment

The separation distance between the potentially most impacted receptors and site construction activities will generally be in excess of 2,000 m. However, it is possible that infrastructure and road works may be carried out at smaller distances.

The nature and levels of vibration emitted by the site will vary with the activities being carried out on site. Table 6-2 outlines typical vibration levels for different plant activities that may be generated on the Project site, sourced from the NSW Roads and Traffic Authority (RTA) *Environmental Noise Management Manual*^[8].

Table 6-2 Typical vibration levels for construction equipment

Plant item	Peak particle velocity at 10 m (mm/s)
Pile driving (impulsive)	12-30
Roller (15 tonne)	7.0-8.0
Dozer	2.5-4.0
Compactor (7 tonne)	5.0-7.0
Rock breaking	7.0
Backhoe	1.0

Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuate with distance. The magnitude and attenuation of ground vibration is dependent on:

- The efficiency of the energy transfer mechanism of the equipment (i.e. impulsive; reciprocating, rolling or rotating equipment)
- The frequency content
- The impact medium stiffness
- The type of wave (surface or body)
- The ground type and topography.

⁸ RTA. 2001. *Environmental Noise Management Manual*. Roads and Traffic Authority - Version 1.0, 2011

The above factors cause inherent variability in ground vibration predictions in the absence of site specific measurement data. The rate of vibration attenuation can be calculated from the following regression analysis formula:

$$V = kD^{-n}$$

where

V = PPV

D = Distance

n = attenuation exponent. The value of n generally lies between 1 and 2 with a relatively common value of 1.5

The predicted ground vibrations at various distances are shown in Table 6-3 for typical construction equipment.

Table 6-3 Predicted construction equipment vibration levels (mm/s PPV)

Plant item	Human perception preferred criteria (maximum criteria)		Predicted ground vibration				
	Day	Night	10 m	30 m	50 m	100 m	300 m
Pile driving (Impulsive)	8.6 (17.0)	2.8 (5.6)	21.0	4.0	1.9	0.7	0.1
Roller (15 tonne)	0.28 (0.56)	0.2 (0.4)	7.5	1.4	0.7	0.2	<0.1
Dozer	0.28 (0.56)	0.2 (0.4)	3.3	0.6	0.3	0.1	<0.1
Compactor (7 tonne)	0.28 (0.56)	0.2 (0.4)	6.0	1.2	0.5	0.2	<0.1
Rock breaking	0.28 (0.56)	0.2 (0.4)	7	1.3	0.6	0.2	<0.1
Backhoe	0.28 (0.56)	0.2 (0.4)	1	0.2	0.1	<0.1	<0.1

Table 6-3 indicates that human perception guidelines for predicted ground vibration are likely to be met at a distance greater than 50 m from the construction activities.

Given the distance to the nearest receptor from the mine site is 30 km, construction vibration is highly unlikely to exceed the human perception criteria and is not discussed further in this assessment.

7. Operational noise assessment

7.1 Noise modelling methodology

Acoustic modelling was undertaken using CadnaA v4.4 noise modelling software to predict the effects of industrial noise generated by the proposed mine. CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates environmental noise propagation according to the CONCAWE noise prediction method. Terrain topography, ground absorption, atmospheric absorption and relevant shielding objects are taken into account in the calculations.

CONCAWE is a mathematical model developed to predict community noise levels from petrochemical and industrial plant for a range of meteorological conditions. A full description of the mathematical model is provided in the report prepared for the Conservation of Clean Air and Water in Europe *Report No. 4/81 -The propagation of noise from petroleum and petrochemical complexes to neighbouring communities* (CONCAWE, 1981). The CONCAWE prediction method is widely used in Australia for predicting noise impacts of mines, power stations and other industry.

The assessment has been modelled based on available data. The proposed layouts for the mine and noise generating equipment were based on information provided at the time of the assessment and may not reflect final detailed design. As such, modelling results should only be used as a guide for comparative purposes and may be revisited in detailed design.

Other parameters used in the model are listed in Table 7-1.

Table 7-1 Model settings

Model setting				
Project layout	As shown in Figure 2-1 for the mine and Figure 2-3 for the loadout facility			
Industry algorithm	CONCAWE			
Ground absorption	0.5			
Terrain	10 m resolution for the mine site			
Model scenarios	Neutral meteorological conditions	Temperature inversion	Dry season	Wet season
Temperature	20	10	10	20
Humidity	80%	50%	50%	80%
Stability class	D	F	D	D
Wind direction	0°	270°	135°	315°
Wind speed	0 m/s	2 m/s	3 m/s	3 m/s

7.2 Noise sources

Modelled overall sound power levels for mobile and fixed sources for the proposed mine are summarised in Table 7-2 and Table 7-3. Estimated sound power levels for each source are provided in Table 7-4 and Table 7-5. These sound power levels are maximum predicted levels produced when machinery is operating under full load.

Typical mining equipment noise levels have been obtained from noise assessments conducted on similar projects and GHD's noise source database.

Table 7-2 Modelled noise sources – Mobile sources

Noise source	Number of items modelled	Sound power level (SWL) dBA
Dump truck (Cat 777F)	7	115
Drill rig (Cat MD5125)	2	120
Track dozer (Cat D9T)	2	110
Wheel dozer (Cat 834)	1	115
Shovel (Cat 6018)	2	113
Shovel (Cat 6015)	1	107
Grader (Cat 16M)	1	111
Water truck (Cat 777D WT)	2	115
Wheel loader (Cat 980H)	7 (mine pit x2, siding x4)	113
Wheel loader (Cat 966H)	1 (bene plant)	105
Roller (Cat CS74)	1	108
Fuel truck (Cat 777G FT)	1	115
Road train	5	104
Light vehicles (utes and 4WDs)	10	100

Table 7-3 Modelled noise sources – Fixed sources

Noise source	Number of items modelled	Sound power level (SWL) dBA
Primary crusher (Grizzly)	1	116
Secondary crusher (jaw)	2	112
Dust collection (dry, silenced)	3	98
Screening plant	2	111
Apron feeders	1	99
Conveyor	11	94 per linear metre
Conveyor drive (unenclosed)	11	112
HPGR mills	2	117
Ball mill	2	117
Pumps (feed, sump or tails)	6	101
Pumps (slurry)	4	108
Agitated tank drive	2	110
Thickener drive	2	107
Filtration plant	2	120
Gas genset engine casing (1.4 MW)	28	106
Gas genset exhaust (1.4 MW, silenced)	28	115
Transformer (16 MVA)	4	64
Transformer (4 MVA)	4	53
Diesel genset engine casing (1.2 MW)	3 (emergency) + 12 (borefield)	108
Diesel genset exhaust (1.2 MW, silenced)	3 emergency) + 12 (borefield)	117

Table 7-4 Mobile sources - Estimated sound power levels, dB

Source	Height (m)	Octave band centre frequency (Hz)									Overall	
		31.5	63	125	250	500	1k	2k	4k	8k	dBA	dB
Dump truck (Cat 777F)	4.0	106	110	115	114	113	111	106	100	96	115	120
Drill rig (Cat MD5125)	3.5	121	124	123	115	119	114	112	107	101	120	129
Track dozer (Cat D9T)	3.0	100	109	109	107	106	104	104	102	97	110	115
Wheel dozer (Cat 834)	4.0	117	117	123	119	111	107	101	91	83	115	126
Shovel (Cat 6018)	4.0	125	119	114	108	109	108	106	105	98	113	127
Shovel (Cat 6015)	3.5	117	111	107	106	104	102	99	93	88	107	119
Grader (Cat 16M)	3.5	137	132	121	110	100	102	95	91	84	111	139
Water truck (Cat 777D WT)	4.0	106	110	115	114	113	111	106	100	96	115	120
Wheel loader (Cat 980H)	4.0	125	119	114	108	109	108	106	105	98	113	127
Wheel loader (Cat 966H)	3.5	96	113	98	108	103	97	94	90	83	105	115
Roller (Cat CS74)	3.5	99	116	101	111	106	100	97	93	86	108	118
Fuel truck (Cat 777G FT)	4.0	106	110	115	114	113	111	106	100	96	115	120
Road train	4.0	105	102	101	101	104	96	94	89	85	104	110
Light vehicles (utes and 4WDs)	2.0	102	99	98	99	101	93	91	86	82	100	107

Table 7-5 Mobile sources - Estimated sound power levels, dB

Source	Height (m)	Octave band centre frequency (Hz)									Overall	
		31.5	63	125	250	500	1k	2k	4k	8k	dBA	dB
Primary crusher (Grizzly)	4.0	107	106	107	112	113	111	108	104	98	116	119
Secondary crusher (Jaw)	3.0	108	108	107	107	108	108	104	102	95	112	116
Dust collection (dry, silenced)	2.0	107	105	107	98	93	93	88	86	-	98	112
Screening plant	2.5	108	104	104	104	104	103	105	104	102	111	114
Apron feeders	2.0	110	101	101	93	93	93	93	88	-	99	111
Conveyor	1.0	82	91	90	90	94	89	82	72	64	94	98
Conveyor drive (unenclosed)	1.5	117	118	115	113	110	107	104	97	88	112	123
HPGR mills	4.0	125	117	112	114	113	114	110	104	94	118	127
Ball mill	4.0	108	110	111	113	112	112	109	108	105	117	120
Pumps (feed, sump or tails)	1.5	90	97	98	93	95	98	95	85	-	101	104
Pumps (slurry)	1.5	84	90	93	102	109	99	92	98	-	108	111
Agitated tank drive	2.0	108	102	105	105	105	108	99	92	86	110	114
Thickener drive	3.0	-	94	97	99	102	102	101	96	88	107	108
Filtration plant	5.0	96	102	105	114	121	111	101	112	110	120	123
Gas genset engine casing (1.4 MW)	2.5	108	107	109	102	101	97	98	98	98	105	114
Gas genset exhaust (1.4 MW, silenced)	10.0	93	111	123	113	108	111	105	91	67	114	124
Transformer (16 MVA)	2.5	50	47	69	68	59	53	54	53	51	64	72
Transformer (4 MVA)	2.5	-	36	58	57	48	42	43	42	40	53	61
Diesel genset engine casing (1.2 MW)	2.0	111	110	112	105	104	100	101	101	101	108	117
Diesel genset exhaust (1.2 MW, silenced)	10.0	96	114	126	116	111	114	108	94	70	117	127

In addition to the above, CadnaA calculation protocols were used to determine internal noise levels in the building containing the generators. Internal noise level calculations were based on a conservative average 0.05 internal absorption coefficient (representing acoustically hard surfaces) and the overall internal surface area of the subject buildings. Results are presented in Table 7-6.

Table 7-6 Estimated internal sound pressure levels, dB

Building	Internal noise level, dB									Overall	
	31.5	63	125	250	500	1k	2k	4k	8k	dBA	dB
Engine hall	106	105	107	99	99	95	95	96	96	103	112

7.2.1 Building details and building component transmission loss

Buildings that have potential to affect noise propagation by means of screening or reflection have been incorporated in the model with consideration. First order reflections only were considered.

The genset buildings at the mine and enclosures at the borefield were modelled as a distinct area sources (i.e. radiating walls and roof). The sound power of such area sources is dependent on the indoor noise levels within the building, the wall or roof sound transmission loss (in other terms, its capacity to attenuate sound levels), absorption coefficient of internal surfaces and overall surface area.

For the genset buildings, the model accounted for all walls and roof surfaces. Based on review of the design drawings, the main building materials found on site would be steel wall cladding (1 mm thickness) and steel roofing (0.4 mm thickness). Weatherproof louvers are located on the west facing wall to provide ventilation for operation of the engines. Table 7-7 presents the sound transmission loss used in the assessment for each of the above.

Table 7-7 Transmission loss of building materials, dB

Building component	Octave band centre frequency, Hz / Sound transmission loss, dB									RW
	31.5	63	125	250	500	1k	2k	4k	8k	
Steel cladding	3	8	15	17	22	27	32	38	45	26
Steel roofing	0	3	8	14	20	23	26	27	35	23
Weatherproof louvers	0	0	2	5	5	5	5	5	5	6

7.3 Noise modelling scenarios

The Project mine site will be developed over the following stages:

- End of year 2: Initial mining focuses on the southern portion of the mine (Stage 1) where the overburden is shallowest and the highest grades exist. Mined ore is fed directly to the process plant
- End of year 4: Mining of ore is taking place in the southern area (Stage 1 and 2) with waste stripping to the northern (Stage 3). The full footprint of the waste dump has been opened. The low grade stockpiles are being filled (to approximately 5 Mt at this stage) as material is mined to uncover higher grade material
- End of year 6: Mining of ore continues in Stage 2 and 3. Material is added to the stockpiles with the total size reaching about 9 Mt at this stage. The higher grade stockpile (southern) is regularly depleted to manage variations in ore delivery
- End of year 8: Stripping of Stage 4 commences as ore mining in Stage 2 and 3 continues

- End of year 10: Stripping of Stage 5 commences as ore mining in Stage 3 and 4 continues
- End of year 12: Waste mining ceases and all stages are being depleted to final depth. The stockpiles peak at just over 12 Mt
- End of year 14: Final ore mining from the pit is completed, while the stockpiles start to be depleted
- End of mine life: mining has been completed. Final stockpile depletion occurs to meet the concentrator capacity.

Noise impacts will be most significant during early mine life as the depth of the pit will be minimal as overburden is removed. As mine development progresses, the depth of the pit will increase, reducing noise emissions from mining equipment operating in the pit. Therefore noise modelling and assessment against assigned night time L_{A10} noise levels has been completed for early mine life (end of year 4) for the purpose of assessing predicted worst case noise levels. This year will also see the movement of around 11.6 Mt of ore and waste, a typical maximum annual production.

During early mine life, haul trucks will haul waste rock to the waste rock dumps. As such, noise modelling has assumed haul road traffic at the required volumes to transport the estimated daily throughput from the pit. Blast hole drilling operations have been assumed to occur during day only.

All other Project sources (including the crushing and processing plants, tailings storage facility and gas fired power station) are assumed to be operating continuously over the entire Project duration. As such, these sources have been modelled as continuous sources at maximum sound power levels which is conservative.

The noise model includes the following operational noise sources, with sound power levels provided in Table 7-2 and Table 7-3 (all plant and equipment is operating continuously unless otherwise noted):

- Two Cat MD5125 blast hole drill rigs
- Two Cat 6018 and one Cat 6015 shovels operating within the mine pit (Stage 3 (northern) and Stage 2 (southern))
- Seven Cat 777F dump trucks hauling ore to the ROM crushing plant and waste rock to the waste rock dump
- Two Cat D9T tracked dozers operating on the waste rock dumps, spreading waste rock as required
- One Cat 834 wheel dozer operating on the tails storage facility
- Two Cat 777D WT water trucks, one Cat 16M grader and one Cat CS74 roller maintaining the haul roads
- Two Cat 980H wheel loader operating at the mine pit
- One Cat 777G FT fuel truck operating within the pit and waste rock dumps
- Five road trains transporting concentrate product from the processing facility to the loadout siding
- Four Cat 980H wheel loaders operating at the loadout siding
- Light vehicles (4WDs and utes) operating across the site

- ROM crushing plant consisting of wheeled loader (Cat 980H), primary (grizzly) and secondary (jaw) crushers with dry dust collection systems and product transfer (conveyors, conveyor drives and vibratory screens)
- Crushed ore stockpile consisting of product transfer (conveyors, conveyor drives, apron feeders and vibratory screens)
- Grinding consisting of two HPGR mills, two ball mills and product transfer (conveyors, conveyor drives and vibratory screens)
- Magnetite concentrator trains, each consisting of pumps (feed, sump, tails and slurry) and drives (agitated tank and thickener)
- Pressure filtration plant consisting of pressure filters and slurry pumps
- Concentrate transfer: Concentrate loaded into trucks
- Gas fired power station consisting of gas gensets (casing and exhaust) and electrical transformers

7.4 Noise modelling results

Due to staging, noise impacts will vary over the proposed life of the mine, depending on where machinery is operating. Areas where these changes will occur are the mine pit and the waste rock dump. The processing facilities and the power station will operate 24 hours a day, 365 days per year. Prevailing winds during the dry season are from the south-east, which are directed away from the nearest noise sensitive receptors. Prevailing winds during the wet season are from the north-west.

Noise propagation modelling has been undertaken with four scenarios:

- Temperature inversion (worst case winds towards closest receptor)
- 3 m/s wind from the south-east (dry season)
- 3 m/s wind from the north-west (wet season)
- Neutral conditions (no wind)

Predicted night $L_{Aeq (15-min)}$ noise levels generated by the Project at noise sensitive receptor locations for different meteorological conditions are summarised in Table 7-8. No predicted night time $L_{Aeq (15-min)}$ noise levels are over the appropriate project specific noise level of 35 dBA.

Table 7-8 Predicted night $L_{Aeq (15-min)}$ noise levels, dBA

Receptor	Neutral	Temperature inversion	Dry season	Wet season
Anningie Station	10.5	7.2	4.9	17.2
Willowra	4.7	-	6.2	0.3
Wilora	13.1	12.5	6.3	21.8
Barrow Creek	9.6	7.3	2.2	18.7
Mine camp site	29.3	34.3	28.6	33.0
Stirling Station	13.1	12.3	6.4	21.9
Ti Tree	7.3	7.0	0.8	16.3

- No noise impact predicted

7.4.1 Neutral meteorological conditions

Noise modelling was conducted under neutral conditions assuming mining, waste rock dump, crushing plant and magnetite concentrator operations were at full production rates. Table 7-8 shows predicted night time $L_{Aeq (15-min)}$ noise levels which comply with the project specific noise level of 35 dBA at all sensitive receptors under neutral meteorological conditions.

A night $L_{Aeq (15-min)}$ noise level contour plot is shown in Figure 7-1, which shows there are no exceedances of the night level of 35 dBA predicted at any sensitive receptors.

7.4.2 Temperature inversion

Noise modelling was conducted under temperature inversion conditions (the level by which noise from the mine is increased as a result of inversion effects) assuming mining, waste rock dump, crushing plant and magnetite concentrator operations were at full production rates. Table 7-8 shows predicted night time $L_{Aeq (15-min)}$ noise levels which comply with the project specific noise level of 35 dBA at all sensitive receptors under temperature inversion conditions.

A night $L_{Aeq (15-min)}$ noise level contour plot under temperature inversion conditions is shown in Figure 7-2, which shows there are no exceedances of the night level of 35 dBA predicted at any sensitive receptors.

7.4.3 Dry season

Noise modelling was conducted under typical dry season meteorological conditions assuming mining, waste rock dump, crushing plant and magnetite concentrator operations were at full production rates. Table 7-8 shows predicted night time $L_{Aeq (15-min)}$ noise levels which comply with the project specific noise level of 35 dBA at all sensitive receptors dry season meteorological conditions.

A night $L_{Aeq (15-min)}$ noise level contour plot is shown in Figure 7-3, which shows there are no exceedances of the night level of 35 dBA predicted at any sensitive receptors.

7.4.4 Wet season

Noise modelling was conducted under typical wet season conditions assuming mining, waste rock dump, crushing plant and magnetite concentrator operations were at full production rates. Table 7-8 shows predicted night time $L_{Aeq (15-min)}$ noise levels which comply with the project specific noise level of 35 dBA at all sensitive receptors under wet season meteorological conditions.

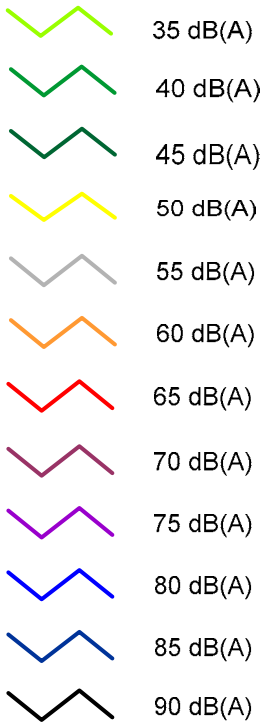
A night $L_{Aeq (15-min)}$ noise level contour plot is shown in Figure 7-4, which shows there are no exceedances of the night level of 35 dBA predicted at any sensitive receptors.

7.5 Road traffic noise assessment

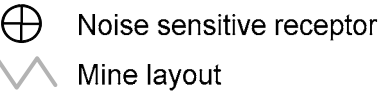
Road access for the traffic including construction, service, delivery and workforce vehicles will be exclusively from the existing Stuart Highway.

As such, the estimated increase in traffic noise due to the Project is not expected to be noticeable to nearby sensitive receptors.

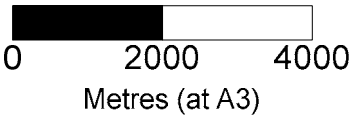
PREDICTED NOISE LEVELS



LEGEND



SCALE



COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.

CREATED JF	CHECKED JF	APPROVED IM

MAP PROJECTION: Universal Transverse Mercator
HORIZONTAL DATUM: Geocentric Datum of Australia (GDA)
GRID: Map Grid of Australia 1994, Zone 53

DATE 28.10.2015	FILE LOCATION
REVISION 0	DRAWING NO.

TNG LIMITED

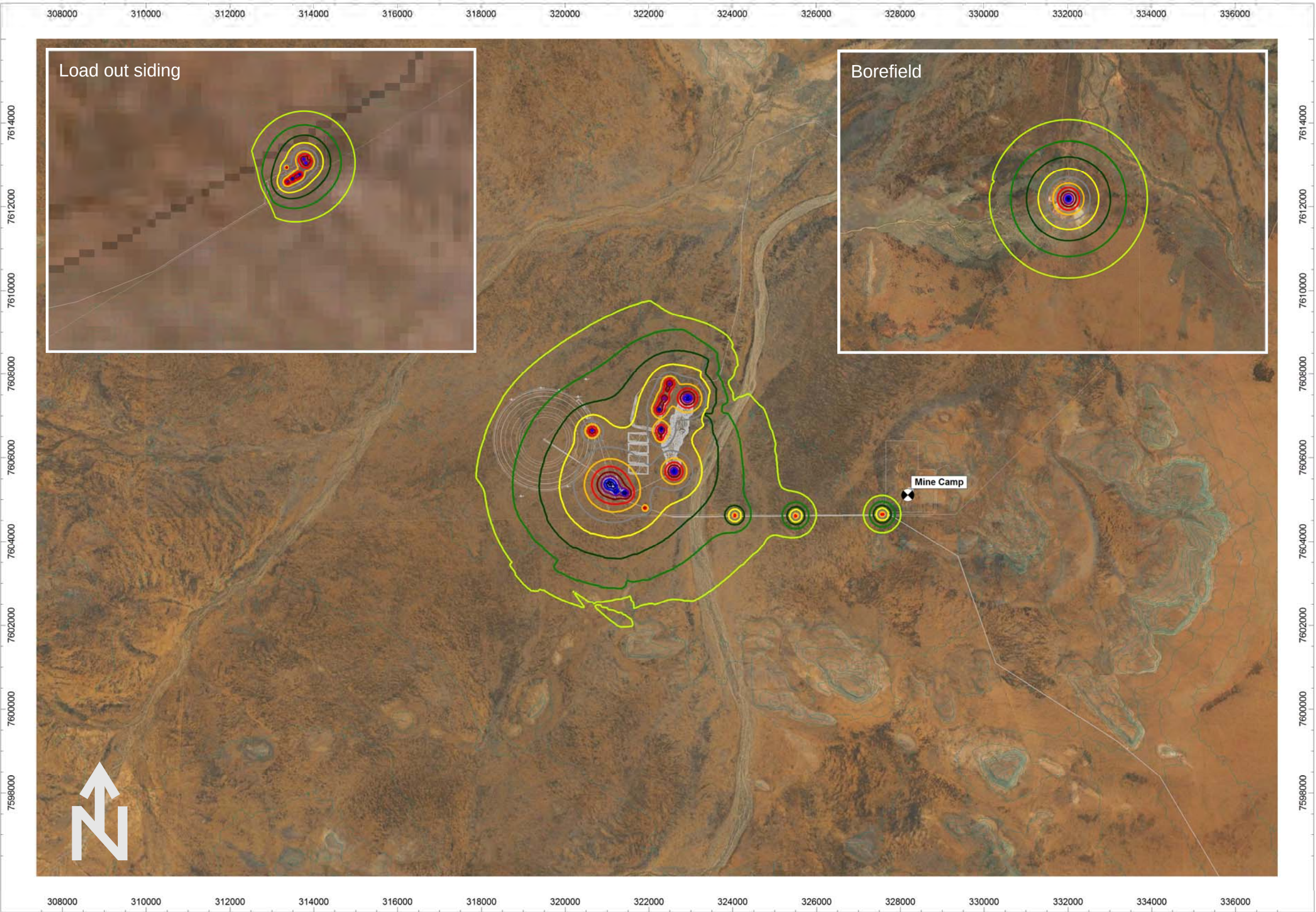
Mount Peake Magnetite Project
Noise and Vibration Assessment

PREDICTED NIGHT NOISE LEVELS

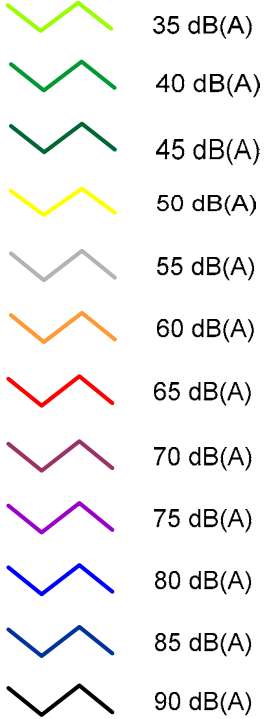
Noise contours: L_{Aeq} (15-min)
Grid height: 1.5 m
Neutral meteorological conditions



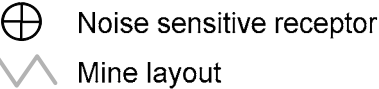
FIGURE 7-1



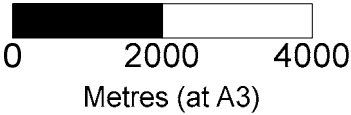
PREDICTED NOISE LEVELS



LEGEND



SCALE



COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.

CREATED JF	CHECKED JF	APPROVED IM

MAP PROJECTION: Universal Transverse Mercator
HORIZONTAL DATUM: Geocentric Datum of Australia (GDA)
GRID: Map Grid of Australia 1994, Zone 53

DATE 28.10.2015	FILE LOCATION
REVISION 0	DRAWING NO.

TNG LIMITED

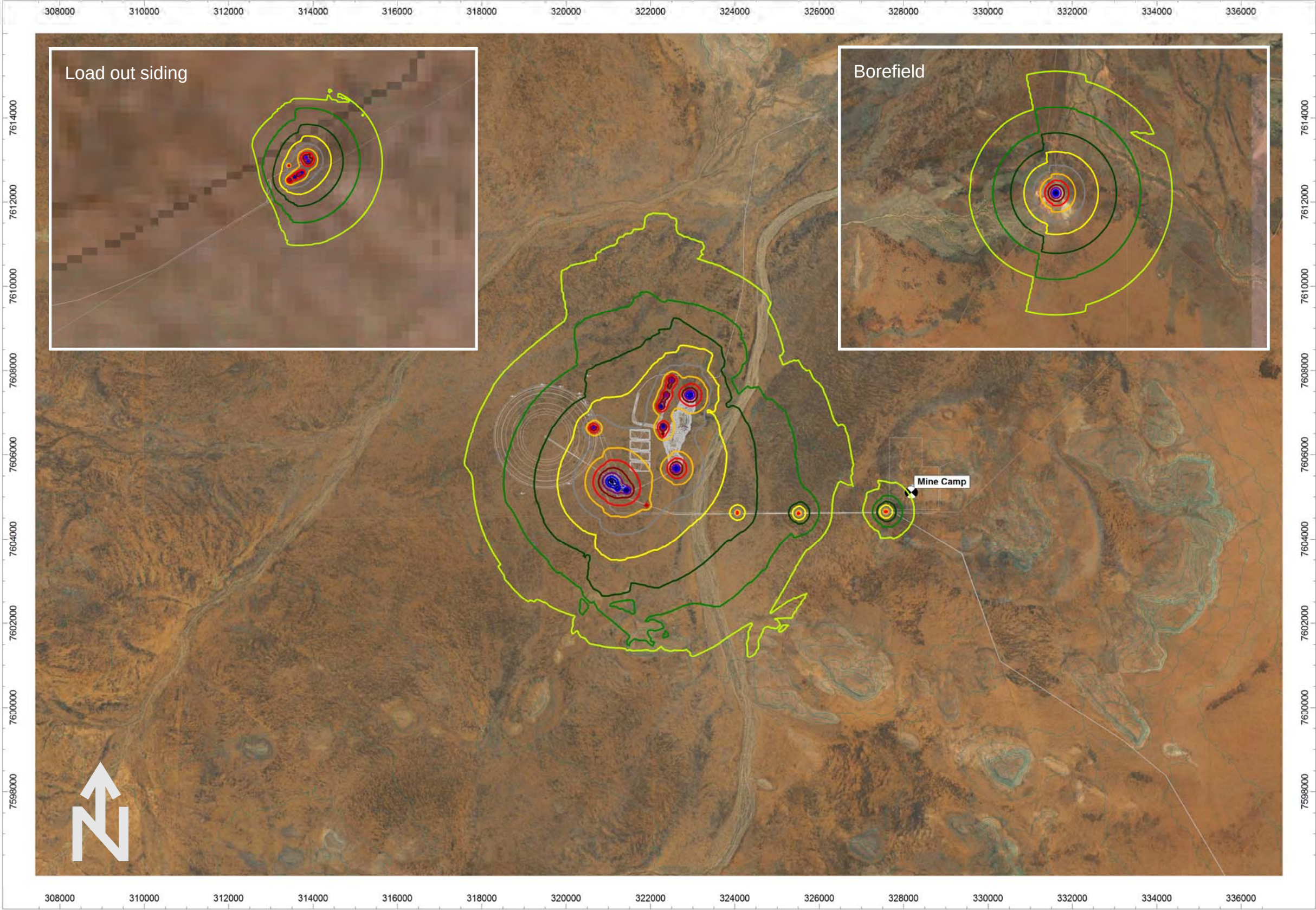
Mount Peake Magnetite Project
Noise and Vibration Assessment

PREDICTED NIGHT NOISE LEVELS

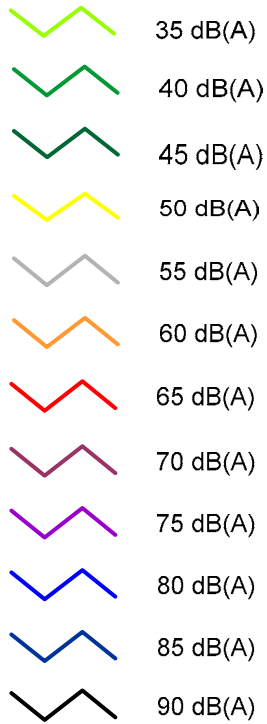
Noise contours: L_{Aeq} (15-min)
Grid height: 1.5 m
Temperature inversion conditions



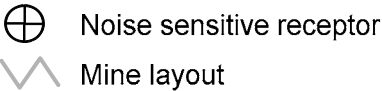
FIGURE 7-2



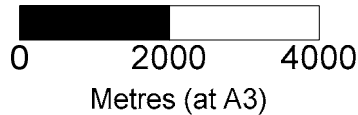
PREDICTED NOISE LEVELS



LEGEND



SCALE



COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.

CREATED JF	CHECKED JF	APPROVED IM

MAP PROJECTION: Universal Transverse Mercator
HORIZONTAL DATUM: Geocentric Datum of Australia (GDA)
GRID: Map Grid of Australia 1994, Zone 53

DATE 28.10.2015	FILE LOCATION
REVISION 0	DRAWING NO.

TNG LIMITED

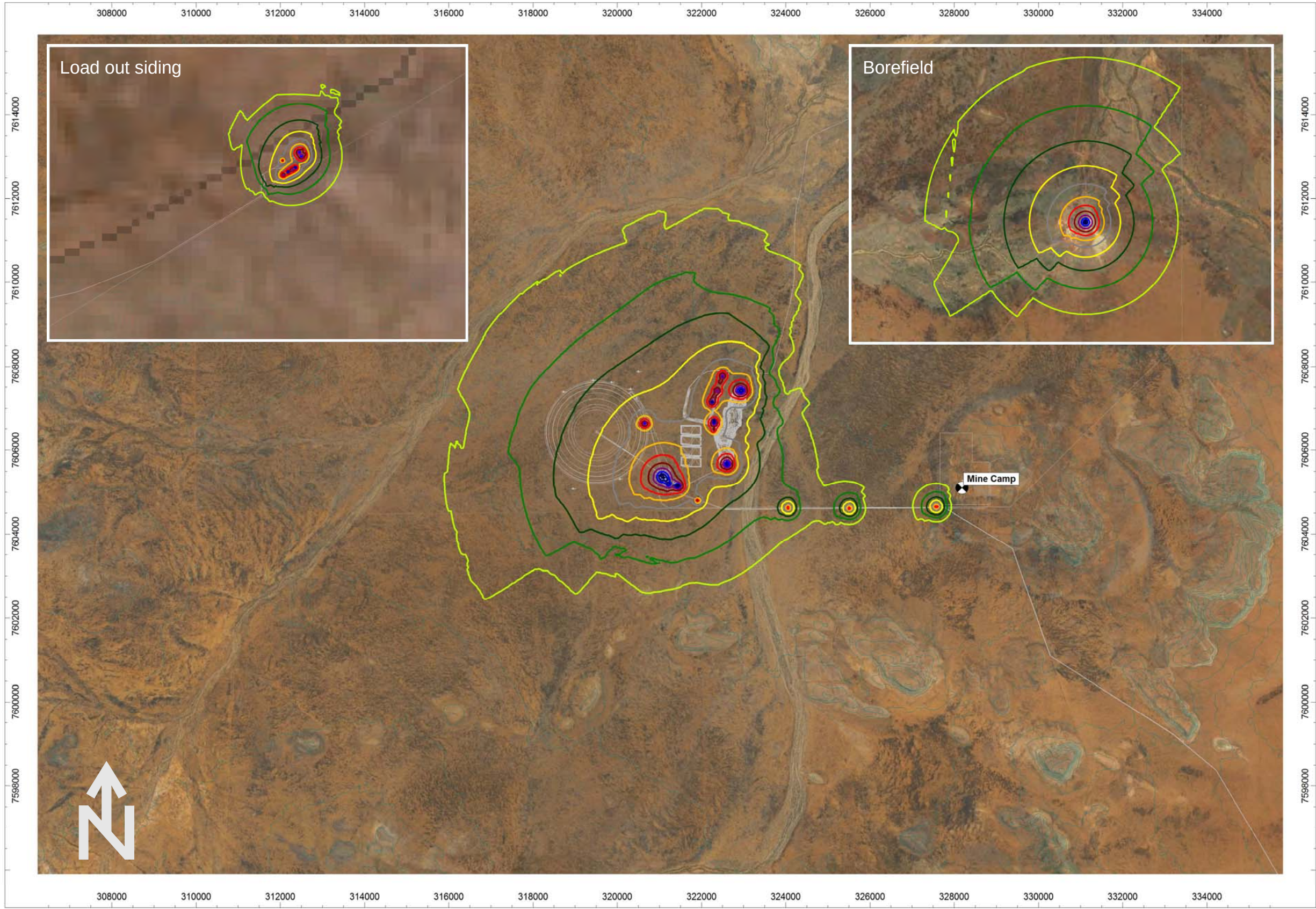
Mount Peake Magnetite Project
Noise and Vibration Assessment

PREDICTED NIGHT NOISE LEVELS

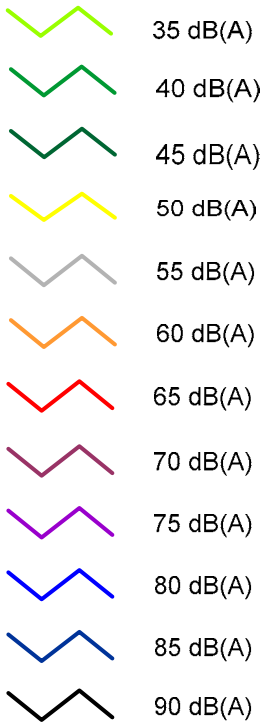
Noise contours: L_{Aeq} (15-min)
Grid height: 1.5 m
Dry season meteorological conditions



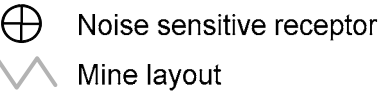
FIGURE 7-3



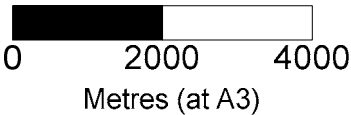
PREDICTED NOISE LEVELS



LEGEND



SCALE



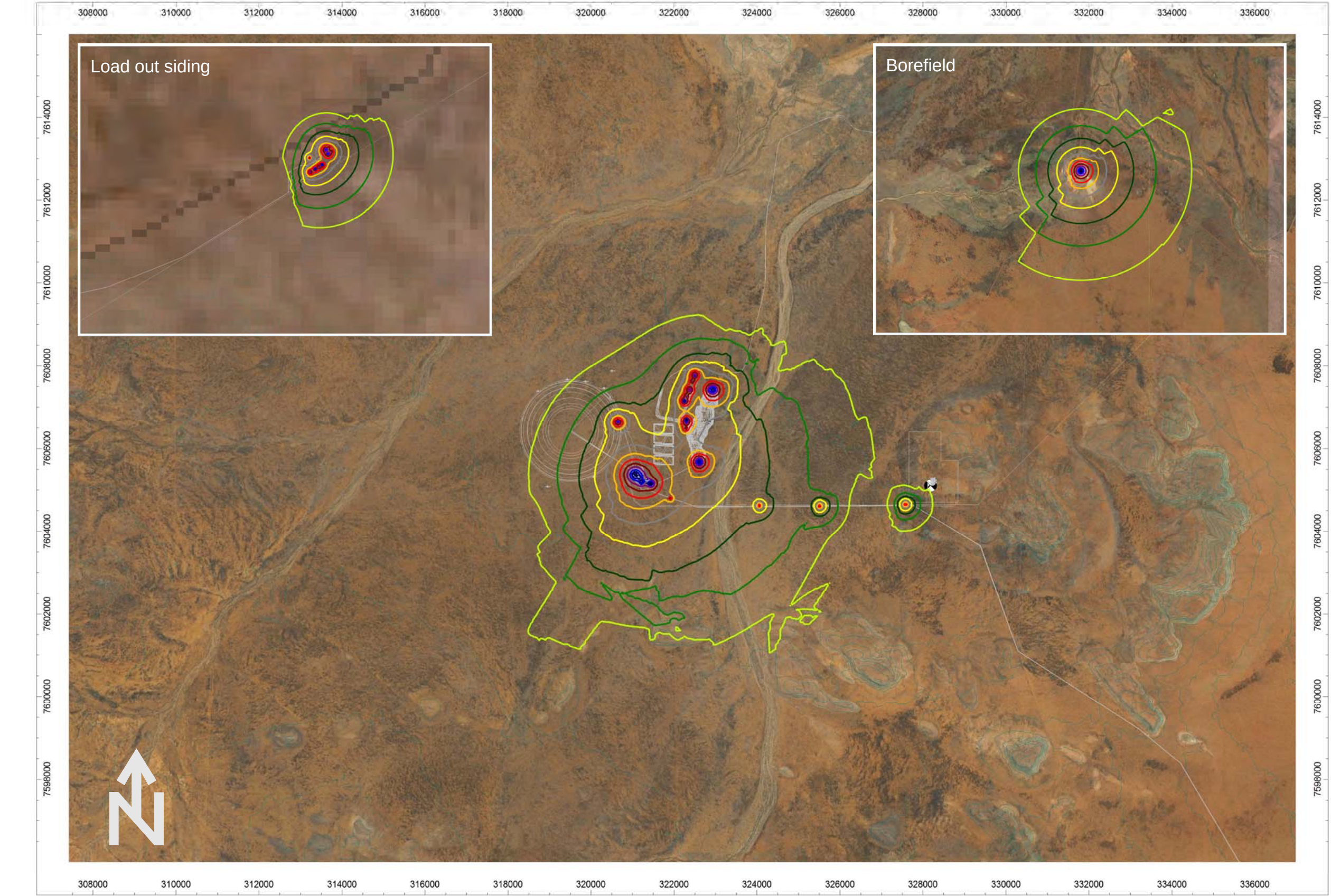
COPYRIGHT

THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF GHD PTY LTD. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION.

CREATED JF	CHECKED JF	APPROVED IM

MAP PROJECTION: Universal Transverse Mercator
HORIZONTAL DATUM: Geocentric Datum of Australia (GDA)
GRID: Map Grid of Australia 1994, Zone 53

DATE 28.10.2015	FILE LOCATION
REVISION 0	DRAWING NO.



TNG LIMITED

Mount Peake Magnetite Project
Noise and Vibration Assessment

PREDICTED NIGHT NOISE LEVELS

Noise contours: L_{Aeq} (15-min)
Grid height: 1.5 m
Wet season meteorological conditions



FIGURE 7-4

8. Mitigation and control measures

Although the Project is not expected to cause adverse noise impacts, GHD recommends that the following measures are adopted during construction and operation to reduce emissions:

- Where practical, construction work should be kept within the working hours prescribed by the ICNG;
- Equipment used on site should be in good condition, working order and fit for purpose, with preference given to silenced equipment whenever possible
- Equipment to be operated as intended by the manufacturer
- As far as possible, material drop heights into or out of trucks to be minimised
- Preference should be given to broadband reversing alarms (audible movement alarms) for site equipment, subject to meeting occupational health and safety requirements
- Fixed and mobile plant to be kept properly serviced and fitted with appropriate mufflers
- Where practical, machinery is to be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods
- Machines found to produce excessive noise compared to industry normal standards should be investigated and if required rectified or replaced
- Site workers are to be made aware of the potential for noise impacts and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities
- Blasting should occur between 9:00 am and 5:00 pm.

Available literature suggests that the impact of noise from the Project is unlikely to result in negative impacts to either livestock or native fauna. As such, no specific management measures, other than those proposed in regard to management of impacts to human receptors, are recommended.

9. Conclusions

9.1 Construction noise and vibration

The results of the construction assessment indicate that noise and vibration levels of the mine are expected to comply with nominated noise criteria at all times for noise and vibration sensitive receptors.

Construction noise is not expected to cause adverse impacts at noise receptors. However, in order to reduce the risk of noise impact, the mitigation measures outlined in Section 8 should be taken into consideration during construction.

9.2 Operational noise and vibration

Noise model results indicate the predicted low frequency for C-weighted and A-weighted noise levels over the same period is less than 15 dB. Therefore, the correction for low frequency noise as specified in INP was not added to the predicted noise levels at the receiver.

The results of the operational assessment indicate that the operational noise and vibration impact of the Project is expected to comply with the nominated noise criteria at all times for noise and vibration sensitive receptors assessed under all weather conditions.

A mine site noise model predicts potential noise levels for a worst case mine operating scenario. The model predicted noise levels under varying meteorological conditions and has assumed that all machinery and plant on the mine site are operating continuously.

Predicted noise levels under worst case conditions (wind assisted conditions during temperature inversion) at the nearest noise sensitive receptor (the mine camp) is 34 dBA, which is below the noise criteria of 35 dBA.

The estimated increase in traffic noise levels due to the Project is not expected to be noticeable.

The nature and levels of vibration emitted by the mine will vary with the activities being undertaken on the site, however, due to the distances between the sources and receptors, vibration is unlikely to have a significant impact.

Available literature suggests that the impact of noise from the Project is unlikely to result in negative impacts to either livestock or native fauna. As such, no specific management measures, other than those proposed in regard to management of impacts to human receptors, are suggested.

Although not expected to cause adverse noise impacts, the mitigation measures detailed in Section 8 should be taken into consideration for operation of the Project in order to reduce risk of noise impact.

Appendices

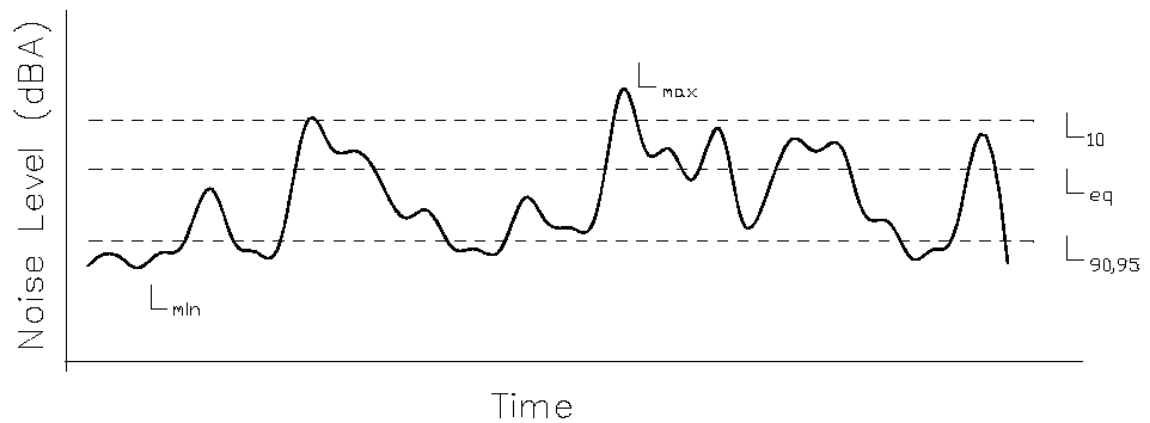
Appendix A – Noise terminology

Ambient noise	Level of noise from all sources, including background noise from near and far and the source of interest.
A-weighted	A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. A-weighted sound level is described as L_A dB.
Background noise	Noise level from sources other than the source of concern.
dB	Decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.
dBA	Unit used to measure 'A-weighted' sound pressure levels.
Hz	Units for frequency are known as Hertz.
Impulsive noise	An impulsive noise source has a short-term banging, clunking or explosive sound. The quantitative definition of impulsiveness is: – A variation in the emission of a noise where the difference between L_A Peak and L_A Max Slow is more than 15 dB when determined for a single representative event.
L_{ASlow}	This is the noise level in decibels, obtained using A-weighting and S time weighting as specified in AS1259.1-1990. Unless assessing modulation, all measurements use the slow time weighting characteristic.
L_{AFast}	This is the noise level in decibels, obtained using A-weighting and F time weighting as specified in AS1259.1-1990. This is used when assessing the presence of modulation only.
L_{APeak}	This is the maximum reading in decibels using A-weighting and P time weighting as specified in S1259.1-1990.
L_{AMax}	$L_{A\ Max}$ level is the maximum A-weighted noise level during a particular measurement.
L_{A1}	$L_{A\ 1}$ level is the A-weighted noise level which is exceeded for 1% of the measurement period and is considered to represent the average of the maximum noise levels measured.
L_{A10}	$L_{A\ 10}$ level is the A-weighted noise level which is exceeded for 10% of the measurement period and is considered to represent the intrusive noise level.
L_{A90}	$L_{A\ 90}$ level is the A-weighted noise level which is exceeded for 90% of the measurement period and is considered to represent the background noise level.
L_{AEq}	The equivalent steady state A-weighted sound level ('equal energy') in decibels which, in a specified time period, contains the same acoustic energy as the time-varying level during the same period. It is considered to represent the average noise level.

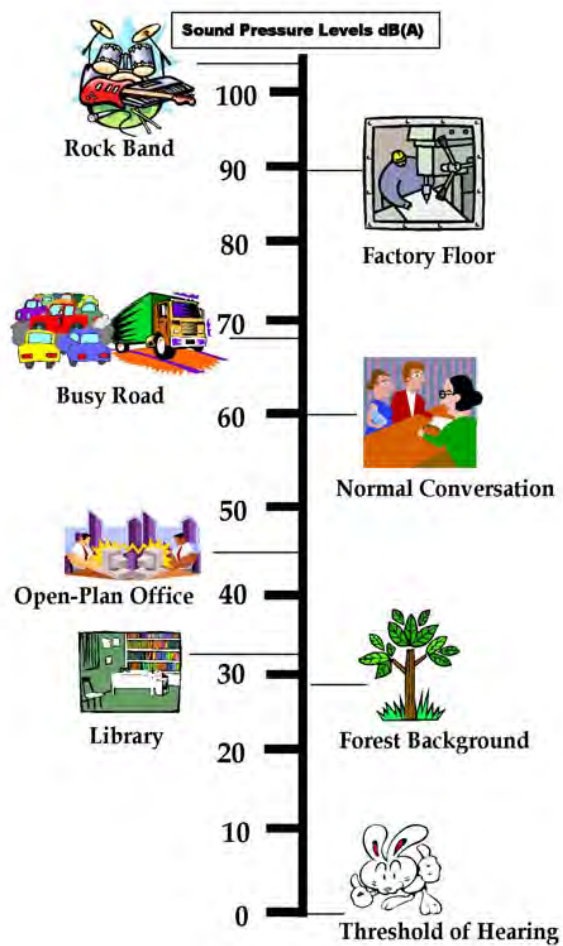
L _{AMax} assigned level	Means an assigned level which, measured as a L _{A Slow} value, is not to be exceeded at any time.
L _{A1} assigned level	Means an assigned level which, measured as a L _{A Slow} value, is not to be exceeded for more than 1% of the representative assessment period.
L _{A10} assigned level	Means an assigned level which, measured as a L _{A Slow} value, is not to be exceeded for more than 10% of the representative assessment period.
Linear	Sound levels measured without any weightings are referred to as 'linear' and the units are expressed as dB(lin).
L linear, peak	Maximum reading in decibels obtained using P-time-weighting characteristic as specified in AS 1259.1-1990.
Maximum design sound level	The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.
Modulating noise	A modulating source is regular, cyclic and audible and is present for at least 10% of the measurement period. The quantitative definition of modulation is: A variation in the emission of noise that - – Is more than 3 dB L_{A Fast} or is more than 3 dB L_{A Fast} in any one-third octave band – Is present for at least 10% of the representative assessment period – Is regular, cyclic and audible
One-third octave band	Means a band of frequencies spanning one-third of an octave and having a centre frequency between 25 Hz and 20,000 Hz inclusive.
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hour period used for the assessment background level). This is the level used for assessment purposes. It is defined as the median value of: – All the day assessment background levels over the monitoring period for the day (7:00 am to 6:00 pm) – All the evening assessment background levels over the monitoring period for the evening (6:00 pm to 10:00 pm) – All the night assessment background levels over the monitoring period for the night (10:00 pm to 7:00 am)
Representative assessment period	Means a period of time not less than 15 minutes and not exceeding four hours, determined by an inspector or authorised person to be appropriate for the assessment of a noise emission, having regard to the type and nature of the noise emission.
Reverberation time	Of an enclosure, for a sound of a given frequency or frequency band, the time that would be required for the reverberantly decaying sound pressure level in the enclosure to decrease by 60 decibels.
RMS	Root mean square level; used to represent the average level of a wave form such as vibration.

Satisfactory design sound level	The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.
Sound pressure level (SPL)	The sound pressure level of a noise source is dependent upon its surroundings (influenced by distance, ground absorption, topography, meteorological conditions etc) and is what the human ear actually hears. Noise modelling predicts the sound pressure level from the sound power levels taking into account ground absorption, barrier effects, distance etc.
Sound power level (SWL)	Under normal conditions, a given sound source will radiate the same amount of energy, irrespective of its surroundings, being the sound power level. The sound power level of a noise source cannot be directly measured using a sound level meter but is calculated based on measured sound pressure levels at known distances. Noise modelling incorporates source sound power levels as part of the input data.
Specific noise	Relates to the component of the ambient noise that is of interest. This can be referred to as the noise of concern or the noise of interest
Tonal noise	A tonal noise source can be described as a source that has a distinctive noise emission in one or more frequencies. An example would be whining or droning. The quantitative definition of tonality is: The presence in the noise emission of tonal characteristics where the difference between - – The A-weighted sound pressure level in any one-third octave band – The arithmetic average of the A-weighted sound pressure levels in the two adjacent one-third octave bands is greater than 3 dB when the sound pressure levels are determined as $L_{A\ eq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels. This is relatively common in most noise sources.
Vibration velocity level	The RMS velocity of a vibration source over a specified time period, measured in mm/s.

Chart of noise level descriptors



Typical noise levels



GHD

GHD, 999 Hay Street, Perth, WA 6000

P.O. Box 3106, Perth WA 6832

T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

© GHD 2015

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\61\2905712\WP\149457.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	J Forrest	J Forrest		I McCardle		29/10/15

www.ghd.com





Appendix K

Aboriginal and Historic Heritage Assessment Report





Mount Peake Project, Northern Territory: Aboriginal & Historic Heritage Assessment

Prepared by Australian Museum Consulting
for TNG Limited

December 2015

1301131

Document Information 1301131

Citation:	Australian Museum Consulting 2015, <i>Mount Peake Project, Northern Territory: Aboriginal & Historic Heritage Assessment</i> . Consultancy report to TNG Limited.
Versions:	Version 1: Draft Report issued December 2015 Version 2: Final Report issued December 2015
Recipient:	Eddie Fry, TNG Consultant
Approved by:	Jennie Lindbergh, Australian Museum Consulting Senior Project Manager,
Primary Authors	Laressa Berehowyj, Australian Museum Consulting Project Officer, Chris Langeluddecke, Australian Museum Consulting Project Manager, Aboriginal Heritage

Executive Summary

Australian Museum Consulting (AM Consulting) was commissioned by TNG Limited (TNG) to prepare an Aboriginal and Historic Heritage Assessment for a proposed mining development on the Murray Creek near Mount Peake, Northern Territory (NT), known as the Mount Peake Project (the project). This assessment is required to address potential impacts to historic and Aboriginal cultural heritage arising from the proposed development. This report forms part of the supporting documentation for the Environmental Impact Statement (EIS) for the project.

Aboriginal community consultation for the project was undertaken by TNG, in conjunction with the Central Land Council and members of the local Aboriginal community. A report detailing the consultation process, and the methodology for obtaining Sacred Sites Clearance and approval from the Aboriginal Areas Protection Authority, has been prepared separately and has not been addressed in this report. Unfortunately, due to unforeseen community circumstances it was not possible for representatives of the local Aboriginal community to participate in the archaeological survey of the project area.

Targeted archaeological survey of the Mount Peake area confirmed the presence of Aboriginal cultural material in the study area. Sixteen previously unidentified Aboriginal stone artefact sites were identified in close proximity to the pipeline and haul road impact areas. These sites, comprising both surface scatters and isolated finds, were located across natural riverbank and foothill landforms, in close proximity to watercourses, significant landscape features and natural resources. Although stone artefact deposits are currently only visible on the sparsely vegetated, partially deflated banks of the Hanson River and ephemeral creeks, it is likely that a large portion of these identified sites extend, with good integrity, as subsurface archaeological deposits.

There are no potential for impacts to historic or Aboriginal archaeological sites or areas of archaeological sensitivity associated with construction of the mine site, camp site and rail siding facilities, and no historic heritage constraints on the proposed haul road and pipeline alignment. No further historic heritage assessment is required prior to commencement of construction on the proposed works.

The construction of the pipeline may impact on artefact scatters MP1 and MP3; and may impact on any subsurface in situ artefact deposits along the Hanson River bank, if excavated and installed below the ground surface. The construction of the haul road is likely to directly impact artefact scatters MP13 and MP14, and may indirectly impact on scatter MP10 and isolated find MP6. Scatter sites MP7-MP9, MP11-MP12 and MP15 are unlikely to be impacted by the proposed works. The proposed haul road and pipeline alignments should be redesigned where possible to minimise impact on areas of archaeological sensitivity and identified Aboriginal sites. If the pipeline and/or haul road alignments are altered outside the assessed corridor, additional archaeological assessment should be undertaken to mitigate impacts.

Where impacts to Aboriginal sites or areas of archaeological sensitivity are unavoidable, artefact recording and relocation, and archaeological excavations should be undertaken to fully record the condition, extent and significance of stone artefact sites along the Hanson River and in the Central Mount Stuart/Djilbari Hills foothills. A Works Approval Application Form should be lodged with the Heritage Branch to allow further archaeological works within the project area, including artefact recording and relocation, and archaeological excavations, in accordance with section 72 of the Heritage Act and heritage best practice. This report would form part of the supporting documentation for the application.

Contents

Executive Summary	III
1 Introduction	1
1.1 Study Area	1
1.2 Proposed Scope of Works.....	6
1.3 Methodology	6
1.3.1 Aboriginal Community Consultation.....	7
1.3.2 Report Structure.....	7
1.4 Authorship.....	7
2 Statutory Context.....	9
2.1 Commonwealth Legislation.....	9
2.1.1 Environment Protection and Biodiversity Conservation Act 1999.....	9
2.1.2 Aboriginal and Torres Strait Islander Heritage Protection Act 1984.....	9
2.1.3 Native Title Act 1993.....	9
2.1.4 Aboriginal Land Rights (Northern Territory) Act 1976.....	11
2.2 NT Legislation.....	11
2.2.1 Northern Territory Heritage Act 2011	11
2.2.2 Northern Territory Aboriginal Sacred Sites Act 1989.....	12
3 Physical Environment.....	14
3.1 Geology & Topography	14
3.2 Soils & Vegetation	14
3.3 Hydrology & Drainage	15
3.4 Land Use & Disturbance	15
4 Cultural Setting.....	16
4.1 Aboriginal History	16
4.1.1 Peopling Australia.....	16
4.1.2 Utilising Natural Resources.....	17
4.1.3 Maintaining Religious Traditions & Ceremonies.....	21
4.2 European History.....	22
4.2.1 Early Exploration.....	22
4.2.2 The Overland Telegraph	23
4.2.3 Early Settlement.....	24
4.2.4 The Stuart Highway	28
4.2.5 Infrastructure Projects in the Late Twentieth Century.....	31
5 Archaeological Context.....	32
5.1 Previous Archaeological Research	32
5.1.1 Regional Research.....	32
5.1.2 Local Research	34
5.2 Summary	35
5.2.1 Aboriginal Heritage Site Predictive Modelling	36
6 Physical Analysis.....	37
6.1 Survey Methodology	37
6.2 Survey Results.....	40
6.2.1 Pipeline.....	40
6.2.2 Haul Road	52
6.2.3 Mine Site	71
6.2.4 Camp Site	73
6.2.5 Rail Siding/Load-Out Facility	74
6.3 Summary	75
6.3.1 Aboriginal Archaeological Potential.....	76
7 Assessment of Heritage Significance	78

7.1	Assessment against Criteria of Aboriginal Heritage Significance.....	78
7.1.1	Pipeline.....	78
7.1.2	Haul Road	80
7.2	Statement of Heritage Significance.....	82
7.2.1	Pipeline.....	82
7.2.2	Haul Road	83
8	Assessment of Heritage Impact	85
8.1	Pipeline.....	85
8.2	Haul Road	86
8.3	Mine Site	87
8.4	Camp Site.....	87
8.5	Rail Siding/Load Out Facility	87
9	Conclusions & Recommendations.....	88
9.1	Pipeline & Haul Road.....	88
9.2	Mine Site, Camp Site and Railway Siding/Load-Out Facility	90
9.3	General Recommendations	90
9.4	Subsequent Design Changes.....	90
	References.....	92

Tables

Table 6.1	Survey coverage table	38
Table 6.2	Site MP1 artefact details.	42
Table 6.3	Site MP2 artefact details.	44
Table 6.4	Site MP3 artefact details.	46
Table 6.5	Site MP4 artefact details.	48
Table 6.6	Site MP5 artefact details.	50
Table 6.7	Site MP16 artefact details.	51
Table 6.8	Site MP6 artefact details.	55
Table 6.9	Site MP7 artefact details.	57
Table 6.10	Site MP8 artefact details.	59
Table 6.11	Site MP9 artefact details.	61
Table 6.12	Site MP10 artefact details.	64
Table 6.13	Site MP11 artefact details.	66
Table 6.14	Site MP12 artefact details.	66
Table 6.15	Site MP13 artefact details.	68
Table 6.16	Site MP14 artefact details.	70
Table 6.17	Site MP15 artefact details.	71
Table 8.1	Pipeline construction impact assessment summary.	85
Table 8.2	Haul road construction impact assessment summary.....	86

Figures

Figure 1.1	Mount Peake Project study area showing proposed haul road and pipeline corridor, mine site, camp site and rail siding site.....	2
Figure 1.2	Detail of Mt Peake mine site project area. Source: TNG Limited.	3
Figure 1.3	Detail of Mount Peake accommodation camp facilities area. Source: TNG Limited.	4
Figure 1.4	Detail of Mount Peake rail siding and load out facility. Source: TNG Limited.	5
Figure 2.1	Extent of the Stirling and Neutral Junction Native Title Determination Claim (Source: National Native Title Tribunal, http://www.nntt.gov.au/searchRegApps/NativeTitleRegisters/RNTC%20Extracts/DC2011_002/2013-09-13%20DC2011-002%20Map%20of%20Amended%20Application%20Area.pdf).	10

Figure 4.1 Carl Strehlow's 1901 map depicting 'Residential Areas of the Aborigines of South and Central Australia' (Source: Strehlow Research Centre).....	17
Figure 4.2 Photographs of shields, storage containers and <i>pitchis</i> gathered from central Australian tribes, by Spencer and Gillen (Source: Spencer & Gillen 1899:585 and p.609).	18
Figure 4.3 Grinding the edge of a diorite axe blank at a quarry near Yuendumu, just outside Anmatyerre country (Source: Edwards 1971, Plate XXX).....	19
Figure 4.4 Unretouched stone knives and axes collected from central Australian tribes by Spencer and Gillen, left, and geometric microliths, thumbnail scrapers and Tula adzes from Puritjarra rock shelter, right (Source: Spencer & Gillen 1899:589 and Smith 2006:396).....	19
Figure 4.5 Illustrations of a diverse range of painted rock art motifs at Glen Thirsty (Source: Smith & Ross 2008:54).....	20
Figure 4.6 Portrait of an 'Unmatjera man' by Spencer and Gillen, Barrow Creek, 1901. The man bears scars on his chest and shoulders as a marker of his status within the community (Source: Museum Victoria, XP143BB).....	21
Figure 4.7 Sketch map of Australia, showing the route John McDougall Stuart took to cross Asustralia from its southern to northern coast (Source: Hardman 1865 [2014]).....	23
Figure 4.8 'Plan Shewing Approximate Positions of Pastoral Claims in the Northern Territory of South Australia', 1878. Those highlighted in pink were 'recently abandoned' (Source: Northern Territory Government, Historic Map Index Map ID. 1753).....	25
Figure 4.9 Central Australian pastoral leases, including Stirling Station, which includes the study area, stocked prior to 1895 (Source: Northern Territory Government, Historic Map Index Map ID. 3541).....	26
Figure 4.10 Proposed alteration of Grazing Licences No.17 and 18 and Reserves under Post and Telegraph Department, 1917. The locations of the Stirling homestead and New Hansen Well are circled (Source: Northern Territory Government, Historic Map Index Map ID3392).	27
Figure 4.11 Photograph of an 'Unmatjera Native in charge of Scott's station at Stirling Creek, with hat made by Scott', taken by Spencer and Gillen, 1901 (Source: Museum Victoria, ID. XP14578). ...	28
Figure 4.12 Car crossing the flooded Stirling Creek, south of Barrow Creek, by A and B Richards, 1934 (Source: Northern Territory Library, Richards Collection, http://hdl.handle.net/10070/20063)...	29
Figure 4.13 Photograph of the Alice Springs-Darwin road soon after completion of the unsealed section between Alice Springs and Tennant Creek, 1942. The road was widened, straightened and levelled and was intended to carry military transport (Source: Australian War Memorial, Department of Information, ID. 150145).	30
Figure 4.14 A convoy approaching a staging camp on the 'North-South Military Highway', 1943. Allied Works Council tar and bitumen boilers, left, were used in the resurfacing works (Source: Australian War Memorial, ID. 014400).	30
Figure 5.1 Location of key archaeological sites in the Central Ranges region, Northern Territory (Source: Gregory et al. 2008:57).....	33
Figure 5.2 Results of a search of the NT Heritage Register and Aboriginal and Macassan Archaeological Places within the study area, boxed in green. Known Aboriginal archaeological sites are identified in red and historic heritage sites are identified in blue (Source: D. Bensley, Northern Territory Heritage Branch, 02/07/2015).....	34
Figure 6.1 Track log and waypoint data recorded during archaeological survey.....	39
Figure 6.2 View south of the access track near Browns Yards, surveyed by vehicle.....	40
Figure 6.3 View east to the clay pan near Browns Yards.....	40
Figure 6.4 View southwest to Boko Bore stockyards.	40
Figure 6.5 View south to flat, open sandplain in the vicinity of an unnamed peak.	40
Figure 6.6 Detail of the location of Aboriginal heritage sites MP1, MP2 and MP3.....	42
Figure 6.7 View northwest to MP1 from the Hanson riverbed.	43
Figure 6.8 View south to MP1. Note sparsely vegetated, well deflated bank of the Hanson River.	43
Figure 6.9 View northwest to Middle Well bore site, from edge of site MP1. The site extends to within 10m of the clearing.....	43
Figure 6.10 Site MP1 quartzite and quartz artefacts.....	43

Figure 6.11 Site MP1 quartz flake with unifacial retouch.	43
Figure 6.12 Site MP1 quartzite flake.	44
Figure 6.13 Site MP1 flaked quartzite piece.....	44
Figure 6.14 View west of Site MP2 on deflated, open flat.....	45
Figure 6.15 View north of alluvial deposit in the bed of the Hanson River, containing disturbed stone artefacts.	45
Figure 6.16 Quartz and quartzite flakes in flat, open ground, MP2.	45
Figure 6.17 Quartz flake, heat treated quartzite core and quartzite flake in alluvial deposit, MP2.	45
Figure 6.18 Site MP3, located in a flat deflated clearing on the western bank of the Hanson River. View to south.	46
Figure 6.19 Site MP3, located in a flat deflated clearing on the western bank of the Hanson River. View to north.	46
Figure 6.20 Evidence of erosion and deflation impacts at Site MP3	46
Figure 6.21 Site MP3 quartz and quartz artefacts.....	46
Figure 6.22 Site MP3 quartz and quartz artefacts.....	47
Figure 6.23 Site MP3 quartz artefact..	47
Figure 6.24 Detail of the location of Aboriginal heritage sites MP4 and MP5.....	48
Figure 6.25 View northwest to Site MP4 on partially deflated open river flat.....	49
Figure 6.26 Site MP4 quartzite flake.	49
Figure 6.27 Site MP4 quartzite flake.	49
Figure 6.28 View west to site MP5, approximately 10m east of the dirt access track. The ephemeral creek flows perpendicular to the track.	50
Figure 6.29 View south to mudstone artefact at site MP5, circled, taken from the bed of the ephemeral creek.	50
Figure 6.30 Silcrete core at site MP5.	50
Figure 6.31 Mudstone scraper at MP5.....	50
Figure 6.32 Detail of location of Aboriginal heritage site MP16.	51
Figure 6.33 View east to site MP16 (circled), on the lower slope/river bank of the Murray Creek.....	52
Figure 6.34 Ventral surface of a quartzite flake from site MP16.....	52
Figure 6.35 View west to Central Mount Stuart along cleared track adjacent to fence line.	53
Figure 6.36 View west of the access track running parallel to the Alice Springs to Darwin Railway, near Adnera.....	53
Figure 6.37 View west of the undulating sandplain valley near Central Mount Stuart. Notice stone scree littering the floor of the valley, bottom of image.	53
Figure 6.38 View northeast of densely treed flat sandplain interspersed with ephemeral creeks, at the foot of the Djilbari Hills.	53
Figure 6.39 View north to haul road on eastern side of the Stuart Highway, taken from a vantage point at the Microwave tower.....	53
Figure 6.40 View southeast of flat sandplain to the east of the highway, characterised by open tracts of low spinifex and patches of dense scrub.....	53
Figure 6.41 View west along proposed route for Haul Road, 3.3km south of the Tinfish Well stockyards.	54
Figure 6.42 Detail of location of Aboriginal heritage site MP6.	55
Figure 6.43 View east to Site MP6.	56
Figure 6.44 Silcrete flake, dorsal surface, site MP6.....	56
Figure 6.45 Detail of the location of Aboriginal heritage sites MP7, MP8 and MP9.....	57
Figure 6.46 View southwest to MP7, western extent.....	58
Figure 6.47 View northeast to MP7, eastern extent.	58
Figure 6.48 Site MP7 quartzite, quartz and silcrete artefacts.	58
Figure 6.49 Site MP7 quartzite, quartz and silcrete artefacts.	58
Figure 6.50 Site MP7 quartzite, quartz and silcrete artefacts.	59
Figure 6.51 Site MP7 quartzite, quartz and silcrete artefacts.	59
Figure 6.52 View north to site MP8, from the crest of the eastern bank of the Hanson River.	60

Figure 6.53 View west to site MP8, along the crest and upper slopes of the eastern bank of the Hanson River.....	60
Figure 6.54 Site MP8 artefacts, comprising quartz and quartzite flakes.....	60
Figure 6.55 Sandstone hammer stone identified at Site MP8.....	60
Figure 6.56 Site MP8 artefact.....	60
Figure 6.57 Site MP8 quartz flake artefact.....	60
Figure 6.58 View north to site MP9, from western bank of the Hanson River.....	61
Figure 6.59 Mudstone, quartzite, quartz and silcrete artefacts sampled from site MP9.....	61
Figure 6.60 Detail of the location of Aboriginal heritage sites MP10, MP11 and MP12.....	63
Figure 6.61 View northwest to MP10 from access track, on lower slope of unnamed creek bank.....	64
Figure 6.62 Site MP10 bidirectional chert core.....	65
Figure 6.63 Site MP10 chert, silcrete and quartz flakes.....	65
Figure 6.64 Site MP10 silcrete and chert choppers/axes and flakes.....	65
Figure 6.65 Site MP10 mudstone and chert flakes, blades, bladelet and scraper.....	65
Figure 6.66 View west of site MP11, Mount Judith in background.....	66
Figure 6.67 Site MP11 quartzite, quartz and chalcedony artefacts.....	66
Figure 6.68 View west to site MP12, in an open, cleared flat plain.....	67
Figure 6.69 View north to site MP12.....	67
Figure 6.70 Dorsal surface of mudstone flake/core with bifacial retouch and negative flake scars at site MP12.....	67
Figure 6.71 Ventral surface of mudstone flake/core with bifacial retouch and negative flake scars at site MP12.....	67
Figure 6.72 Detail of the location of Aboriginal heritage sites MP13, MP14 and MP15.....	68
Figure 6.73 View northeast of site MP13, on well deflated, lower slope of an ephemeral creek bank.....	69
Figure 6.74 View south of site MP13, on well deflated, lower slope of an ephemeral creek bank.....	69
Figure 6.75 Chert core at site MP13.....	69
Figure 6.76 Quartzite flakes and core at site MP13.....	69
Figure 6.77 Chert and quartz flakes at site MP13.....	69
Figure 6.78 Chalcedony flake at site MP13.....	69
Figure 6.79 Western extent of MP14, on lower slopes of an unnamed creek. View to east.....	70
Figure 6.80 Eastern extent of MP14, on lower slopes of an unnamed creek. View to west.....	70
Figure 6.81 Site MP14 chalcedony, quartzite, quartz and mudstone flake artefacts.....	70
Figure 6.82 Site MP14 chalcedony, quartzite, quartz and mudstone flake artefacts.....	70
Figure 6.83 View southwest to MP15 in relatively open flat above northern bank of an unnamed creek.....	71
Figure 6.84 MP15 quartz flake.....	71
Figure 6.85 View northwest towards clearing and access track for borehole sample site; mine pit area...72	72
Figure 6.86 View east towards cleared and partially graded access road between borehole sample locations, mine pit area.....	72
Figure 6.87 View east towards unnamed stony rise beyond Murray Creek, mine pit area.....	72
Figure 6.88 View northeast of natural stone outcrop, northern extent of mine pit area.....	72
Figure 6.89 View north to tract of dense tall shrubs from patch of exposed soil and low grass tufts, south western corner of mine site.....	73
Figure 6.90 View northwest of processing plant area, characterised by dense tall shrubs and low grasses.....	73
Figure 6.91 View north of waste dump 1 area.....	73
Figure 6.92 View east of waste dump 2 area.....	73
Figure 6.93 View south to stone outcrop, campsite area.....	74
Figure 6.94 View north to ephemeral drainage channel, camp site area.....	74
Figure 6.95 View south towards airstrip, northern extent.....	74
Figure 6.96 View north towards airstrip, southern extent.....	74
Figure 6.97 View northeast to rail siding site.....	75

Figure 6.98 View south to proposed rail siding site, showing large concentration of quartz and quartzite nodules. 75

Figure 6.99 Areas of Archaeological Sensitivity associated with watercourses and significant landforms.77

1 Introduction

Australian Museum Consulting (AM Consulting) has been commissioned by TNG Limited (TNG) to prepare an Aboriginal and Historic Heritage Assessment for a proposed mining development on the Murray Creek near Mount Peake, Northern Territory (NT), known as the Mount Peake Project (the project). The project involves the mining, beneficiation and transportation of a vanadium-titanium-iron ore body from the project site to the Port of Darwin for processing and export.

In 2013, the Northern Territory Environment Protection Authority (NTEPA) and the Australian Department of the Environment (DotE) determined that an Environmental Impact Statement (EIS) was required under the *Northern Territory Environmental Assessment Act 1982*. The EIS would identify and address potential environmental impacts and would develop management and control measures for the project. This report addresses Aboriginal and Historic heritage constraints and issues arising from the proposed development.

1.1 Study Area

The Mount Peak study area is located approximately 240 km north-northwest of Alice Springs and approximately 50 km west of the Stuart Highway in the Central Desert Local Government Area (LGA) (see Figure 1.1). The study area refers to the mining area, accommodation camp facilities area, haul road transport corridor, infrastructure (water pipeline) corridor, and rail siding and load-out facility.

Mining and processing would occur within the mining area, located within Mineral Lease Application (MLA) 28341 for the mine pit and MLA 29855 for all mine facilities (see Figure 1.2). The accommodation facilities would be located within MLA 29856, 5 km to the east of the mine area (see Figure 1.3). The mining area would be accessed via a restricted, unsealed road from the Stuart Highway.

A proposed transport corridor for site access and product haulage runs 100 km south-east from the mining area to a proposed new rail siding and load-out facility on the Alice Springs to Darwin railway near Adnera (see Figure 1.4). A proposed infrastructure corridor for a water/slurry pipeline runs 42km to the north of the transport corridor. All proposed work areas are on the Stirling Station pastoral lease, although they closely adjoin Anningie station, aside from a portion of crown land adjacent to the Stuart Highway that is intersected by the two corridors.

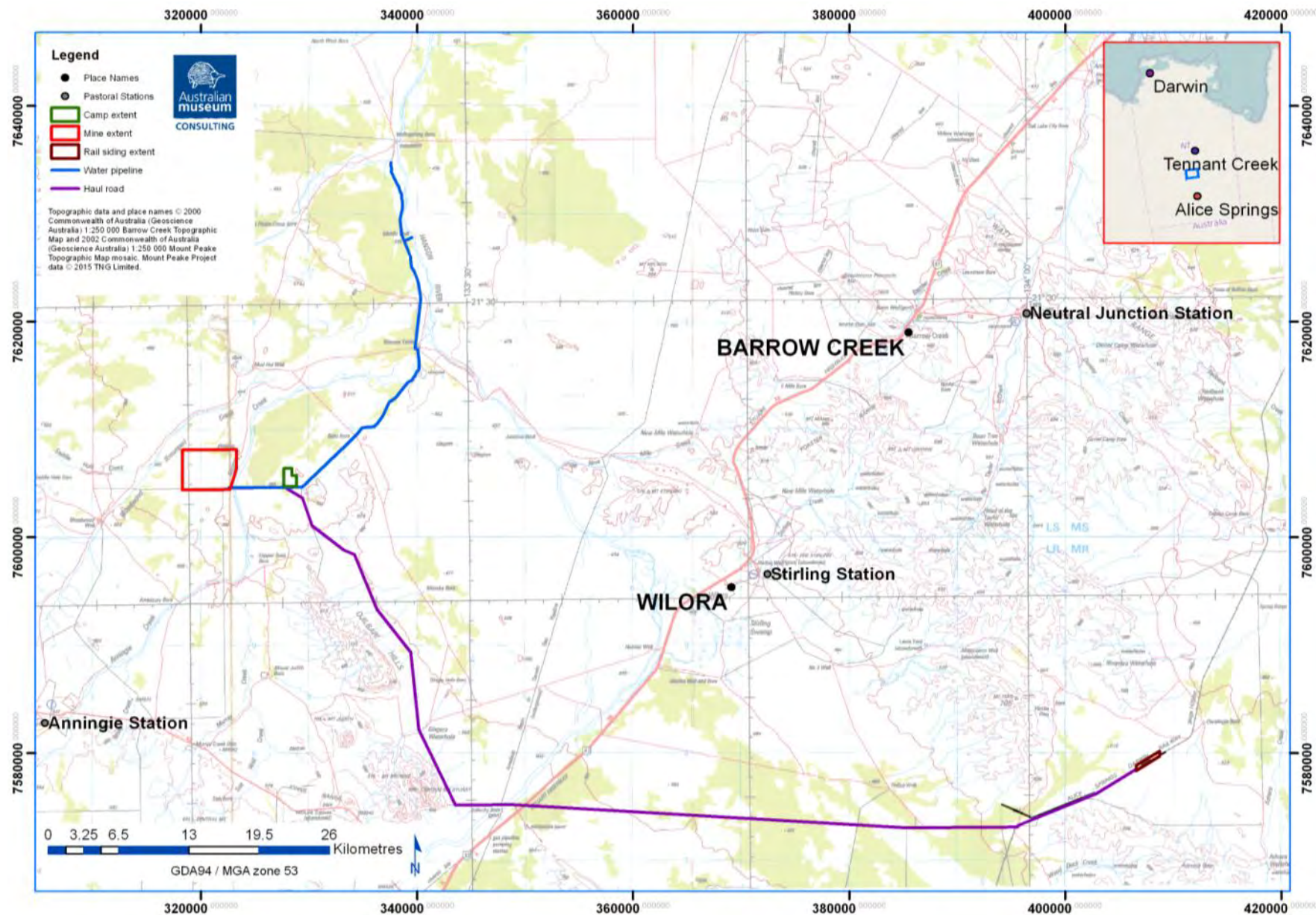


Figure 1.1 Mount Peake Project study area showing proposed haul road and pipeline corridor, mine site, camp site and rail siding site.

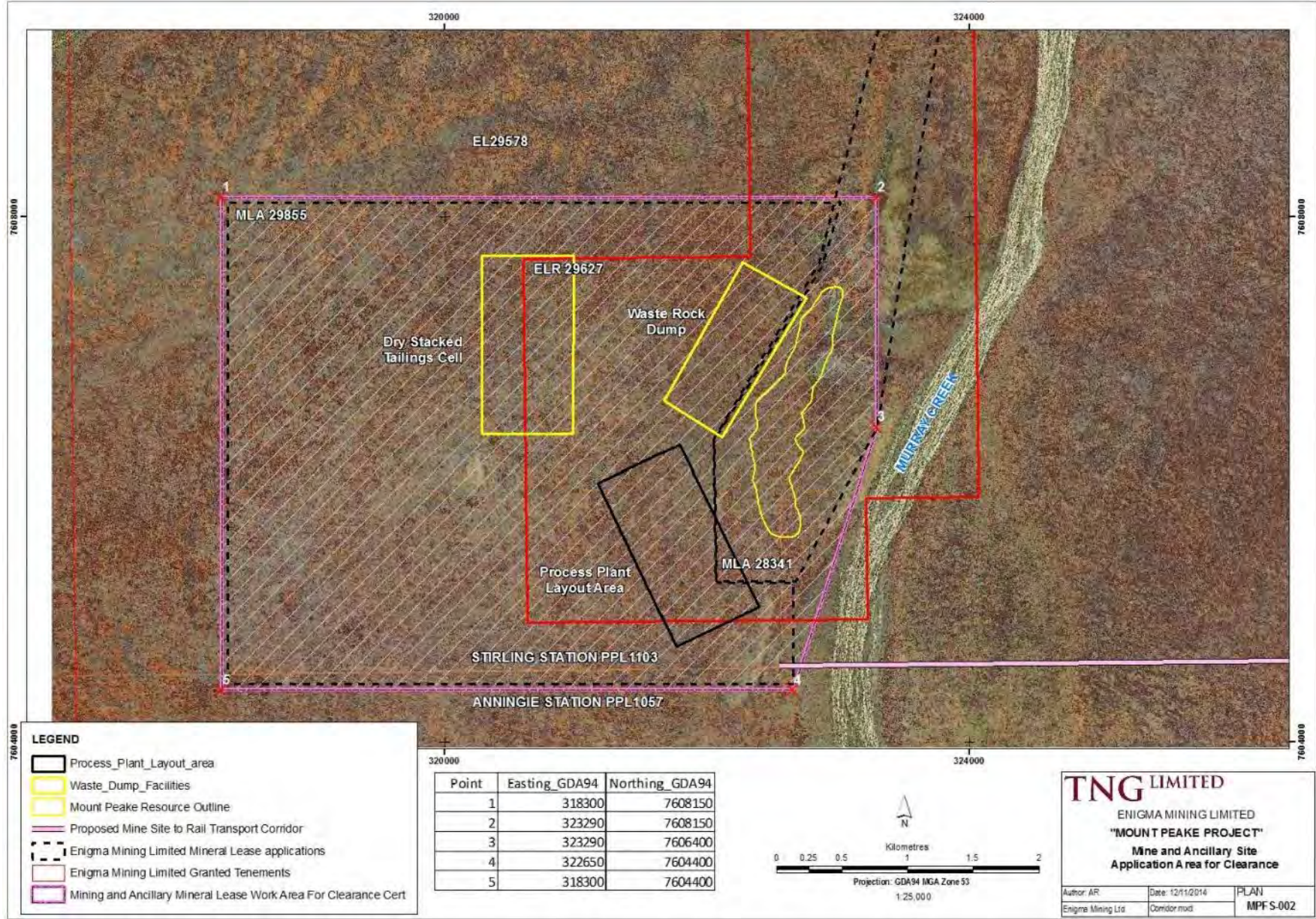


Figure 1.2 Detail of Mt Peake mine site project area. Source: TNG Limited.

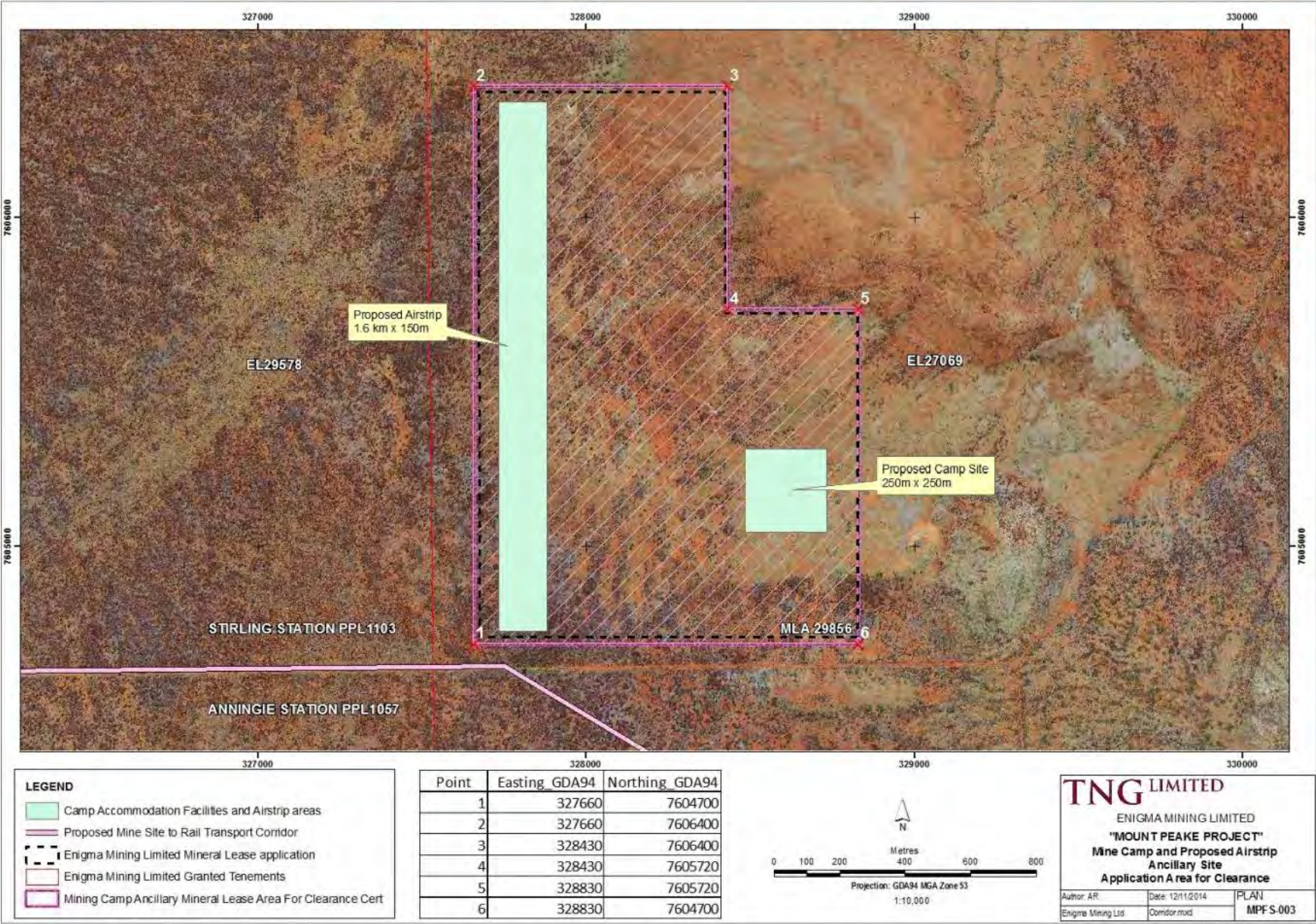


Figure 1.3 Detail of Mount Peake accommodation camp facilities area. Source: TNG Limited.

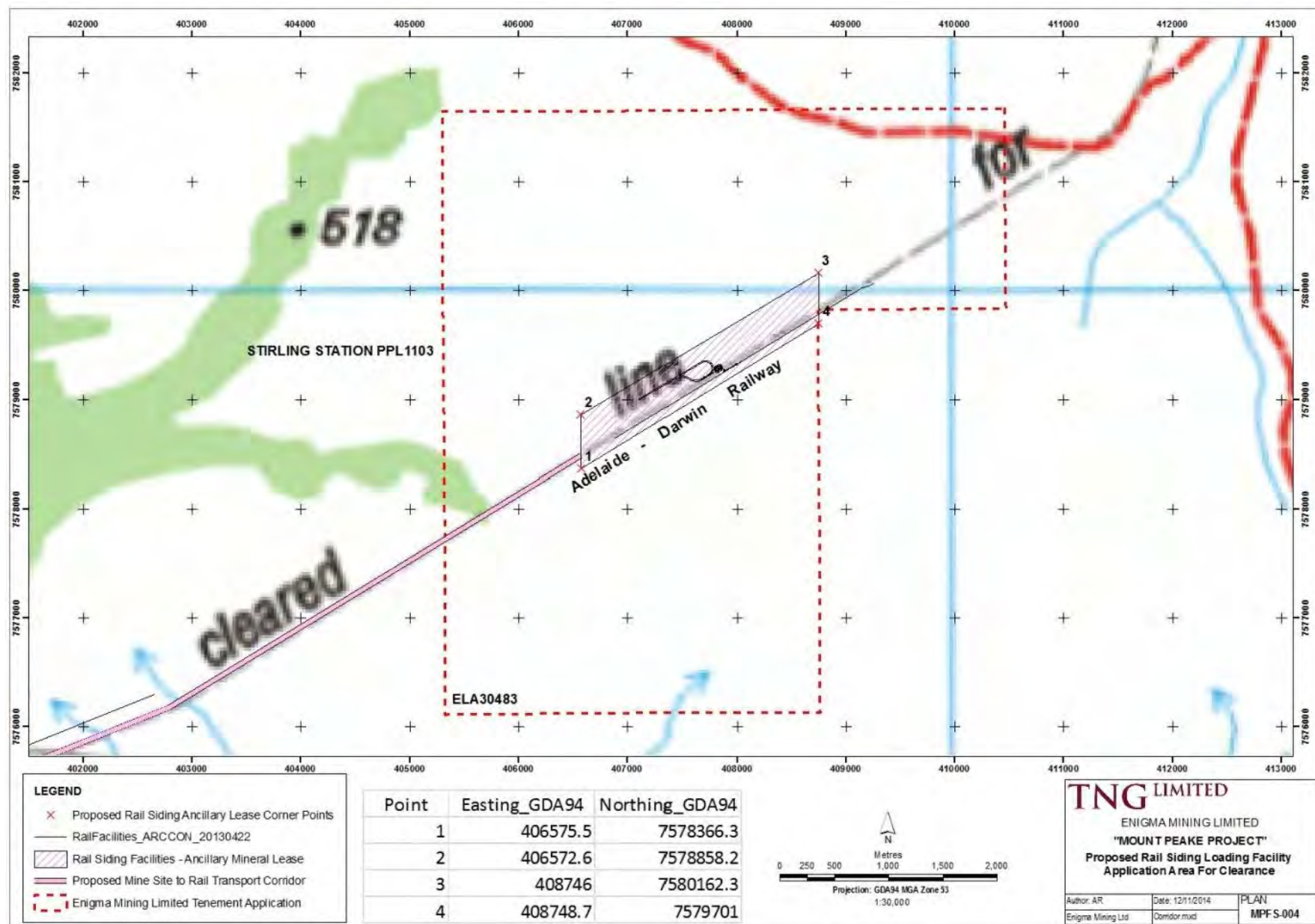


Figure 1.4 Detail of Mount Peake rail siding and load out facility. Source: TNG Limited.

1.2 Proposed Scope of Works

The major components of the Mount Peake Project are:

- Construction of processing facilities at the mine site, including tailings storage facility, processing beneficiation plant and waste rock dump;
- Construction of a 1600x150m airstrip and 250x250m camp site approximately 5km east of the mine site, for a peak construction workforce of approximately 350 people;
- Construction of rail transportation facilities on the Alice Springs to Darwin railway at Adnera, including new railway siding and loading bins, covered stockpile and road train unloading facility;
- Construction of a 100km restricted access unsealed road, for the transportation of ore from the mine pit to the Adnera rail siding;
- Installation of 42km water pipeline from the Wollagalong Bore site to the mine site; and
- Open cut truck and shovel mining of the ore body to a maximum depth of 150-200m below ground level, thereby intersecting the water table and requiring dewatering to facilitate mining.

It is expected that approximately 1.7 million tonnes per annum (Mtpa) of concentrate would be produced at peak production, which would require up to 100 return truck movements per day between the mine site and Adnera. The life of the mine is expected to be 20 years.

1.3 Methodology

This report has been prepared in accordance with the principles of the *Burra Charter*; *The Australia ICOMOS charter for the conservation of places of cultural significance 2013* and has been prepared in accordance with current heritage best-practice guidelines as identified in the Department of Lands, Planning and the Environment Heritage Branch's *Scope of Works for an Archaeological Survey* and associated supplementary publications.

The key heritage requirements for this assessment are to:

- Identify any previously recorded Aboriginal sites or landscape features likely to indicate the presence of Aboriginal objects within the study area;
- Identify any previously recorded historic heritage items, places or archaeological sites or features likely to indicate the presence of historical archaeological sites within the study area;
- Identify any constraints and heritage impacts arising from the presence of known or potential built heritage, archaeological or Aboriginal sites; and
- Outline management recommendations and any requirements for additional heritage investigations or permits.

To fulfil the requirements of the assessment, the following tasks have been undertaken:

- Search and review of the NT Aboriginal Areas Protection Authority (AAPA) Register of Sacred Sites, as well as the Heritage Branch's Heritage Register databases, to determine the location and nature of any Aboriginal or historic sites recorded within, or in the vicinity of, the study area;
- Review of relevant statutory and non-statutory Commonwealth and NT registers and lists;
- Review of relevant previous archaeological and heritage consultancy reports, to determine the extent of past archaeological research in the local area;
- Review of the environmental and Aboriginal heritage context of the Mount Peake area, and development of a predictive model for Aboriginal heritage for the local region, based on the current understanding of Aboriginal heritage and archaeology;

- Targeted survey of potential historic and Aboriginal heritage sites within areas of high or moderate archaeological potential in the study area, to establish their extent and current condition; and
- Preparation of a report describing the results of the background research, assessing the heritage impact of the proposed mining project and outlining recommendations for the management of historic and Aboriginal cultural heritage within the study area.

1.3.1 Aboriginal Community Consultation

Aboriginal community consultation for the Mount Peake project was undertaken by TNG, in conjunction with the Central Land Council and members of the local Aboriginal community. A report detailing the consultation process, a cultural heritage assessment, and the methodology for obtaining Sacred Sites Clearance and approval from the Aboriginal Areas Protection Authority, has been prepared separately by the CLC. The cultural heritage report has not been provided for consideration as part of this assessment, and is not addressed in this report.

AM Consulting contacted the CLC to facilitate engagement with the local Aboriginal community for this archaeological assessment, and to organise the participation of community representatives in the archaeological survey. Unfortunately, due to an unexpected death in the community immediately prior to the scheduled survey, the CLC was unable to contact the appropriate community members, and AM Consulting was forced to proceed without community involvement in fieldwork.

1.3.2 Report Structure

As per the Heritage Branch *Scope of Works for an Archaeological Survey*, this report is structured as follows:

- Section 1 - brief introduction to the project, the study area and the proposed scope of works;
- Section 2 - outlines relevant Commonwealth, State and local government legislation that apply to the project;
- Section 3 - environmental context of the local area;
- Section 4 - brief historical overview of the study area using primary and secondary sources;
- Section 5 – summary of the archaeological context of the broader region, and details previously recorded Aboriginal and historic sites within the study area;
- Section 6 describes the methodology and results of the archaeological survey.
- Section 7 assesses the heritage significance of archaeological sites identified during the survey.
- Section 8 assesses the impact of the proposed mine site development on the identified archaeological sites.
- Section 9 offers heritage impact recommendations to minimise impacts to identified archaeological sites.

1.4 Authorship

This report has been prepared by AM Consulting Project Officer, Laressa Berehowyj and AM Consulting Project Manager Aboriginal Heritage, Chris Langeluddecke. AM Consulting Senior Project Manager, Jennie Lindbergh reviewed the report for quality and consistency.

Laressa Berehowyj and Chris Langeluddecke undertook an archaeological survey of the study area from 15 June to 20 June 2015. All photographs in this report were taken by AM Consulting staff unless indicated otherwise.

The authors would like to thank the following for their assistance during the preparation of this report:

- Dianne Bensley, Senior Heritage Officer, Heritage Branch, Department of Lands, Planning and the Environment
- Anita McCarthy, Stirling Station

2 Statutory Context

The conservation and management of heritage items, places, and archaeological sites takes place within the framework of relevant Commonwealth, State or local government legislation. Non-statutory heritage lists and registers, ethical charters, conservation policies, and community attitudes and expectations can also have an impact on the management, use, and development of heritage items. The following describes the relevant statutory and non-statutory heritage listings for the study area.

2.1 Commonwealth Legislation

2.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a legal framework for the protection and management of places of national environmental significance. Several heritage lists are addressed by the EPBC Act, including the National Heritage List (NHL) and the Commonwealth Heritage List (CHL). The NHL protects places that have outstanding value to the nation. The CHL protects items and places owned or managed by Commonwealth agencies. The Australian Government Department of the Environment is responsible for the implementation of national policies and programs to protect and conserve the environment, water and heritage, and promote climate action. The Minister's approval is required for controlled actions which would have a significant impact on items and places included on the NHL or CHL.

There are no Aboriginal or historic heritage items, places or archaeological sites listed on the NHL or CHL within the study area or in its vicinity.

2.1.2 *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*

The purpose of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (ATSIHP Act) is to preserve and protect areas and objects in Australia and in Australian waters, that are of particular significance to Indigenous people in accordance with their traditions. The ATSIHP Act allows the Minister for the Environment to make a declaration protecting significant Indigenous areas or objects, including human remains, from 'threat of injury or desecration'. Emergency declarations can also be made by the Minister, or authorised officers, where there is a serious and immediate threat. The ATSIHP does not protect all forms of Indigenous heritage; for example, it does not cover areas and objects whose heritage significance is due to their archaeological, scientific or historical interest (Department of the Environment 2014:5).

There are no areas or objects within the vicinity of the Mount Peake study area that are the subject of a declaration under the ATSIHP Act.

2.1.3 *Native Title Act 1993*

Native title is the recognition by Australian law that Aboriginal peoples or Torres Strait Islanders have rights and interests to land and waters that arise from traditional laws and customs. The *Native Title Act 1993* (Native Title Act) recognises and protects native title in Australia, and establishes a mechanism for determining native title claims. It also provides for negotiations between native title holders or registered native title claimants (native title parties) and other parties regarding the use and management of land and waters, in the form of Indigenous Land Use Agreements (ILUAs).

The Native Title Registrar of the National Native Title Tribunal (NNTT) keeps three public registers of native title information: the National Native Title Register, the Register of Native Title Claims, and

the Register of Indigenous Land Use Agreements. Registered native title holders are recognised as having a right to speak for Country on Aboriginal culture and heritage.

There are no ILUAs or Aboriginal places listed on the National Native Title Register within the vicinity of the study area.

Register of Native Title Claims

There is one native title determination application within the study area that has met the requirements for registration on the Register of Native Title Claims, the Stirling and Neutral Junction (NNTT Application Reference DC2011/002, Figure 2.1). The Mount Peake Project mining area and part of the transport corridor is covered by the application.

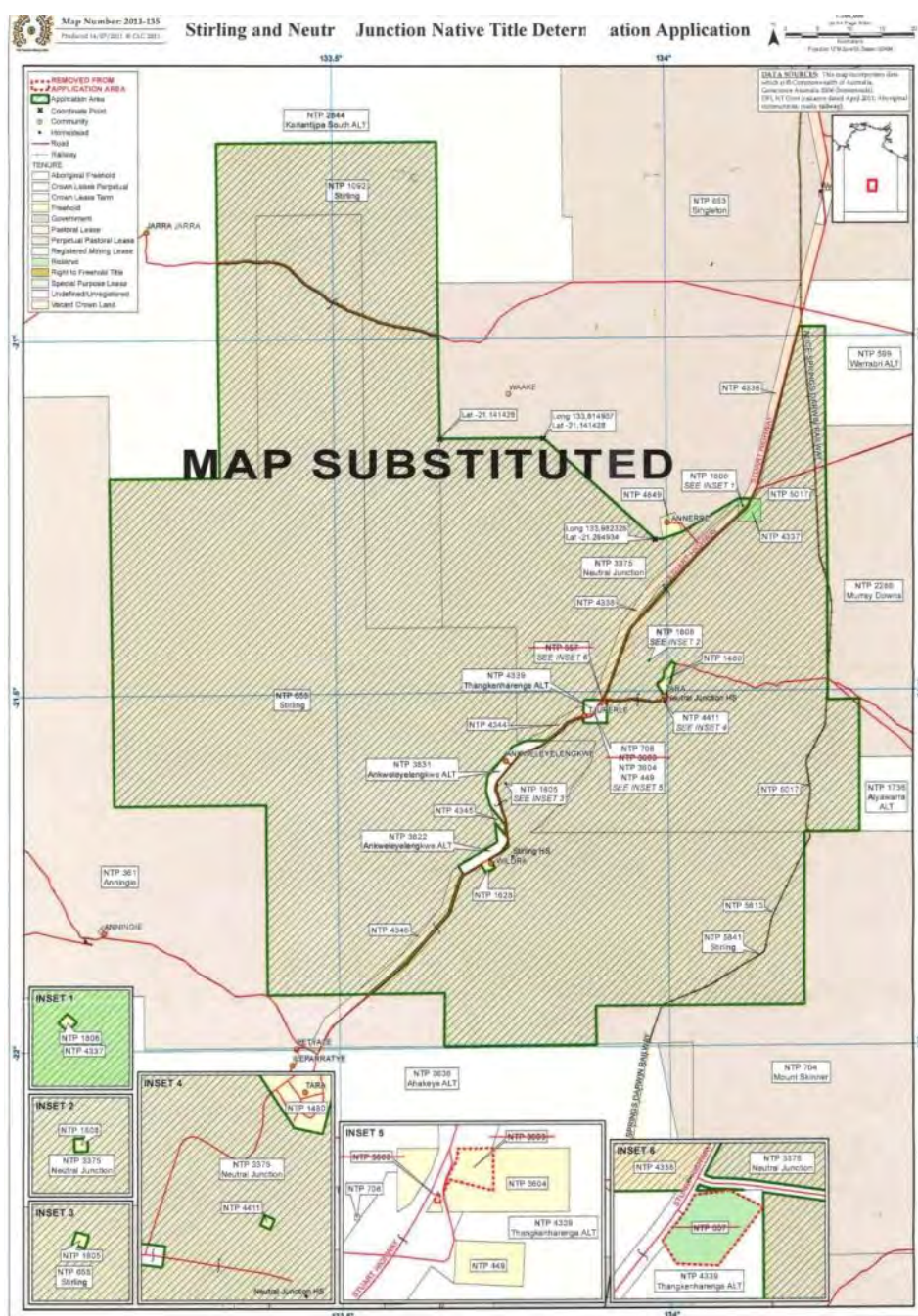


Figure 2.1 Extent of the Stirling and Neutral Junction Native Title Determination Claim (Source: National Native Title Tribunal, http://www.nntt.gov.au/searchRegApps/NativeTitleRegisters/RNTC%20Extracts/DC2011_002/2013-09-13%20DC2011-002%20%20Map%20of%20Amended%20Application%20Area.pdf).

2.1.4 *Aboriginal Land Rights (Northern Territory) Act 1976*

The *Aboriginal Land Rights (Northern Territory) Act 1976* (Land Rights Act) establishes a basis for Aboriginal people in the NT to claim rights to land based on traditional occupation. The Act establishes Aboriginal Land Councils as statutory authorities, to administer areas of land in the Territory, including the Central Land Council (CLC).

The CLC issues Sacred Site Clearance Certificates to establish conditions for applicants to prevent damage to, and interference with, Aboriginal sacred sites. The certificate sets out conditions in relation to entering and working on subject lands, and protects the Applicant against prosecution for entering, damaging, or interfering with sacred sites under the *Northern Territory Aboriginal Sacred Sites Act 1989* and the Land Rights Act.

2.2 NT Legislation

2.2.1 *Northern Territory Heritage Act 2011*

Under the provisions of the *Northern Territory Heritage Act 2011* (Heritage Act), the Minister for Lands and Planning is responsible for the care, control, management and protection of natural and cultural heritage places, items, buildings, works, relics, moveable objects, precincts and archaeological sites throughout the NT. The Heritage Council is responsible for assessing the heritage significance of places and making recommendations to the Minister for Lands, Planning and Environment about whether or not a place should be declared as a heritage place.

All Aboriginal or Macassan archaeological places and objects are automatically protected under the Heritage Act regardless of their significance or land tenure. Aboriginal objects and places can include pre-contact features such as scarred trees, rockshelters and open camp sites, as well as physical evidence of post-contact use of the area such as Aboriginal reserves and pastoral stations. Other places can be declared by the Minister as a heritage places if they meet the criteria for listing and have historical, scientific, aesthetic or social significance.

Under Sections 111 to 114 of the Heritage Act, it is an offence for a person to destroy, deface, damage, desecrate, alter, remove or carry out work of any sort to a heritage place or object without the prior issue of a Works Approval. The Act requires a person to take reasonable precautions to avoid impacts to heritage places. Under Section 72, approvals for minor works to heritage places may only be obtained from the Heritage Council; or directly from the Minister if major works are to be undertaken.

NT Heritage Register

Part of the regulatory framework for the implementation of the Heritage Act is the Heritage Register, maintained by the NT Department of Lands, Planning and Environment. The Heritage Register includes a database of natural and cultural heritage sites, buildings, items, places and other objects that have been nominated as or declared as heritage places; but does not include information about Aboriginal and Macassan archaeological places. A separate Aboriginal and Macassan archaeological places database is maintained by the Heritage Branch, while an Aboriginal Sacred Sites Register is kept by the Aboriginal Areas Protection Authority (see Section 2.2.2 below). The Heritage Register is not a comprehensive list of all heritage sites in NT; rather, it reflects information which has been reported to the Department of Lands, Planning and Environment.

There are no Aboriginal or historic heritage items or places listed on the Heritage Register in or within the vicinity of the study area.

NT Aboriginal and Macassan Archaeological Places Database

The Heritage Branch maintains a database of all known Aboriginal and Macassan archaeological places in the Northern Territory, for the purpose of informing decision-making about the management of such places. Information held in the database is treated as culturally sensitive, and the Heritage Branch will only give out information contained in the database to those who have a legitimate interest, and where this is in the interests of appropriate management of Aboriginal and Macassan archaeological places. In accordance with the Heritage Act, any archaeological survey work carried out in the Northern Territory which results in the discovery of any Aboriginal or Macassan archaeological place is to be supplied to the Heritage Branch for inclusion of relevant information in the database.

The results of a site search for the local area are presented in Section 5.1.2.

2.2.2 Northern Territory Aboriginal Sacred Sites Act 1989

The *Northern Territory Aboriginal Sacred Sites Act 1989* (Aboriginal Sacred Sites Act) provides further protection for Aboriginal sacred sites throughout the NT, defined as sites that are ‘sacred to Aboriginals, or [are] otherwise of significance to Aboriginals according to Aboriginal tradition’. Aboriginal sacred sites are declared by the Aboriginal Areas Protection Authority (AAPA). The AAPA is responsible for:

- a) Responding to requests for sacred site protection from Aboriginal custodians, including the recording and documenting of sacred site information, registration of sacred sites, the provision of related protection measures and the keeping of confidential sacred site records;*
- b) Maintaining the Register of Sacred Sites, the Authority Certificate register and other records;*
- c) Responding to applications for Authority Certificates, carrying out research and surveys, and consulting with Aboriginal custodians to determine the constraints, if any, imposed on proposed works on or use of land by the protection of sacred sites;*
- d) Facilitating discussions between proponents and custodians [where necessary] and issuing or refusing to issue an Authority Certificate accordingly;*
- e) Making available for public inspection the Register of Sacred Sites and the Register of Authority Certificates, and providing sacred site records information to assist with the avoidance of sacred sites;*
- f) Enforcing the Aboriginal Sacred Sites Act, including prosecuting for offences against the Sacred Sites Act; and*
- g) Approving entry onto a sacred site (AAPA 2015).*

Under Sections 33 to 39 of the Aboriginal Sacred Sites Act, it is an offence for a person to enter or remain on, carry out work on or use, or desecrate a Sacred Site without the prior issue of an Authority Certificate, issued under Section 22 of the Act. Authority Certificates are issued by the AAPA if it is satisfied that:

- a) the work or use of the land could proceed or be made without there being a substantive risk of damage to or interference with a sacred site on or in the vicinity of the land; or*
- b) an agreement has been reached between the custodians [of the site] and the applicant.*

Authority Certificates set out the conditions on which work may be carried out or the land used, according to Aboriginal custodians’ wishes.

AAPA Records: Register of Sacred Sites

The AAPA is required, under Section 29 of the Aboriginal Sacred Sites Act, to maintain publicly available registers of all Aboriginal sacred sites that have been reported in the Northern Territory. This

includes a Register of Sacred Sites and a Register of Authority Certificates, kept by the AAPA Records division. The AAPA records are not a comprehensive list of Aboriginal sites in NT; rather, they reflect information which has been reported to AAPA. Sites become known to the AAPA through the Authority Certificate process, or when custodians ask the AAPA to investigate sacred site issues on their country. This often occurs when sacred sites are at risk from development or from other activities. The sites that are listed by the Records division fall into two main categories; Registered Sites that have been comprehensively documented, mapped and evaluated by the AAPA, and Recorded Sites that have been made known to the AAPA but have not been fully assessed or mapped. Only those Registered Sites that have been accurately documented and investigated are included on the Register of Sacred Sites.

A search of the Register of Sacred Sites was not undertaken for the purposes of this assessment.

3 Physical Environment

An understanding of environmental factors within the local landscape provides a context for past human occupation and history of an area. The analysis of environmental factors contributes to the development of the predictive modelling of archaeological sites, but it also is required to contextualise archaeological material and to interpret patterns of past human behaviour. In particular, the nature of the local landscape including topography, geology, soils, hydrology and vegetation are factors which affect patterns of past human occupation.

Current land use practices have the potential to affect the visibility of archaeological material; they may obscure, or expose archaeological sites. In addition, previous disturbances may have also exposed archaeological material, such as excavation for dams or other ground disturbing works. It is important that such factors are also considered in making assessments of archaeological resources in an area and understanding the distribution of observed sites.

3.1 Geology & Topography

The study area is underlain by the Grant Bluff and Central Mount Stuart formations of the Mopunga Group within the southern Georgina Basin, and consists of un-metamorphosed Cryogenian to Devonian sedimentary rocks laid down during the Neoproterozoic. These include medium to coarse grained sandstone, quartz, quartzite, siltstone, dolostone and shale lenses. The Central Mount Stuart formation is overlain by cross-bedded, medium-grained feldspathic quartz sandstone and orthoquartzite, with a local upper interval of red-brown sandstone and siltstone; sediments of which form prominent hills and uplands that characterise the region (Wilson et al. 1990:4; Tille 2006:114; Kruse et al. 2013:10-11).

The region, like much of Central and Western Australia, is characterised by flat to gently undulating sandplains and is dominated by linear or longitudinal dunes and sand ridges and valleys. Explorers and anthropologists Baldwin Spencer and Francis James Gillen described the topography of Anmatyerre country at the turn of the twentieth century:

From the top of the saddle [Foster Range], looking southwards, the great plain stretches on every hand to the horizon, the line of which is broken only at one spot by the low dome of distant Central Mount Stuart. On the north side the same plain country extends as far as one can see out westwards... (Spencer & Gillen 1904:4-5).

These extensive sandplains are interspersed with scattered low rises, isolated stony hills and broad sandstone ranges (Long 1971:263; Wilson et al. 1990:4; Smith and Hesse 2005:5-6; Tille 2006:115). Broadly, the region has an elevation of between 450m and 550m AHD; though higher elevations of 846m, 736m and 705m are recorded at Central Mount Stuart, the Djilbari Hills and Mount Judith respectively.

3.2 Soils & Vegetation

Soils of the study area, like much of Central Australia's Arid Zone, are generally alluvial in origin and are characterised by mostly deep yet infertile red sandy earths and red clayey sands, with minor areas of yellow earth on lateritic surfaces (Wilson et al. 1990:4; Hesse et al. 2005:57; Tille 2006:115). Stony soils as well as red shallow sands and loams are found on the hills and ranges.

Vegetation patterns in arid Australia are controlled by a combination of low and highly unpredictable rainfall, soil characteristics and the local topography, though there are few areas that are not at least

sparsely vegetated (Hesse et al. 2005:65; Tille 2006:115). Many of the plant species of the region have subterranean tubers and seed stores to combat the erratic rainfall. Spinifex (*Triodia* spp.) is the dominant cover on hills, sandplains, dunes and sand ridges in the vicinity of the study area; varieties included soft or gummy spinifex (*Triodia pungens*), feathertop spinifex (*Triodia schinzii*), buck spinifex (*Triodia basedowii*) and giant grey spinifex (*Triodia longiceps*). Spinifex country is often associated with scattered tracts of low, open scrub, with species including desert bloodwood (*Corymbia dichromophloia*), snappy gum (*Eucalyptus brevifolia*), corkwood (*Hakea suberea*) and mulga (*Acacia aneura*) (Long 1971:263; Wilson et al. 1990:11; Hesse et al. 2005:60; Tille 2006:115).

3.3 Hydrology & Drainage

The central NT desert is characterised by several major river systems that generally only flow for short periods after heavy rains (Wilson et al. 1990:4; Smith and Hesse 2005:10). The western portion of the study area is arguably more watered than the landscape to the east of the highway. The Hanson River and its tributary, the Murray Creek, bisect the project area; while a number of small unnamed and ephemeral creeks and channels have been formed at the foot of the Djilbari Hills and Central Mount Stuart in the west and Mount Tops and Mount Octy in the east. These drainage systems are by no means permanent, but, when inundated by large flows after heavy rains, are likely to have been a source of fresh water for Aboriginal people in the past. Other shallow pools, claypans and rock reservoirs filled by lighter falls could have supplied groups for a short period of time.

3.4 Land Use & Disturbance

The major part of the land in the NT is held under Pastoral Lease, Aboriginal Land Trusts or Conservation and Recreation reserves, with localised mining leases and freehold title (Wilson et al. 1990:3). The Mount Peake study area is predominantly held under Pastoral lease, with a small corridor of Crown Land on either side of the Stuart Highway. The Stirling Pastoral Station was established in the 1890s and a small homestead, a number of storage sheds and outbuildings, and numerous stockyards, dams and bores were constructed. The majority of the land, however, remains as unfenced cattle grazing paddocks and has not been significantly disturbed by current land use practices. The study area is likely to retain a high degree of archaeological integrity.

4 Cultural Setting

Commonwealth and State government authorities have developed a series of Historic Themes to provide a framework for identifying and understanding heritage places. These themes focus on the human activities that produced the places we value, and the human response to Australia's natural environment. The major and minor historic themes that are identified as applying to the study area are discussed below.

4.1 Aboriginal History

4.1.1 Peopling Australia

Aboriginal occupation of the Australian desert is likely to have spanned at least 35,000 years, though dates of more than 35,000 years have been claimed for artefacts from the Puritjarra rockshelter in the Northern Territory (45,000 BP, Smith 2006:404), and from Allen's Cave on the Nullabor Plain (39,800 BP, Roberts et al. 1996:15). These earlier dates, however, are likely to reflect intermittent, fleeting visits rather than continuous occupation. Aboriginal occupation seems to have intensified during the Late Pleistocene, and by around 30,000BP, small groups of highly mobile hunter-gatherers were using pockets of country across the interior of the continent, from Central Australia to the Pilbara, and from Lake Mungo to the southern Kimberley (O'Connor et al. 1998:21; Smith 2005:104). Though little archaeological work has been undertaken in the central Australian desert region, Late Pleistocene occupation sites have been identified at Puritjarra and Kulpi Mara in the Central Australian Ranges (32,000 BP, Smith 2006:371; and 29,500 BP, Thorley et al. 2011:47), and from Serpent's Glen in the Western Desert (23,600 BP, O'Connor et al. 1998:13).

Occupation of the central Australian desert appears to have intensified during the Holocene. Radiocarbon dates obtained from basal occupation deposits during archaeological excavation of the Puntutjarpa rock shelter in Western Australia indicate it was first occupied 10,000 years ago (Gould 1977:60). Other Aboriginal sites in the broader arid region with evidence of Holocene occupation include the Puritjarra rock shelter (7,500 BP, Smith 2006:374), Kulpi Mara, Arnngu and Glen Thirsty rock shelters in the Palmer River catchment (4,000 to 1,500 years BP, Thorley 1999:45; Thorley et al. 2011; Smith & Ross 2008:50), Serpent's Glen rock shelter in Western Australia (4,700 BP, O'Connor et al. 1998:17) and Pine Gap rock shelter near Alice Springs (1,000 BP, Napton & Greathouse 1985:102).

At the time of European settlement, the Aboriginal people of the central Australian desert were organised into named territorial groups. Those groups local to the study area are likely to have spoken the Anmatyerre [Anmatyerr] language. According to anthropologist Norman Tindale, the Anmatyerre occupied a vast area of land bound by Mount Leichhardt, Coniston, Stuart Bluff Range, Rembrandt Rock, Hann Range, Woodgreen, Harper Spring and Central Mount Stuart (Tindale 2015 [1974]). Tindale's descriptions of tribal boundaries are based on the distribution of language groups in this area, which are derived largely from linguistic evidence published from 1884 to 1969; however, the boundaries are approximate, and probably varied over time. The Forster Range marked the northern boundary between Anmatyerre and Kaitish country, while Mount Barkly and Mount Leichhardt marked the western boundary between the Anmatyerre and neighbouring Walpiri people (Forster Range, Spencer & Gillen 1904:4; Mount Barkly, Meggitt 1962:40; see also Figure 4.1). However, it should be noted that there is significant overlap between the Anmatyerre and the neighbouring Walpiri, Arrernte and Alyawarr language groups.



Figure 4.1 Carl Strehlow's 1901 map depicting 'Residential Areas of the Aborigines of South and Central Australia' (Source: Strehlow Research Centre).

4.1.2 Utilising Natural Resources

The sandplain and scrub country of the Anmatyerre region is comparatively rich in water, animal and plant resources and natural resources, and would have been particularly attractive to Aboriginal people (Young 1987:160; Rea 2009:5). After heavy rains rock holes, soakages, springs, and creeks provided fresh water and more abundant plant foods, and often terrestrial animals were also drawn to the water. The Anmatyerre people relied on a mixed but rich economy of plant and animal resources. The types of traditional foods consumed and the methods for their procurement are described in contemporary ethnographic sources and the later oral testimony of traditional elders (Spencer & Gillen 1899:18-27; 1904:4; Long 1971:267-268; Green 2000; 2003a; 2003b; Rea 2009:5).

Wild game such as kangaroo, euro, possums, emu, dingos, echidnas and spinifex pigeons, as well as goannas, perenties, lizards, mice and other small mammals were amongst the wide range of fauna that inhabited the arid Central Australian region, and were available to Anmatyerre people (Spencer & Gillen 1899: 18-26; Devitt 1994:28; Green 2000:44). Nancy Mpetyan grew up on Napperby Station at Laramba in the early twentieth century, and remembered traditional methods for cooking large game such as kangaroos, goannas and other animals:

We gutted the animal and cleaned out the intestines. Mum made a hollow, placed the firewood in it, then put two skewers in the animal. We dislocated the two thigh joints. Then we threw the animal onto the fire to singe the hair off, then scraped the burnt hair off the tail... The meat was cooked and cooked and then quickly cut up – with a stone knife (Green 2000:30).

In addition to animals, bush plums, wild oranges and figs, native peaches and currants, conkerberry and other fruits, wild onions, desert yams, pencil yams and bush potatoes, the leaves, roots and fruit of the wild banana, mulga beans, buck spinifex, nuts and seeds would have been consumed by

Anmatyerre people living in the area (Long 1971:268; Green 2000:26; Green 2003a:2-29; Spencer & Gillen 1899:21-22; Flood 2004:252; Rea 2009:4). The majority of these plant foods were cooked in open fires or on coals, consumed raw, or mixed with water and drunken. The seeds of the Dogwood (*Acacia coriacea*), Armgrass millet (*Urochloa piligera*) and mulga (*Acacia* sp.) were ground into flour and mixed with water to make a bread or damper that was roasted over coals. Lerp was obtained from the bark of the river red gum (*Eucalyptus camaldulensis*), and was either mixed with water to make a sweet drink or consumed whole (Green 2003a:29).

Aboriginal women and girls also collected and used plants for medicinal purposes. The leaves of the samphire (*Halosarcia indica*) and hill fuchsia could be soaked in water to produce a soapy liquid that could be used as an antiseptic or for the head. The leaves and stems of the snake vine (*Tinospora smilacina*) were mashed and wrapped around the head to treat headache and dizziness, or heated and applied to the body to relieve aches, rheumatoid arthritis and other inflammatory disorders. Sap from the milk weed or mat spurge (*Euphorbia drummondii*) was used to treat boils and other skin lesions, while native lemongrass and witchetty bush were both used to relieve colds (Green 2003a:34; 2003b:114-115).

Plant resources were also utilised for the fabrication of tools, implements and shelters. In the 1890s, Spencer and Gillen observed Aboriginal men on the banks of the Stirling Creek using timber from the bean-tree (*Erythrina vespertilio*) to make storage containers, *pitchis*, and shields (Figure 4.2, Spencer & Gillen 1904:4). Spinifex grass (*Triodia* sp.) was woven to make weatherproof shelters and was used for signalling, while the resin of the soft or gummy spinifex (*Triodia pungens*) was used as an adhesive (Green 2003a:50; Flood 2004:252; Moloney 2005:4). Kangaroo grass (*Themeda triandra*) was woven into matting and used for bedding, or was used to keep water cool when carried in wooden water dishes (Green 2003a:49-50).

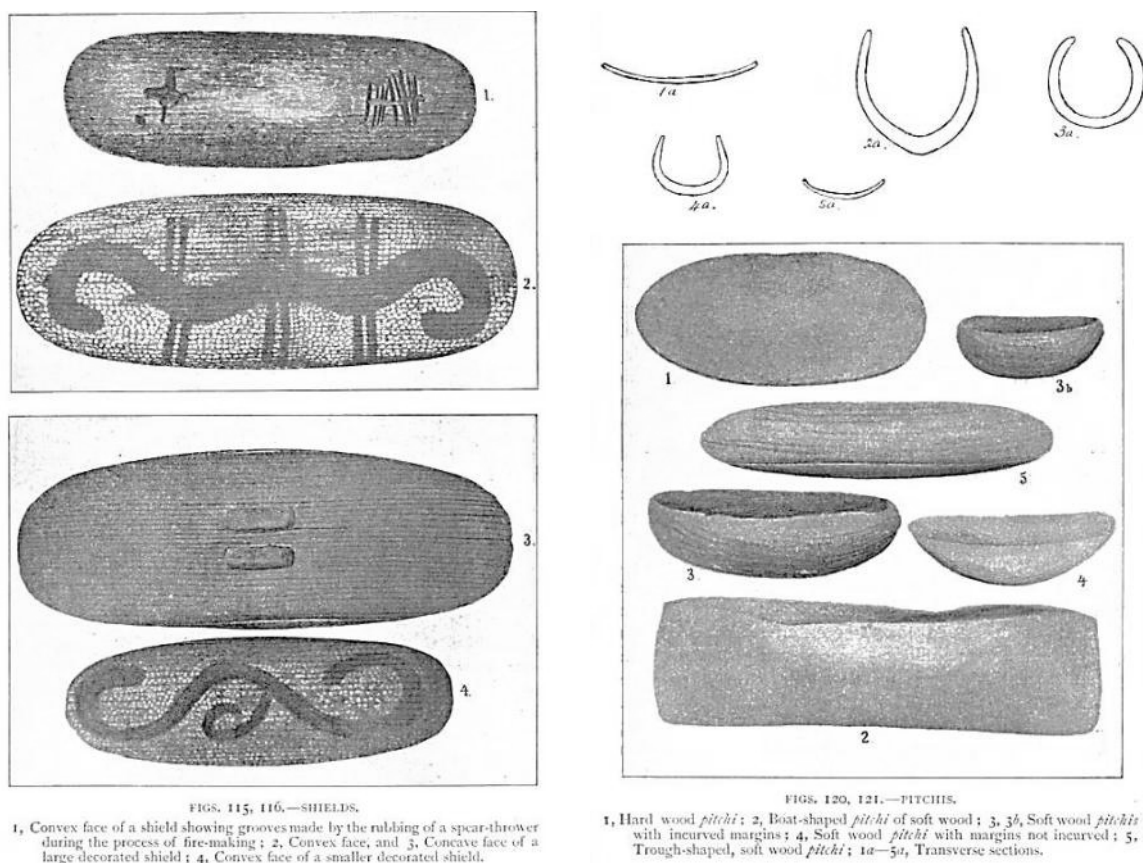


Figure 4.2 Photographs of shields, storage containers and *pitchis* gathered from central Australian tribes, by Spencer and Gillen (Source: Spencer & Gillen 1899:585 and p.609).

Grant Bluff and Central Mount Stuart sandstone provided limited material with which to make tools, though when overhanging it provided shelter from the elements. It was also a surface on which engraved and pigmented images were likely to be depicted, and on which ground edge implements could be shaped and sharpened (Figure 4.3). Quartz, quartzite, greywacke, diorite, siltstone, mudstone and chert occur naturally as lenses within the sandstone bedrock, and when chipped or weathered out could have been used for flaked stone artefacts. Excavated artefacts from the Puritjarra rock shelter and the Campbell Ranges ochre mine site suggest that both retouched and unretouched flakes, as well as formal tool types, were utilised (Peterson & Lampert 1985:2; Smith 2006: 395).



Figure 4.3 Grinding the edge of a diorite axe blank at a quarry near Yuendumu, just outside Anmatyerre country (Source: Edwards 1971, Plate XXX).

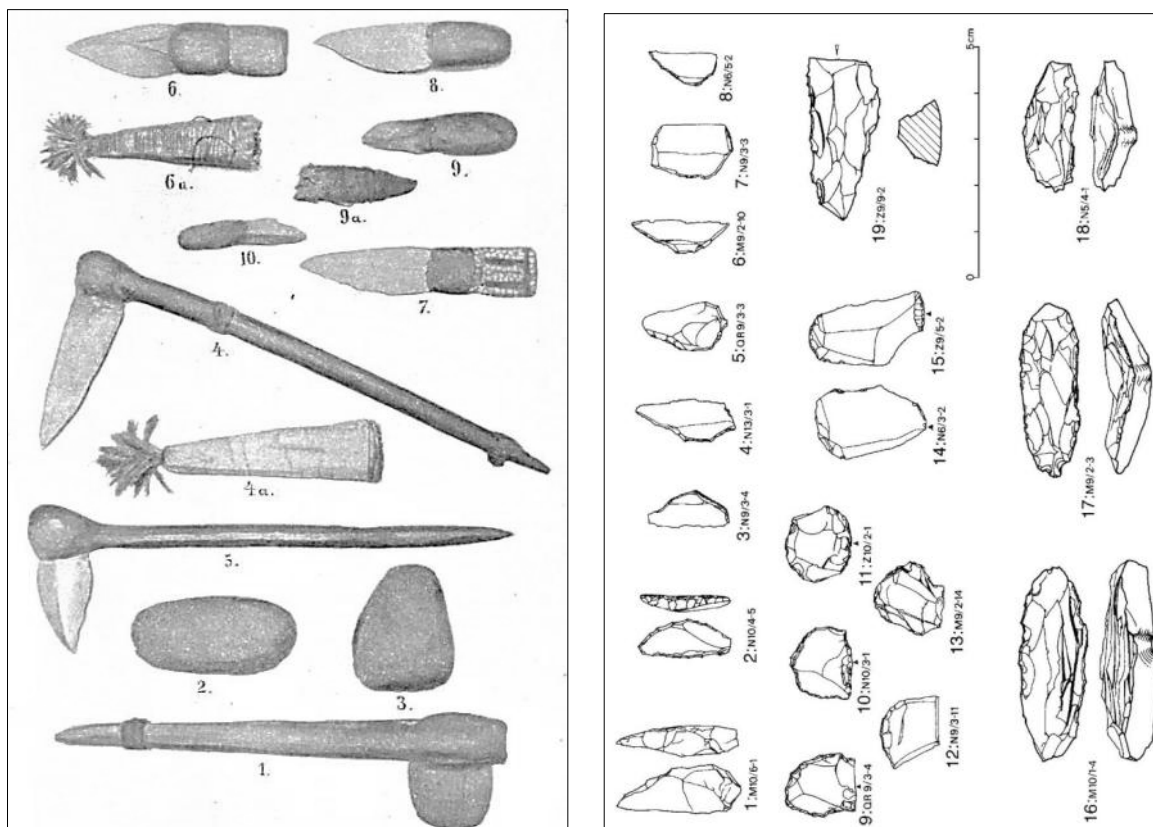


Figure 4.4 Unretouched stone knives and axes collected from central Australian tribes by Spencer and Gillen, left, and geometric microliths, thumbnail scrapers and Tula adzes from Puritjarra rock shelter, right (Source: Spencer & Gillen 1899:589 and Smith 2006:396).

Though no engraved or pigmented art has been identified within the Mount Peake study area, rock art complexes have been identified in the Amadeus Basin near Alice Springs approximately 220km south of the study area. Most art sites occur on open rock faces in sheltered gorges or on rocky outcrops, particularly in close proximity to water sources (Edwards 1971:358; Ross 2005:221).

According to archaeologists Mike Smith and June Ross, rock art complexes across Central Australia bear similar characteristics in terms of their motif vocabulary or core motifs, the colour range utilised and the method of application (Smith & Ross 2008:54). Monochromatic and polychromatic painted oval and U-shaped motifs and striped panels were discovered on rock faces at Kuyunba and Emily's Gap respectively, two sacred men's sites used as templates for ceremonial body decorations (Ross 2005:219). Paint colours were derived from natural pigments and comprised white clay, red, dark red, cream and yellow ochre, and powdered charcoal and ash. Ochre was obtained from places such as the Campbell Ranges near Waite Creek, in Walpiri country (Peterson & Lampert 1985:2) or from Rumbalara, approximately 200km southeast of Alice Springs (Sullivan & Opik 1951:9); and may have even been gathered from the Yarrakina mine at Parachilna, in the Flinders Ranges of South Australia, or from Wilgamia near Geraldton in Western Australia (Peterson & Lampert 1985:1).

Thirteen rock art sites were identified at Glen Thirsty, eleven of which contain painted, drawn, or stencilled art, and three with engravings. Hand stencils and handprints, trails of macropod or possum tracks, concentric circles and snake outlines are dominant motifs, the majority of which are drawn in outline form and filled in with red, dark red or white ochre (Figure 4.5). Cream, black, pink, yellow and grey pigments were also recorded. Shallow pecked engravings line the horizontal slabs and boulders adjacent to the Glen Thirsty waterhole, and comprise bird and macropod tracks, plain, barred and concentric circles, spirals, ovals and a small amorphous maze (Smith & Ross 2008:53-57). This pecked track and circle tradition, known as the 'Panaramitee Style', is widely distributed across Australia but is best known from the arid Central Australian region (Flood 2004:161-162). Pecked track and circle motifs were also found at both the Cleland Hills and Purnitjarra rock shelters, though a unique group of human faces and anthropomorphic figures were identified in the Cleland Hills site (Edwards 1971, Plates XXVI and XXVII; Flood 2004:163-164; Ross 2005:225).



Figure 4.5 Illustrations of a diverse range of painted rock art motifs at Glen Thirsty (Source: Smith & Ross 2008:54).

4.1.3 Maintaining Religious Traditions & Ceremonies

The passage from childhood to adulthood was marked by traditional initiation ceremonies, bringing about greater spiritual awareness, knowledge and responsibility for both men and women. Initiates were put through a series of ordeals or trials, shown tribal boundaries and received instruction from elders regarding medicine and the healing arts, spiritual beliefs and traditional customs. Members of the opposite sex, or uninitiated tribespeople were strictly forbidden from attending these ceremonies. After passing through their apprenticeship from childhood to adulthood, initiates had their chests and shoulders marked with cuts and filled with ash to create raised scars. Pronounced chest cicatrices were worn with pride as marks of initiation (Figure 4.6, Jones 2007:203).



Figure 4.6 Portrait of an ‘Unmatjera man’ by Spencer and Gillen, Barrow Creek, 1901. The man bears scars on his chest and shoulders as a marker of his status within the community (Source: Museum Victoria, XP143BB).

Many Aboriginal places of significance are secret and sacred; however, there are a number of natural landscape features in the Anmatyerre region that have mythological importance. Anmatyerre people perceive the land as comprising more or less discrete ‘countries’. Each country is associated with one or more of the *Altyerrenge* (Dreaming) Beings, and contains sites marking the scenes of their travels and activities. Some of these beings travelled widely and have sites along their tracks which span several countries, or are limited to a single country. These Beings reside in significant landscape features such as the Hanson River (*Mer Petyal*), Central Mount Stuart (*Amakweng*), waterholes, rock outcrops and other mountain peaks (Green 2003b:21; Rea 2009:7). The travels and activities of the *Altyerrenge* beings are recorded in stories and songs and are depicted in ceremonies. Honey Ant (*Yerrampe*) and Native Cat (*Malpwenke*) Beings camped at several sites as they travelled across Anmatyerre country (Office of the Aboriginal Land Commissioner 1987:11-12).

4.2 European History

4.2.1 Early Exploration

The first Europeans to set foot in Anmatyerre country were members of John McDougall Stuart's exploration party, which crossed the Australian continent from its southern to northern coast in a series of expeditions between 1858 and 1862. Stuart reached Central Mount Stuart, three miles from the centre of the continent, in April 1860:

Sunday, 22nd April, Small Gum Creek, under Mount Stuart, Centre of Australia. To-day I find from my observations of the sun, 111 degrees 00 minutes 30 seconds, that I am now camped in the centre of Australia. I have marked a tree and planted the British flag there. There is a high mount about two miles and a half to the north-north-east. I wish it had been in the centre; but on it tomorrow I will raise a cone of stones, and plant the flag there, and name it Central Mount Stuart...

Monday, 23rd April, Centre. Took Kekwick and the flag, and went to the top of the mount, but found it to be much higher and more difficult of ascent than I anticipated. After a deal of labour, slips, and knocks, we at last arrived on the top. It is quite as high as Mount Serle, if not higher. The view to the north is over a large plain of gums, mulga, and spinifex, with watercourses running through it. The large gum creek that we crossed winds round this hill in a north-east direction; at about ten miles it is joined by another. After joining they take a course more north, and I lost sight of them in the far-distant plain. To the north-north-east is the termination of the hills; to the north-east, east and south-east are broken ranges, and to the north-north-west the ranges on the west side of the plain terminate. To the north-west are broken ranges; and to the west is a very high peak, between which and this place to the south-west are a number of isolated hills (Hardman 1865 [2014]).

From there, Stuart's party travelled north along the Hanson River to Mount Barkly; but the arid spinifex-grass country, and a large band of apparently armed Aboriginal [Warramunga] people, forced them to turn back just north of Tennant Creek. During subsequent expeditions, Stuart remarked that the country all around the Hanson was covered in Aboriginal tracks, and that a great number of Aboriginal people occupied the area (Hardman 1865 [2014], Tuesday, 17th July). He posited that Aboriginal people congregated around the Hanson and other permanent soaks and rock holes in times of water shortage, and could extract potable water by means of sinking wells into the sandy banks (Hardman 1865 [2014], Tuesday, 22nd May; Sunday, 5th October; Meggitt 1962:17-18). Stuart's party completed the crossing of the continent in July 1862 (Figure 4.7).



Figure 4.7 Sketch map of Australia, showing the route John McDougall Stuart took to cross Australia from its southern to northern coast (Source: Hardman 1865 [2014]).

4.2.2 The Overland Telegraph

A secondary goal of Stuart's expedition was the mapping of a navigable route for the eventual establishment of an overland telegraph line. Stuart made note of the best places for river crossings, documented reliable sources of timber for telegraph poles at Chambers Creek, and the Hugh, Finke and Roper Rivers, and identified permanent water resources (Hardman 1865 [2014], preface, Saturday 2nd March). In 1865 the South Australian Parliament authorised the construction of a telegraph line between Adelaide and Port Augusta, and the 3,200km route to Darwin was approved in 1870. The route for the telegraph line was surveyed by John Ross and Alfred Giles in 1871, and was to closely follow the route traversed by John McDougall Stuart (Office of the Aboriginal Land Commissioner 1987:1; Young 1987:160; Central Desert Shire c2008:7).

The contract for the construction of the Overland Telegraph, as it came to be known, was given to South Australian Superintendent of Posts and Telegraphs Charles Todd. Initially, crude materials and methods of construction were utilised. Hand tools were used to clear vegetation anthills and other obstructions, and fire ploughs and V-shaped screeds were dragged by teams of bullocks or horses. Equipment for the line was transported by Afghan cameleers, and supplies and provisions for the teams of surveyors, linesmen, carpenters, labourers and cooks were carried by wagon. Cypress pine posts were used to convey the galvanised telegraph wire along the line, and telegraph repeater stations were constructed every 250km.

Maintenance of the Overland Telegraph was an ongoing and substantial operation. The route was kept clear of trees and debris, to facilitate regular inspection of the posts, insulators and line, and to enable the efficient resupplying of provisions at repeater stations. The timber posts were destroyed by white ants and were gradually replaced with wrought iron Oppenheimer poles from 1873 onwards. In time, a track was established along the route of the line and was frequently used by travellers, drovers and adventurers. It later became the route for settlers to transport their cattle and livestock, and encouraged settlement of the neighbouring landscape (Office of the Aboriginal Land Commissioner 1987:2; Poole 2007:4). During the Second World War a telephone cable was installed to facilitate communication between military personnel in Darwin and the southern states (see Section 4.2.4 below).

4.2.3 Early Settlement

The region's earliest settlers were principally stock drovers, enticed to the central desert in the 1870s by reports of favourable, relatively well-watered grazing land from Stuart himself, staff at the repeater stations and other early settlers (Meggitt 1962:19; Young 1987:160; Devitt 1994:25; Paterson 2005:268; Central Desert Shire c2008:7). Pastoralists moved into the Northern Territory via the Gulf Country of western Queensland and via Central Australia, and by the late 1870s had claimed large tracts of land in the eastern portion of the Northern Territory, between the Overland Telegraph line and the Queensland border.

The Buchanan, Gordon, Farquharson and Durack families ran large herds of cattle in the Barkly Tablelands region, while the Malcolm, Parr, Meñatt and Manchee families managed smaller holdings in Anmatyerre country. These early pastoral ventures relied heavily on the prevalence of surface waters such as waterholes, springs and small lakes, but long periods of drought in the 1880s meant that competition for scarce water supplies, and occasionally, was fierce (Young 1987:160; Devitt 1994:26). Successful pastoral ventures relied on the ability to move stock to avail distant waters and pastures. Stock was highly mobile and there was little investment in infrastructure such as fences and elaborate homesteads. Most of these enterprises were short lived, particularly on smaller runs where good water and pasture land was lacking. In reality, many claims were forfeited or abandoned and offered for auction, though few were taken up again (Figure 4.8). The historian Charles Edwin Woodrow Bean remarked that *around Lake Eyre, and over some part of Central Australia you may see them today – deserted homesteads standing out from the desert with the marks of old settlement around them* (Bean 1910:16).

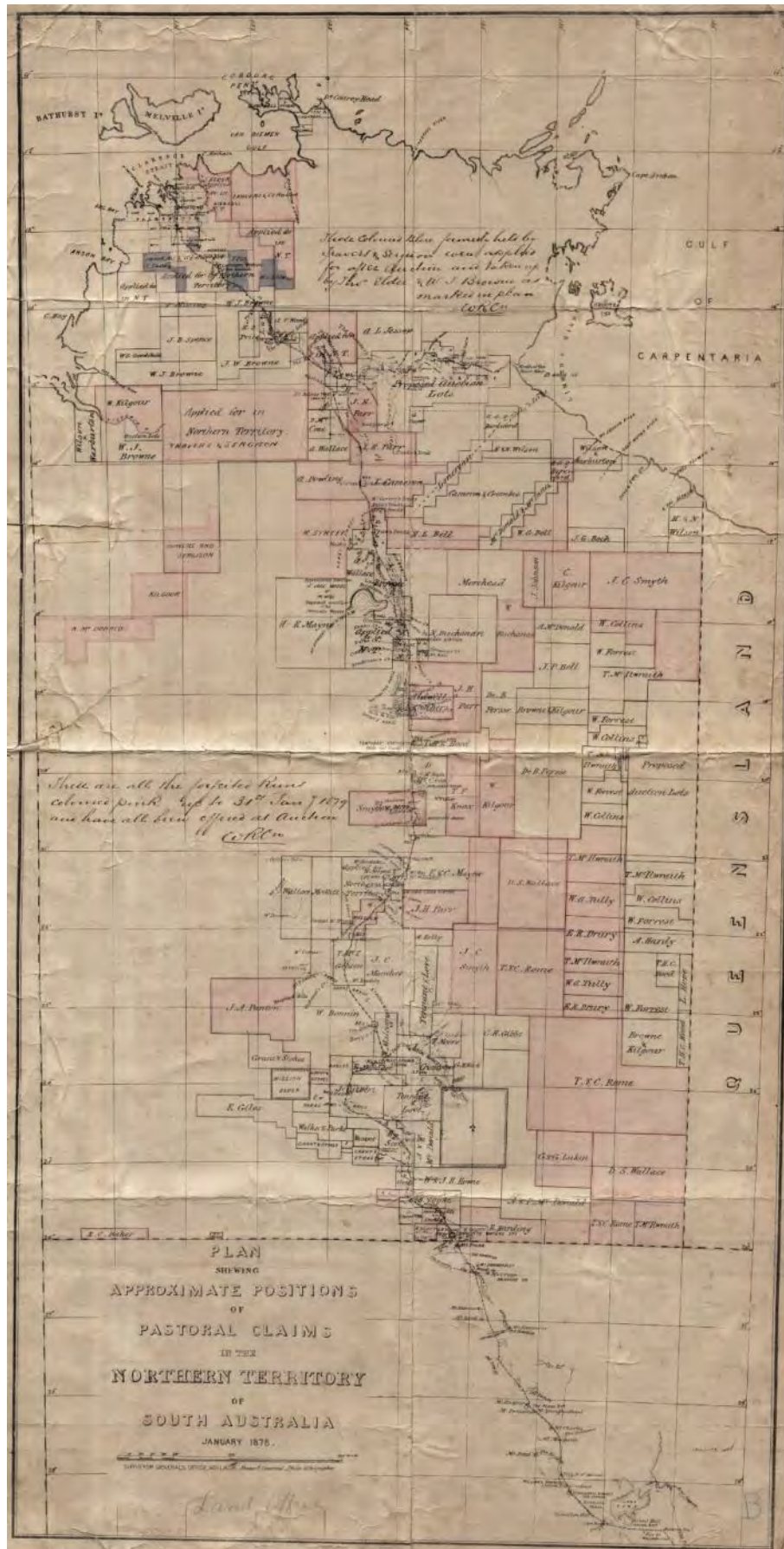


Figure 4.8 'Plan Shewing Approximate Positions of Pastoral Claims in the Northern Territory of South Australia', 1878. Those highlighted in pink were 'recently abandoned' (Source: Northern Territory Government, Historic Map Index Map ID. 1753).

Pastoral noting plans reveal that the study area was leased to D Murray, JB Spence and AM Wooldridge in 1883 (Northern Territory Government, Historic Map Index Map ID. 1687). By 1891 the run, now known as 'Stirling', had been abandoned:

The Stirling Swamps were all under water, and we had to wade through the lagoons and waterholes. The country here has a fresh appearance, and grass and herbage grow luxuriantly. There was a cattle station on the banks of the Stirling Creek at one time, but the run has been abandoned, and the country at present is idle (Adelaide Observer, Saturday 15 August 1891:6).

Evidently, the 'luxuriant' countryside attracted further settlement, and the Stirling run was revived in the mid-1890s. While details about its origins are unclear, it was likely established as a stocked cattle station; and encompassed land on the eastern and western sides of the Overland Telegraph, in the vicinity of the Hanson River, Mount Stirling and Mount Peake (Figure 4.9, *Newcastle Morning Herald and Miners' Advocate*, 6 July 1896:4).

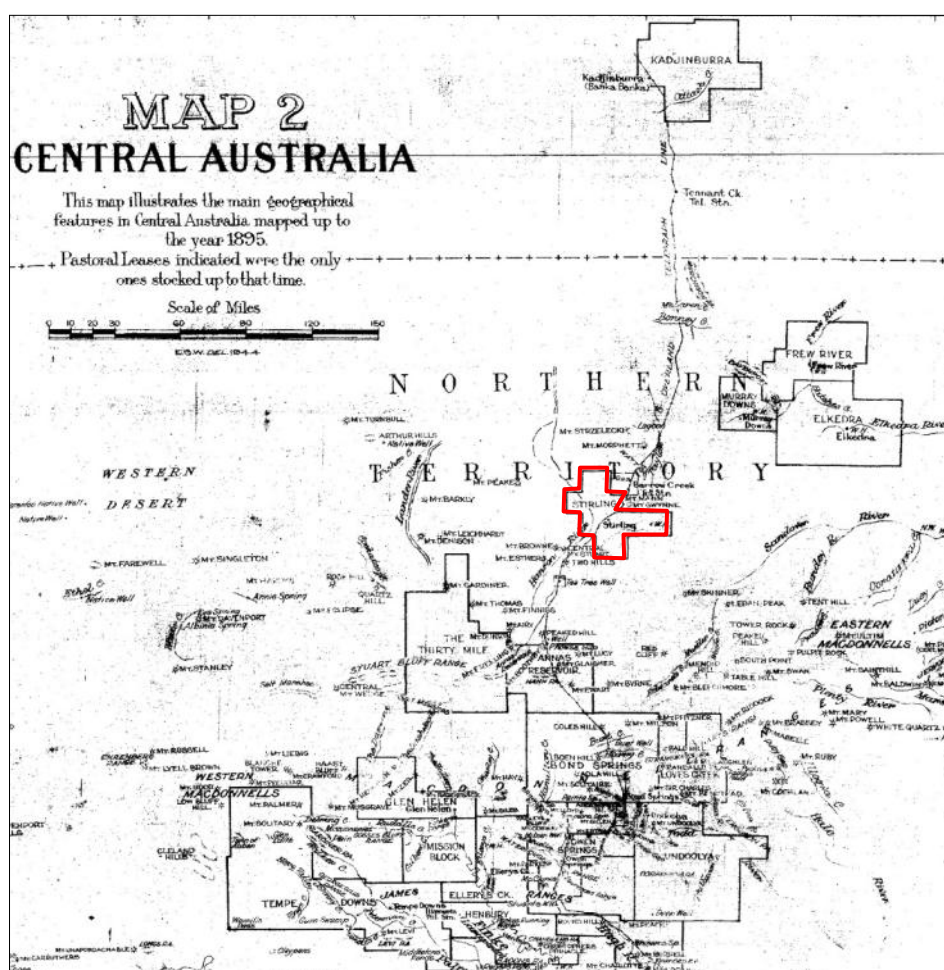


Figure 4.9 Central Australian pastoral leases, including Stirling Station, which includes the study area, stocked prior to 1895 (Source: Northern Territory Government, Historic Map Index Map ID. 3541).

At the turn of the century, staff from the Barrow Creek Telegraph Station took up grazing licences on the Stirling and Taylor Creeks, to supplement pasture land for the Station's stock. This included Station Master Francis Robert William Scott, who leased Blocks 424 and 1983, Licences 67 and 220 and Permit 95 of Stirling Station (Northern Territory Government, Historic Map Index, Map ID. 3269 and 3392). Severe drought in 1902-1905 forced a number of small landholders out of the area, but Stirling Station endured (Meggitt 1962:20). Though little capital was invested across the lease, the majority was concentrated on Block 1983 in the vicinity of Stirling Swamp, which was periodically inundated. The Station homestead was constructed approximately two miles east of the Overland

Telegraph Line and eighteen miles southwest of the Barrow Creek Telegraph Station, while the 'New Hansen Well' was sunk six miles south of the homestead (Figure 4.10). As Station Master and Assistant Returning Officer for the local Electoral District, Scott was frequently away and, at least initially, employed a local Anmatyerre man as manager of Stirling Station (Figure 4.11). Due to their intricate knowledge of the landscape and of reliable water and plant resources it is likely that other Anmatyerre people were employed on the Station, as stockmen and drovers, as fence builders or in domestic roles (Young 1987:162; Devitt 1994:26-27; Central Desert Shire c2008:8).

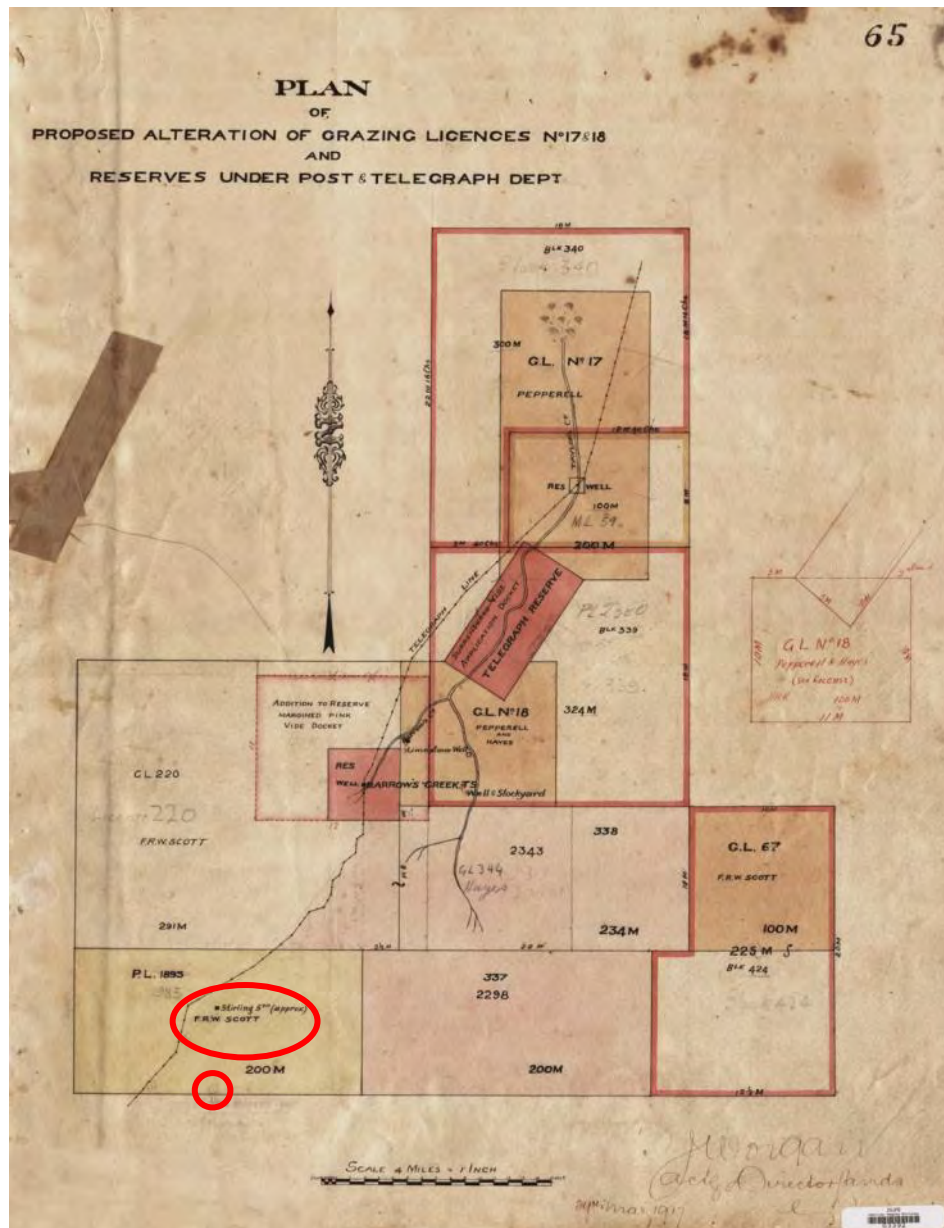


Figure 4.10 Proposed alteration of Grazing Licences No.17 and 18 and Reserves under Post and Telegraph Department, 1917. The locations of the Stirling homestead and New Hansen Well are circled (Source: Northern Territory Government, Historic Map Index Map ID3392).



Figure 4.11 Photograph of an 'Unmatjera Native in charge of Scott's station at Stirling Creek, with hat made by Scott', taken by Spencer and Gillen, 1901 (Source: Museum Victoria, ID. XP14578).

Francis Robert William Scott continued to operate Stirling Station throughout the 1900s and 1910s, and by 1921 was a notable pastoralist with considerable experience in the region. He gave evidence during a Federal enquiry into the construction of a north-south railway through the Northern Territory, and advocated for the construction of the line through the abundantly watered and fertile Barkly Tablelands region. He argued that the neighbouring region could better support a large proportion of stock, which could be raised and subsequently transported throughout the Territory to South Australia and Queensland. At the time Scott's Stirling Station holding comprised 890 square miles, on which he ran 2,000 head of cattle and 500 horses (*Adelaide Observer*, 23 July 1921:30). The railway was not to eventuate for another 80 years.

Following Scott's death in 1923, Stirling Station changed hands a number of times. It was leased by Messrs Spencer, Turner and Harris in 1925 and was purchased by Sir Sydney Kidman and son Walter Kidman in 1928 (*Northern Territory Times and Gazette*, 3 November 1925:1; *Northern Standard*, 15 June 1928:3). In the late 1930s and early 1940s it was subleased or managed by Stan Brown, and was acquired by the McCarthy family who have managed the property for at least three generations. Today, the property encompasses an area of 7,200 square km and runs 8,000 head of cattle (pers. comm. A McCarthy 16/06/2015).

4.2.4 The Stuart Highway

The Stuart Highway was first established in the 1870s as a supply track for the Overland Telegraph, and essentially facilitated transportation throughout and settlement of the Northern Territory interior. The dirt track was periodically inspected and maintained in conjunction with the upkeep of the telegraph line. Like other Australian roads, the track was merely cleared, levelled and formed up of using horse-drawn ploughs and screeds, and timber posts were laid in corduroy fashion along sandy and marshy sections to prevent bogging (Lay 1992:207; Heritage Concepts 2008:22; Department of Infrastructure and Transport c2012:1). In the south, spinifex was also used to enable crossing of sandy sections and creek beds, though little could be done to help traverse inundated creeks in the absence of adequate bridges. Henry Dutton and Murray Aunger attempted to traverse the Overland Telegraph

track from South Australia by car in 1907, but following torrential rain the track turned into a quagmire and the trip was abandoned at Tennant Creek. The track, like other remote roads of the period, was not designed to be traversed during heavy rain and was subsequently impassable for lengthy periods of time (Figure 4.12; Poole 2007:5).



Figure 4.12 Car crossing the flooded Stirling Creek, south of Barrow Creek, by A and B Richards, 1934 (Source: Northern Territory Library, Richards Collection, <http://hdl.handle.net/10070/20063>).

The discovery of gold at Tennant Creek in 1934 brought increased volumes of traffic along the dirt track from Alice Springs, but this had little impact on its maintenance and repair. Few improvements were made to correct the drainage capacity, grading and alignment of the dirt track until the 1940s, when the Australian Department of Defence identified the need for efficient transportation of troops in the defence of Australia. Responsibility for the track was assumed by the Department of Defence in 1940, and within months major construction and drainage works were scheduled. Reconnaissance surveys were carried out, new road alignments were pegged and a number of bores were sunk from Alice Springs through to Larrimah in the state's north (Office of the Aboriginal Land Commissioner 1987:2; Ling 2015). The section of road between Alice Springs and Tennant Creek was widened and straightened to facilitate faster transportation, but in a bid to cut down on time and labour resources, was gravelled and left unsealed (Figure 4.13). Large amounts of plant and equipment including tractors, end loaders, tip trucks and water carts were mobilised for the construction of a wide sealed gravel road between Tennant Creek and Larrimah, which was completed in three months. But, following a particularly devastating wet season in 1940-1941, it was realised that an all-weather bitumen road with bridged creek crossings was required across the length of the Alice-Darwin transport road (Poole 2007:5).



Figure 4.13 Photograph of the Alice Springs-Darwin road soon after completion of the unsealed section between Alice Springs and Tennant Creek, 1942. The road was widened, straightened and levelled and was intended to carry military transport (Source: Australian War Memorial, Department of Information, ID. 150145).

Staged construction of the new bitumen sealed road began at the northern end of the highway in 1941, and was completed by 1944. The previously unsealed gravel road between Alice Springs and Tennant Creek was re-sheeted in gravel and then surfaced in bitumen by the Country Roads Board of Victoria. Bitumen for the project was transported from the Alice Springs railhead in three-ton truck convoys, mixed and poured on site (Figure 4.14). The Stuart Highway passed back into the NT Department of Construction/Works ownership in 1945.



Figure 4.14 A convoy approaching a staging camp on the 'North-South Military Highway', 1943. Allied Works Council tar and bitumen boilers, left, were used in the resurfacing works (Source: Australian War Memorial, ID. 014400).

In the period between 1970 and 1992, further upgrades were made to the highway's alignment, built structures and drainage capacity, in order to meet National Highway Standards. This included the

reconstruction of a number of bridges to meet increased loading standards, the provision of overtaking lanes and, more recently, the introduction of open speed limit zones (Department of Transport 2014).

4.2.5 Infrastructure Projects in the Late Twentieth Century

In the earliest stages of European colonisation, settlements were established primarily along the Australian coastline. As settlers moved into increasingly more rural locations and inland resources were exploited it became necessary to establish reliable methods of transportation, culminating in the construction of independent colonial railways. In the province of South Australia the first government-owned railway line was opened between Adelaide and Port Adelaide, in 1856. It was extended to Kapunda in 1860 and to Roseworthy in 1870.

Plans for the construction of a regional railway through the central Australian interior began in 1878 with the construction of the Central Australian Railway. It was conceived mainly to serve the mining and pastoral industries in far north SA, reaching Quorn in 1879, Beltana in 1881, Marree in 1884 and Oodnadatta in 1891. For nearly forty years an additional stretch to Government Gums (Farina) was completed by camel, until the railway line was extended past the township and as far north Alice Springs in 1929. A second railway line was constructed from Darwin in 1888, reaching Pine Creek in 1889, the Katherine River in 1917 and Birdum in 1929. The section of linking track between Alice Springs and Birdum, whilst planned for completion from the outset, was indefinitely postponed during the Interwar period. To correct difficult grades and alignments and prevent delays caused by flooding, the Adelaide to Alice Springs line was redirected via Tarcoola in 1957, and the Northern Territory Government began preparing a feasibility study for the completion of the railway line from Alice Springs to Darwin.

The development of the Alice to Darwin railway proposal stalled in the 1970s and 1980s, and may have been hampered by the NT Government's decision to construct a 1,600km long buried natural gas pipeline along the Sturt Highway, from the Amadeus Basin to Darwin. The route was surveyed and acquired from landowners in 1984, and was scheduled to be completed in four stages. The contract for the fabrication of the 14in steel pipeline was awarded to two Port Kembla (New South Wales) companies, the pipes of which were likely carted inland via rail or shipped to Darwin for installation. The project was completed in 1986.

The contract for the Alice Springs to Darwin railway was awarded to the Asia Pacific Transport Consortium in 2000. Work began in 2001 and incorporated substantial earth and drainage works, including the clearance of an approximately 100m wide corridor along the length of the track, and the construction of bridges along the Elizabeth, Adelaide, Cullen, Fergusson, Edith and Katherine Rivers. Cement sleepers were manufactured at dedicated plants along the line and carted along the length of the track. The Alice Springs to Darwin section was opened to passenger and freight traffic in 2004.

5 Archaeological Context

Historic research indicates that Stirling Station was utilised as a pastoral station from at least the 1890s, and was primarily used for the grazing of cattle. With the exception of the homestead site and a possible well to the east of the Highway, as well as perimeter fencing and a number of government and privately-sunken bores, little development of the study area, particularly in the vicinity of the proposed mine site and transport corridor, has occurred. Where present, these occupation sites are comparatively recent and are representative of other pastoral station complexes in the broader central desert region. As such, it is considered unlikely that historic sites of considerable heritage value would be present within the study area.

This section describes the nature of the known Aboriginal archaeology of the study area, based upon a review of relevant region-wide archaeological reports and publications, and a search and review of previously recorded sites in the NT Heritage Register and the NT Aboriginal and Macassan Archaeological Places.

5.1 Previous Archaeological Research

5.1.1 Regional Research

In contrast to the coastal Kimberley and Katherine regions of the NT, comparatively few archaeological investigations have been undertaken in the central Australian arid region. Archaeological investigations have focused primarily on rock shelter and open occupation sites in the Cleland Hills, George Gill, James and MacDonnell Ranges, in landscapes more than 200km south of the study area. While many of these sites have been identified in association with academic research and in the construction of roads and town infrastructure, a regional comparison reveals that the majority have been located in close proximity to water courses, natural resources, and significant landscape features (Figure 5.1).

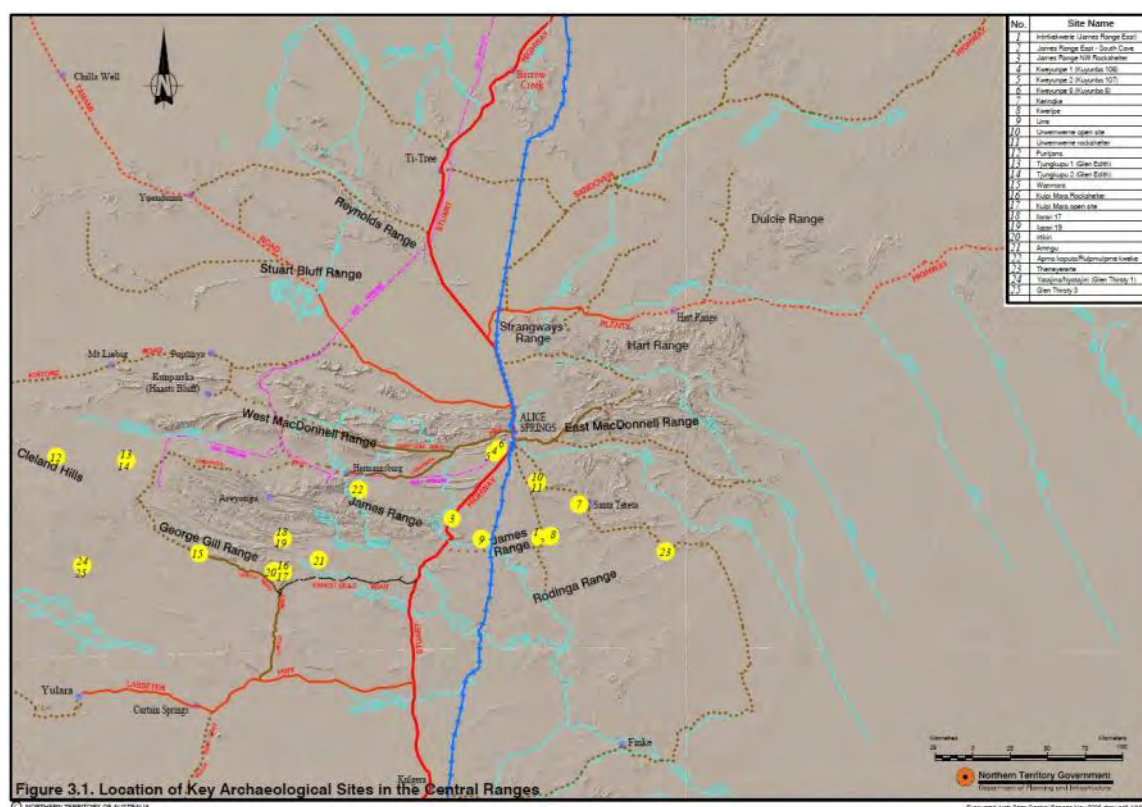


Figure 5.1 Location of key archaeological sites in the Central Ranges region, Northern Territory (Source: Gregory et al. 2008:57).

Archaeologist Mike Smith undertook excavations of the Puritjarra rock shelter site in 1986-1990, located at the foot of a small sandstone escarpment in the Cleland Hills region adjacent to a sand plain and spinifex hummock grassland. Stratified deposits containing silcrete and chalcedony flakes suggest that the shelter was occasionally utilised by small, highly mobile groups from 32,000 to 18,000 years BP. After this point the site was used more frequently and for greater periods of time, as groups focused more on the local country than the wider territory previously occupied. Archaeological evidence from the shelter suggests that grindstones, large implements, pits or hearths and pigmented rock art became more prevalent at 13,000 BP; and by 3,500 BP a specialised Aboriginal 'tool kit' was used. This included formal scrapers, adzes and geometric microliths, as well as specialised seed grinding implements for processing acacia and grass seeds, and other composite artefacts manufactured from wood, stone and resin. A greater concentration of occupational debris, including flaked stone artefacts, seed grinding implements, charcoal, discrete hearths and pits, ochre, bone and eggshell, suggests that the site was used more intensively during the past 800 years (Flood 2004:102-104; Smith 2006:405-406; Gregory et al. 2008:31-34).

Smith also undertook excavations of an open campsite area at Wanmara in the George Gill Ranges in 1988. The site was located on a sandplain, within 50-200m of a main spring and in close proximity to abundant plant food resources. It was occupied by 2,600 BP, though substantially more intensive occupation of the site occurred from 1,300 BP. This was evidenced by an increase in the density of stone artefacts and increases in the number of grindstones and seed grinding implements, retouched artefacts, and bone, charcoal and ochre. Initially, locally available silcrete was used for the production of stone artefacts; but within the last thousand years non-local chert became an equally important resource. The surface of the site was covered in stone artefacts; and included hundreds of seed grinding implements such as mullers and mortars and pestles (Smith 1988:161-198).

Kyle Napton and Elizabeth Anne Greathouse excavated two rock shelter sites at Pine Gap, on the southern flank of the MacDonnell Ranges, in 1980. The rock shelter sites, known as Kuyunba 106

and Kuyunba 107, occupy elevated positions above a long, narrow but open level valley between two sandstone ridges. Similar artefacts were located across both sites, and included milling stone fragments, adzes and adze slugs, backed blades, end-scrapers, retouched flakes and waste material. The principal raw materials across both rock shelter sites were quartzite, chalcedony and other cryptocrystallines. According to Napton and Greathouse, the artefacts found in Kuyunba 106 and 107 were not particularly distinctive or unusual, but were characteristic examples of the general range of artefacts known to occur in surface sites in central Australia (Napton & Greathouse 1985:99, 102).

5.1.2 Local Research

A search of the NT Heritage Register and the NT Aboriginal and Macassan Archaeological Places confirms that comparatively few archaeological investigations have been undertaken within the vicinity of the study area (Figure 5.2). This is likely owing to the pastoral nature of the surrounding landscape, whereby little development and archaeological investigation of the land has occurred. Large scale infrastructure projects throughout the study area, such as the construction of the Stuart Highway and installation of the Amadeus Basin to Darwin Pipeline, were likely undertaken without prior archaeological assessment or investigation. An Aboriginal archaeological survey of the proposed Alice Springs to Darwin railway was, however, conducted in 1997 by archaeologist Mike Smith.

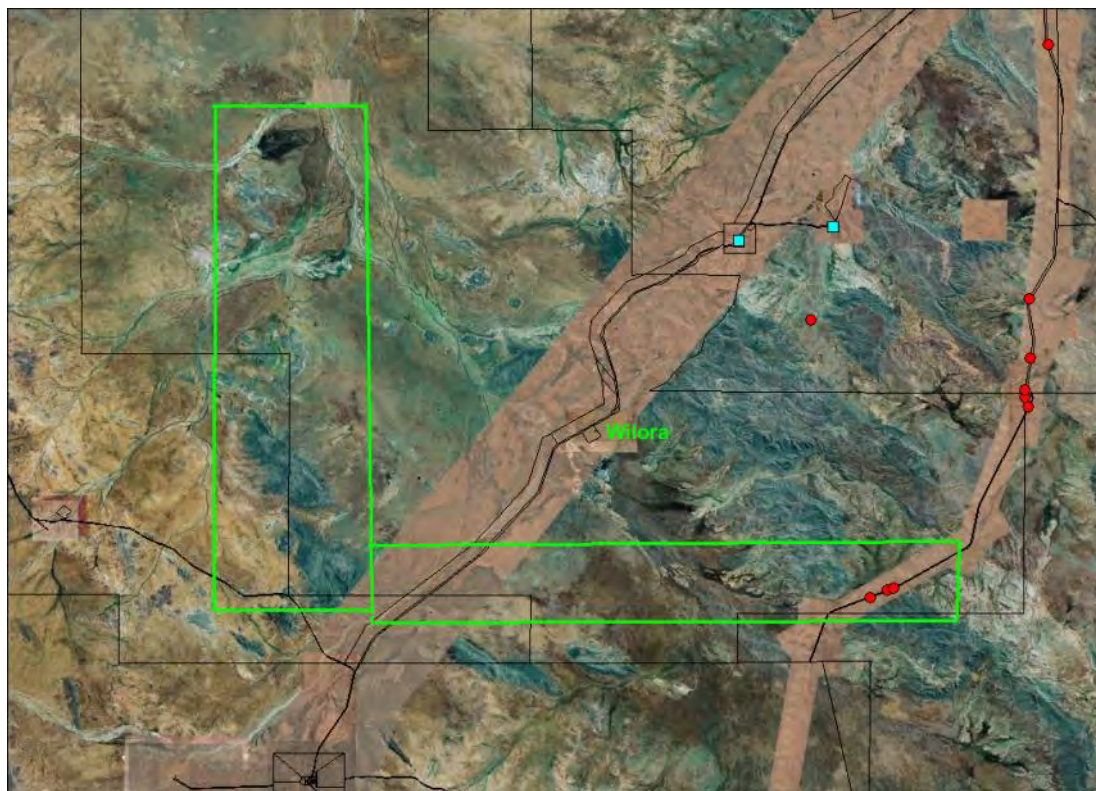


Figure 5.2 Results of a search of the NT Heritage Register and Aboriginal and Macassan Archaeological Places within the study area, boxed in green. Known Aboriginal archaeological sites are identified in red and historic heritage sites are identified in blue (Source: D. Bensley, Northern Territory Heritage Branch, 02/07/2015).

Archaeological survey of the proposed Alice Springs to Darwin railway: Alice Springs to Buchanan Highway

During a survey of the proposed route for the railway between Alice Springs and the Buchanan Highway, Smith (1997) identified two previously recorded (Mt Tops/Mt Octy Gap 1 and Mt Tops/Mt Octy Gap 2) and one newly identified (Mt Tops/Mt Octy Gap 3) artefact scatters within the vicinity of the rail corridor. These sites were located on the banks of ephemeral creeks, at the foot of two mountain ranges. Mt Tops/Mt Octy Gap 1 was a flaked and ground artefact scatter site on the

northern bank of an ephemeral creek, located within 50m either side of the pegged railway centreline at chainage 208.1. At the time it was originally documented in 1983, all stone artefacts visible on the ground surface, including a complete grindstone, were collected and lodged with the Northern Territory Museum. During the subsequent survey in 1997 no other artefacts were observed (Smith 1997:40).

Mt Tops/Mt Octy Gap 2 was an artefact scatter approximately 400x500m in size, situated on a flat sandy plain that extended along both sides of an ephemeral creek at chainages 208.6 to 209.1. The site extended 300m to the east and 100m to the west of the pegged centreline. The scatter contained flakes, retouched flakes, cores, grinding dish fragments and at least one anvil, pestle and tula slugs. Approximately 85% of the assemblage comprised chalcedony, with smaller quantities of quartz, chert, sandstone and silcrete. Artefacts were distributed in a clustered, discontinuous fashion, with the highest artefact densities on the north bank of the creek and the lowest on the graded railway survey line. At the time the sites was originally recorded, a representative sample of surface artefacts was made within a 50m corridor to either side of the pegged railway, and were lodged with the Northern Territory Museum. Owing to the high density (as many as 13/m²) of artefacts within the scatter, however, the recorders stressed that this collection represented a minimum sample of the total artefact assemblage. Smith concluded that:

Mt Tops/Mt Octy Gap 2 contains a relatively diverse assemblage of artefact and raw material types, and could therefore potentially be of great interest in any study of prehistoric settlement patterns and raw material transport within the region. While part of the site has been disturbed during construction of the railway survey line, the majority of the scatter remains intact. The site is regarded as possessing a high level of archaeological significance (Smith 1997:39).

Smith determined that a small proportion of the scatter would be destroyed as a result of the railway construction, and recommended that heavy earth moving machinery should not be permitted to operate more than 10m to either side of the pegged railway survey line at chainages 208.6 to 209.1. This would ensure that disturbance to the scatter was restricted to an area in which salvage artefact collections had been previously made and which had already been impacted by earth moving machinery (Smith 1997:39-40).

Mt Tops/Mt Octy Gap 3 was an artefact scatter approximately 130x130m in size on the banks of a shallow ephemeral creek, on a gently undulating sandplain more than 50m to the west of the pegged centreline at an undisclosed chainage. A line of low hills was visible several kilometres to the southeast of the scatter, and a fence line passed through the site at a bearing of 240°. Artefact types included flakes, retouched flakes, cores, tula slugs, hammer stones, grinding dish fragments and pestle fragments, the majority of which were manufactured from chalcedony with lesser quantities of quartz and sandstone. This site represented a type that was relatively common in the region (Smith 1997:41). While artefact densities ranged up to 7/m², artefacts occurred in densities of less than 0.5/m² across most of the site. An area of disturbance was identified in a 20m corridor along the fence line. Many of the flakes were quite small which, according to Smith, suggested that artefact manufacture was an important activity at the site (Smith 1997:40-41). The scatter was regarded as possessing a moderate level of significance.

5.2 Summary

According to the Heritage Branch, the limited number of identified Aboriginal and historic sites within the study area is reflective of a lack of archaeological investigation, rather than an absence of archaeological sites (D. Bensley pers. comm. 02/07/2015). Three Aboriginal artefact scatter sites have been previously identified in the study area, located on relatively flat sandy plains in close proximity to ephemeral creeks (Smith 1997:39-41). These results correlate with the body of archaeological and

academic research in the broader central desert region; where people tended to camp more frequently in close proximity to water, resources or vantage points (Napton & Greathouse 1985:95; Smith 1988:161; 2005:94; 2006:373; 2013:12). Groups moved transiently through the open countryside in search of water and food resources; and such sites are likely to be represented by smaller, background scatters and isolated, discarded artefacts.

5.2.1 Aboriginal Heritage Site Predictive Modelling

On the basis of the archaeological sites registered in the region and review of previous archaeological studies, the following conclusions can be drawn regarding the potential presence and location of Aboriginal heritage sites within the landscape of the study area:

- Open artefact sites usually appear as surface scatters of stone artefacts, in areas where vegetation is limited and ground surface visibility increases. Such scatters of artefacts are also often exposed by erosion, pastoral events such as stocking, and the creation of informal, unsealed vehicle access tracks and walking paths. There is potential for artefact scatters to be found in all environmental contexts and landforms, although larger and denser sites are predominantly located on the riverbanks and lower slopes facing watercourses, and on elevated ridgelines;
- Flat, open areas associated with the creeks and their resource-rich surrounds would have offered ideal camping areas to the Aboriginal inhabitants of the local area. Sites found here could include artefact scatters as well as isolated artefacts. Isolated artefacts may represent a single item discard event, or be the result of limited stone knapping activity. Isolated artefacts are also likely to be located on landforms associated with past Aboriginal activities, such as ridgelines and valley floors that would have provided ease of movement through the area;
- Culturally modified trees display scars resulting from the removal of bark or wood for cultural purposes, such as for the construction of canoes or shields, to mark the tree, or to gain access to food resources. Culturally modified trees may be present throughout the study area, in areas where remnant old growth vegetation survives;
- Where exposed rock surfaces and shelters occur in Grant Bluff and Central Mount Stuart sandstone geology, pigmented and engraved art sites, as well as grinding grooves may be present; and
- Discrete rock outcrops suitable for the manufacture of stone artefacts may also be located within the study area, in areas of suitable geology.

6 Physical Analysis

6.1 Survey Methodology

An archaeological survey of the study area was undertaken from 15 to 20 June 2015 by AM Consulting Project Manager Aboriginal Heritage and archaeologist Chris Langeluddecke and AM Consulting Project Officer and archaeologist Laressa Berehowyj. Aerial photographs and 1:250 000 Topographic maps were used to guide the survey, supplemented with handheld Global Positioning Systems (GPS) loaded with centreline data for the proposed haul road and pipeline design, and outlines of the mine site, camping area and rail siding site.

Given the size of the currently proposed project area, the targeted survey sought to sample landforms and environments across the project area, to test the results of the predictive modelling, inform the impact analysis, and allow development of heritage impact mitigation options. The purpose of the survey was to:

- Inspect a large proportion of the study area through targeted pedestrian and vehicular survey;
- Identify the location and extent of artefact scatter sites Mt Tops/Mt Octy Gap 2 and Mt Tops/Mt Octy Gap 3 previously identified within the study area;
- Record any Aboriginal or historic archaeological sites identified during the survey; and
- Identify any areas of potential Aboriginal or historic heritage sensitivity, and determine the likelihood of Aboriginal archaeological sites occurring within the proposed project areas.

Pedestrian transects were surveyed throughout the mine, camping and rail loading sites, focusing particularly on areas of ground surface exposure and in the vicinity of ephemeral watercourses or stone resources. The proposed route for the water pipeline was surveyed by vehicle, with targeted pedestrian survey of areas in close proximity to the Hanson River. Sections of the proposed haul road followed existing station tracks; where feasible, these areas were surveyed by vehicle. Two sections of haul road were located away from established tracks in dense scrub, particularly in the vicinity of the Djilbari Hill and Central Mount Stirling, and to the east of the Stuart Highway. Due to difficulties accessing the area, a representative sample of these latter areas was traversed by foot, and particular attention was paid to areas of exposed ground surface on sandplains, near waterholes, creeks and drainage lines, and in close proximity to stone outcrops (see Table 6.1 and Figure 6.1).

Where Aboriginal artefacts were encountered, notes were to be made regarding their type, size and material. In addition, descriptions of the site were to be recorded, including their environmental setting with details of any disturbance to archaeological material in the site's vicinity, and Australian Map Grid (AMG) coordinates were taken using Garmin Oregon 300 handheld GPS units. Photographs of the area, sites and artefacts identified were taken with Fujifilm Finepix H20 EXR digital cameras. A track log of the survey and plotted waypoints, recorded by the GPS, is provided in Figure 6.1.

For the purposes of this assessment, stone artefact sites were identified under two categories; isolated artefacts and artefact scatters. An isolated artefact is identified as a single artefact, located more than 50m from another artefact. An artefact scatter is defined as a collection of two or more artefacts within 50m of one another.

Table 6.1 Survey coverage table.

Survey Unit	Landform	Description	Approximate Distance/Area Surveyed
Pipeline	Flat, Lower Slopes, Banks	Proposed pipeline corridor from Wollagalong Bore to the mine site, passing Middle Well, Browns Yards and Boko Bore. The northern section follows the western bank of the Hanson River. Route traverses an existing stockyard access track.	35 km
Haul Road	Slopes, Valley, Flat	Proposed transport corridor between the mine site and the Alice Springs to Darwin railway, near Adnera. Proposed route passes to the east of Djilbari Hills, Mount Judith and Central Mount Stuart, and between Mount Tops and Mount Octy. Traverses existing tracks along fence lines, existing access roads, flat vegetated sandplain and vegetated undulating slopes/valley bottom.	65 km
Rail Siding	Flat	Proposed rail siding and load out facility on northern side of the railway line at Adnera, east of Mount Tops and Mount Octy. Traverses undeveloped ground.	1 km ²
Camp Site	Flat	Proposed camp site location in the vicinity of the eastern bank of the Murray Creek, beside two unnamed mountain peaks. Access track and clearings created during mining exploration activities; the western portion of the site is undeveloped.	1 km ²
Mine Site	Flat	Proposed mine site location on the western bank of the Murray Creek, containing a processing plant, two waste dump sites and mine pit. Access tracks and clearings created during mining exploration activities; the majority of the site is undeveloped.	1.5 km ²

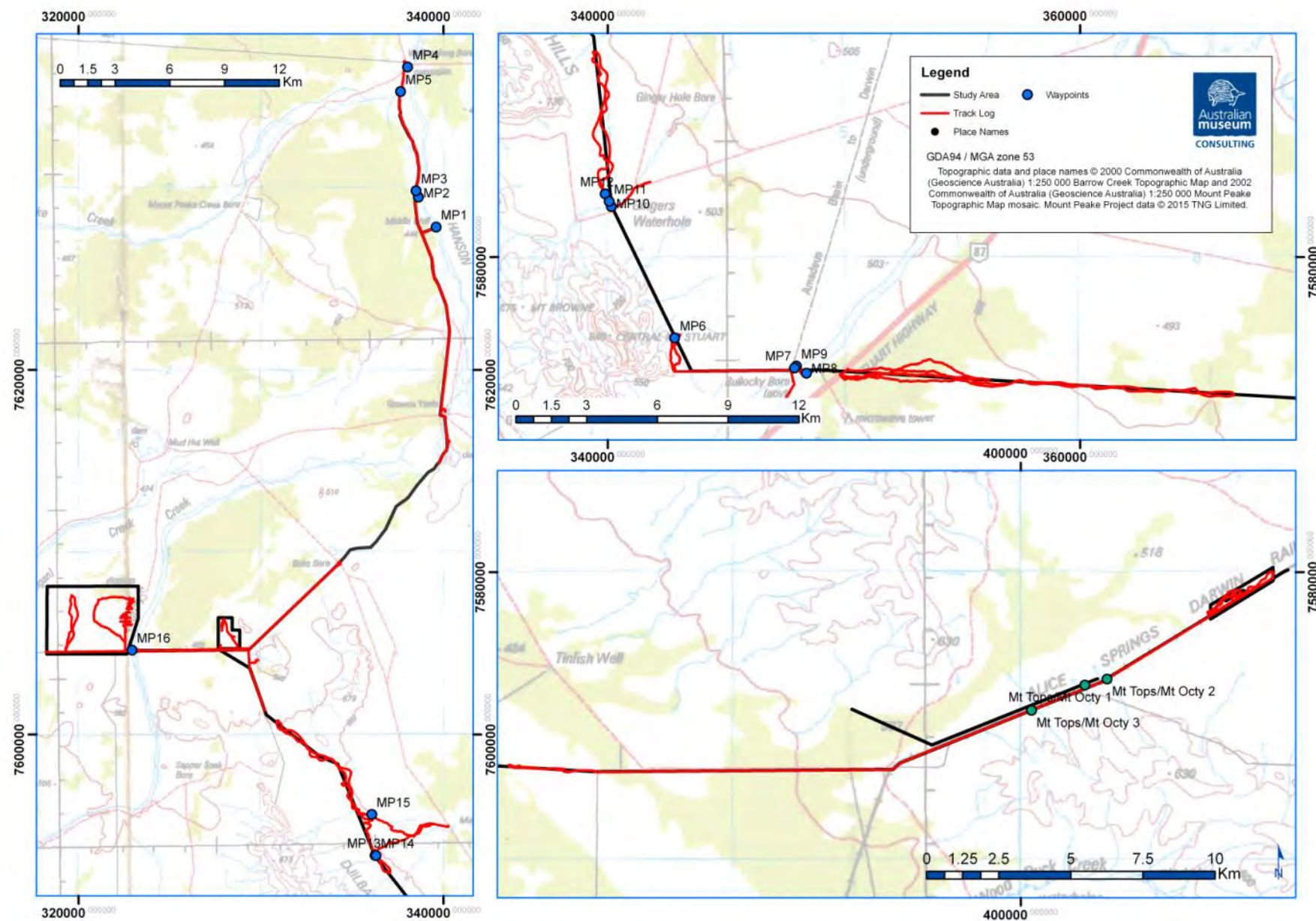


Figure 6.1 Track log and waypoint data recorded during archaeological survey.

6.2 Survey Results

No historic heritage sites or areas of potential archaeological deposit were identified within the study area, and 16 Aboriginal archaeological sites were identified. On the whole, ground surface visibility across the study area was high; the dominant ground cover was dispersed low spinifex grasses with large patches of exposed soil. These exposed surfaces are subject to deflation; a process that refers to the removal and transportation of dry unconsolidated sand and dust particles from the ground surface by wind (Pye 1987:142). To the east of the highway ground surface visibility was moderate to high; the dominant ground cover was low spinifex grassland with tracts of dense mulga, and in the vicinity of the junction between the railway and the haul road the dominant ground cover comprised low, prickly spinifex grass with isolated outcrops of limestone. To facilitate discussion, the study area has been broken up according to the five areas to be impacted as part of the proposed works.

6.2.1 Pipeline

The current route for the water pipeline follows an existing access track leading from Boko Bore to the Wollagalong Bore. Visibility along the access track was high; the track has been cleared of existing vegetation but does not appear to have been graded. The entire 42km length of access track for the pipeline corridor, minus an inaccessible sandy section between Boko Bore and the Browns Yards clay pan, was traversed by vehicle; and no Aboriginal sites or artefacts were identified. Pedestrian surveys of the clay pan area, the Boko Bore stockyards and a section of flat open sandplain in the vicinity of an unnamed peak revealed no evidence for Aboriginal occupation (Figure 6.2-Figure 6.5).



Figure 6.2 View south of the access track near Browns Yards, surveyed by vehicle.



Figure 6.3 View east to the clay pan near Browns Yards.



Figure 6.4 View southwest to Boko Bore stockyards.



Figure 6.5 View south to flat, open sandplain in the vicinity of an unnamed peak.

Between Browns Yards, Middle Well and the Wollagalong Bore, however, the proposed pipeline route traverses the western bank of the Hanson River. Here the survey involved pedestrian transects spaced 50-100m apart, focusing particularly on exposed ground surfaces on higher ground above the river. Aboriginal artefacts were located at five of the six transects surveyed; thus reinforcing the sensitive nature of the landscape in close proximity to the Hanson River. A total of five Aboriginal heritage sites were identified in the vicinity of the proposed pipeline alignment.

Mount Peake (MP) 1 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 339591E, 7627823N (centre point)

Landform: Flat/ River Bank

Site Size: 160m²

Exposure: Sparsely vegetated, deflated flat on western bank of Hanson River

Site Description:

Site MP1 is located on the western bank and lower slopes of the Hanson River, approximately 10m east of the Middle Well bore site clearing (see Figure 6.6). The area within the river bank and flat is sparsely treed and partially covered with low spinifex grasses, such that ground visibility was high (Figure 6.7-Figure 6.9). The current proposed pipeline route runs approximately 85m southwest of the site and is not likely to impact on the area.

The scatter comprises a total of 18 stone artefacts, visible on the eroding creek bank and on the flat above (Table 6.2). The site measures approximately 80x20m, and artefacts were observed on the river flat and moving down the eroding slopes of the river bank. Artefacts observed comprised quartzite and quartz materials. Notable artefacts were the distal end of a broken quartz flake, a small symmetrical leaf-shaped quartz flake with unifacial stepped retouch, a complete quartzite flake with parallel dorsal flakes and overhang removal, two angular quartzite fragments, the proximal end of a broken quartzite flake, and seven small quartz flakes (Figure 6.10-Figure 6.13). The artefact scatter was visibly denser along the banks of the river, and became increasingly more dispersed towards the bore.

The seasonally dry western bank of the river is well deflated, such that fine sand and dirt is being blown from the site (Figure 6.8). This does not however, preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

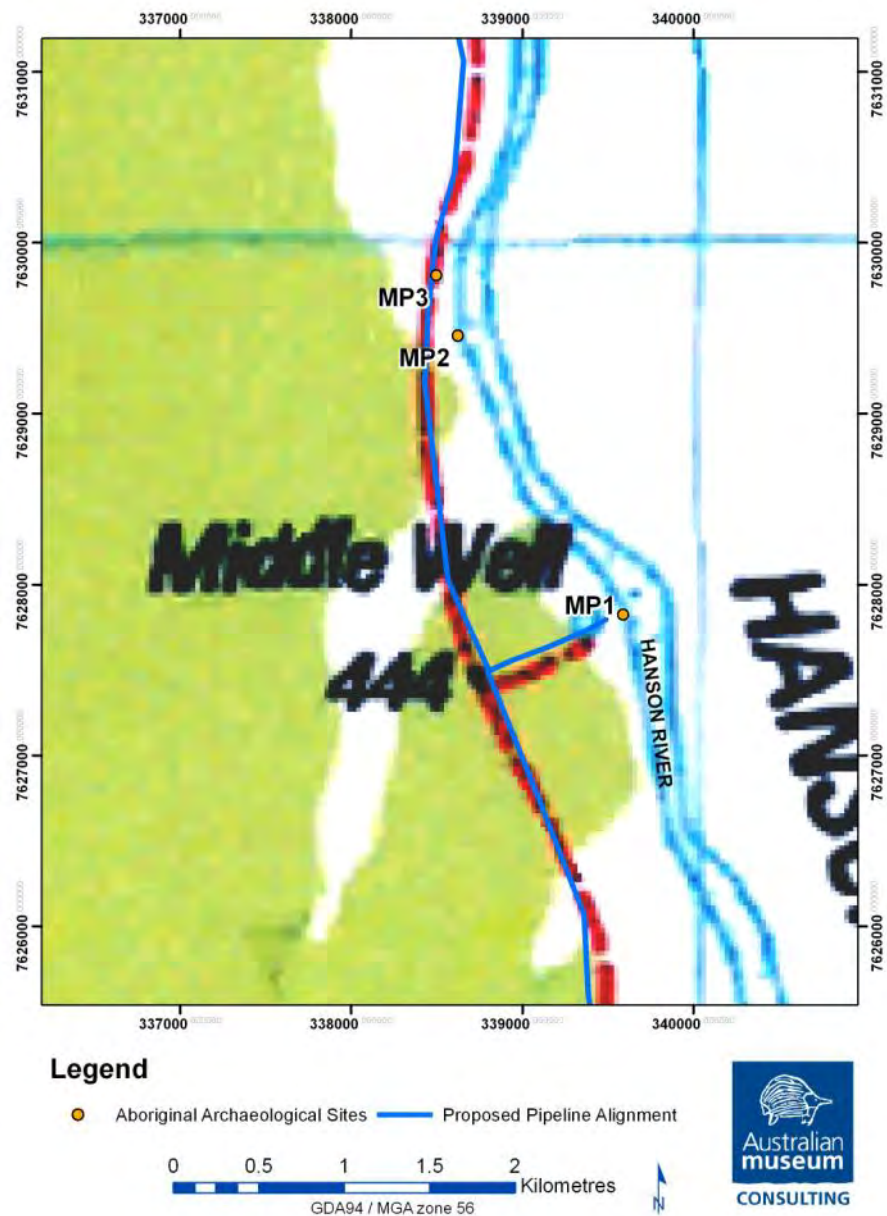


Figure 6.6 Detail of the location of Aboriginal heritage sites MP1, MP2 and MP3.

Table 6.2 Site MP1 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartz	White	19 x 23 x n/a	Distal Flake
Quartz	White	18 x 23 x n/a	Flake
Quartz	White	18 x 18 x n/a	Scraper
Quartz	White	15 x 16 x n/a	Flake
Quartz	White	10 x 8 x n/a	Flake
Quartz	White	10 x 7 x n/a	Flake
Quartz	White	25 x 12 x n/a	Flake
Quartzite	Tan	30 x 41 x n/a	Core
Quartzite	Dark Grey	20 x 76 x n/a	Flaked Piece
Quartzite	Dark Grey	29 x 27 x n/a	Flaked Piece
Quartzite	Brown	49 x 27 x n/a	Flake
Quartzite	Grey	28 x 22 x n/a	Flaked Piece
Quartzite	Grey	15 x 17 x n/a	Proximal Flake

Quartz	White	13 x 17 x n/a	Flake
Quartzite	Tan	44 x 42 x n/a	Flaked Piece
Quartzite	Tan	32 x 34 x n/a	Flaked Piece
Quartzite	Dark Grey	38 x 28 x n/a	Flake
Quartzite	Brown	22 x 27 x n/a	Flaked Piece



Figure 6.7 View northwest to MP1 from the Hanson riverbed.



Figure 6.8 View south to MP1. Note sparsely vegetated, well deflated bank of the Hanson River.



Figure 6.9 View northwest to Middle Well bore site, from edge of site MP1. The site extends to within 10m of the clearing.



Figure 6.10 Site MP1 quartzite and quartz artefacts.



Figure 6.11 Site MP1 quartz flake with unifacial retouch.



Figure 6.12 Site MP1 quartzite flake.



Figure 6.13 Site MP1 flaked quartzite piece.

MP2 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 338594E, 7629462N

Landform: Flat/ River Bank

Site Size: 25m²

Exposure: Flat, deflated clearing on the western bank of Hanson River

Site Description:

Site MP2 is located on the western bank of the Hanson River, approximately 1.9km northwest of MP1 (see Figure 6.6). The site is located within an approximately 5x5m relatively flat and open, partially deflated clearing, where ground surface visibility is high (Figure 6.14). The current proposed pipeline route passes 150m west of site MP2 and would not directly impact on the area.

The site comprises two stone artefacts on the open flat area, as well as three additional stone artefacts deposited in a disturbed context in the bed of the river (Figure 6.15). The three artefacts in the river bed are likely to have been transported from the bank or upriver during a period of inundation. MP2 artefacts were manufactured of quartzite and quartz. They consist of one crystal quartz flake, the proximal ends of broken quartzite and quartz flakes, a heat treated quartzite core and the distal end of a broken quartzite flake (Figure 6.16-Figure 6.17).

The open clearing is currently being impacted by wind erosion but this does not appear to be impacting the site. There remains the potential for the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sandy sediment.

Table 6.3 Site MP2 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartz	Crystal	26 x 18 x n/a	Flake
Quartzite	Brown	50 x 48 x n/a	Proximal Flake
Quartz	Yellow	21 x 24 x 18	Proximal Flake
Quartzite	Grey/Buf	19 x 24 x 11	Heat Treated Core
Quartzite	Tan	22 x 18 15	Distal Flake



Figure 6.14 View west of Site MP2 on deflated, open flat.



Figure 6.15 View north of alluvial deposit in the bed of the Hanson River, containing disturbed stone artefacts.



Figure 6.16 Quartz and quartzite flakes in flat, open ground, MP2.



Figure 6.17 Quartz flake, heat treated quartzite core and quartzite flake in alluvial deposit, MP2.

MP3 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 338498E, 7629811N (centre point)

Landform: Flat/ River Bank

Site Size: 80m²

Exposure: Flat, deflated open clearing on the western bank of Hanson River

Site Description:

Site MP3 is an artefact scatter located on the western bank of the Hanson River, approximately 375m northwest of MP2 (see Figure 6.6). The scatter is situated within a large, level and deflated open clearing, with high ground surface visibility (Figure 6.18-Figure 6.20). The current proposed pipeline route runs approximately 20m west of the site and, depending on the width of the corridor, has potential to impact the area.

The site comprises a total of twelve quartzite and quartz artefacts (Table 6.4). These included a quartzite multidirectional core, a quartzite flake, four small quartz flakes, a small quartzite bladelet and two quartz scrapers (Figure 6.21-Figure 6.23).

The open clearing is being impacted by deflation, such that finer sand and dirt is being blown from the site. This does not however, preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

Table 6.4 Site MP3 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartzite	Brown	33 x 48 x 22	Core
Quartzite	Dark Grey	15 x 17 x n/a	Distal Flake
Quartzite	Brown	44 x 30 x n/a	Core
Quartz	White	24 x 14 x n/a	Flake
Quartzite	Light Grey	20 x 10 n/a	Bladelet
Quartz	White	11 x 16 x n/a	Thumbnail Scraper
Quartz	White	8 x 15 x n/a	Flake
Quartz	White	7 x 15 x n/a	Flake
Quartzite	Red	13 x 19 x n/a	Flake
Quartz	Crystal	17 x 15 x n/a	Flake
Quartz	White	13 x 15 x n/a	Distal Flake
Quartz	White	25 x 34 x n/a	Scraper



Figure 6.18 Site MP3, located in a flat deflated clearing on the western bank of the Hanson River. View to south.



Figure 6.19 Site MP3, located in a flat deflated clearing on the western bank of the Hanson River. View to north.



Figure 6.20 Evidence of erosion and deflation impacts at Site MP3



Figure 6.21 Site MP3 quartz and quartz artefacts.



Figure 6.22 Site MP3 quartz and quartz artefacts.



Figure 6.23 Site MP3 quartz artefact..

MP4 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 338031E, 7636588N (centre point)

Landform: Flat/ River Bank

Site Size: 20m²

Exposure: Flat, partially deflated open clearing on the western bank of Hanson River

Site Description:

Site MP4 is located on the western bank of the Hanson River, to the east and southeast of the Wollagalong Bore stock yards (see Figure 6.24). Like the majority of other sites along the banks of the river, MP4 is situated in a large, open and partially deflated clearing, where ground surface visibility was high (Figure 6.25). Site MP4 is located 1.8km northeast of the endpoint of the proposed pipeline corridor, and would not be impacted by the works.

Two broken quartzite flakes were identified within a 20m² clearing along the river flat (Figure 6.26- Figure 6.27). The open clearing is being impacted by deflation, such that finer sand and dirt is being blown from the site. This does not however, preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment. No visible animal disturbance was observed across the site, though it was noted that the site was located in close proximity to existing stock yards.

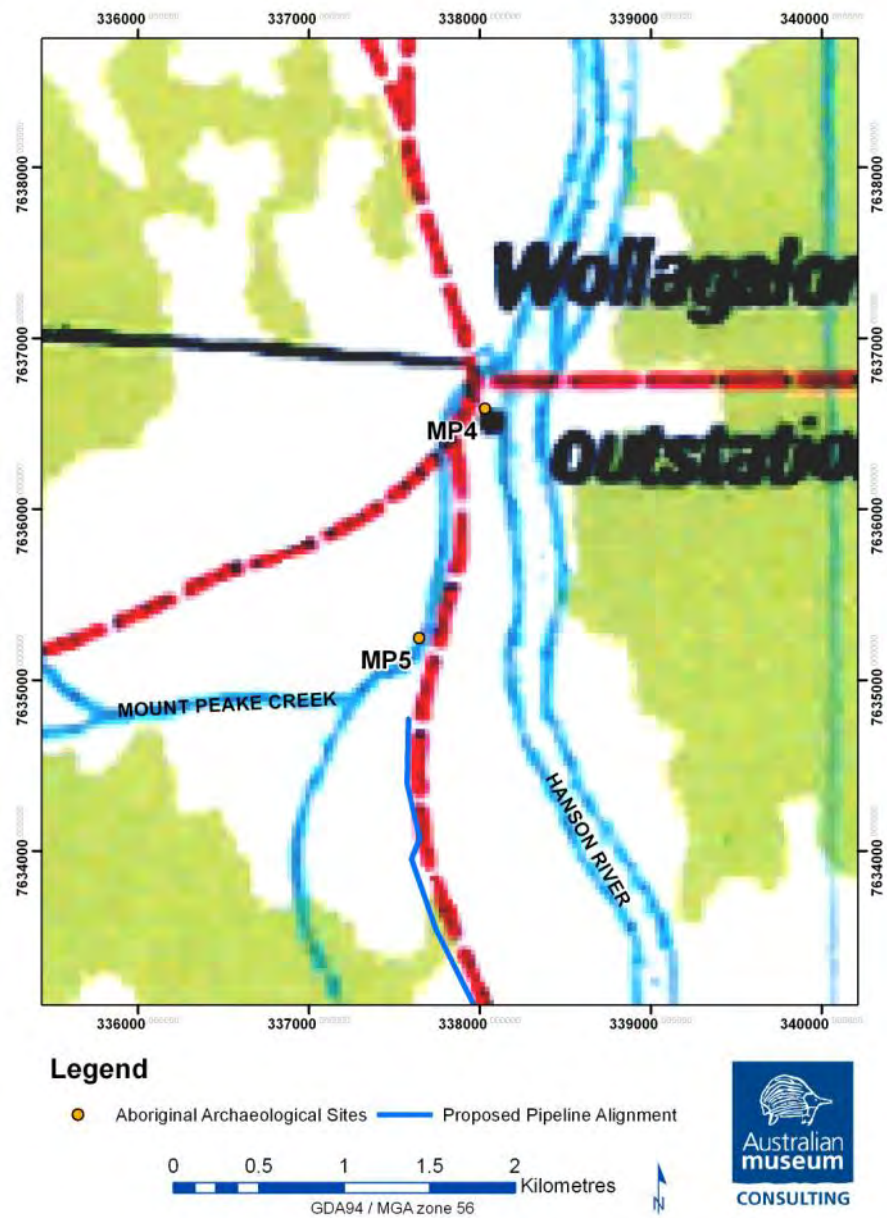


Figure 6.24 Detail of the location of Aboriginal heritage sites MP4 and MP5.

Table 6.5 Site MP4 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartzite	Dark Grey	46 x 52 x n/a	Medial Flake
Quartzite	Tan	49 x 36 x n/a	Flake



Figure 6.25 View northwest to Site MP4 on partially deflated open river flat.



Figure 6.26 Site MP4 quartzite flake.



Figure 6.27 Site MP4 quartzite flake.

MP5 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 337647E, 7635247N (centre point)

Landform: Flat/ River Bank

Site Size: 44m²

Exposure: Eroding, deflated banks of an ephemeral creek; a tributary of Hanson River

Site Description:

Site MP5 is located along the confluence of two unnamed tributaries and lower order streams of the Hanson River (see Figure 6.24 and Figure 6.28-Figure 6.29). Where the tributary crosses the dirt access track, the roadway caused the creek's eastern bed to silt up. A unidirectional silcrete core with approximately 25% cortex was found on the northern bank near the crossing, approximately 10m east of the access track (337668E, 7635243N). A further 44m west, on the southern bank of the creek approximately 22m west of the access track, a mudstone thumbnail scraper was found (337625E, 7635252N; Figure 6.24). The current proposed pipeline route ends approximately 475m southwest of site MP5, and would not directly impact on the area.

While the soil profile is relatively stable to the east of the access track, the creek banks on the western side of the access track are being impacted by extensive erosion. It is unclear whether the mudstone scraper has eroded from *in situ* archaeological deposits in the creek bank or was moving down the eroding, deflated slope from the ridge above. No other artefacts were observed within the vicinity of the ephemeral creek.

Table 6.6 Site MP5 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Silcrete	Orange	34 x 26 x n/a	Core
Mudstone	Buff	17 x 18 x n/a	Thumbnail Scraper



Figure 6.28 View west to site MP5, approximately 10m east of the dirt access track. The ephemeral creek flows perpendicular to the track.



Figure 6.29 View south to mudstone artefact at site MP5, circled, taken from the bed of the ephemeral creek.



Figure 6.30 Silcrete core at site MP5.

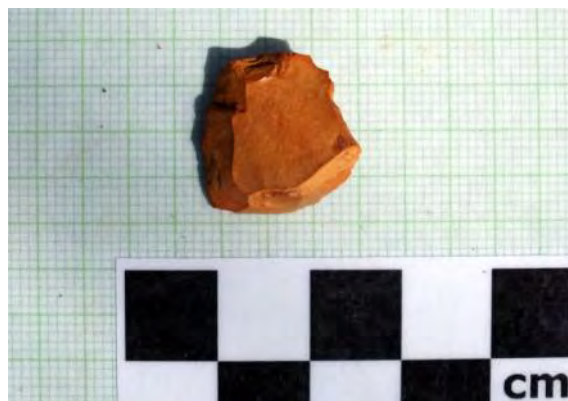


Figure 6.31 Mudstone scraper at MP5.

MP16 – Isolated Find

Location: GDA 1994 MGA Zone 53; 322940E, 7604635N

Landform: Lower Slope/ River Bank

Site Size: n/a

Exposure: Small exposure on the lower slopes of the western bank of Murray Creek

Site Description:

Site MP16 is located on the lower slopes of the western bank of the Murray Creek; 12m north of the current proposed pipeline and 220m east of the easternmost edge of the mine site area (see Figure 6.32). The site may be indirectly impacted by construction of the pipeline.

The western bank of the creek line is somewhat overgrown with long but dispersed spinifex grass; though patches of exposed ground surface are visible. The site is situated within a roughly 3x2m area of exposed sand, and comprises one quartzite scraper (Figure 6.33-Figure 6.34). Camel tracks were identified throughout the site area.

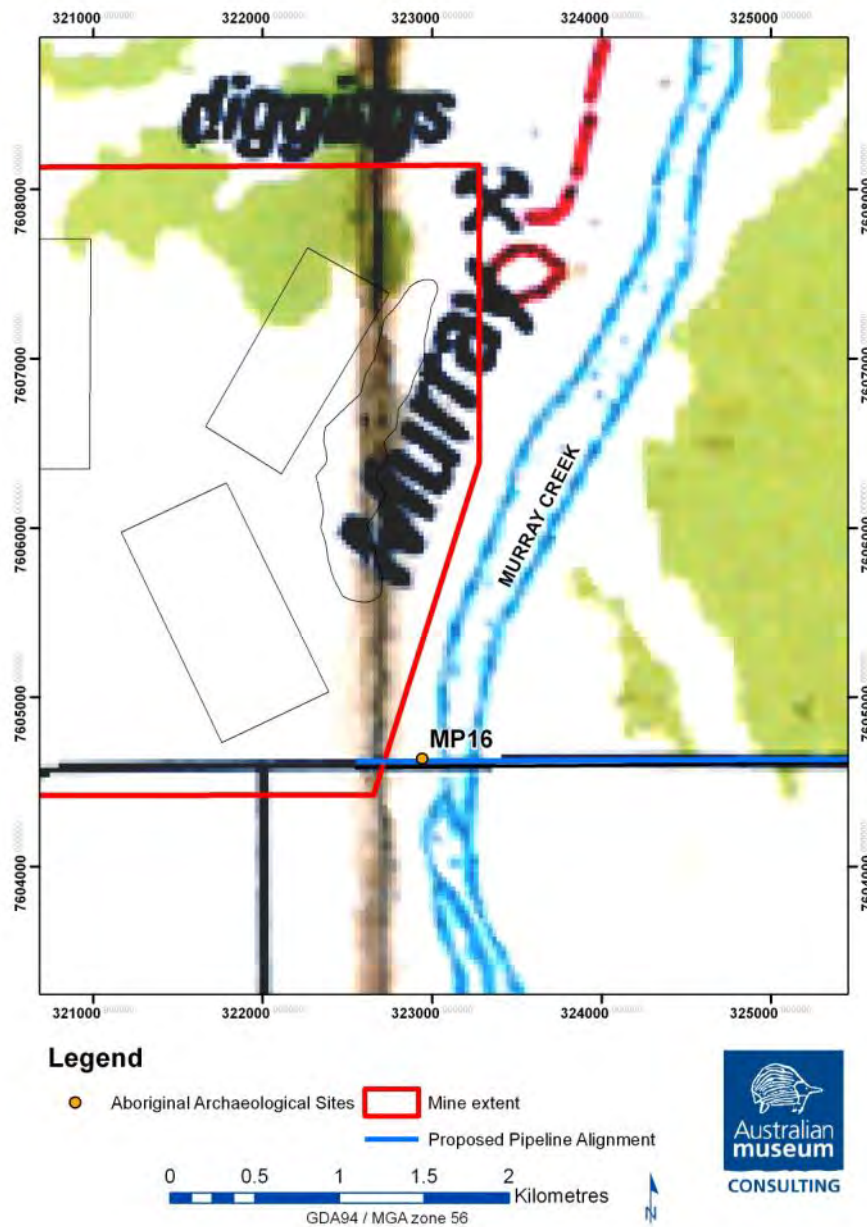


Figure 6.32 Detail of location of Aboriginal heritage site MP16.

Table 6.7 Site MP16 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartzite	Tan	35 x 45 x n/a	Scraper



Figure 6.33 View east to site MP16 (circled), on the lower slope/river bank of the Murray Creek.



Figure 6.34 Ventral surface of a quartzite flake from site MP16.

6.2.2 Haul Road

Sections of the proposed route for the Haul Road also follow existing access tracks, as well as corridors of cleared land along fence lines (Figure 6.35-Figure 6.36). Visibility was unimpeded along the cleared access track sections of the Haul Road, and no Aboriginal sites or artefacts were identified at these sites during the vehicular survey. Neither sites Mt Tops/Mt Octy 2 nor Mt Tops/Mt Octy 3 were located during the survey, and may have been partially destroyed during construction of the Alice Springs-Darwin railway.

In the vicinity of Central Mount Stuart, Djilbari Hills and the western portion of Stirling Station between the microwave tower and Tinfish Well, the Haul Road traverses natural, undeveloped landscapes (Figure 6.37-Figure 6.38). Vehicular access to the undisturbed areas of land was made difficult due to dense tree cover, multiple creek crossings and undulating terrain; therefore pedestrian survey was required. This severely limited the extent to which the landscape could be surveyed, therefore a decision was made to concentrate on areas identified in the predictive model as having potential to contain archaeological sites, in order to obtain an effective archaeological sample of the study area. Denser patches of scrub opened up to tracts of low spinifex country; thus ground surface visibility in these areas was generally high. Aboriginal archaeological sites were identified at five of the six transects surveyed in the vicinity of the Djilbari Hills and Central Mount Stuart, especially in close proximity to prominent vantage points, potential stone resources and ephemeral watercourses. In contrast, no artefacts were identified along an 8km transect of the Haul Road between the Microwave tower and Tinfish Well (Figure 6.39-Figure 6.41). This flat, densely vegetated landscape with limited water resources was likely used less frequently by Aboriginal people as a transport corridor and is less likely to retain archaeological evidence for Aboriginal occupation.



Figure 6.35 View west to Central Mount Stuart along cleared track adjacent to fence line.



Figure 6.36 View west of the access track running parallel to the Alice Springs to Darwin Railway, near Adnera.



Figure 6.37 View west of the undulating sandplain valley near Central Mount Stuart. Notice stone scree littering the floor of the valley, bottom of image.



Figure 6.38 View northeast of densely treed flat sandplain interspersed with ephemeral creeks, at the foot of the Djlbari Hills.



Figure 6.39 View north to haul road on eastern side of the Stuart Highway, taken from a vantage point at the Microwave tower.



Figure 6.40 View southeast of flat sandplain to the east of the highway, characterised by open tracts of low spinifex and patches of dense scrub.



Figure 6.41 View west along proposed route for Haul Road, 3.3km south of the Tinfish Well stockyards.

MP6 – Isolated Find

Location: GDA 1994 MGA Zone 53; 342838E, 7576572N

Landform: Flat/Creek bank

Site Size: n/a

Exposure: Open, deflated flat sparsely vegetated with low spinifex grass

Site Description:

Site MP6 is located at the base of an undulating valley between Central Mount Stuart and an unnamed low stony rise (see Figure 6.42). The majority of the surrounding sandplain is covered by low spinifex grass and mulga, as well as scree from the surrounding formations. This scree had accumulated on the slopes and at the base of hills and on valley floors as a result of rock fall, limiting ground surface visibility. The current proposed haul road route runs approximately 25m to the northwest of site MP6, and, depending on the width of the Haul Road route, may indirectly impact the site.

An isolated silcrete flake with a crushed platform and less than 25% cortex was found in a relatively flat and well deflated clearing devoid of scree, on the southern bank of an ephemeral creek. No other artefacts were observed in the site's vicinity, however, and it is considered unlikely that the site has potential to retain sub-surface *in situ* archaeological deposits.

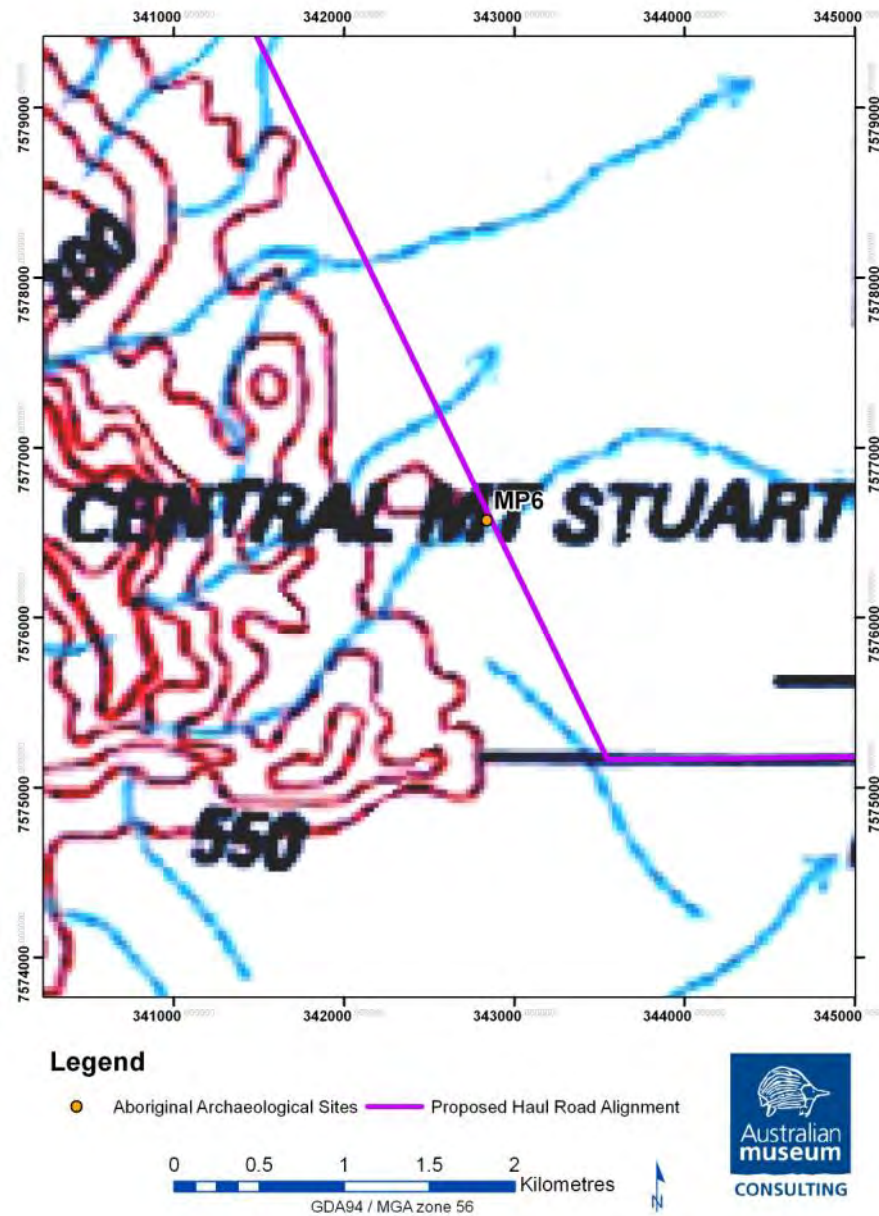


Figure 6.42 Detail of location of Aboriginal heritage site MP6.

Table 6.8 Site MP6 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Silcrete	Orange	47 x 44 x 28	Flake

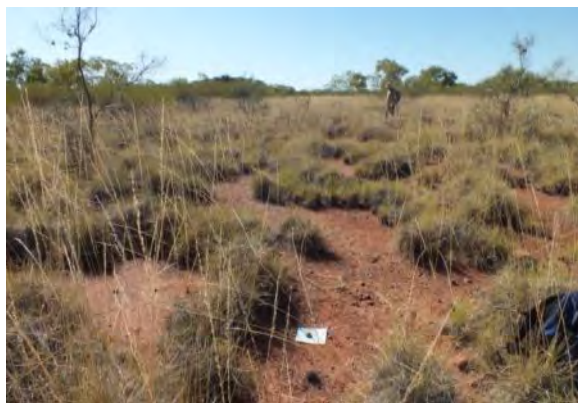


Figure 6.43 View east to Site MP6.



Figure 6.44 Silcrete flake, dorsal surface, site MP6.

MP7 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 347906E, 7575295N (centre point)

Landform: Flat/ River Bank

Site Size: 311m²

Exposure: Flat, open and well deflated bank of Hanson River

Site Description:

Site MP7 is located on the western bank of the Hanson River; 225m to the east of the Amadeus gas pipeline and approximately 1.25km northeast of Bullocky Bore (see Figure 6.45). The area within the river bank is flat, sparsely treed and partially covered with low spinifex grasses, such that ground visibility was high (Figure 6.46-Figure 6.47). The site covers an area of approximately 311m, with artefact concentrations located 71m northeast, 44m northwest and 71m southwest of the centre point. The current proposed route for the Haul Road passes between 50-100m south of MP7, such that the site is unlikely to be impacted during the works.

A total of 32 stone artefacts were recovered from the site, and were predominantly manufactured of quartz, quartzite and silcrete (Table 6.9). While two silcrete and quartzite cores were found, the majority of artefacts were flakes (Figure 6.48-Figure 6.51). This included six quartz scrapers, three quartzite scrapers and a red/yellow quartz flake.

The seasonally dry western bank of the river is well deflated, such that finer sand and dirt is being blown from the site. The eastern margin of the site is currently being impacted by erosion and flooding from the adjacent river, which has resulted in the likely transportation, reworking and deposition of alluvial material and some surface artefacts. These factors do not however, preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

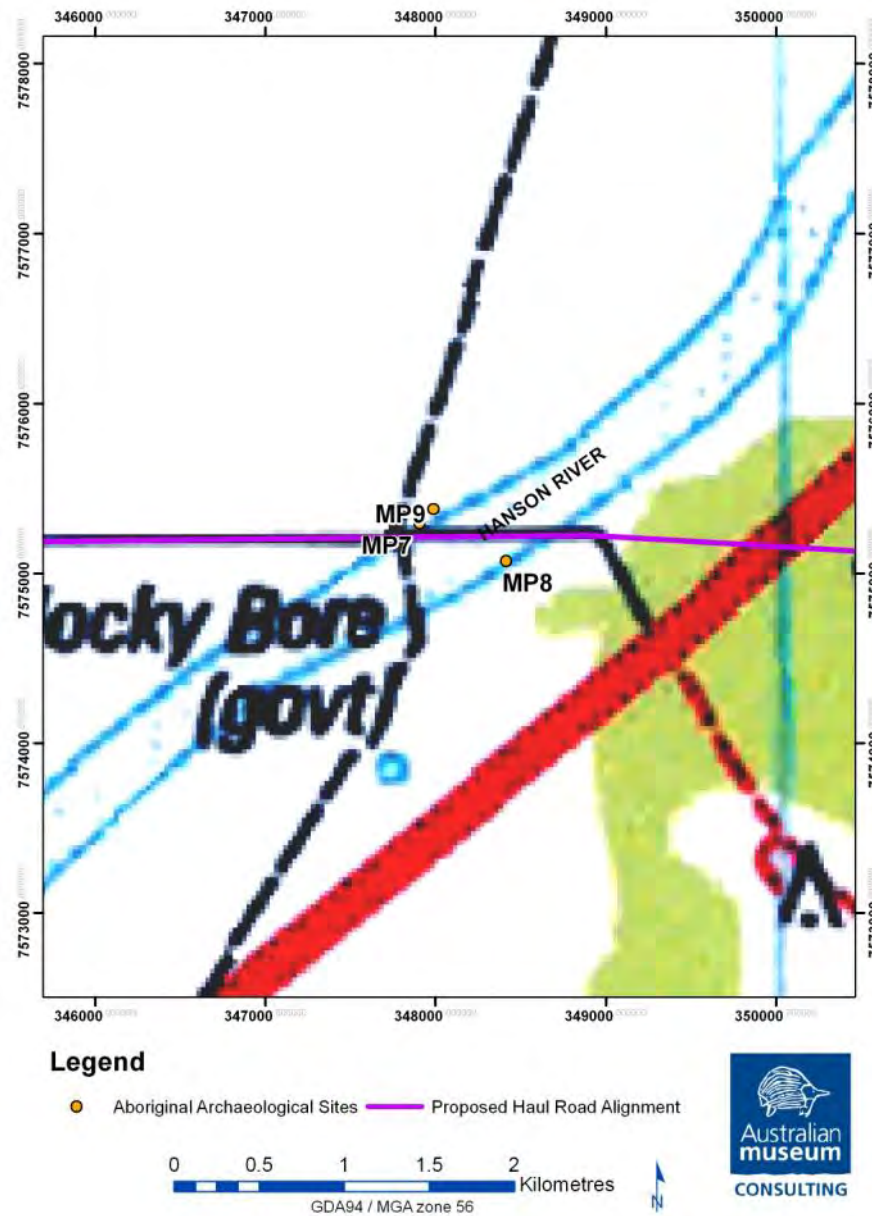


Figure 6.45 Detail of the location of Aboriginal heritage sites MP7, MP8 and MP9.

Table 6.9 Site MP7 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartz	Crystal	11 x 11 x n/a	Medial Flake
Quartzite	Tan	20 x 15 x n/a	Scraper
Quartz	White	18 x 22 x n/a	Proximal Flake
Quartz	Crystal	26 x 15 x n/a	Scraper
Quartz	Crystal	22 x 11 x n/a	Scraper
Quartz	Crystal	19 x 14 x n/a	Flake
Quartz	Crystal	17 x 8 x n/a	End Scraper
Quartz	Crystal	15 x 16 x n/a	Scraper
Quartz	Crystal	11 x 24 x n/a	Flake
Quartz	Crystal	11 x 13 x n/a	Flaked Piece
Quartz	Crystal	26 x 15 x n/a	Flake
Quartz	Crystal	21 x 16 x n/a	Scraper
Silcrete	Red/Yellow	26 x 24 x n/a	Heat Treated Core

Silcrete	Tan	13 x 15 x n/a	Scraper
Silcrete	Tan	16 x 20 x n/a	Distal Flake
Quartz	Crystal	19 x 9 x n/a	Flake
Quartz	Crystal	14 x 20 x n/a	Distal Flake
Quartz	Crystal	14 x 22 x n/a	Distal Flake
Quartz	Crystal	7 x 5 x n/a	Flake
Quartz	Crystal	35 x 14 x n/a	Flake
Quartz	Crystal	19 x 17 x n/a	Flake
Mudstone	Buff	16 x 23 x n/a	Scraper
Quartzite	Tan	22 x 27 x n/a	Flake
Quartzite	Dark Grey	50 x 38 x n/a	Core
Quartz	Crystal	10 x 15 x n/a	Scraper
Quartz	Crystal	15 x 19 x n/a	Scraper
Quartz	Crystal	17 x 24 x n/a	Flake
Quartz	Crystal	19 x 24 x n/a	Flake
Quartzite	Dark Grey	26 x 17 x 7	Scraper
Quartzite	Dark Grey	17 x 27 x 5	Scraper
Quartz	Red/Yellow	21 x 10 x n/a	Flake
Quartz	Crystal	13 x 14 x n/a	Flaked Piece



Figure 6.46 View southwest to MP7, western extent.



Figure 6.47 View northeast to MP7, eastern extent.



Figure 6.48 Site MP7 quartzite, quartz and silcrete artefacts.



Figure 6.49 Site MP7 quartzite, quartz and silcrete artefacts.



Figure 6.50 Site MP7 quartzite, quartz and silcrete artefacts.



Figure 6.51 Site MP7 quartzite, quartz and silcrete artefacts.

MP8 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 348415E, 7575377N (centre point)

Landform: Upper Slope/Crest

Site Size: 373m²

Exposure: Sparsely vegetated, partially deflated open upper slope and crest of Hanson River

Site Description:

Site MP8 is located approximately 555m southeast of Site MP7, on the upper slopes and crest of the eastern bank of the Hanson River in the vicinity of Bullocky Bore (see Figure 6.45). The area within the eastern river bank is open, partially deflated and sparsely covered with low spinifex grasses, with high ground visibility. The current proposed Haul Road route runs between 95-200m north of Site MP8, and is not likely to impact on the area.

The site comprises a total of 13 stone artefacts, found on the upper slopes and crest of the eastern river bank (Table 6.10). The site covers an area of approximately 373m, with the most dense artefact concentration located 15m northeast of the centre point. Artefacts observed comprised quartz and quartzite flakes and scrapers, as well as a sandstone hammer stone with visible pitting. Some deflation of the upper slope and crest has occurred as a result of sparse cover, though this process is unlikely to have significantly disturbed any subsurface *in situ* archaeological deposits. Surface artefacts from site MP8 do not appear to be being impacted by cattle movement, though cattle were observed in the vicinity of the western river bank during the archaeological survey.

Table 6.10 Site MP8 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartzite	Tan/Grey	49 x 42 x n/a	Flake
Quartz	Crystal	13 x 21 x n/a	Medial Flake
Sandstone	Brown	118 x 95 x 62	Hammer stone
Quartz	White	16 x 15 x n/a	Scraper
Quartz	White	15 x 24 x n/a	Flake
Quartzite	Tan/Grey	20 x 31 x n/a	Flake
Quartz	Orange	24 x 19 x n/a	Distal Flake
Quartz	White	30 x 22 x n/a	Flake
Quartz	Pink	32 x 19 x n/a	End Scraper
Quartz	White	25 x 13 x n/a	Flake
Quartz	White	21 x 14 x n/a	Distal Flake
Quartz	Crystal	10 x 20 x n/a	Flaked Piece
Quartz	Crystal	15 x 17 x 3	Scraper



Figure 6.52 View north to site MP8, from the crest of the eastern bank of the Hanson River.



Figure 6.53 View west to site MP8, along the crest and upper slopes of the eastern bank of the Hanson River.



Figure 6.54 Site MP8 artefacts, comprising quartz and quartzite flakes.



Figure 6.55 Sandstone hammer stone identified at Site MP8.



Figure 6.56 Site MP8 artefact.

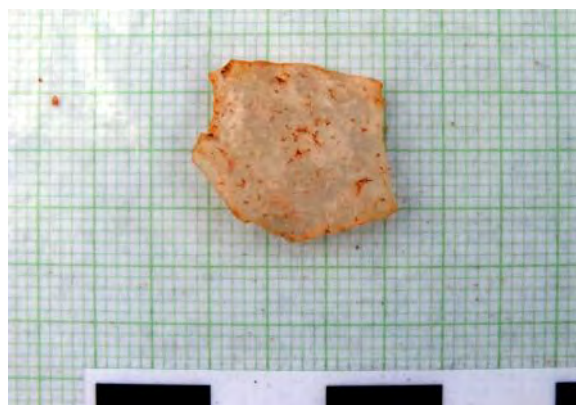


Figure 6.57 Site MP8 quartz flake artefact.

MP9 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 347988E, 7575373N

Landform: Flat/ River Bank

Site Size: 200m²

Exposure: Flat open sandplain devoid of ground cover

Site Description:

Site MP9 is located on the western bank of the Hanson River, approximately 115m northeast of the centre point for artefact scatter site MP7, and 520m northwest of the centre point for site MP8 (see Figure 6.45). Site MP9 is located approximately 50m from the river bank, in a large, 20x10m eroded

flat open clearing with high ground surface visibility (Figure 6.58). The current proposed Haul Road route runs 160m to the south of site MP9, and is unlikely to directly impact on the area.

A total of 18 mudstone, quartzite, quartz and silcrete artefacts were identified within the eroded area (Table 6.11). Artefacts were predominantly mudstone and quartzite, with smaller proportions of quartz and silcrete (Figure 6.59). The majority of the artefacts observed were flakes and scrapers, which included two mudstone thumbnail scrapers. Artefacts were recovered from a small triangular sample area 14x6x8m in size, in the south-eastern corner of the open clearing, though it is likely that the entire clearing contains Aboriginal artefacts.

The site is currently being impacted by both wind and water erosion as a result of its flat, open nature. These aeolian and alluvial processes have both deposited and eroded fine sands to varying degrees across the site, and are likely to have both exposed and buried artefacts. It is likely that subsurface *in situ* archaeological deposits may be present at the site.

Table 6.11 Site MP9 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartz	Crystal	13 x 19 x n/a	Scraper
Mudstone	Orange	19 x 27 x n/a	Flake
Mudstone	Buff	23 x 21 x n/a	Scraper
Quartzite	Tan	18 x 11 x n/a	Flaked Piece
Quartzite	Tan	23 x 9 x n/a	Flaked Piece
Quartz	Crystal	17 x 12 x n/a	Flake
Mudstone	Buff	15 x 11 x n/a	Thumbnail Scraper
Quartzite	Tan	23 x 16 x n/a	Scraper
Quartz	Crystal	27 x 16 x n/a	Flake
Mudstone	Buff	11 x 11 x n/a	Thumbnail Scraper
Mudstone	Buff	12 x 18 x n/a	Distal Flake
Quartz	White	22 x 14 x n/a	Flake
Silcrete	Tan	16 x 19 x n/a	Proximal Flake
Quartzite	Light Grey	14 x 16 x n/a	Scraper
Quartz	Crystal	23 x 20 x n/a	Proximal Flake
Quartz	Crystal	17 x 19 x n/a	Flake
Mudstone	Buff	14 x 14 x n/a	Flaked Piece
Mudstone	Buff	18 x 25 x n/a	Flake



Figure 6.58 View north to site MP9, from western bank of the Hanson River.



Figure 6.59 Mudstone, quartzite, quartz and silcrete artefacts sampled from site MP9.

MP10 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 340146E, 7582138N* (centre point)

Landform: Lower Slope/Creek Bank

Site Size: 43m²

Exposure: Open, sparsely vegetated lower slope of southern bank of an unnamed creek

Site Description:

Site MP10 is located approximately 55m north of an unsealed access track between Mount Browne and Djilbari Hills, and 1km southwest of Ginger's Waterhole (see Figure 6.60). The site is located on the lower slopes of the southern bank of an unnamed creek, at the foot of Central Mount Stuart. The area within the creek line is sparsely vegetated by low spinifex grass and small low shrubs, with high ground surface visibility (Figure 6.61). The current proposed Haul Road route runs approximately 25m to the east of site MP10, and, depending on the width of the road, may impact the site.

The site comprises a total of 25 stone artefacts on the lower slope of the creek bank (Table 6.12). The majority of artefacts were manufactured from mudstone, quartzite, silcrete and chert; one small quartz flake was recovered. Artefact types included a bidirectional chert core with parallel flake scars and flaked platforms, a large chert flake with 25% cortex, one silcrete and one chert chopper or axe, one mudstone blade, a mudstone backed blade and a mudstone bladelet, and a mudstone scraper (Figure 6.62-Figure 6.65).

Some deflation of the lower slope of the creek bank has occurred as a result of sparse cover, though this process is unlikely to have significantly disturbed any subsurface *in situ* archaeological deposits. The site retains the potential for subsurface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

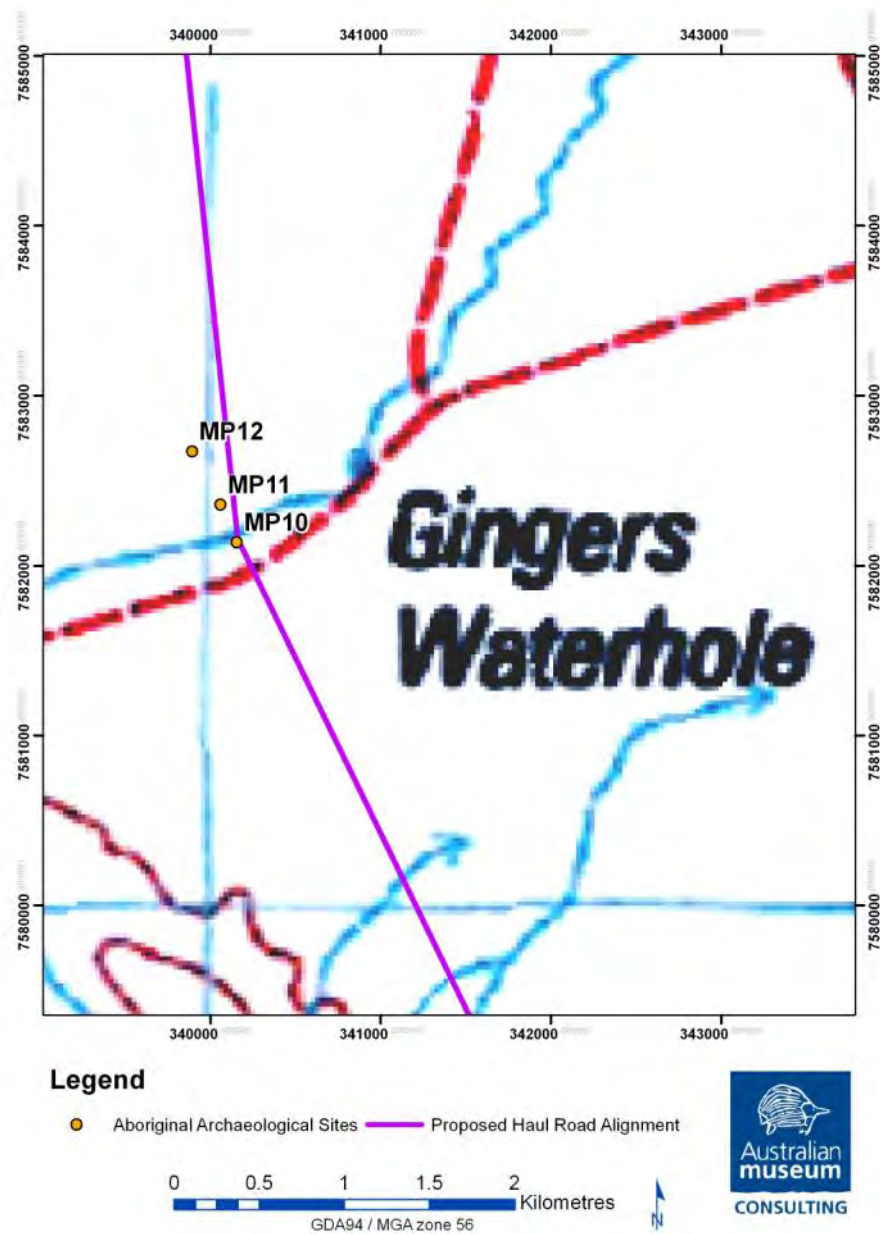


Figure 6.60 Detail of the location of Aboriginal heritage sites MP10, MP11 and MP12.

Table 6.12 Site MP10 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Chert	Dark Grey	61 x 48 x n/a	Flake
Quartzite	Tan	30 x 42 x n/a	Scraper
Mudstone	Buff	30 x 37 x n/a	Scraper
Quartzite	Light Grey	36 x 23 x n/a	Flake
Quartz	White	35 x 17 x n/a	Flake
Quartzite	Light Grey	32 x 32 x n/a	Flake
Mudstone	Buff	26 x 20 x n/a	Core
Mudstone	Buff	17 x 16 x n/a	Flake
Chert	Dark Grey	45 x 51 x 29	Core
Silcrete	Dark Grey	53 x 24 x n/a	Chopper/ Axe
Silcrete	Tan	30 x 35 x n/a	Core
Silcrete	Tan	43 x 50 x n/a	Core
Chert	Dark Grey	42 x 30 x n/a	Flake
Chert	Dark Grey	80 x 43 x n/a	Chopper/ Axe
Mudstone	Buff	19 x 10 x n/a	Flaked Piece
Mudstone	Buff	34 x 13 x n/a	Blade
Chert	Dark Grey	20 x 15 x n/a	Medial Flake
Quartzite	Brown	23 x 13 x n/a	Distal Flake
Quartzite	Dark Grey	18 x 30x n/a	Proximal Flake
Mudstone	Buff	19 x 11 x n/a	Bladelet
Mudstone	Tan	9 x 8 x n/a	Flake
Mudstone	Buff	23 x 13 x n/a	Proximal Flake
Mudstone	Buff	37 x 15 x n/a	Backed Blade
Quartzite	Dark Grey	38 x 24 x n/a	Flake
Mudstone	Buff	15 x 22 x n/a	Scraper



Figure 6.61 View northwest to MP10 from access track, on lower slope of unnamed creek bank.



Figure 6.62 Site MP10 bidirectional chert core.



Figure 6.63 Site MP10 chert, silcrete and quartz flakes.



Figure 6.64 Site MP10 silcrete and chert choppers/axes and flakes.



Figure 6.65 Site MP10 mudstone and chert flakes, blades, bladelet and scraper.

MP11 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 340060E, 7582359N

Landform: Flat

Site Size: n/a

Exposure: Open flat sparsely vegetated with low spinifex grass

Site Description:

Site MP11 is located 240m northwest of site MP10 and more than 200m north of the banks of an unnamed ephemeral creek, in the vicinity of Ginger's Waterhole (see Figure 6.60). The site is located in an open and level plain with sparse tree cover, and has high ground surface visibility (Figure 6.66). The area has distant views to the creek to the south and to Mount Judith to the west. The site is located 78m west of the current proposed Haul Road alignment, and is therefore unlikely to be impacted.

Three stone artefacts were recovered from the site (Table 6.13). These included a quartzite scraper with unifacial retouch, a quartz thumbnail scraper and a chalcedony core (Figure 6.67). No visible erosional or animal disturbance was observed across the site.

Some deflation of the sandplain has occurred as a result of sparse cover, though this process is unlikely to have significantly disturbed any subsurface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

Table 6.13 Site MP11 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartzite	Buff	20 x 12 x n/a	Scraper
Quartz	Crystal	10 x 10 x n/a	Thumbnail Scraper
Chalcedony	White	22 x 18 x n/a	Core



Figure 6.66 View west of site MP11, Mount Judith in background.

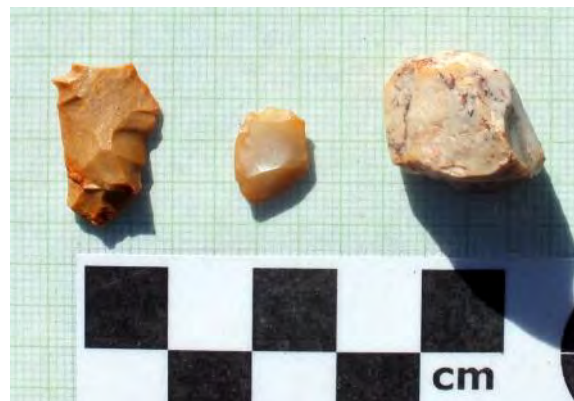


Figure 6.67 Site MP11 quartzite, quartz and chalcedony artefacts.

MP12 – Isolated Artefact

Location: GDA 1994 MGA Zone 53; 339892E, 7582673N

Landform: Flat

Site Size: n/a

Exposure: Open flat sparsely vegetated with low spinifex grass

Site Description:

Site MP12 is located 355m northwest of site MP11 and 545m northwest of the banks of the ephemeral creek, in the vicinity of Ginger's Waterhole (see Figure 6.60). Like MP11, site MP12 is located in a large open, level plain with sparse tree cover, and has high ground surface visibility (Figure 6.68-Figure 6.69). The area has distant views to the ephemeral creek to the south and to Mount Judith to the west. The site is located 213m west of the current proposed Haul Road alignment, and is therefore unlikely to be impacted.

The site comprises one isolated mudstone artefact. The artefact is a flake/core with less than 25% cortex, negative flake scars and bifacial retouch along its distal end (Figure 6.70-Figure 6.71). No other artefacts were identified within an area of 40 square metres.

Some deflation of the sandplain has occurred as a result of sparse cover, though this process is unlikely to have significantly disturbed any subsurface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment. The likelihood of substantial subsurface *in situ* archaeological deposits at this site is low.

Table 6.14 Site MP12 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Mudstone	Buff	48 x 39 x 15	Flake/Core



Figure 6.68 View west to site MP12, in an open, cleared flat plain.



Figure 6.69 View north to site MP12.



Figure 6.70 Dorsal surface of mudstone flake/core with bifacial retouch and negative flake scars at site MP12.



Figure 6.71 Ventral surface of mudstone flake/core with bifacial retouch and negative flake scars at site MP12.

MP13 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 336250E, 7593385N (centre point)

Landform: Lower Slope/Creek Bank

Site Size: 805m²

Exposure: Open, sparsely vegetated and well deflated lower slope of bank of an unnamed creek

Site Description:

Site MP13 is located approximately 5km west of the dirt access track in the vicinity of Mistake Bore (see Figure 6.72). The site is situated within a large, open and sparsely vegetated area on the well deflated lower slopes of the northern bank of an unnamed creek, at the foot of the Djlbari Hills (Figure 6.73-Figure 6.74). Site MP13 straddles the Haul Road in the vicinity of Access Road Point 8, extending 90m southwest and 360m northeast of the Haul Road centre line. The site would be impacted by the construction of the Haul Road at its current alignment.

Site MP13 comprises a total of 9 stone artefacts, found on the lower slopes of the creek bank (Table 6.15). The site extends for approximately 240m along the northern creek bank. Artefacts observed comprised both flakes and cores and were manufactured of quartzite, chert, chalcedony and quartz (Figure 6.75-Figure 6.78).

The site is being impacted by deflation, such that finer sand and dirt is being blown from the site. This does not however, preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

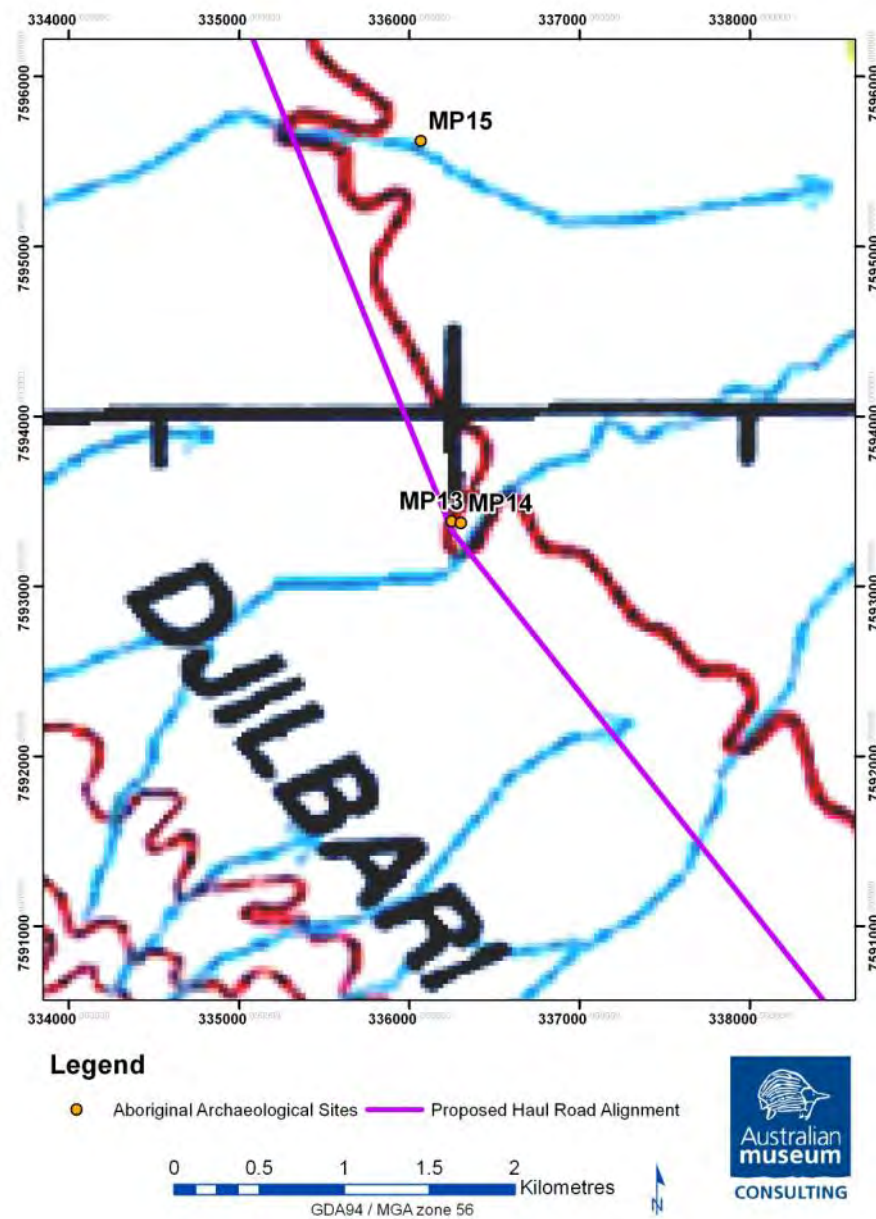


Figure 6.72 Detail of the location of Aboriginal heritage sites MP13, MP14 and MP15.

Table 6.15 Site MP13 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartzite	Grey	13 x 12 x 2	Proximal Flake
Chalcedony	White	19 x 10 x n/a	Flake
Chert	Dark Grey	12 x 14 x n/a	Distal Flake
Quartz	Grey	22 x 18 x n/a	Flake
Chert	Dark Grey	78 x 65 x n/a	Core
Quartzite	Grey	31 x 20 x n/a	Flake
Quartzite	Grey	28 x 32 x n/a	Core
Quartzite	Grey	22x 18 x n/a	Distal Flake
Quartzite	Grey	25 x 24 x n/a	Flake



Figure 6.73 View northeast of site MP13, on well deflated, lower slope of an ephemeral creek bank.



Figure 6.74 View south of site MP13, on well deflated, lower slope of an ephemeral creek bank.



Figure 6.75 Chert core at site MP13.

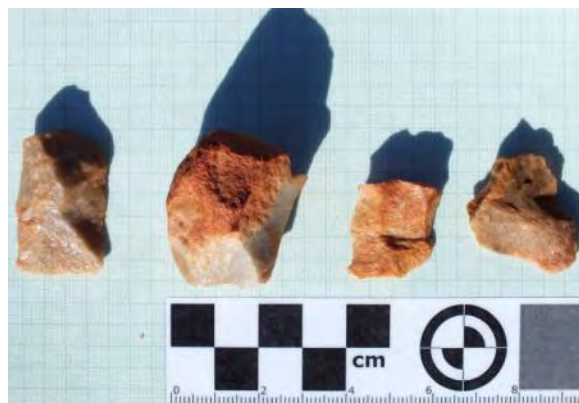


Figure 6.76 Quartzite flakes and core at site MP13.



Figure 6.77 Chert and quartz flakes at site MP13.



Figure 6.78 Chalcedony flake at site MP13

MP14 – Artefact Scatter

Location: GDA 1994 MGA Zone 53; 336302E, 7593373N (centre point)

Landform: Lower Slope/Creek Bank

Site Size: 272m²

Exposure: Open, sparsely vegetated and well deflated lower slope of bank of an unnamed creek

Site Description:

Site MP14 is located approximately 5km west of the dirt access track in the vicinity of Mistake Bore, and 53m southeast of site MP13 (see Figure 6.72). The site is situated within a large, open and sparsely vegetated area on the well deflated lower slopes of the southern bank of an unnamed creek, at the foot of the Djilbari Hills (Figure 6.79-Figure 6.80). Artefacts were identified between 6m and

140m northeast of the Haul Road centre line, though the site is likely to extend further upstream of the creek in unsurveyed areas. It is considered likely that the site would be impacted by the construction of the Haul Road at its current alignment.

The site comprises a total of 10 stone artefacts situated on the lower slopes of the creek bank (Table 6.16). This included three chalcedony scrapers and a chalcedony flake, three quartzite flakes, a quartz scraper and flake and a mudstone flake (Figure 6.81-Figure 6.82).

The site is being impacted by erosion as fine sand and dirt is being blown from the site. This does not however, preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment.

Table 6.16 Site MP14 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartz	Crystal	14 x 18 x n/a	Scraper
Quartzite	Grey	42 x 23 x n/a	Flake
Chalcedony	Light Grey	23 x 18 x n/a	End Scraper
Quartzite	Grey	32 x 18 x n/a	Flake
Quartz	White	14 x 19 x n/a	Proximal Flake
Chalcedony	White	20 x 17 x n/a	Scraper
Mudstone	Grey	24 x 24 x n/a	Flake
Quartzite	Grey	19 x 22 x n/a	Flaked Piece
Chalcedony	White	18 x 15 x n/a	Flake
Chalcedony	White	9 x 17 x n/a	Scraper



Figure 6.79 Western extent of MP14, on lower slopes of an unnamed creek. View to east.



Figure 6.80 Eastern extent of MP14, on lower slopes of an unnamed creek. View to west.



Figure 6.81 Site MP14 chalcedony, quartzite, quartz and mudstone flake artefacts.



Figure 6.82 Site MP14 chalcedony, quartzite, quartz and mudstone flake artefacts.

MP15 – Isolated Find**Location:** GDA 1994 MGA Zone 53; 336067E, 7595622N**Landform:** Flat/Creek Bank**Site Size:** n/a**Exposure:** Flat, relatively open clearing on bank of an unnamed creek**Site Description:**

Site MP15 is located approximately 2.25km north of site MP13 and 3.8km west of the dirt access track near Mistake Bore (see Figure 6.72). The site is situated within a flat and relatively open area on the northern bank of an unnamed creek, at the foot of the Djilbari Hills (Figure 6.83). The ground surface within the creek bank is partially obscured by low spinifex grass and small shrubs. The site is located 745m east of the current proposed Haul Road centre alignment, and is therefore unlikely to be impacted.

One isolated quartz stone artefact was identified on the slightly elevated northern bank of the creek, in an area of exposed sand (Table 6.17-Figure 6.84). Whilst some deflation was observed on the northern bank, deposited alluvium was noted along the slightly lower southern bank. This alluvium comprised large sand grains and roughly sorted small (<3mm) pebbles, and was likely deposited from upriver during a period of inundation.

Table 6.17 Site MP15 artefact details.

Material	Colour	Maximum Dimensions [length x width x thickness] (mm)	Artefact Type
Quartz	White	20 x 13 x n/a	Flake

**Figure 6.83 View southwest to MP15 in relatively open flat above northern bank of an unnamed creek.****Figure 6.84 MP15 quartz flake.****6.2.3 Mine Site**

No stone artefacts or evidence for Aboriginal occupation of the mine site area was observed during the archaeological survey of the Mine Site.

The mine pit area is a flat, open landform characterised by clusters of dense tall shrubs and patches of exposed soil and low spinifex grass. The mine pit area was found to have been disturbed by previous resource exploration activities, which included the clearing of multiple sites for the collection of borehole samples as well as the clearing and grating of access roads throughout the area (Figure 6.85-Figure 6.86). Ground surface visibility was generally low due to extensive grass cover, though exposures with high visibility were present along access tracks and amongst dispersed grass.



Figure 6.85 View northwest towards clearing and access track for borehole sample site; mine pit area.



Figure 6.86 View east towards cleared and partially graded access road between borehole sample locations, mine pit area.

A 300m transect of the northern edge of the proposed mine pit was surveyed by foot, focusing on an area of flat open ground with distant views to Murray Creek and an unnamed stony rise to the east of the camp site (Figure 6.87). Natural outcroppings of stone comprising cherts, mudstones, quartzites and shales was noted during the survey, though no evidence for quarrying or cultural artefacts was observed (Figure 6.88). The remainder of the mine pit area was surveyed by vehicle along established access tracks, and particular attention was given to identifying stone outcrops and possible artefact material. No such evidence was found.



Figure 6.87 View east towards unnamed stony rise beyond Murray Creek, mine pit area.



Figure 6.88 View northeast of natural stone outcrop, northern extent of mine pit area.

A 255m transect of the south western corner of the mine site was traversed by foot, originating from the access track along the fence line approximately 1.05km from the western edge of the mine site area. The western portion of the mine site area is characterised by dense tall shrubs and patches of exposed soil and low spinifex grass (Figure 6.89). Patches of exposed soil were visible throughout the area surveyed and, while outcrops of quartz and mudstone were observed, no evidence for quarrying or Aboriginal cultural artefacts was identified. A 5km transect of the central portion of the mine site, passing through the proposed processing plant and waste dump areas, was also traversed by foot (Figure 6.90-Figure 6.92). The central portion, like the eastern and western portions, is defined as an open, flat expanse characterised by dense clusters of tall shrubs and patches of exposed sandy soil and low to medium spinifex tufts. A few quartz stone pieces were identified but were visibly natural; no Aboriginal cultural artefacts or evidence for Aboriginal occupation were observed at any of the proposed processing or waste sites.



Figure 6.89 View north to tract of dense tall shrubs from patch of exposed soil and low grass tufts, south western corner of mine site.



Figure 6.90 View northwest of processing plant area, characterised by dense tall shrubs and low grasses.



Figure 6.91 View north of waste dump 1 area.



Figure 6.92 View east of waste dump 2 area.

The mine site area, with its flat, featureless and densely vegetated landscape, and lack of water and stone resources, would likely have been an unattractive area for Aboriginal occupation. The mine site area is unlikely to retain evidence of Aboriginal cultural occupation.

6.2.4 Camp Site

No evidence for Aboriginal stone artefacts or Aboriginal occupation of the camp site area was observed during the archaeological survey.

The proposed campsite is located in the eastern portion of the camp site area, in a flat, open sandplain sparsely vegetated by small shrubs and dispersed, low spinifex grass. A 140,000m² area encompassing the proposed campsite has been cleared of its native vegetation, such that ground surface visibility was high. Here, patches of exposed soil were observed amongst dispersed low grasses, and along a southeast-northwest aligned dirt access track. Natural outcrops of stone comprising cherts, mudstones, ironstones and shales were noted throughout the campsite area, though no evidence for quarrying or cultural artefacts was observed.

A 450m transect of the eastern portion of the camp site area was undertaken by foot, in the vicinity of an ephemeral drainage channel located 30m northwest of the campsite. Particular attention was paid to areas of exposed ground on the flat ground above the channel though no evidence for Aboriginal occupation was observed. The ground surface here was largely devoid of stone material.



Figure 6.93 View south to stone outcrop, campsite area.



Figure 6.94 View north to ephemeral drainage channel, camp site area.

Two pedestrian transects were surveyed in the western portion of the camp site area, passing through the current proposed airstrip site. A 1.4km transect was surveyed through the northern half of the airstrip, while a 280m transect was surveyed through the southern section. In contrast to the eastern portion, the western portion of the camp site area retains its natural vegetation. The landscape is characterised by long tracts of dense, tall shrubs and trees, overgrown with long tall grasses. Ground surface visibility was somewhat impeded by the overgrown grass, though small exposures were found amongst grass tufts and in small clearings. While some small, natural pebbles were observed no evidence for Aboriginal stone artefacts or Aboriginal occupation was found.



Figure 6.95 View south towards airstrip, northern extent.



Figure 6.96 View north towards airstrip, southern extent.

The flat, featureless and densely vegetated nature of the camp site area, coupled with its absence of water resources, would have been an unattractive area for Aboriginal occupation. The camp site area is unlikely to retain evidence of Aboriginal cultural occupation.

6.2.5 Rail Siding/Load-Out Facility

No stone artefacts or evidence for Aboriginal occupation of the Rail Siding and Load-Out facility areas was observed during the archaeological survey.

The Rail Siding and Load-Out Facility is a flat plain located in the valley bottom between two mountain ranges; Mount Tops to the north and Mount Octy to the south. A 3km transect along the length of the proposed siding facility was surveyed by foot. The landscape is dominated by large open patches of low spinifex grass, and is interspersed with clusters of small shrubs and thin, low trees. Ground surface visibility across the proposed rail siding and loading site was high; large patches of

exposed soil are visible. Large concentrations of naturally worn quartz and quartzite nodules and pebbles, ranging in size from 1-10cm, were identified across the area; within open clearings largely devoid of ground cover. No major creeks or drainage channels were found across the rail siding site, and the area is unlikely to have been an attractive area for Aboriginal occupation.



Figure 6.97 View northeast to rail siding site.



Figure 6.98 View south to proposed rail siding site, showing large concentration of quartz and quartzite nodules.

6.3 Summary

No historic heritage structures, places or archaeological sites of known or potential significance were identified within the pipeline and haul road corridors nor the mine, camp or rail siding sites, or their immediate vicinity, during the field survey.

Sixteen new Aboriginal heritage sites were identified within the Mount Peake Project study area during archaeological survey. The majority of these sites were stone tool artefact scatters or isolated stone artefacts found within 200m of watercourses. Nine sites were identified on the lower slopes and banks of the Hanson River (MP1-MP5, MP7-MP9), one isolated artefact was found on the bank of Murray Creek (MP16), and five sites were recorded on the banks of ephemeral watercourses at the foot of Djilbari Hills and Central Mount Stuart (MP6, MP10, MP13-MP15). Two isolated artefact sites were recorded on open, flat plains more than 200m from the nearest watercourse (MP11-MP12); though these sites are likely reflective of more fleeting occupation of the area and may represent one-off discard events by people travelling through the Djilbari Hills/Central Mount Stuart countryside. The predominant raw material employed across the study area was quartzite, quartz, and mudstone, with less frequent use of silcrete, chert and chalcedony. Flakes and scrapers made up a large portion of the assemblages identified, though cores as well as backed blades, retouched flakes and choppers/axes were observed.

The presence of these sites corresponds with the results of previous research in the wider region and the predictive model for the study area developed in Section 5.2.1, and may represent evidence of Aboriginal camping and utilisation of the resources associated with these watercourses. The majority of identified Aboriginal heritage sites were exposed in relatively open, partially deflated contexts in close proximity to both ephemeral and significant watercourse. Wind erosion appears to be impacting a number of sites along the Hanson River, though this does not preclude the presence of sub-surface *in situ* archaeological deposits, particularly where vegetation anchors the surrounding sediment. On the basis of the archaeological survey, it is considered that relatively flat, open land in the vicinity of ephemeral and major watercourses, and significant landscape features, retain the potential for subsurface *in situ* archaeological deposits (Figure 6.99).

In contrast, no Aboriginal archaeological sites or evidence for Aboriginal occupation was observed in landscapes that lacked adequate water and stone resources and comprised featureless, densely vegetated sandplain country. This included the mine, camp and rail siding sites. These areas were either less frequently occupied or utilised as transitory landscapes; and are less likely to preserve archaeological evidence for Aboriginal occupation.

6.3.1 *Aboriginal Archaeological Potential*

Results of the archaeological field survey have been used to inform an estimate of archaeological potential for landforms within the study area. This estimation considers both the predictive model for Aboriginal heritage and Aboriginal sites identified during the survey. For the purposes of this assessment, archaeological potential is described as the potential for selected landforms and areas to contain undetected buried archaeological deposits.

Given the predictive model for Aboriginal sites, the relatively undisturbed nature of the study area, landforms present, and the results of the archaeological survey, the following conclusions can be made regarding the Aboriginal archaeological potential of the study area:

- Creek and river banks within the study area have a high potential for surface Aboriginal stone artefact sites to be present, and may retain undisturbed *in situ* archaeological deposits;
- Flat, open plains in the vicinity of watercourses, major landscape features such as large hills and stone resources have moderate to high potential for Aboriginal stone artefact sites to be present, and may retain undisturbed *in situ* archaeological deposits;
- Flat, featureless and densely vegetated plains of a considerable distance from watercourses, significant landscape features and stone resources have low potential to contain Aboriginal archaeological sites.

Areas of archaeological sensitivity in the vicinity of the study area with potential to contain Aboriginal archaeological sites in association with watercourses and major landscape features are mapped in Figure 6.99.

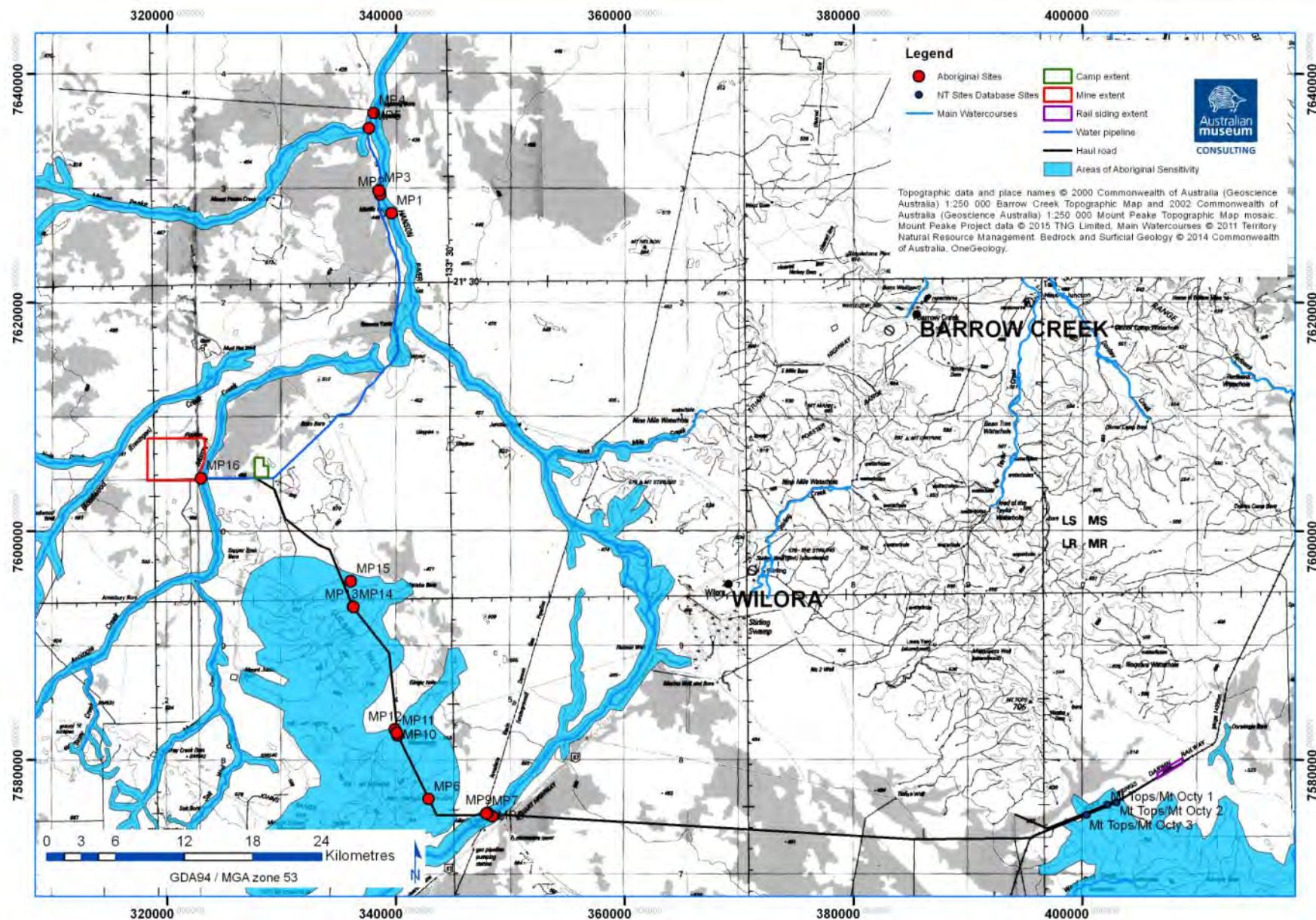


Figure 6.99 Areas of Archaeological Sensitivity associated with watercourses and significant landforms.

7 Assessment of Heritage Significance

A primary step in the process of Aboriginal cultural heritage management is the assessment of significance, which involves assessing the heritage values present across the subject area and identifying why they are archaeologically and culturally important. ‘Heritage value’ is a term used to express the tangible and intangible values of an item, place or archaeological site, and the response that it evokes in the community. Archaeological significance relating to Aboriginal sites, objects and places in the NT is assessed in accordance with best practice processes as set out in the Burra Charter, and cultural significance is identified by Aboriginal communities. The Burra Charter criteria encompass aesthetic, historic, scientific, social or spiritual value, for assessing cultural significance for past, present and future generations (Article 1.2).

Not all sites are equally significant and not all are worthy of equal consideration and management. The significance of a site is not fixed for all time; what is considered as significant at the time of assessment may change as similar items are located, more research is undertaken and community values change. This does not lessen the value of the heritage approach, but enriches both the process and the long-term outcomes for future generations as the nature of what is conserved and why, may change over time (Pearson and Sullivan 1995:7).

7.1 Assessment against Criteria of Aboriginal Heritage Significance

This assessment is informed by the results of the environmental and Aboriginal heritage context, the predictive model for Aboriginal sites in the region, and the results of the Aboriginal archaeological survey, and is structured according to the areas to be impacted during the works.

The NT Heritage Branch has identified eight heritage assessment criteria, designed to assess and identify the heritage significance of Aboriginal sites, objects and places in the NT, which are consistent with the Burra Charter guidelines for the assessment of significance. For the purposes of this assessment, Aboriginal heritage sites are considered to have heritage significance if they meet one or more of the following criteria, as defined in the *Heritage Act 2011*.

7.1.1 Pipeline

Criterion a) whether it is important to the course, or pattern, of the Territory's cultural or natural history – Historic value

Collectively, Aboriginal artefact scatters MP1-MP5 and isolated artefact MP16 provide evidence for the manufacture and use of stone tools, as well as the use of the Hanson River and Murray Creek landscapes, by local Anamtyerre people. Though there is no conclusive evidence directly linking these sites to important historically recorded events, they are reflective of the broader historical use of the local area. Artefact scatters MP1-MP5 and isolated find MP16 do not meet the threshold for inclusion for this criterion.

Criterion b) whether it possesses uncommon, rare or endangered aspects of the Territory's cultural or natural history – Rarity value

It is not possible to accurately assess the rarity value of scatters MP1-MP5 and isolated find MP16 on the basis of the current assessment, given that only a representative sample of the area's landforms were surveyed. However, additional sites are likely to be identified through further survey, which in turn may suggest that sites MP1-MP5 and MP16 are representative of similar sites in the local area and the region, and as such they do not meet the threshold for inclusion for this criterion.

Criterion c) whether it has potential to yield information that will contribute to an understanding of the Territory's cultural or natural history – Scientific value and Research Potential

To date, limited cultural heritage information exists relating to the Aboriginal people of the Anmatyerre region outside of oral history. Aboriginal archaeological sites, including both stone artefact scatters and isolated finds, therefore represent tangible evidence of past Aboriginal occupation. They have the potential to yield information that contributes to an understanding of local campsite locations and of raw material procurement, stone tool use and manufacturing processes. Based on the relative dearth of Aboriginal site in the local area, all of the identified Aboriginal sites during the archaeological survey hold scientific value and research potential.

Stone artefact scatters MP1 and MP3 comprise a moderate density of stone artefacts, and have the potential to retain intact subsurface archaeological deposits. They have the potential to contribute evidence of stone tool manufacturing processes and the use of the Hanson River as a camp site by local Aboriginal people. When compared to other identified sites in the local area, sites MP1 and MP3 are considered to have moderate (local) scientific and archaeological value, and moderate archaeological research potential, and meet the threshold for inclusion for this criterion.

Sites MP2, MP4-MP5 and MP16 have limited potential to contribute evidence of stone tool manufacturing processes and occupational patterns, and are not indicative of complex archaeological deposits. Site MP2 and MP4 are identified as low density scatters in partially disturbed contexts. These sites are likely to represent incidental, background Aboriginal activity in the area, and have limited potential as a teaching site for educating the public about the Aboriginal past. When compared to other identified sites in the local area sites MP2, MP4-MP5 and MP16 have low (local) scientific and archaeological value, and low archaeological research potential; however, given the limited archaeological understanding of the region, the sites do meet the threshold for inclusion for this criterion.

Criterion d) whether it is important in demonstrating the principal characteristics of a class of cultural or natural places or environments – Representative value

It is not possible to accurately assess the representative value of scatters MP1-MP5 and isolated find MP16 on the basis of the current assessment, given that only a sample of the area's landforms were surveyed. Stone artefact scatter sites MP1 and MP3 are tentatively considered to be representative of other artefact scatter sites in the local area, comprising primarily quartz and quartzite flakes, retouched flakes, scrapers and cores. Sites MP2, MP4-MP5 and MP16 are considered to represent incidental, background Aboriginal activity in the local area. All identified sites represent a continuity of use of water resources across the study area, and are considered to be representative of the local archaeology, and therefore meet the threshold for inclusion for this criterion.

Criterion e) whether it is important in exhibiting particular aesthetic characteristics

Criterion f) whether it is important in demonstrating a high degree of creative or technical achievement during a particular period – Aesthetic and Technical/Creative value

Stone artefact scatters MP1 and MP3 contain artefacts of some aesthetic and technical value, including a symmetrical leaf-shaped retouched crystal quartz flake, a quartzite bladelet and a quartz thumbnail scraper. Sites MP1 and MP3 have low (local) aesthetic and technical value.

Artefact scatters MP2 and MP4-MP5 and isolated find MP16 mainly unretouched flakes, cores and angular fragments, and are not aesthetically or technically distinctive. These sites do not meet the aesthetic and technical value criterion.

Criterion g) whether it has a strong or special association with a particular community or cultural group for social, cultural or spiritual reasons, including the significance of a place to Aboriginal people as part of their continuing and developing cultural traditions – Social, Cultural and Spiritual Value

This criterion concerns the value of the subject area to a particular community group – in this case the local Aboriginal community. Aspects of social value include social, cultural and spiritual associations, and are relevant to sites, items and landscapes that are important, or have become important, to the local Aboriginal community. This importance concerns traditional links with specific areas as well as an overall concern by Aboriginal people for sites and landscapes generally and their continued protection. Aboriginal cultural assessments can only be made by the Aboriginal community, and have not been undertaken for the purposes of this report.

It should be noted, however, that sites MP1 and MP3 are representative of past activity by local Aboriginal people. Though no Aboriginal community consultation could be undertaken for this assessment it is acknowledged that Central Mount Stuart and Djilbari Hills and the Hanson River are significant Aboriginal landscape features, and hold significance for local Aboriginal people. These sites, particularly those located in close proximity to significant landscape features, watercourses and natural resources have potential to retain cultural significance, a sense of place, and heritage value for local Aboriginal people.

In the absence of local Aboriginal community participation in the field survey, this criterion cannot be assessed at this time.

Criterion h) whether it has a special association with the life or works of a person, or group of persons, of importance in the Territory's history – Associative value

There are no identified associations between sites MP1-MP5 and MP16 and the life or works of persons or people of importance in the Territory's history outside of the sites' association with the local Anmatyerre people. As such, the sites do not meet the threshold for inclusion for this criterion.

7.1.2 Haul Road

Criterion a) whether it is important to the course, or pattern, of the Territory's cultural or natural history – Historic value

Aboriginal artefact scatters MP7-MP11 and MP13-MP14 provide evidence for the manufacture and use of stone tools and grinding implements, as well as the use of the Hanson River and minor creeklines at the foot of the Djilbari Hills and Central Mount Stuart, by local Aboriginal people. Though there is no conclusive evidence directly linking these sites to important historical events, they are reflective of the broader historical use of the local area. Artefact scatters MP7-MP11 and MP13-MP14 meet the threshold for inclusion for this criterion.

Criterion b) whether it possesses uncommon, rare or endangered aspects of the Territory's cultural or natural history – Rarity value

It is not possible to accurately assess the rarity value of scatters MP7-MP10 and MP13-MP14 and isolated finds MP6, MP12 and MP15 on the basis of the current assessment, given that only a representative sample of the area's landforms were surveyed. Additional sites may be identified through further survey, which in turn may suggest that the sites are representative of similar sites in the local area and the region.

However, artefact scatter site MP10 contains silcrete and chert choppers, blades and backed blades and bladelets - all artefact types which appear to be relatively uncommon in the local area. Isolated find

MP12 comprises a symmetrical mudstone flake with bifacial retouch and negative bladelet flake scars on its ventral surface, suggesting it was also used as a core. Artefact scatter site MP11 and isolated artefact MP12 are both located on open, flat sandplains more than 200m from the closest watercourse and with distant views to significant landscape features.

On the basis of the current evidence, sites MP10, MP11 and MP12 appear to be archaeologically rare and meet the threshold for inclusion for this criterion.

Criterion c) whether it has potential to yield information that will contribute to an understanding of the Territory's cultural or natural history – Scientific value and Research Potential

Artefact scatter sites MP7, MP8, MP9 and MP10 comprise a high density of *in situ* stone artefacts, and have potential to retain intact subsurface archaeological deposits. Artefact scatters MP7, MP8 and MP9 have the potential to contribute evidence of stone tool manufacturing processes and the use of the Hanson River as a camp site for Aboriginal people. Scatter MP10 is also considered a site that yields information relating to stone tool manufacturing processes, and the use of ephemeral creeklines in close proximity to significant landscape features as campsites by local Aboriginal people. These sites are likely indicative of complex archaeological deposits in the local area, and, when compared to other identified sites in the local area, have high (local) scientific (archaeological) value and research potential.

Artefact scatter sites MP11, MP13 and MP14 feature artefacts that have been manufactured from chalcedony, a raw material not available in the local area and likely acquired by travelling into neighbouring territories or through trade. Sites MP13 and MP14 comprise a moderate density of *in situ* stone artefacts, and have some potential to retain intact subsurface archaeological deposits. Sites MP13 and MP14 have the potential to yield information about raw material procurement and trade as well as some evidence for stone tool manufacture and Aboriginal occupation. Sites MP13 and MP14 are likely indicative of complex archaeological deposits in the local area, and, when compared to other identified sites in the local area, have moderate (local) scientific (archaeological) value, and meet the threshold for inclusion for this criterion.

Sites MP6, MP11, MP12 and MP15 have limited potential to contribute evidence of stone tool manufacturing processes and occupational patterns, and are not likely indicative of complex archaeological deposits. These sites are likely to represent incidental, background Aboriginal activity in the area, and, when compared to other identified sites in the region, are considered to have low (local) scientific and archaeological value and research potential, and do not meet the threshold for inclusion for this criterion.

Criterion d) whether it is important in demonstrating the principal characteristics of a class of cultural or natural places or environments – Representative value

It is not possible to accurately assess the representative value of artefact scatters MP7-MP10 and MP13-MP14 and isolated finds MP6, MP12 and MP15 on the basis of the current assessment, given that only a sample of the area's landforms were surveyed.

Stone artefact scatter sites MP7-MP11 and MP13-MP14 are tentatively considered to be representative of other artefact scatter sites in the local region, are located in close proximity to watercourses and comprise quartz, quartzite and mudstone flakes, retouched flakes, scrapers and cores. Sites MP6, MP12 and MP15 are likely to represent such incidental, background Aboriginal activity in the region. All identified sites represent a continuity of use of water resources across the study area, are considered to be representative of the local archaeology, and do not meet the threshold for inclusion for this criterion.

Criterion e) whether it is important in exhibiting particular aesthetic characteristics – Aesthetic

Criterion f) whether it is important in demonstrating a high degree of creative or technical achievement during a particular period – Aesthetic and Technical/Creative value

Sites MP10 and MP12 contain artefacts of some aesthetic and technical value. These include two large choppers, a blade, a backed blade and bladelet from MP10 and a symmetrical mudstone flake/core with bifacial retouch and negative bladelet scars from MP12. Sites MP10 and MP12 are considered to have moderate (local) aesthetic and technical value, and meet the threshold for inclusion for this criterion.

Scatter sites MP7-MP9 and MP13-MP14, as well as isolated finds MP6 and MP15, comprise mainly unretouched flakes, cores and angular fragments; and are not considered aesthetically or technically distinctive. These sites do not meet the aesthetic and technical value criterion and have no aesthetic or technical value.

Criterion g) whether it has a strong or special association with a particular community or cultural group for social, cultural or spiritual reasons, including the significance of a place to Aboriginal people as part of their continuing and developing cultural traditions – Social, Cultural and Spiritual value

This criterion concerns the value of the subject area to a particular community group – in this case the local Aboriginal community. Aspects of social value include social, cultural and spiritual associations, and are relevant to sites, items and landscapes that are important, or have become important, to the local Aboriginal community. This importance concerns traditional links with specific areas as well as an overall concern by Aboriginal people for sites and landscapes generally and their continued protection. Aboriginal cultural assessments can only be made by the Aboriginal community, and have not been undertaken for the purposes of this report.

It should be noted, however, that sites MP7-MP10 and MP13-MP14 are representative of past activity by local Aboriginal people. Though no Aboriginal community consultation was undertaken for the purposes of this report it is acknowledged that Central Mount Stuart and Djilbari Hills and the Hanson River are significant Aboriginal landscape features, and hold significance for local Aboriginal people. Sites MP7-MP10 and MP13-MP14 are likely to retain cultural significance, a sense of place, and heritage value for local Aboriginal people.

In the absence of local Aboriginal community participation in the field survey, this criterion cannot be assessed at this time.

Criterion h) whether it has a special association with the life or works of a person, or group of persons, of importance in the Territory's history – Associative value

There are no identified associations between sites MP6-MP15 and the life or works of persons or people of importance in the Territory's history outside of their association with the local Anmatyerre people. These sites therefore do not meet the threshold for inclusion in this criterion.

7.2 Statement of Heritage Significance

7.2.1 Pipeline

Stone artefact surface scatters MP1 and MP3 comprise a moderate density of stone artefacts on the banks of the Hanson River, and have the potential to retain intact subsurface archaeological deposits despite evidence of erosion and deflation impacts. They have the potential to yield information relating to stone tool manufacturing processes and the use of the Hanson River as a campsite by local

Anmatyerre people. They contain artefacts of some aesthetic and technical value, including a symmetrical leaf-shaped retouched crystal quartz flake from MP1, and a quartzite bladelet and a quartz thumbnail scraper from MP3. Scatters MP1 and MP3 are indicative of complex archaeological deposits, are representative of past activity by local Aboriginal people, and are likely to retain cultural significance, a sense of place, and heritage value for local Aboriginal people. Based on current evidence, stone artefact scatter sites MP1 and MP3 are assessed as having **moderate** (local) scientific (archaeological) significance and research potential and **low** (local) aesthetic significance.

Stone artefact scatter sites MP2, MP4-MP5 and isolated find MP16 comprise low density sites on the Hanson River and Murray Creek, and, when compared to other identified sites in the local area, have limited potential to contribute evidence of stone tool manufacturing processes and occupational patterns. They are not indicative of complex archaeological deposits, and feature unretouched flakes, cores and angular fragments that are not aesthetically or technically distinctive. Based on current evidence, sites MP2, MP4-MP5 and MP16 are assessed as having **low** (local) scientific (archaeological) significance and research potential and **no** aesthetic or technical significance.

7.2.2 Haul Road

Artefact scatter MP10 comprises a high density scatter of *in situ* stone artefacts, on the bank of an ephemeral creek at the foot of the culturally significant Central Mount Stuart. The scatter has the potential to retain intact subsurface archaeological deposits, and may yield information relating to stone tool manufacturing processes as well as the use of ephemeral creeklines as campsites by local Aboriginal people. Scatter MP10 contains two large silcrete and chert choppers, a blade, backed blade and bladelet – all artefact types which appear to be relatively rare in the local area and are of moderate aesthetic and technical value. MP10 is indicative of a complex archaeological deposit, is representative of past activity by local Aboriginal people, and is likely to retain cultural significance, a sense of place, and heritage value for local Aboriginal people. Based on current evidence, stone artefact scatter site MP10 is assessed as having **high** (local) scientific (archaeological) significance and research potential and **moderate** (local) aesthetic significance.

Stone artefact scatter sites MP7-MP9 comprise a high density scatter of *in situ* artefacts on the banks of the Hanson River. These scatters have the potential to retain intact subsurface archaeological deposits, and may contribute evidence for stone tool manufacturing processes, stone tool use, and the use of the Hanson River as a camp site for Aboriginal people. Sites MP7-MP9 are tentatively considered to be typical of other artefact scatters in the region featuring unretouched flakes, cores and angular fragments, and are not considered aesthetically or technically distinctive. They are, however, indicative of complex archaeological deposits, are representative of past activity by local Aboriginal people, and are likely to retain cultural significance, a sense of place, and heritage value for local Aboriginal people. On the basis of current evidence, stone artefact scatter sites MP7-MP9 are assessed as having **high** (local) scientific (archaeological) significance and research potential but have **no** aesthetic or technical significance.

Artefact scatter sites MP13 and MP14 comprise a moderate density scatter of *in situ* artefacts, on the banks of an unnamed creek at the foot of the Djilbari Hills. These scatters have the potential to retain intact subsurface archaeological deposits, and may yield some information about raw material procurement as well as some evidence for stone tool manufacture and Aboriginal occupation. Sites MP13 and MP14 contain few artefacts manufactured from chalcedony, a material not common in the local area; but comprise mainly unretouched flakes, cores and angular fragments and are not considered aesthetically or technically distinctive. They are likely indicative of complex archaeological deposits in the local area, and are likely to retain cultural significance, a sense of place, and heritage value for local Aboriginal people. Based on current evidence, stone artefact scatter sites MP13 and

MP14 are assessed as having **moderate** (local) scientific (archaeological) significance and research potential but have **no** aesthetic or technical significance.

Stone artefact scatter MP11 is a low density artefact scatter on a flat open sandplain at the foothills of Central Mount Stuart, more than 200m from an ephemeral watercourse. On present evidence, this site appears to be a relatively uncommon site location in the local area. It features, amongst other nondescript flakes, a single artefact that has been manufactured from chalcedony; a raw material not commonly available in the local area and likely acquired by travelling into neighbouring territories or through trade. When compared to other identified sites in the local area, MP11 has limited potential to contribute evidence of stone tool manufacturing processes and occupational patterns, and is not indicative of complex archaeological deposits. MP11 probably represents incidental, background Aboriginal activity in the area, and is considered to have **low** (local) scientific (archaeological) significance and research potential and **no** aesthetic or technical significance.

Isolated artefact MP12 is located on a flat open sandplain at the foothills of Central Mount Stuart, more than 200m from an ephemeral watercourse. Isolated find MP12 comprises a symmetrical mudstone flake with bifacial retouch and negative bladelet flake scars on its ventral surface, suggesting it was also used as a core. On present evidence, this site appears to contain a relatively uncommon and technically significant stone tool type, and is located in an area that does not typically retain evidence of Aboriginal occupation. When compared to other identified sites in the local area, however, it has limited potential to contribute evidence of stone tool manufacturing processes and occupational patterns, and is likely representative of incidental, background Aboriginal activity in the area. Isolated artefact MP12 is assessed as having **low** (local) scientific (archaeological) significance and research potential, **moderate** (local) aesthetic and technical significance and is **rare** on a local level.

Isolated artefact finds MP6 and MP15 have limited potential to contribute evidence of stone tool manufacturing processes and occupational patterns. They are not indicative of complex archaeological deposits, and feature unretouched flakes, cores and angular fragments that are not aesthetically or technically distinctive. These sites probably represent incidental, background Aboriginal activity in the area, and are assessed as having **low** (local) scientific (archaeological) significance and research potential and **no** aesthetic or technical significance.

8 Assessment of Heritage Impact

The following section assesses the impacts of the proposed Mount Peake Project on the significance of the identified heritage sites in the study area. The proposed works have potential to have negative impacts to Aboriginal heritage sites and *in situ* archaeological deposits which may be present.

Implementation of the project should observe the principles of the Burra Charter, which define standards of best practice for the conservation and management of heritage places. The aim of conservation is to preserve and protect the cultural significance of a place. Proposed impacts are discussed below according to the five areas to be impacted as part of the proposed works.

8.1 Pipeline

The Mount Peake Project involves the installation of a 42km long water pipeline along an existing cleared dirt access track that runs roughly from the Wollagalong Bore site to the mine site. The design and exact location has yet to be finalised and it is unclear whether the pipeline would be buried or raised above the ground surface on a supporting framework. Should construction of the pipeline be elevated above the current ground surface, excavation and potential impacts to any subsurface archaeological deposits would be limited. Greater impacts to any potential or known surface scatters or subsurface *in situ* deposits can be expected if excavation is required.

Six Aboriginal archaeological sites were identified in the vicinity of the centreline of the proposed pipeline alignment; five surface artefact scatter sites on the western bank of the Hanson River (MP1-MP5), and one isolated find on the western bank of the Murray Creek (MP16). Given that scatter sites MP2, MP4 and MP5 are located more than 150m from the pipeline alignment they are unlikely to be impacted by the proposed works.

Disturbance of the land to the east of the access track may result in indirect impacts to surface scatters MP1 and MP3, and may impact on any subsurface *in situ* artefact deposits along the Hanson River bank. Excavation for and installation of the pipeline to the west of the access track would help to prevent impacts to underlying deposits.

Installation of the pipeline in the vicinity of Murray Creek has the potential to cause impacts to any surface or *in situ* archaeological deposits along the creek banks, as well as indirect impacts to isolated find MP16. Substantial impacts are expected for the construction of the haul road at this location, which would likely involve the construction of concrete culverts, sinking substantial foundations for a bridge crossing and/or disturbance to the creek from heavy machinery. Fixing the pipeline to the formed road by means of a services gantry would also prevent additional and unnecessary impacts to underlying deposits.

Table 8.1 Pipeline construction impact assessment summary.

Proposed Works	Site Number	Type of Harm	Degree of Harm	Consequence of Harm
Pipeline installation	MP1	Indirect	Partial	Partial loss of value
	MP2	None	None	No loss of value
	MP3	Indirect	Partial	Partial loss of value
	MP4	None	None	No loss of value
	MP5	None	None	No loss of value
	MP16	Indirect	Partial	Partial loss of value

8.2 Haul Road

A 104km long haul road is proposed to be constructed for the transportation of ore from the mine pit to the Adnera rail siding. The proposed road would be an unsealed, dual lane restricted access road for use by road trains, and is likely to be fenced from adjacent station land to protect stock from entering the roadway. While the design is yet to be finalised, it is proposed that the haul road would traverse undulating sandplain country at the foothills of the Djilbari Hills and Central Mount Stuart, before crossing the Stuart highway into the eastern section of the Stirling Station, and following an existing dirt access track along the Alice Springs to Darwin railway near Adnera.

Surface scatter sites MP13 and MP14 would be directly impacted by the construction of the haul road, while scatter sites MP6 and MP10 are likely to be indirectly impacted by the construction of the haul road. Furthermore, impacts to existing surface scatters and subsurface *in situ* archaeological deposits can be expected wherever the haul road would cross the Murray Creek, the Hanson River and other ephemeral creeks near Djilbari Hills and Central Mount Stuart. Where the road crosses the Murray Creek, the Hanson River and other ephemeral creeks it is possible that large concrete culverts would be installed and the roadway formed over the top and battered down, to enable sediment and water to pass unimpeded through the watercourse. It can be expected that there would be considerable disturbance to the land in the haul road corridor, and especially where heavy machinery would be required to clear vegetation and for the installation of culverts. This may have a direct impact on underlying *in situ* archaeological deposits in areas of archaeological potential.

Re-aligning the haul road between Djilbari Hills and the Stuart Highway to avoid or minimise impacts to sites MP13, MP14, MP6 and MP10, as well as any underlying archaeological deposits or areas of archaeological potential, would be a positive heritage outcome. Relocating the haul road further east of its current alignment onto flat sandplain landscapes would minimise impacts to areas of archaeological potential in the vicinity of Djilbari Hills and Central Mount Stuart, and create a safer access grade.

In the vicinity of Tin Fish Well construction of the haul road is proposed within the disturbed footprint of existing access tracks, located along a fence line and the existing Alice Springs to Darwin railway line. The haul road is unlikely to impact on surface or *in situ* Aboriginal heritage sites, objects or places to the east of Tin Fish Well. While the Mt Tops/Mt Octy 2 and Mt Tops/Mt Octy 3 sites could not be located during the survey, both sites lie within the rail corridor and adjacent track, and were likely destroyed or significantly disturbed by its construction. As such, the construction of the haul road is unlikely to impact on Mt Tops/Mt Octy 2 and Mt Tops/Mt Octy 3.

Table 8.2 Haul road construction impact assessment summary.

Proposed Works	Site Number	Type of Harm	Degree of Harm	Consequence of Harm
Haul Road	MP6	Indirect	Partial	Partial loss of value
	MP7	None	None	No loss of value
	MP8	None	None	No loss of value
	MP9	None	None	No loss of value
	MP10	Indirect	Partial	Partial loss of value
	MP11	None	None	No loss of value
	MP12	None	None	No loss of value
	MP13	Direct	Partial	Partial loss of value
	MP14	Direct	Partial	Partial loss of value
	MP15	None	None	No loss of value

8.3 Mine Site

As part of the Mount Peake Project, it is proposed to conduct open cut truck and shovel mining of the ore body to a maximum depth of 150-200m below ground level, in a demarcated mine pit area to the west of the Murray Creek. This excavation would have a substantial impact to the ground surface. A processing beneficiation plant, tailings storage facility, and waste rock dumps would also be constructed to the south and west of the mine pit, in a purpose-cleared area of 18km². Excavation of the mine pit, construction of the processing plant and clearance of the 18km mine site area would not impact areas of archaeological potential, and is not likely to impact on surface or *in situ* Aboriginal heritage sites, objects or places.

8.4 Camp Site

A 1.7km² area of land to the east of the Murray Creek is to be cleared for the construction of a camp site area. The proposed camp site area includes a 1600m by 150m air strip and a 250m by 250m camp site clearing. A large part of the eastern portion of the camp site area, in the vicinity of the camp site clearing, has been previously cleared of its densely forested vegetation; the campsite area is planned to be constructed within its disturbed footprint. Clearing the camp site area, as well as construction of camp site facilities, would not impact areas of archaeological potential, and is not likely to impact on surface or *in situ* Aboriginal heritage sites, objects or places.

8.5 Rail Siding/Load Out Facility

Construction of a new railway siding and load out facility is planned for the Mount Peake Project, along the existing Alice Springs to Darwin railway at Adnera. The 1.04km² site would likely be cleared and levelled; while excavation may be required to construct a road train unloading facility and for laying drainage and other services. Construction of the railway siding and load out facilities would not impact areas of archaeological potential, and is not likely to impact on surface or *in situ* Aboriginal heritage sites, objects or places.

9 Conclusions & Recommendations

Archaeological survey conducted for this assessment identified sixteen previously unrecorded Aboriginal archaeological sites, located on the banks of the Hanson River and in the foothills of Central Mount Stuart and Djilbari Hills. The identified sites fall within the currently proposed alignment of the project haul road and water pipeline. The results of the survey concur with the predictive model of Aboriginal heritage detailed in Section 5.2.1, and suggest that areas of archaeological sensitivity with potential to contain surface and subsurface Aboriginal archaeological sites are associated with natural landforms in the vicinity of watercourses, significant landscape features and natural resources across the haul road and water pipeline alignments.

No Aboriginal archaeological sites were identified within the footprint of the mine site, camp site and railway siding/load-out facility areas during the survey. The results of the survey concur with the predictive model, which indicates that surface and subsurface Aboriginal archaeological sites are not likely to be present in featureless, densely vegetated plains a considerable distance from watercourses, significant landscape features and stone resources.

No historic heritage structures, places or archaeological sites of known or potential significance were identified during survey of the study area; within the pipeline alignment, haul road alignment, mine site, camp site, or rail siding/load-out facility, or their immediate vicinity.

The following recommendations are based on the statutory requirements, a review of the environmental, historic and Aboriginal heritage context of the study area, and the results of the archaeological survey.

9.1 Pipeline & Haul Road

The construction of the proposed water pipeline may require excavation into the natural sandplain and Hanson River bank landform, and excavation of the bed and banks of the Murray Creek landform. Similarly, the construction of the haul road would require clearing, levelling and minor excavation of the lower foothills of the Djilbari Hills and Central Mount Stuart landforms, and excavation of the beds and banks of ephemeral creeks. The current pipeline and haul road alignment is likely to impact on a number of Aboriginal sites identified during this survey, and on areas of archaeological sensitivity. Any works within areas of archaeological sensitivity have potential to impact surface and subsurface *in situ* Aboriginal archaeological sites. Conservation through the avoidance of impacts to Aboriginal archaeology is the preferred option for identified sites and areas of archaeological sensitivity. Where possible, TNG should consider relocating the haul road and pipeline away from identified sites and areas of archaeological sensitivity.

Recommendation 1

The proposed haul road and pipeline alignments should be redesigned to minimise impact on areas of archaeological sensitivity and identified Aboriginal sites, if possible.

Given the level of previous assessment within the study area, it is likely that additional archaeological ground survey in the local area would identify previously unrecorded surface sites. Should the haul road and pipeline alignments be altered beyond the currently identified corridor, additional archaeological assessment in consultation with the Aboriginal community should be undertaken of the new development footprint.

Recommendation 2

If the pipeline and/or haul road alignment is altered outside the assessed corridor, additional archaeological assessment in consultation with the Aboriginal community should be undertaken to assess the impact of the project on the new area. This report should be amended to reflect any design changes and additional heritage impacts.

This assessment has determined that there is potential for Aboriginal stone artefact deposits to be present across natural riverbank and foothill landforms within the study area, but it is not possible to accurately determine the extent, condition or integrity of such deposits in the impact area through surface survey alone. Where it is not possible to avoid impacts to areas of archaeological sensitivity or identified Aboriginal heritage sites, TNG should apply for an appropriate work approval under Section 72 of the *Heritage Act 2011* to allow archaeological mitigation of impacts prior to construction. Mitigation measures should include detailed recording and collection or relocation of surface artefacts, and archaeological test and salvage excavations.

Archaeological excavations should be undertaken in areas with potential to retain *in situ* Aboriginal archaeological deposits to establish the extent, integrity and significance of any cultural deposit prior to works being undertaken. The methodology and scope of the excavations should be determined following finalisation of the development design and impact footprint, and all archaeological works should be undertaken in consultation and conjunction with representatives of the local Aboriginal community. Under section 72 of the Heritage Act, approval is required from the Heritage Branch to carry out archaeological excavations. TNG should apply for a Works Approval prior to undertaking the archaeological test excavations, with the support of the Aboriginal community stakeholders.

Recommendation 3

A Works Approval Application Form should be lodged with the Heritage Branch to allow further archaeological works within the project area, including artefact recording and relocation, and archaeological excavations, in accordance with section 72 of the Heritage Act and heritage best practice. This report would form part of the supporting documentation for the application.

Recommendation 4

The current alignment of the pipeline and haul road is likely to impact on a number of Aboriginal archaeological sites identified during this survey. Where impacts to areas of archaeological sensitivity are unavoidable, artefact recording and relocation, and archaeological excavations should be undertaken to fully record the condition, extent and significance of stone artefact sites along the Hanson River and in the Central Mount Stuart/Djilbari Hills foothills.

The background historic research and heritage survey conducted for this assessment have identified no historic heritage sites within the proposed Pipeline and Haul Road corridors. No further historic heritage assessment is required prior to the commencement of works.

Recommendation 5

There are no historic heritage constraints on the proposed haul road and pipeline alignment. No further historic heritage assessment is required prior to commencement of construction on the proposed works.

9.2 Mine Site, Camp Site and Railway Siding/Load-Out Facility

No Aboriginal or historic heritage sites were identified within the proposed mine site, camp site, and rail siding/load-out facility during the archaeological survey. These three landform areas, characterised by limited water and natural resources, and an absence of significant landscape features, are likely to have been unattractive areas for Aboriginal occupation or European settlement. The survey confirmed the assumption that it would be highly unlikely that evidence of previous occupation would be present within this area. The proposed Mount Peake Project is unlikely to impact on any potential or identified Aboriginal heritage sites, or subsurface, *in situ* archaeological deposits. No further historic or Aboriginal cultural heritage assessment is required prior to the commencement of works.

Recommendation 8

There are no Aboriginal or historic heritage constraints on the proposed mine site, camp site, rail siding/load-out facility. No further Aboriginal cultural or historic heritage assessment is required prior to commencement of construction on the proposed works.

9.3 General Recommendations

All personnel involved in the proposed works should be made aware of the statutory obligations relating to historic and Aboriginal cultural heritage and requirements of permits granted for the works by the Heritage Branch, as well as abiding by the mitigation measures installed to prevent impact to the archaeological resource.

Recommendation 9

Prior to the commencement of construction works for the Mount Peake Project, all on-site personnel should be briefed on the statutory requirements of the Heritage Act 2011 and the NT Aboriginal Sacred Sites Act and their obligations regarding protection of historic and Aboriginal places and objects.

In accordance with the Heritage Act, any archaeological survey work carried out in the Northern Territory which results in the discovery of an Aboriginal or Macassan archaeological place is to be provided to the Heritage Branch so that the relevant information can be included on the database. Aboriginal site recording forms for sites recorded during this assessment should be lodged with the Northern Territory Heritage Branch, together with a copy of this report.

Recommendation 10

Aboriginal site recording forms for sites recorded during this archaeological survey should be lodged with the Northern Territory Heritage Branch, along with a copy of this report.

9.4 Subsequent Design Changes

Subsequent to the archaeological survey and assessment of the project area, TNG undertook changes to the proposed project design in response to a Cultural Heritage Report prepared by the CLC. The Cultural Heritage Report identified several areas of cultural significance to the local Aboriginal community, and recommended two changes to the alignment of the haul road. The specific locations of the areas of cultural significance are regarded as confidential, and have not been provided for this assessment.

The CLC report recommended realigning the haul road corridor away from the base of Central Mount Stewart, further east onto the adjacent sandplain. The revised alignment is approximately 4km east of that section of the corridor assessed by the archaeological survey, and avoids sites MP6, MP10, MP11 and MP12. The revised alignment will impact less watercourses with potential archaeological significance, although it does still cross several watercourses, including the Hanson River. The

alignment crosses Hanson River approximately 800m east of the recorded location of sites MP8, MP9 and MP10, but does still impact on the area of archaeological sensitivity associated with the River.

The alignment of the haul road is also being redesigned at its eastern extent, so that it no longer impacts on an area of cultural sensitivity where the road initially meets the Alice to Darwin Railway. This portion revised alignment does impact on identified Aboriginal archaeological sites, or areas of archaeological sensitivity.

In order to limit impacts around the Hanson River, and to limit the scale of necessary track and pipeline construction, the proposed design of the pipeline and associated borefield has been altered. The revised design relocates the pipeline to the west of the currently established track, away from the archaeological sensitive banks of the Hanson River.

The revised alignment of the haul road will avoid impacts to identified sites MP6, MP8, MP9, MP10, MP11 and MP12, but has potential to impact Aboriginal heritage sites where the pipeline crosses archaeologically sensitive areas, in particular the Hanson River. The revised design of the water pipeline will avoid impacts to identified sites MP1, MP2 and MP3, and will limit impacts to archaeologically sensitive areas associated with the Hanson River. The revised project design complies with Recommendation 1, and as per Recommendation 2, additional archaeological assessment in consultation with the Aboriginal community should be undertaken to assess the impact of the project on the new areas.

References

Articles, Books & Reports

Australia ICOMOS 2013, *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Heritage Significance, 2013*, Australia ICOMOS, <http://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf>.

Bean, CEW 1910, *On the wool track, illustrated with photographs by George Bell*, A Rivers, London.

Begnaze Pty Ltd 2011, *Environmental Impact Assessment McArthur River Mine Phase 3 Development Project: Report on Archaeology and Historic Heritage*, consultancy report to MET Serve on behalf of Xstrata Zinc.

Commonwealth of Australia 2012, *Caring for Our Country: Case Study Working on Country Anmatyerr (Ti Tree) Rangers, Northern Territory*, Commonwealth of Australia, <http://www.environment.gov.au/indigenous/workingoncountry/publications/pubs/casestudy-woc-anmatyerr-rangers.pdf>

Department of Infrastructure and Transport c2012, *A History of Australian Road and Rail*, Department of Infrastructure and Transport, http://investment.infrastructure.gov.au/publications/reports/pdf/history_of_road_and_rail.pdf.

Department of the Environment 2014, *Guide to the Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)*, Department of the Environment.

Department of Transport 2014, *Open Speed Trial – drive to conditions*, Northern Territory Department of Transport, <http://www.transport.nt.gov.au/safety/road-safety/open-speed-trial>

Devitt, J 1994, *Apmer anwekantherrenh = Our country: An introduction to the Anmatyerr and Alyawarr people of the Sandover River Region, Central Australia*, Urapuntja Health Service Council, Utopia, NT.

Earth Sea Pty Ltd 2011, *Heritage Assessment of the form Rum Jungle Mine Site, Northern Territory*, consultancy report to the Department of Resources, Northern Territory.

Edwards, R 1971, 'Art and Aboriginal prehistory', in DJ Mulvaney and J Golson (eds.), *Aboriginal Man and Environment in Australia*, Australian National University Press Canberra.

Flood, J 2004, *Archaeology of the Dreamtime: The story of prehistoric Australia and its people*, JB Publishing, Marlestone, South Australia.

GHD 2013, *Mount Peake Project Notice of Intent*, consultancy report to TNG Limited.

Gould, RA 1977, 'Puntutjarpa Rockshelter and the Australian Desert Culture', *Anthropological Papers of the American Museum of Natural History*, vol. 54(1): 1-188.

Green, J 2000, *Alherramp-areny angkety arelh-kenh = Women's stories from Laramba*, IAD Press, Alice Springs.

Green, J 2003a, *Anmatyerr ayey arnang-akert: Anmatyerr plant stories by the women from Laramba (Napperby) community*, IAD Press, Alice Springs.

Green, J 2003b, *Central Anmatyerr Picture Dictionary*, IAD Press, Alice Springs.

Gregory, R, Dewar, M, Mitchell, S, Murray, D & Murray, P 2008, *The Cultural Values of the Central Ranges (including the West MacDonnells): A preliminary report*, consultancy report to the Northern Territory Parks and Wildlife Commission.

Hardman, W 1865, *The Journals of John McDouall Stuart during the years 1858, 1859, 1860, 1861, & 1862, when he fixed the centre of the continent and successfully crossed it from sea to sea*, Second Edition, Saunders, Otley & Co., London, digitised by the University of Adelaide, 2014, https://ebooks.adelaide.edu.au/s/stuart/john_mcdouall/journals/complete.html.

Heritage Branch (Department of Lands, Planning and the Environment) n.d., *Scope of Works for an Archaeological Survey*, Heritage Branch, Northern Territory.

Heritage Concepts Pty Ltd 2008, *Statement of Heritage Impact Archaeological Monitoring & Test Excavation Report Wooden Corduroy Road Eastern End of Ourimbah Creek Road*, draft consultancy report to Roads and Traffic Authority.

Hesse, PP, Luly, JG & Magee, JW 2005 'The Beating Heart: Environmental history of Australia's deserts', in M Smith & P Hesse (eds.), *23°S: Archaeology and Environmental History of the Southern Deserts*, National Museum of Australia Press, Canberra.

Holdaway, S & Stern, N 2004, *A Record in Stone: The study of Australia's flaked stone artefacts*, Museum Victoria, Melbourne.

Jones, P 2007, *Ochre and Rust: Artefacts and Encounters on Australian Frontiers*, Wakefield Press, South Australia.

Kruse, PD, Dunster, JN & Munson, TJ 2013, 'Georgina Basin', in M Ahmad & TJ Munson (comps.), *Geology and mineral resources of the Northern Territory: Northern Territory Geological Survey, Special Publication 5*, Northern Territory Department of Mines and Energy.

Lay, MG 1992, *Ways of the World: A history of the world's roads and of the vehicles that used them*, Rutgers University Press, New Brunswick.

Ling, T 2015, *Administration of the Northern Territory during the war*, National Archives of Australia, <http://guides.naa.gov.au/records-about-northern-territory/part1/chapter4/4.4.aspx#>

Long, JPM 1971, 'Arid Region Aborigines: The Pintubi', in DJ Mulvaney & J Golson (eds.), *Aboriginal Man and Environment in Australia*, Australian National University Press, Canberra.

Meggitt, MJ 1962, *Desert People: A study of the Walbiri Aborigines of Central Australia*, Angus & Robertson Publishers, North Ryde, NSW.

Moloney, J 2005, *The Fire Book*, Tangentyere Landcare, Alice Springs.

Mountford, CP 1976, *Nomads of the Australian Desert*, Rigby Limited, Adelaide.

Napton, LK & Greathouse, EA 1985, 'Archaeological Investigations at Pine Gap (Kuyunba), Northern Territory', *Australian Archaeology*, vol. 20: 90-108.

O'Connor, S, Veth, P & Campbell, C 1998, 'Serpent's Glen Rockshelter: Report of the first Pleistocene-aged occupation sequence from the Western Desert', *Australian Archaeology*, vol. 46: 12-22.

Office of the Aboriginal Land Commissioner 1980, *Lander Warlpiri Anmatjirra Land Claim to Willowra Pastoral Lease*, Report by the Aboriginal Land Commissioner, Mr. Justice Toohey, to the Minister for Aboriginal Affairs and to the Administrator of the Northern Territory, Australian Government Publishing Service, Canberra.

Office of the Aboriginal Land Commissioner 1987, *Ti-Tree Station Land Claim*, Report by the Aboriginal Land Commissioner, Mr. Justice Maurice, to the Minister for Aboriginal Affairs and to the Administrator of the Northern Territory, Australian Government Publishing Service, Canberra.

Paterson, A 2005, 'Historical interactions between Aborigines and European pastoralists in Australia's drylands', in M Smith & P Hesse (eds.), *23°S: Archaeology and Environmental History of the Southern Deserts*, National Museum of Australia Press, Canberra.

Patterson, A, Gill, N & Kennedy, M 2003, 'An archaeology of historical reality? A case study of the recent past', *Australian Archaeology*, vol. 57: 82-89.

Pearson, M, & Sullivan, S 1995, *Looking After Heritage Places: The Basics of Heritage Planning for Managers, Landowners and Administrators*, Melbourne University Press, Carlton.

Peterson, N & Lampert, R 1985, 'A Central Australian Ochre Mine', *Records of the Australian Museum*, vol. 37(1): 1-9.

Poole, P 2007, *Challenging Terrain No Match for Engineering Ingenuity*, Engineers Australia Heritage Committee, Northern Territory, https://www.engineersaustralia.org.au/portal/system/files/engineering-heritage-australia/nomination-title/Stuart_Highway.pdf

Pye, K 1987, *Aeolian Dust and Dust Deposits*, Academic Press Inc. (London) Limited, London.

Rea, N 2009, *Provision for Cultural Values in Water Management*, Land and Water Australia, Canberra.

Roberts, RG, Spooner, NA, Jones, R, Cane, S, Olley, JM, Murray, AS & Head, MJ 1996, 'Preliminary luminescence dates for archaeological sediments on the Nullarbor Plain, South Australia', *Australian Archaeology*, vol. 42: 7-16.

Ross, J 2005, 'Rock Art of the Red Centre', in M Smith & P Hesse (eds.), *23°S: Archaeology and Environmental History of the Southern Deserts*, National Museum of Australia Press, Canberra.

Smith, M 1997, *Archaeological Survey of the Proposed Alice Springs to Darwin Railway: Alice Springs to Buchanan Highway*, consultancy report to the Department of Transport and Works, Darwin.

Smith, MA 1988, *The Pattern and Timing of Prehistoric Settlement in Central Australia*, Unpublished PhD thesis, Department of Archaeology and Palaeoanthropology, University of New England, Armidale.

Smith, M 2005, 'Moving into the southern deserts: An archaeology of dispersal and colonisation', in M Smith & P Hesse (eds.), *23°S: Archaeology and Environmental History of the Southern Deserts*, National Museum of Australia Press, Canberra.

Smith, MA 2006, 'Characterizing Late Pleistocene and Holocene Stone Artefact Assemblages from Puritjarra Rock Shelter: A Long Sequence from the Australian Desert', *Records of the Australian Museum*, vol. 58: 371–410.

Smith, M 2013, *The Archaeology of Australia's Deserts*, Cambridge University Press, New York

Smith, M & Hesse, P 2005, 'Capricorn's Deserts', in M Smith & P Hesse (eds.), *23°S: Archaeology and Environmental History of the Southern Deserts*, National Museum of Australia Press, Canberra.

Smith, M & Ross, J 2008, 'Glen Thirsty: The history and archaeology of a desert well', *Australian Archaeology*, vol. 66: 45-59.

Spencer, B and Gillen, FJ 1899, *Native Tribes of Central Australia*, Macmillan and Co. Limited, London, <https://archive.org/details/nativetribesofce00spenuoft>

Spencer, B and Gillen, FJ 1904, *The Northern Tribes of Central Australia*, Macmillan and Co. Limited, London.

Sullivan, CJ, & Opik, AA 1951, *Ochre Deposits, Rumbalara, Northern Territory*, Bulletin 8, Commonwealth of Australia, Ministry of National Development, Bureau of Mineral Resources, Geology and Geophysics.

Thorley, P 1999, 'A resin-hafted stone implement from the middle Palmer River Catchment, Central Australia', *Australian Archaeology*, vol. 48: 45.

Thorley, P, Faulkner, P & Smith, M 2011, 'New Radiocarbon Dates for Kulpi Mara Rockshelter, Central Australia', *Australian Archaeology*, vol. 72: 47-49.

Tille, P 2006 *Soil-landscapes of Western Australia's Rangelands and Arid Interior: Resource Management Technical Report 313*, Department of Agriculture and Food, Government of Western Australia.

Tindale, N B 2015 [1974], *Tindale's Catalogue of Australian Aboriginal Tribes*, South Australian Museum Archives, <http://archives.samuseum.sa.gov.au/tindaletribes/>

Wilson, BA , Brocklehurst, PS, Clark, MJ & Dickinson, JKM 1990 *Vegetation Survey of the Northern Territory, Australia: Explanatory Notes to Accompany 1:1,000,000 Map Sheets*, Conservation Commission of the Northern Territory Australia.

Young, E 1987, 'Resettlement and Caring for the Country: The Anmatyerre experience', *Aboriginal History*, vol. 11 no. 2:156-170.

Trove Newspapers

Newcastle Morning Herald and Miner's Advocate, 'Northern Territory Mining', 6 July 1896 p.4, <http://trove.nla.gov.au/ndp/del/article/136263663>

Northern Standard, 'Territory Stations: Two More Bought by Kidmans', 15 June 1928 p.3, <http://trove.nla.gov.au/ndp/del/article/48029646>

Northern Territory Times and Gazette, 'Nelson's Close Call: Lived on Engine Oil for Two Days', 3 November 1925 p.1, <http://trove.nla.gov.au/ndp/del/article/3381179>

Observer, 'North-South Line', 23 July 1923 p.30, <http://trove.nla.gov.au/ndp/del/article/165651802>

Websites (General)

Aboriginal Areas Protection Authority (AAPA)
<<http://www.aapant.org.au/>>