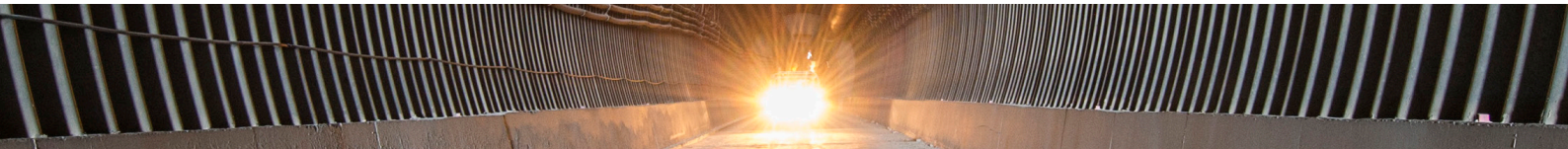


# **Appendix 7**

## **Noise and vibration impact assessment**





PREPARED BY:

SLR Consulting Australia Pty Ltd  
ABN 29 001 584 612  
10 Kings Road New Lambton NSW 2305 Australia

**DOCUMENT CONTROL**

Reference	Status	Date	Prepared	Checked	Authorised
630.10155.00300-R3	Rev 0	23 April 2014	Nathan Archer	John Cotterill	John Cotterill

# CONTENTS

<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
<b>2</b>	<b>ASSESSMENT REQUIREMENTS</b>	<b>1</b>
	2.1 Northern Territory Environmental Protection	1
	2.2 Rio Tinto Environmental Standard	2
	2.3 Relevant Policy Documents	2
<b>3</b>	<b>OBJECTIVES</b>	<b>3</b>
<b>4</b>	<b>SITE AND PROJECT DESCRIPTION</b>	<b>3</b>
	4.1 Proposed Project	3
	4.2 Potential Sources of Noise and Vibration	5
	4.2.1 Ventilation	5
	4.2.2 Refrigeration	5
	4.2.3 Backfill plant	5
	4.2.4 Crushing and screening plant	5
	4.2.5 Power generation	7
	4.2.6 Haulage	7
	4.2.7 Blast operations	7
	4.2.8 Ventilation raise construction	7
	4.3 Noise and Vibration Sensitive Receptors	8
	4.3.1 Residential and Public Sensitive Receptors	10
	4.3.2 Cultural Receptors	10
	4.3.3 Ecologically Sensitive Areas	10
<b>5</b>	<b>NOISE MODELLING METHODOLOGY</b>	<b>12</b>
<b>6</b>	<b>PLANT AND EQUIPMENT SOUND POWER LEVELS</b>	<b>12</b>
	6.1 Existing Ranger Mine Plant and Equipment	12
	6.2 Proposed Ranger 3 Deeps Operational Plant and Equipment	14
	6.3 Proposed Ranger 3 Deeps Construction Plant and Equipment	14
<b>7</b>	<b>EXISTING RANGER MINE NOISE EMISSIONS</b>	<b>15</b>
	7.1 General Methodology	15
	7.2 Ambient Noise Monitoring Results	15
	7.3 Predicted Maximum Operating Noise Levels from Existing Operations	16
<b>8</b>	<b>NOISE AND VIBRATION IMPACT ASSESSMENT – RESIDENTIAL AND PUBLIC RECEIVERS</b>	<b>17</b>
	8.1 Assessment Procedure	17
	8.2 Operational Noise Assessment	18
	8.2.1 Operational Noise Assessment Criteria	18
	Assessing Intrusiveness	18
	Assessing Amenity	18
	8.2.2 Operational Project Specific Noise Levels	20
	8.2.3 Operational Noise Modelling Scenarios	21
	8.2.4 Operational Noise Modelling Results and Discussion	22
	8.3 Construction Noise Impact Assessment	22
	8.3.1 Procedures	22
	8.3.2 Project Specific Construction Noise Goals	23
	8.3.3 Construction Noise Modelling Scenarios	23
	8.3.4 Construction Noise Modelling Results and Discussion	24
<b>9</b>	<b>NOISE IMPACT ASSESSMENT ON FAUNA GROUPS</b>	<b>24</b>

9.1	Literature Review	24
9.1.1	Invertebrates	25
9.1.2	Amphibians	25
9.1.3	Reptiles	25
9.1.4	Birds	26
9.1.5	Mammals	27
9.2	Potential Ranger 3 Deeps Noise Impacts	27
9.2.1	Noise Disturbances	27
9.2.2	Types of Noise	27
9.2.3	Responses to Noise Events	28
9.2.4	Bird activities	29
9.3	Ranger 3 Deeps Proposed Noise Criteria	29
9.4	Fauna Noise Impact Assessment	30
9.4.1	Construction	30
	Steady or continuous noise sources LAeq(15minute) (dBA)	30
	Episodic (single event or short-term) noise sources L <sub>Amax</sub> (dBA)	30
9.4.2	Operation	31
9.4.3	Discussion	32
<b>10</b>	<b>VIBRATION IMPACT ASSESSMENT</b>	<b>33</b>
10.1	Underground Blasting	33
10.1.1	Blasting Design Goals	33
10.1.2	Site Specific Blasting Criteria	35
10.1.3	Blasting Parameters	35
10.1.4	Ground Vibration Site Law	35
10.1.5	Predicted Blasting Emissions	36
10.1.6	Blast Monitoring	36
10.2	Surface Facility Construction Vibration	37
<b>11</b>	<b>SUMMARY</b>	<b>37</b>
<b>12</b>	<b>REFERENCES</b>	<b>39</b>
<b>13</b>	<b>CLOSURE</b>	<b>41</b>

## FIGURES

Figure 1: Ranger 3 Deeps Project area	4
Figure 2: Ranger 3 Deeps Noise Sources	6
Figure 3: Defined receptor locations	9
Figure 4: Location of Survey Area, Magela Creek, Georgetown Billabong and Retention Pond 1	11
Figure 5: Construction Vibration as a Function of Distance (Amick and Gendreau 2000)	37

## TABLES

Table 1: Meteorological Parameters for Noise Predictions	12
Table 2: 2010 Noise Model Acoustically Significant Plant and Equipment (Heggies 2010)	13
Table 3: Additional Equipment Sound Power Levels	14

## Noise and Vibration Impact Assessment

Table 4: Proposed Ranger 3 Deeps Plant Sound Power Levels	14
Table 5: Construction Plant and Sound Power Levels	14
Table 6: Operator Attended Noise Monitoring Results	16
Table 7: Predicted Maximum Operating Noise Levels from Existing Operations	17
Table 8: Amenity Criteria – Recommended LAeq Noise Levels from Industrial Noise Sources	19
Table 9: Modification to Acceptable Noise Level (ANL)* to Account for Existing Levels of Industrial Noise	20
Table 10: Operational Project Specific Noise Criteria	21
Table 11: Operational Noise Modelling Scenario – Ranger 3 Deeps additional equipment	21
Table 12: Predicted Operational Noise Levels	22
Table 13: Interim Construction Noise Guideline (Residences)	23
Table 14: Project Specific Construction Noise Criteria	23
Table 15: Predicted Construction Noise Levels	24
Table 16: Noise thresholds for responses by North American birds (Modified from USFWS 2004)	26
Table 17: Likely responses of terrestrial fauna (birds and amphibians) to noise stimuli	28
Table 18: Likely effects on terrestrial fauna as a result of the construction and operation of the Project	29
Table 19: Predicted Construction Noise Levels at Ecologically Sensitive Receptors	30
Table 20: Maximum Sound Power Levels	31
Table 21: Predicted Operational Noise Levels at Ecologically Sensitive Receptors	31
Table 22: Ground vibration limits for human comfort chosen by some regulatory authorities (AS 2187.2 2006)	34
Table 23: Recommended ground vibration limits for control of damage to structures (AS 2187.2 2006)	34
Table 24: Adopted Vibration Criteria for Cultural Heritage Sites	35
Table 25: Site Specific Blast Criteria	35
Table 26: Blast Parameters for access, lateral and stope development	35
Table 27: Predicted Ground Vibration Levels	36

## GLOSSARY OF TERMS AND ABBREVIATIONS

ABL	The Assessment Background Level (from the INP) is the single-figure background level representing each assessment period – day, evening and night. Three ABLs are determined for each 24-hour monitoring period. (See also Background Noise and RBL.)
Ambient Noise	The all-encompassing noise associated with a given environment. It is the composite of sounds from many sources, both near and far, and is often (but need not necessarily be) assigned the LAeq descriptor.
Attenuation	The reduction of noise levels.
A-weighting	The adjustment made to measured noise spectra, via use of an electronic filter, to approximate the response of the human ear.
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed.
Compliance	Where noise levels meet the criteria.
Day or Daytime	The duration of the assessment period – which may change according to the particular Standard or Guideline. For INP purposes, it is 07.00 am to 6.00 pm (Monday to Saturday) and 08.00 am to 6.00 pm on Sundays and public holidays.
DECCW	NSW Department of Environment, Climate Change and Water. (Previously the DECC and subsequently the Office of Environment and Heritage.)
dB	Abbreviation for decibel – a unit of (amongst other things) sound measurement.
dB(A) or dB(A)	A-weighted decibel. A single number measurement of the sound pressure based on the decibel but weighted to approximate the response of the human ear with respect to frequencies. A noise level of 56 dBA may also be written as 56 dB(A) LA 56, or 56 LA.
EPA	NSW Environment Protection Authority – the current environmental protection authority in NSW.
Evening	The duration of the assessment period – which may change according to the particular Standard or Guideline. For INP purposes, it is 06.00 pm to 10.00 pm.
ICNG	Interim Construction Noise Guideline. The ICNG provides a guideline for the assessment of noise impacts from construction activities.
INP	Industrial Noise Policy. Administered by the NSW Government's EPA. The INP provides a framework and process for deriving noise limit conditions for consents and licenses that will enable the EPA to regulate premises.
L <sub>Amax</sub>	Maximum noise level measured at a given location over a specified time interval.
LAN	LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. (See also LA1 etc.)
LA1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
LA10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured. During a 15 minute survey, it would represent the loudest 90 seconds.
LA90	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise. During a 15 minute survey, it would represent the quietest 90 seconds.
LAeq	Equivalent sound pressure level – the steady sound level that, over a specified period of time, would produce the same energy as the fluctuating sound level actually occurring.
LAeq(15minute)	The LAeq noise level for the 15 minute period. In accordance with the INP Intrusive criteria, LAeq(15minute) from industry is assessed against the RBL + 5 dBA.
LAeq(period)	The LAeq noise level for the assessment period. For the INP day is 7.00 am to 6.00 pm, evening 6.00 pm to 10.00 pm and night 10.00 pm to 7.00 am. In accordance with the INP amenity criteria, LAeq(period) from industry is assessed against the day/evening/night amenity goal.
Level	See Sound Pressure Level.
Night or Night-time	The duration of the assessment period – which may change according to the particular Standard or Guideline. For INP purposes, it is 10.00 pm to 07.00 am (Monday to Saturday) and 10.00 pm to 08.00 am on Sundays and public holidays.
Noise Level	See Sound Pressure Level.
OEH	NSW Office of Environment and Heritage. (Previously the DECCW and subsequently the EPA.)
Peak Velocity, PPV	The maximum instantaneous velocity (of vibration), without any averaging. Sometimes referred to as 'peak

## Noise and Vibration Impact Assessment

	particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period. (See also rms Velocity and Vibration.)
RBL	The Rating Background Level (from the INP) is obtained by calculating the median values of the day /evening /night ABLs. For example, for a weeks worth of monitoring, the night RBL is the median of the seven ABLs. (See also ABL and Background Noise.)
Sound Level	See Sound Pressure Level.
Sound Power Level SWL or Lw	The Sound Power Level of a noise source is an inherent quality of that source and does not depend upon its location or the distance from it. On the other hand, however, the sound pressure level, of say a vacuum cleaner, will depend upon the distance from it and /or the acoustic conditions ("reverberant" or not) of the room in which it is located. (See also Sound Pressure Level.)
Sound Pressure Level SPL or Lp	The level of noise, usually expressed in dBA, as measured by a sound level meter with a microphone. The sound pressure level due to a noise source (eg, a vacuum cleaner, or an item of mechanical plant) will depend upon the distance from the source and /or the acoustic conditions ("reverberant" or not) of the space in which it is located, as well as the "directionality" of the noise source and the location of any reflecting surfaces near to the source and /or the measurement location. (See also Sound Power Level.)
Vibration	Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration, or the risk of damage to buildings, use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

# 1 INTRODUCTION

Energy Resources of Australia Ltd (ERA) is required to undertake an Environmental Impact Assessment (EIA) for the Ranger 3 Deeps underground mine (the Project). The proposed EIA is in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Northern Territory Environmental Assessment Act*.

SLR Consulting Australia Pty Ltd (SLR) [formerly Heggies Pty Ltd (Heggies)] has been commissioned by ERA to undertake a Noise and Vibration Impact Assessment for the Project in accordance with the requirements of the Northern Territory Environment Protection Authority (NTEPA) and Commonwealth Department of the Environment<sup>1</sup> *Guidelines for the Preparation of an Environmental Impact Statement – Ranger 3 Deeps Underground Mine* dated August 2013 (the Guidelines).

Acoustic terminology used in this report is presented in **Appendix A**.

## 2 ASSESSMENT REQUIREMENTS

### 2.1 NORTHERN TERRITORY ENVIRONMENTAL PROTECTION

The following extracts from the Guidelines are of relevance to the noise and vibration impact assessment:

#### ***Section 3.3 Proposal Components***

##### ***Section 3.3.9 Noise***

*Provide relevant information with respect to noise, including but not limited to:*

- *The expected noise levels associated with the proposal construction and operation, including timing and duration, in comparison to levels associated with the existing operation, sensitive receptors and nominated noise criteria and standards; and*
- *Describe the management of relevant noise impacts.*

#### ***Section 4.3 Human Health and Safety***

##### ***Section 4.3.3 Information requirements***

*Identify all hazards, including physical hazards, noise, emissions and radiation, as a consequence of the action.*

#### ***Section 4.5 Flora and Fauna***

##### ***Section 4.5.4.2 Relevant potential impacts***

*The EIS must include a description of any relevant impacts during both the construction, operational and decommissioning phases of the project. The following information must be provided for listed threatened species:*

- *A detailed assessment of the potential impacts upon native fauna including consideration, where relevant of noise.*

---

<sup>1</sup> Formerly the Commonwealth Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC)

#### **Section 4.5.5.2 Relevant potential impacts**

*The EIS must include a description of any relevant impacts during both the construction, operational and decommissioning phases of the project. The following information must be provided for listed migratory species:*

- *A detailed assessment of the presence and potential impacts upon migratory species including consideration, where relevant of noise.*

#### **Section 4.5.6 Assessment of risks**

*Provide an assessment of risk to flora and fauna species likely to occur from the proposed action. In particular discuss:*

- *Any impacts to native flora and fauna due to noise and vibration;*
- *An assessment of risk to significant cultural sites from vibration.*

#### **Section 4.9 Additional Matters of National Environmental Significance**

##### **Section 4.9.3 Relevant impacts**

*The EIS must include a description of the relevant impacts during both construction, operational and (if relevant) the decommissioning phases of the project. The following information must be provided for Kakadu National Park world heritage property and national heritage place, Ramsar wetland, and Commonwealth land:*

- *Noise impacts.*

## **2.2 RIO TINTO ENVIRONMENTAL STANDARD**

The Rio Tinto Environment Standard (the Standard) dated September 2003 includes a section regarding noise and vibration control. The Standard states the following with regard to noise and vibration control:

*The intent of this standard is to ensure that Rio Tinto operations minimise their noise and vibration impacts on the surrounding environment and communities. This is to be accomplished by identifying noise and vibration sources, evaluating and prioritising the sources according to significance of potential impacts then taking effective measures to design and implement appropriate controls.*

## **2.3 RELEVANT POLICY DOCUMENTS**

In the absence of Northern Territory specific noise regulations, the noise and vibration impact assessment has been prepared with reference to the Rio Tinto Environmental Standard and the following Australian Standards and policy documents:

- Australian Standard AS 1055:1997 Description and Measurement of Environmental Noise Parts 1, 2 and 3.
- Environmental Protection Authority (EPA) NSW Industrial Noise Policy (INP).
- NSW Department of Environment, Climate Change and Water (DECCW) Interim Construction Noise Guideline (ICNG).

### 3 OBJECTIVES

The objective of this assessment is to identify the incremental change to the noise and vibration profile associated with the Project relative to existing Ranger operations.

The study scope involved:

- Updating the existing Ranger mine noise model based on information provided by ERA to incorporate additional infrastructure that has been constructed since the most recent update in 2010.
- Modelling noise emissions from the updated existing Ranger mine operations to determine the current baseline noise profile.
- Modelling the additional plant and equipment associated with the Ranger 3 Deeps project to determine the noise levels from the construction and operation of the Project in comparison with noise levels associated with existing operations.
- Assessing the possible impacts of noise on the nearest noise sensitive receptors with respect to the nominated noise criteria.
- Assessing the possible impacts of increased noise levels on native fauna at nearby ecologically sensitive receptors.
- Assessing the possible impacts of vibration on the nearest vibration sensitive receptors including culturally sensitive receptors.

### 4 SITE AND PROJECT DESCRIPTION

#### 4.1 PROPOSED PROJECT

- The Project is situated within the footprint of the current Ranger uranium mine, on the Ranger Project Area (RPA). The RPA is located 260 km east of Darwin and 11 km east of the regional centre of Jabiru (**Figure 1**). The Project lies directly east and south-east of the existing Ranger Pit 3.
- All surface infrastructure and land disturbance will occur within the existing footprint of, or adjacent to, current mining operations. Primary surface infrastructure will comprise a number of ventilation raises and associated stack assembly constructed in the vicinity of the decommissioned Magela Land Application Area (MLAA) 1. This infrastructure will augment the existing ventilation system built to maintain air quality in the underground exploration decline.
- Ancillary surface infrastructure for the Project will comprise a backfill plant, refrigeration plant(s) and additional power generation.
- Mining will be by a series of drive and stope developments, accessed via a decline allowing material transport to the surface in trucks. The main mine workings will be greater than 300 m below the surface.

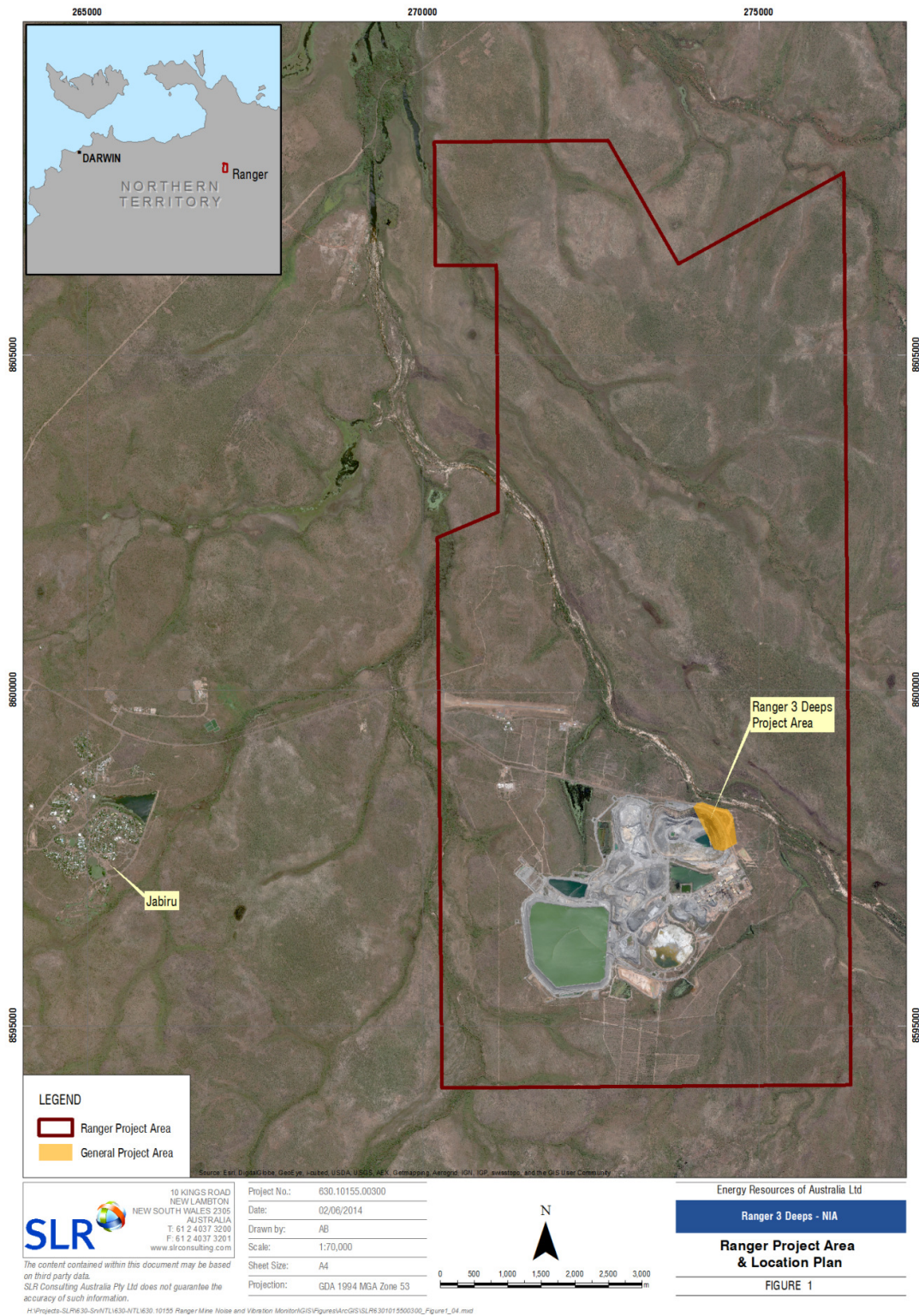


Figure 1: Ranger 3 Deeps Project area

## 4.2 POTENTIAL SOURCES OF NOISE AND VIBRATION

The predominate sources<sup>2</sup> of noise and vibration associated with the project are presented in **Figure 2** and detailed in **Section 4.2.1** to **Section 4.2.8**. It is noted that other non-routine noise producing activities may occur on occasions; however, these are considered to be infrequent and are not assessed in this report as they are not significant to the overall Project noise profile.

### 4.2.1 Ventilation

Mining will be progressed using the 'footwall' mine design. To maintain suitable underground air quality, the Project will have six exhaust vents along its length, at four different locations. The northern and southern locations (exhaust 1 and exhaust 4) each have a single ventilation fan, while the two central locations (exhaust 2 and exhaust 3), each have two fans in close proximity to one another. For modelling purposes, each of these two central exhaust locations have been modelled as a single point source, incorporating the noise output of two fans.

### 4.2.2 Refrigeration

Ranger is located in a region that is known to have high rock temperatures. This, in addition to heat generated underground by equipment, necessitates the installation of refrigeration units cooling the intake air in order to meet defined thermal thresholds. Refrigeration units will be located adjacent to each of the air intakes, including the decline portal.

### 4.2.3 Backfill plant

All mined out stopes will be backfilled with cemented paste aggregate fill. Aggregate will be sourced from stockpiled waste rock, then crushed and screened using a crushing and screening unit. Tailings will be sourced fresh from the mill, de-slimed (fine particles removed) and filtered using vacuum filters.

The backfill plant will be located near the portal adjacent to the waste rock stockpile. The backfill plant will include the following general infrastructure; cement silos, aggregate stockpile, tailing treatment (de-sliming and filtration), paste batching plant, pipes and pumps.

### 4.2.4 Crushing and screening plant

Prior to being transferred to the existing ore sorter, Ranger 3 Deeps ore material will be fed into a crushing and screening plant. The maximum throughput will be approximately 400,000 tonnes per annum.

In addition to ore crushing and screening, waste rock material will be fed into this plant to produce aggregate for the backfill plant. The maximum throughput will be approximately 600,000 tonnes per annum.

A front end loader will be used to feed material into both the crushing and screening plant and the ore sorter. This will be the same front end loader used by existing operations to feed the existing primary crusher from the existing ore stockpile.

---

<sup>2</sup> The final built infrastructure and its location will be determined in the detailed engineering phase. This overview of infrastructure is based on the engineering pre-feasibility study.

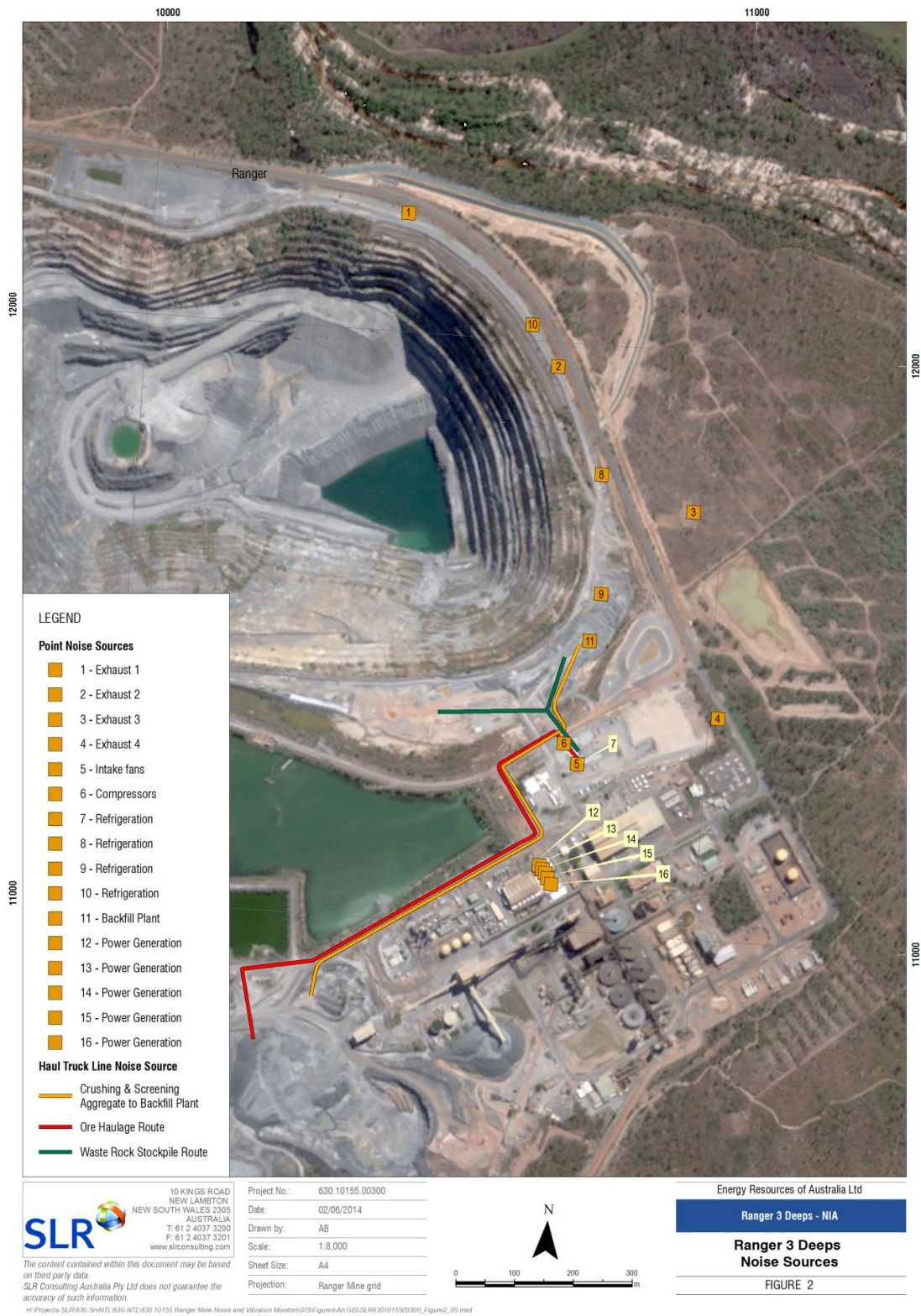


Figure 2: Ranger 3 Deeps Noise Sources

#### **4.2.5 Power generation**

Ranger 3 Deeps power requirements will be serviced by five 2 MW high speed diesel generators. These are similar to those currently used for the brine concentrator water treatment plant. It is assumed that the noise measurements for the brine concentrator generators are representative of that expected for this new infrastructure.

The generators will be located to the eastern side of the existing power station.

#### **4.2.6 Haulage**

The current exploration decline will be utilised as the haulage route for mined ore and waste rock. There are three predominant surface haulage routes. These consist of the following:

- Ore: Ranger mine entrance to the existing ore stockpile (distance is approximately 1 km);
- Waste rock: Ranger mine entrance to waste rock stockpile.
- Crushing and screening unit to backfill plant.

#### **4.2.7 Blast operations**

Blasted material from development and stoping will be transferred from low profile loaders to trucks and hauled to the surface.

Mining depths will range from approximately 300 m to 500 m. Blasting will be performed using explosives which have previously been used for open pit operations.

The nearest surface structures will be at least 300 m vertically above underground blast activity with stope blasts predominantly occurring at or below this level.

#### **4.2.8 Ventilation raise construction**

The general approach for ventilation raise construction, known as “raise boring” involves the following steps:

- Excavate a pit (pre-sink) to a depth of approximately 6 m;
- Fill the trench with concrete;
- Establish the pile and raiseborer slab;
- Drill pile holes and reinforce with fibre reinforced concrete around the circumference of the shaft development to a depth appropriate to the geotechnical conditions at the particular location;
- Erect the raiseborer and drill a pilot hole through to the underground development;
- Attach the raise bore reamer head to the drill shaft underground and progressively ream the shaft back to the surface;
- Shotcrete the completed shaft;
- If required, install a steel liner in the upper, near-surface zone.

Construction of the ventilation raises may require some civil works to prepare the construction pads, and access tracks where required. It is anticipated that these civil works will be undertaken by a grader, excavator and tip truck.

The approximate timeframe to complete a ventilation raise is as follows:

- Pad and access road construction 20 days;
- Drilling, piling and raise bore civil works 40 days;
- Raisebore pilot hole 15 - 20 days;
- Raisebore reaming to surface 30 - 50 days (dependent on depth).

### **4.3 NOISE AND VIBRATION SENSITIVE RECEPTORS**

A number of residential, public, cultural and ecological receivers have been identified for the purpose of this study as detailed in **Section 4.3.1** to **Section 4.3.3**.

**Figure 3** illustrates the location of the Ranger mine in relation to the nearest noise and vibration sensitive receivers.<sup>3</sup>

---

<sup>3</sup> The Tree Snake Dreaming site has been considered in this assessment, however, at the request of the Traditional Owners, is not disclosed in Figure 3.

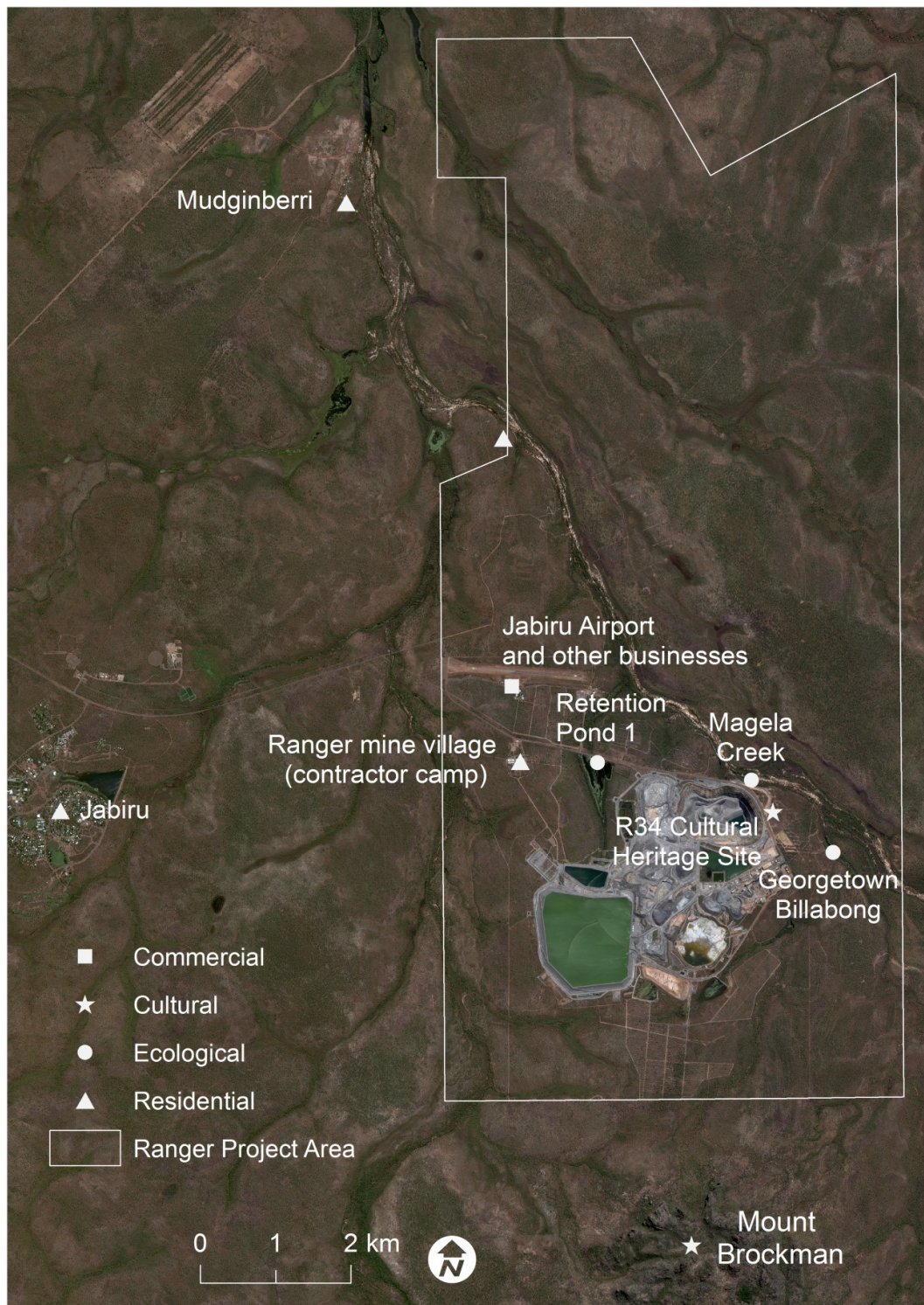


Figure 3: Defined receptor locations

### 4.3.1 Residential and Public Sensitive Receptors

The nearest potentially affected residential receivers to the site are the township of Jabiru and the ERA contractor camp which are located approximately six km and two km west of the western Ranger mine boundary respectively. A transient local aboriginal camp (Camp 009) is situated 4 km north of the mine site with the Mudginberri Aboriginal community around 11 km to the north west of pit 3.

The airport and other businesses<sup>4</sup> are located between approximately two and three km from the mine.

Noise impacts to residential and public sensitive receptors are addressed in **Section 8**.

### 4.3.2 Cultural Receptors

A number of cultural receptors in the form of aboriginal heritage sites have been identified which may potentially be affected by vibration from the Project. Cultural sites potentially sensitive to vibration include rock shelters, grinding grooves and stone arrangements.

The identified receptors include the following:

- Mount Brockman escarpment – this dreaming site contains a number of rock shelters and rock art galleries and is located approximately 4.5 km south of the nearest Ranger 3 Deeps operations.
- The R34 cultural heritage site – this occupancy site contains stone artefacts and evidence of occupancy such as grinding grooves and is located directly above the underground decline.
- The Tree Snake Dreaming site – this is a dreaming site located to the north west of the nearest Ranger 3 Deeps infrastructure.

Vibration impacts to the cultural receptors are assessed in **Section 10**.

### 4.3.3 Ecologically Sensitive Areas

Ecologically sensitive areas have been identified in the vicinity of the Ranger uranium mine and the proposed Ranger 3 Deeps project.

A flora and fauna survey was conducted by Eco Logical Australia to establish the habitat characteristics and presence of flora and fauna, including threatened and migratory species in the vicinity of the Project (Eco Logical Australia 2014). The survey area is defined **Figure 4**.

Noise impacts to the ecologically sensitive areas are addressed in **Section 9**.

---

<sup>4</sup> The airport terminal is occupied by a number of small business operators



Figure 4: Location of Survey Area, Magela Creek, Georgetown Billabong and Retention Pond 1

The ecologically sensitive areas identified and surveyed included Magela Creek, Georgetown Billabong and the associated riverine vegetation corridor as well as the wetland area of Retention Pond 1 (Eco Logical Australia 2014).

Eco Logical Australia (2014) concluded the following with regard to fauna species in the area:

*The range of species recorded during fauna surveys reflects the high richness of birds, and low diversity and abundance of small mammals (e.g. melomys, antechinus) typical of Top End woodlands. While larger mammals (such as wallabies and dingos) remain common, many smaller species have undergone significant declines over most of the Top End during the last 20 years (Woinarski et al. 2010).*

*Wetland areas including RP1 and Georgetown Billabong had the highest species richness (primarily comprising birds). Eastern Partridge Pigeons (listed as vulnerable) were observed on two occasions in Eliocharis sedgeland at the edge of Magela Creek to the south of the Billabong.*

*The listed migratory species that were recorded within the survey area (Cattle and Eastern Great Egrets, Rainbow Bee-eater, White-bellied Sea-eagle and Saltwater Crocodile) are all species that are resident and commonly occur in suitable habitats in the Northern Territory. Within the survey site A, active Rainbow Bee-eater and White-Bellied Sea-eagle nests were recorded in the Magela Creek area. The survey was conducted outside the breeding season of the other migratory species present, but it can be assumed that they breed either within the survey area or in the surrounding Kakadu National Park.*

To determine potential noise impacts on resident fauna groups, this assessment will consider the noise emissions predicted to occur at the ecologically sensitive receivers shown in **Figure 3**.

## 5 NOISE MODELLING METHODOLOGY

Noise modelling of the Project was conducted using Concawe algorithms incorporated in the SoundPlan noise modelling software. The modelling process has utilised the Ranger mine noise model developed by SLR for ERA (refer Heggies Report *30-1478-R3R1 Ranger Uranium Mine – Noise and Vibration Impact Assessment* dated 19 April 2010). This noise model has been updated to reflect current operational configurations at the Ranger mine.

The Ranger mine noise model uses three-dimensional digital terrain maps giving all relevant topographic information, together with noise source data, ground type, shielding such as barriers and/or adjacent buildings and atmospheric information to predict noise levels in the vicinity of the mine. The Ranger mine noise model has been modified to include the plant and equipment associated with the construction and operation of the Ranger 3 Deeps project.

Current topographic information and drawings of the Project were supplied by ERA and were utilised for the purpose of modelling noise.

As part of this assessment, acoustically adverse meteorological parameters have been considered in order to provide a conservative approach. Meteorological parameters under which noise predictions were made are given in **Table 1**.

Table 1: Meteorological Parameters for Noise Predictions

Scenario	Wind Speed	Wind Direction	Stability Class
Calm	0 m/s	n/a	D
Source to Receiver Wind (Worst case)	3 m/s	Source to receiver	D

The Ranger mine noise model incorporates all the acoustically significant plant and equipment from existing mining operations at the mine, including mobile plant within Pit 3 and fixed plant within the processing area. Note that during the anticipated Project time frame, mobile plant activities within Pit 3 will have ceased as Pit 3 will be receiving tailings during this period. Mobile plant will be constrained to moving low grade ore from an existing stockpile to the run of mine stockpile for subsequent processing.

A list of additional acoustically significant plant and equipment expected to be utilised as part of the construction and operation of the Project was provided by ERA. The existing and proposed plant and equipment together with the associated sound power levels (SWL) are presented in **Section 6**.

Where possible, SWLs of all acoustically significant plant and equipment were determined through on-site noise measurements of similar items of plant already in operation at Ranger mine.

Where onsite measurements were not possible, SWLs of items of plant and equipment similar to those proposed have been obtained from an SLR database of measured levels.

## 6 PLANT AND EQUIPMENT SOUND POWER LEVELS

### 6.1 EXISTING RANGER MINE PLANT AND EQUIPMENT

Source noise levels for existing plant and equipment operating at the Ranger mine were obtained from onsite measurements taken between 16 September 2009 and 18 September 2009 using a Brüel & Kjær 2250 integrating sound level meter (s/n: 20600507). These levels are presented in **Table 2**.

Table 2: 2010 Noise Model Acoustically Significant Plant and Equipment (Heggies 2010)

Equipment	Sound Power Level (dBA)
<b>Fixed Plant</b>	
Primary Crusher	113
Primary Crusher Scrubbing Fan	106
Primary Crusher Extraction Fan	105
Secondary Crusher	114
Secondary Crusher Scrubbing Fan	101
End of Stockpiling Conveyor (Conveyors No. 2 & 3)	109
Power Station	111
Cooling Towers	106
Grinding Building	111
Heavy Vehicle Workshop	108
Lime Mill	119
Precipitation Building	105
Laterite Plant	105
Ore Sorter <sup>1</sup>	N/A
<b>Mobile Plant</b>	
CAT 777B Water Carts <sup>2</sup>	115
CAT 785C Haul Trucks	110
CAT 992G Loader (loading CAT785)	112
Komatsu WA900 Loader	110
Hitachi EX2500 Excavator (load cycle)	117
Hitachi EX1200 Excavator <sup>2</sup>	112
CAT D10N Dozer <sup>2</sup>	115
CAT 365C Backhoe	107
CAT 16H Grader	107
CAT 844H Wheeled Dozer	112
Mobile Crusher <sup>2</sup>	114
Mobile Screen <sup>2</sup>	113
SMV Forklift	110
Ingersol-Rand 45 Drill Rig <sup>2</sup>	110

1 – The ore sorter was not operating during the Heggies site visit due to technical problems and so no noise measurements could be obtained.

2 – Noise levels obtained from Heggies database of similar equipment measurements.

Since the development of the Ranger mine noise model in 2010, additional plant and equipment associated with existing Ranger mine operations has been approved and commissioned at the site. Noise levels of additional plant and equipment have been provided by ERA from onsite measurements and have been supplemented by SLR with site measurements undertaken on 17 December 2013 using a RION NA27 integrating sound level meter (s/n: 00960103). **Table 3** presents the SWLs of the additional plant and equipment.

Table 3: Additional Equipment Sound Power Levels

Equipment	Sound Power Level (dBA)
Brine concentrator – four x 2 MW high speed diesel generators	106 per unit
Ore sorter <sup>1</sup>	122
Retention Pond 1 pump	96

1 – Sound power levels calculated from noise measurements provided by ERA.

## 6.2 PROPOSED RANGER 3 DEEPS OPERATIONAL PLANT AND EQUIPMENT

The proposed ventilation system for the Project will consist of AL25 axial flow fans manufactured by Korfmann Lufttechnik GmbH (or similar). Sound power level data has been provided by ERA for un-attenuated and attenuated units.

SWLs of the proposed refrigeration plant and backfill plant have been obtained from an SLR database of measured levels. The proposed power generation units are anticipated to be identical to those utilised in the brine concentrator, therefore, the measured noise levels detailed in **Table 3** have been assumed.

**Table 4** presents the sound power levels of each item of additional plant and equipment associated with the Ranger 3 Deeps project.

Table 4: Proposed Ranger 3 Deeps Plant Sound Power Levels

Equipment	Sound Power Level (dBA)
Ventilation Fan - AL25 Axial Fans (four units) at Exhausts 2 and 3	119 per unit
Ventilation Fan - AL25 Axial Fans – with noise attenuation (two units) at Exhausts 1 and 4	109 per unit
Intake fans (two units)	90 per unit
Refrigeration unit (five units)	101 per unit
Backfill plant	106
Compressor unit (two units)	75 per unit
CAT AD55B Haul Truck	110
Power generation – five x 2 MW high speed diesel generators	106 per unit

## 6.3 PROPOSED RANGER 3 DEEPS CONSTRUCTION PLANT AND EQUIPMENT

A summary of the plant and equipment and associated sound power levels proposed to be utilised in the construction of the Ranger 3 Deeps project is provided in **Table 5** below.

Table 5: Construction Plant and Sound Power Levels

Equipment	Sound Power Level (dBA)
Drill/auger	110
CAT D9 Dozer	109
CAT 16H Grader	107
CAT 825 Vibratory Roller	110
CAT 777 Water Cart	115
1000 kva Genset	107 <sup>1</sup>

1 – Noise levels obtained from an SLR database of similar equipment measurements.

## 7 EXISTING RANGER MINE NOISE EMISSIONS

### 7.1 GENERAL METHODOLOGY

Operator attended noise surveys were conducted to characterise and quantify the existing acoustical environment in the area surrounding existing Ranger mine operations and the proposed Ranger 3 Deeps site. Noise monitoring was undertaken at three locations considered representative of the nearest noise sensitive receivers presented in **Figure 3**. The noise monitoring locations were:

- Ranger mine contractor camp.
- Retention Pond 1.
- Georgetown Billabong.

All acoustic instrumentation employed throughout the monitoring programme has been designed to comply with the requirements of IEC 61672.1-2004 “*Electroacoustics – Sound Level Meters – Specifications*” and carries current NATA or manufacturer calibration certificates. Instrument calibration was checked before and after each measurement survey, with the variation in calibrated levels not exceeding  $\pm 0.5$  dBA.

The purpose of the noise monitoring was to identify existing Ranger mine noise emissions at the nearest sensitive receivers and to validate the existing noise model.

### 7.2 AMBIENT NOISE MONITORING RESULTS

Operator attended noise measurements were conducted during the daytime period on 29 January 2014 over a 15 minute period using a SVAN 957 integrating sound level meter (s/n: 23816).

The results of the operator attended noise measurements are given in **Table 6**. Ambient noise levels given in the tables include all noise sources such as traffic, insects, birds, and Ranger operations as well as any other noise sources.

The tables provide the following information:

- Monitoring location.
- Date & start time.
- Wind velocity (m/s) and Temperature ( $^{\circ}$ C) at the measurement location.
- Typical maximum ( $L_{Amax}$ ) and contributed noise levels.

The acoustic terminology and noise descriptors used in **Table 6** are described and explained in **Appendix A**.

Table 6: Operator Attended Noise Monitoring Results

Location	Date/Start Time/Weather	Primary Noise Descriptor (dBA re 20 µPa)					Comments and Description of Noise Emissions
		L <sub>Amax</sub>	L <sub>A1</sub>	L <sub>A10</sub>	L <sub>A90</sub>	L <sub>Aeq</sub>	
Ranger mine village (contractor camp)	29/01/2014 11:49 W = Calm Temp = 27°C	64	50	47	44	46	Contractor camp water treatment plant, approximately 100m from the monitoring location dominated background noise levels. Ranger operations were not discernible.  Estimated existing Ranger operations L <sub>Aeq</sub> (15min) contribution <34 dBA. <sup>1</sup>
		Estimated existing Ranger operations L <sub>Aeq</sub> (15min) contribution <34 dBA. <sup>1</sup>					
Georgetown Billabong	29/01/2014 12:16 W = Calm Temp = 27°C	64	51	47	43	46	Exploration drilling, approximately 150m from the monitoring location dominated ambient noise levels. Other Ranger operations discernible in the background at approximately ~ 40 dBA  Estimated existing Ranger operations L <sub>Aeq</sub> (15min) contribution ~ 46 dBA.
		Estimated existing Ranger operations L <sub>Aeq</sub> (15min) contribution ~ 46 dBA.					
Retention Pond 1	29/01/2014 11:24 W = Calm Temp = 27°C	82	72	55	45	59	Retention Pond 1 pump house, approximately 150m from the monitoring location dominated background noise levels. Road traffic noise levels also contribute to ambient noise levels Other Ranger operations were not discernible.  Estimated existing Ranger operations L <sub>Aeq</sub> (15min) contribution ~ 45 dBA.
		Estimated existing Ranger operations L <sub>Aeq</sub> (15min) contribution ~ 45 dBA.					

Note 1 – Ranger operations not discernible over the existing ambient noise levels. Where this is the case, noise levels from sources are typically 10 dBA (or more) below the measured L<sub>A90</sub> noise level. Therefore, estimated existing Ranger operations noise contribution equals L<sub>A90</sub> minus 10 dBA.

The following observations were made during the operator attended noise monitoring conducted on 29 January 2014:

- Existing Ranger mine noise sources were generally not discernible at any of the monitoring locations.
- Ambient noise levels at each location were dominated by localised noise sources as follows:
  - Ranger mine contractor village noise levels were dominated by the water treatment plant with mining or processing operations not audible.
  - Georgetown Billabong noise levels were dominated by exploration drilling.
  - Retention Pond 1 noise levels were dominated by the RP1 pump house with other mining and processing operations not audible. It is understood that the pump house mainly operates during the wet season only.
- Typical Ranger mine operations were only audible at the Georgetown Billabong noise monitoring location at levels of approximately 40 dBA.

### 7.3 PREDICTED MAXIMUM OPERATING NOISE LEVELS FROM EXISTING OPERATIONS

The Australian Government Department of Industry (DoI)<sup>5</sup> best practice document (RET 2009) states the following with regard to noise modelling and model validation:

<sup>5</sup> Previously known as Department of Resources, Energy and Tourism (RET)

*“At the start of a planning process, a noise model cannot predict with a high degree of accuracy (1-2 dBA) what the noise level will be at a particular residence over a 15-minute period for a specific operational scenario. Over time (several years), with enough validation during the detailed design phases and the operational phases, the noise model should evolve such that it becomes very site specific and more accurate”.*

Since the development of the 2010 Ranger mine noise model, some additional items of plant and equipment have been commissioned at the site. As such, in order to calibrate and validate the updated noise model, SLR has conducted operator-attended noise surveys at a number of calibration receivers across the study area.

The operational noise modelling includes all significant items of plant and equipment working concurrently to simulate the maximum operating capacity of the Ranger Mine facility and to predict the maximum operating intrusive LAeq(15minute) noise levels. Noise levels have been predicted for the meteorological conditions in **Table 7** for each assessment location.

Predicted outer envelope (worst case) maximum operating noise contours for existing operations are presented in **Appendix B**.

Table 7: Predicted Maximum Operating Noise Levels from Existing Operations

Receptor Location	Predicted Noise Level LAeq(15minute) (dBA)		Estimated Measured Noise Level LAeq(15minute) (dBA)
	Calm	Worst Case	Calm
Ranger mine village (contractor camp)	<30	35	<34
Georgetown Billabong	41	45	40
Retention Pond 1	42	46	44

As presented in **Table 7** predicted Ranger mine noise levels calibrate well to the measured Ranger mine noise levels (+/- 2 dBA). Small differences between the results can be due to varied locations of mobile plant and equipment and precise operating configurations during the measurements.

Notwithstanding this, it is considered that the noise model of existing Ranger mine operations provides an accurate representation of maximum operating noise levels.

## 8 NOISE AND VIBRATION IMPACT ASSESSMENT – RESIDENTIAL AND PUBLIC RECEIVERS

### 8.1 ASSESSMENT PROCEDURE

The process for assessing the noise impacts from the Project is as follows:

- Establish noise criteria for the Project with reference to the relevant environmental standards including the Rio Tinto Noise and Vibration Control Standards, the NSW Industrial Noise Policy (INP) and Interim Construction Noise Guideline (ICNG).
- Predict noise levels from the construction and operation of the Project using the noise modelling methodology described in **Section 5**.
- Compare the predicted noise levels with the relevant criteria in order to assess the possible noise impact of the Project.
- Where noise levels exceed the relevant noise criteria, identify noise mitigation and management strategies which may be implemented to achieve the noise criteria at the nearest receivers.

## 8.2 OPERATIONAL NOISE ASSESSMENT

### 8.2.1 Operational Noise Assessment Criteria

Section 1.3.1 of the Rio Tinto Environment Standard Noise and Vibration Control Guidance Note makes reference to the NSW INP for the purpose of assessing potential operational noise impacts at residential and other noise sensitive receivers. In the absence of Northern Territory specific noise regulations, the INP has been adopted for the purpose of this assessment.

The INP was released in January 2000 and provides a framework and process for deriving noise criteria with the aim of achieving the following objectives:

- To establish noise criteria that would protect the community from excessive intrusive noise and preserve amenity for specific land uses.
- To use the criteria as the basis for deriving project specific noise levels.
- To promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects.
- To outline a range of mitigation measures that could be used to minimise noise impacts.
- To provide a formal process to guide the determination of feasible and reasonable noise limits for consents or licences that reconcile noise impacts with the economic, social and environmental considerations of industrial development.
- To carry out functions relating to the prevention, minimisation and control of noise from industrial premises.

In assessing noise impact there are two components that need to be considered; controlling intrusive noise impacts and maintaining amenity for particular land uses. The INP provides separate criteria for each and the more stringent of the two will become the project specific noise level.

#### Assessing Intrusiveness

For assessing intrusiveness, the background noise level must be measured. The intrusiveness criterion essentially means that the equivalent continuous noise level ( $L_{Aeq}$ ) of the source should not be more than five decibels above the measured background level ( $L_{A90}$ ). Where the background level, as determined by methodology described in the INP, is found to be less than 30 dBA, then the background is set to 30 dBA.

#### Assessing Amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise and do not include road, rail or community noise. To limit continuing increases in industrial noise levels, the maximum ambient noise levels from industrial noise sources in an area should not normally exceed the acceptable noise levels specified in **Table 8**. Meeting the acceptable noise levels in **Table 8** will protect against noise impacts at the nearest sensitive receivers.

**Table 8** also includes recommended maximum noise levels for different land uses. This provides guidance on an upper limit to the level of noise from industry.

Table 8: Amenity Criteria – Recommended LAeq Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day <sup>1</sup>	Recommended LAeq(Period) Noise Level (dBA)	
			Acceptable	Recommended Maximum
Residence	Rural <sup>2</sup>	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
	Urban/Industrial Interface (for existing situations only)	Day	65	70
		Evening	55	60
		Night	50	55
School classrooms - internal	All	Noisiest 1 hour period when in use	35	40
Hospital wards - internal - external	All	Noisiest 1 hour period	35	40
			50	55
Place of worship - internal	All	When in use	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

Note 1: Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am, On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am. The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Note 2: The acoustic environment surrounding the Ranger mine typifies a rural environment. Therefore, the rural criteria have been used for the purpose of this assessment.

The recommended acceptable and maximum amenity noise levels detailed in **Table 8** refer to noise from industrial sources only. However, they apply to noise from all industrial noise sources at the receiver location and not only noise from the project. As such, if noise levels from existing industrial operations (excluding the project) already approach or exceed the amenity criteria, then the allowable amenity noise levels from the project need to be set such that the project does not increase the cumulative industrial noise to above the amenity criteria.

Where this is the case, the amenity criteria provided in **Table 8** are adjusted for the project, based upon the existing level of industrial noise. **Table 9** presents the modification to the acceptable noise levels for the project to account for the level of existing industrial noise.

Table 9: Modification to Acceptable Noise Level (ANL)\* to Account for Existing Levels of Industrial Noise

Total Existing LAeq noise level from Industrial Noise Sources	Maximum LAeq Noise Level for Noise from New Sources Alone, dBA
≥ Acceptable noise level plus 2 dBA	If existing noise level is <i>likely to decrease</i> in future acceptable noise level minus 10 dBA If existing noise level is <i>unlikely to decrease</i> in future existing noise level minus 10 dBA
Acceptable noise level plus 1 dBA	Acceptable noise level minus 8 dBA
Acceptable noise level	Acceptable noise level minus 8 dBA
Acceptable noise level minus 1 dBA	Acceptable noise level minus 6 dBA
Acceptable noise level minus 2 dBA	Acceptable noise level minus 4 dBA
Acceptable noise level minus 3 dBA	Acceptable noise level minus 3 dBA
Acceptable noise level minus 4 dBA	Acceptable noise level minus 2 dBA
Acceptable noise level minus 5 dBA	Acceptable noise level minus 2 dBA
Acceptable noise level minus 6 dBA	Acceptable noise level minus 1 dBA
< Acceptable noise level minus 6 dBA	Acceptable noise level

\* ANL = recommended acceptable LAeq noise level for the specific receiver, area and time of day from **Table 8**

The INP project specific noise levels are the more stringent of either the amenity or intrusive criteria. The INP states that these criteria have been selected to protect at least 90 % of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90 % of the time. Provided the criteria in the INP are achieved, it is unlikely that most people would consider the resultant noise levels excessive.

In those cases where the INP project specific noise levels are not achieved, it does not automatically follow that all people exposed to the noise would find the noise unacceptable. In subjective terms, exceedances of the INP project specific assessment criteria can be generally described as follows:

- Negligible noise level increase <1 dBA (not noticeable by all people).
- Marginal noise level increase 1 dBA to 2 dBA (not noticeable by most people).
- Moderate noise level increase 3 dBA to 5 dBA (not noticeable by some people but may be noticeable by others).
- Appreciable noise level increase >5 dBA (noticeable by most people).

## 8.2.2 Operational Project Specific Noise Levels

Typically, when conducting a noise impact assessment, background noise levels in the vicinity of the subject site would be measured and utilised in determining amenity and intrusive noise goals. In this case, given the remoteness of the subject area, background noise levels have been assumed to be the minimum value prescribed in the INP of 30 dBA (refer **Section 8.2.1**).

The existing acoustical environment typifies a rural environment; “*an area with an acoustical environment that is dominated by natural sounds with little or no road traffic*”. Therefore, the nearest noise sensitive receivers have been assessed as “rural” noise amenity areas as per **Table 8**. There are no existing (non-Ranger mine) industrial operations in the area, therefore, in accordance with **Table 9**, no modification has been made to the acceptable noise levels for a rural area (refer **Table 8**).

The relevant project specific noise criteria at the nearest noise sensitive receivers are provided in **Table 10**.

Table 10: Operational Project Specific Noise Criteria

Location	Period	Intrusiveness Criteria LAeq(15minute) (dBA)	Amenity Criteria LAeq(Period) (dBA)	Project Specific Noise Criteria LAeq (15 minute) (dBA)
Nearest noise sensitive receivers	Day	35 dBA	50 dBA	35 dBA
	Evening	35 dBA	45 dBA	35 dBA
	Night	35 dBA	40 dBA	35 dBA

### 8.2.3 Operational Noise Modelling Scenarios

As outlined in **Section 4.2**, the equipment associated with the operational phase of the Project includes the ventilation fans, backfill plant, refrigeration, power generation, compressed air and the transportation of material along the haulage routes.

A summary of the plant and equipment included in the noise modelling scenario is provided in **Table 11** below. All plant and equipment has been assumed to be operating concurrently 24 hours per day.

Operational noise modelling has been carried out under the meteorological parameters identified in **Table 1**.

Table 11: Operational Noise Modelling Scenario – Ranger 3 Deeps additional equipment

Equipment	Description	Number	Easting	Northing
Attenuated Ventilation Fan	Return Air Raise – South (Exhaust 4)	1	274717	8597374
	Return Air Raise – Far North (Exhaust 1)	1	274200	8598242
Un-attenuated Ventilation Fan	Return Air Raise – a/b Central <sup>6</sup> (Exhaust 3)	2	274679	8597726
	Return Air Raise – a/b - North (Exhaust 2)	2	274452	8597977
Intake fans	Mine entrance	2	274478	8597299
Refrigeration units	Refrigeration	2	274478	8597299
		1	274524	8597792
		1	274521	8597589
Compressor units	Compressed air	1	274410	8598049
		2	274454	8597335
Backfill plant	Backfill	1	274500	8597509
CAT 785 Haul Truck	Waste Rock route	1	N/A <sup>1</sup>	N/A <sup>1</sup>
	Crushing and screening to backfill plant	1	N/A <sup>1</sup>	N/A <sup>1</sup>
	Ore haulage	1	N/A <sup>1</sup>	N/A <sup>1</sup>
2 MW high speed diesel generators	Power generation	5	274410	8597127
			274415	8597121
			274420	8597114
			274424	8597105
			274430	8597095

1 – Mobile noise source

<sup>6</sup> This return air raise is existing infrastructure but has been considered as a component of the Project noise source assessment

## 8.2.4 Operational Noise Modelling Results and Discussion

The predicted LAeq(15 minute) noise levels for the existing Ranger mine operations and the cumulative existing and proposed Ranger 3 Deeps operations at the nearest potentially affected receiver are presented in together with the project specific noise criteria.

Table 12: Predicted Operational Noise Levels

Receptor	Period	Predicted Noise Level LAeq(15minute) (dBA)				Project Specific Noise Criteria (LAeq,15min)
		Existing		Cumulative existing and Ranger 3 Deeps		
		Calm	Source to receiver winds (worst case)	Calm	Source to receiver winds (worst case)	
ERA Contractor Camp	All periods (daytime, evening and night-time)	<30	35	<30	35	35
All other residential and public receivers		<30	<30	<30	<30	

Predicted LAeq(15minute) outer envelope (worst case) noise contours for the cumulative operation of the proposed Ranger 3 Deeps project with existing Ranger mine operations are provided in **Appendix C**.

The 35 dBA noise contour indicates the INP intrusiveness criteria identified for the Project (refer **Table 10**). As such, this noise contour indicates the extent to where noise impacts may occur at residential properties from mining operations.

As indicated in **Appendix C** and **Table 12** predicted cumulative noise levels from existing operations and the additional infrastructure associated with the Project are at or below the operational project specific noise criteria at all residential and public receiver locations.

As presented in **Table 12** the incremental noise level increase at the nearest residential and public noise sensitive receivers, which are all located to the west and north-west of the site, is negligible (less than 1 dBA).

## 8.3 CONSTRUCTION NOISE IMPACT ASSESSMENT

### 8.3.1 Procedures

The Interim Construction Noise Guideline (ICNG) sets out noise management levels, in relation to construction type activities for residential and other sensitive receivers and how they are to be applied. A summary of the noise management levels from the ICNG is contained in **Table 13**.

Table 13: Interim Construction Noise Guideline (Residences)

Time of day	Management level LAeq(15minute)	How to apply
Recommended standard hours Monday to Friday 7am to 6pm Saturday 8am to 1pm No work Sundays or public holidays	Noise affected RBL <sup>1</sup> + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. <ul style="list-style-type: none"> <li>Where the predicted or measured LAeq (15 min)<sup>2</sup> is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.</li> <li>The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.</li> </ul>
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. <ul style="list-style-type: none"> <li>Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:                             <ol style="list-style-type: none"> <li>times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences.</li> <li>if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.</li> </ol> </li> </ul>
Outside recommended standard hours	Noise affected RBL <sup>1</sup> + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. <ul style="list-style-type: none"> <li>The proponent should apply all feasible and reasonable work practices to meet the noise affected level.</li> <li>Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.</li> </ul>

1 – RBL – Rating Background Level: the overall single figure background noise level representing each assessment period (day/evening/night) over the whole monitoring period.

2 – LAeq(15 minute) – The equivalent continuous noise level: the level of noise equivalent to the energy average of noise levels occurring over a 15 minute period.

### 8.3.2 Project Specific Construction Noise Goals

Typically, when conducting a noise impact assessment, background noise levels in the vicinity of the subject site would be measured and utilised in determining amenity and intrusive noise goals. In this case, given the remoteness of the subject area, background noise levels have been assumed to be the minimum value prescribed in the INP of 30 dBA (refer **Section 8.2.1**).

The project specific construction noise criteria, presented in **Table 14** are applicable for the proposed modification.

Table 14: Project Specific Construction Noise Criteria

Location	Period	Construction Noise Criteria LAeq(15minute)	
		Noise Affected	Highly Noise Affected
All residential and public locations	Day	40	75
	Evening	35	N/A
	Night	35	N/A

### 8.3.3 Construction Noise Modelling Scenarios

Surface construction activities associated with the Project consist of the installation of the required ventilation raises and associated surface infrastructure. This will involve the preparation of the site, the drilling of the bore hole and the installation of the fan structure and ducting (**Section 4.2.8**). It is noted that additional plant and equipment will be utilised underground during the construction of the Project, however, noise impacts from underground equipment would be negligible.

Construction noise modelling has assumed that all the plant and equipment detailed in **Table 5** are being utilised concurrently at each of the ventilation raise locations. Since ventilation raise construction will be staggered, this provides a conservative assessment approach. Therefore, actual noise levels are likely to be lower than predicted for much of the time.

Construction noise modelling has been carried out under the meteorological parameters identified in **Table 1**.

### 8.3.4 Construction Noise Modelling Results and Discussion

The predicted  $L_{Aeq(15\text{minute})}$  noise levels for Ranger 3 Deeps construction activities (only) at the nearest potentially affected receiver are presented in **Table 15** together with the construction noise criteria.

Table 15: Predicted Construction Noise Levels

Location	Period	Predicted Noise Level $L_{Aeq(15\text{minute})}$ (dBA)		Construction Noise Criteria $L_{Aeq(15\text{minute})}$ (dBA)	
		Calm	Worst-case (source to receiver winds)	Noise Affected (day/evening/night)	Highly Noise Affected
ERA Contractor Camp	All periods (daytime, evening and night-time)	<30	<30	40/35/35	75
All other residential and public receivers		<30	<30		

As presented in **Table 15**, construction noise levels are predicted to be well below the noise affected construction noise goals at all residential and public receiver locations during all periods.

## 9 NOISE IMPACT ASSESSMENT ON FAUNA GROUPS

### 9.1 LITERATURE REVIEW

The potential effects of noise on terrestrial fauna include physical damage to hearing organs, increased energy expenditure or physical injury while responding to noise, interference with normal animal activities, and impaired communication. The ongoing impacts of these effects may include habitat loss through avoidance, reduced reproductive success and increased mortality (Dawe and Goosem 2008; Mancini *et al* 1988; USFWS 2004).

There are no current government policies or other widely accepted guidelines as to noise levels or thresholds of relevance for terrestrial fauna, partly because the effects of noise on most fauna species are poorly understood (Larkin *et al* 1996, Brown 2001; OSB 2003).

This limited understanding of the effects of noise on fauna is understandable when the following points are considered:

- responses to noise disturbance cannot be generalised across species or genera;
- studies of one species cannot be extended to other species;
- responses even of individuals within a single species may vary;
- hearing characteristics are species-specific – for example, noise impacts on humans are determined using a frequency weighting filter (A-weighting) which corresponds to human hearing characteristics, determined through laboratory testing. The frequency-dependent hearing characteristics of fauna cannot be determined in this way;

- when studying the effects of noise on fauna, it can be difficult to separate noise effects from other sensory disturbing effects (for example, visual or olfactory cues); and
- experimental research in a laboratory is not always applicable in a natural setting.

As with humans, an animal's response to noise can depend on a variety of factors including noise level, frequency distribution, duration, number of events, variation over time, rate of onset, noise type, existence and level of ambient noise, time of year and time of day. The animal's location, age, sex, and past experience may also affect their response to noise.

Despite the difficulties associated with assessing noise impacts on animals, there are a few studies that can assist in drawing some general conclusions. The literature in the field has been collated in a number of reviews including AMEC (2005) (noise from mining operations), Dawe and Goosem (2008) (an Australian study on road traffic noise impacts), Mancini *et al* (1988) (effects of aircraft noise and sonic booms), and the United States Department of Transportation Federal Highways Administration (US FHWA 2004) (road traffic noise impacts). Some key findings of these reviews are summarised in the following sections of this Report.

### **9.1.1 Invertebrates**

Mancini *et al* (1988) describes several studies on the effects of noise on insects. In some cases, noise has been studied with a view to controlling pest insects such as meal-moths and flour beetles, with some success in reducing hatching from the larval stage. Some studies have shown reduced lifespan in insects exposed to noise, and reduced number of eggs produced by females.

Some insects (including bees) stop moving when exposed to high noise levels. Honey bees ceased moving for up to 20 minutes in response to frequencies of approximately 200 Hz – 2,000 Hz with intensities varying from 107 – 119 dB, and did not appear to habituate to the sound (Mancini *et al* 1988).

### **9.1.2 Amphibians**

Sound influences the activities of most amphibians and plays a substantial role in the reproductive behaviour of many, but not all, species (Mancini *et al* 1988). Dawe and Goosem (2008) consider that the degree to which traffic noise affects frog densities remains unclear, although some factors associated with roads and traffic have been shown to reduce frog populations.

In a report on nocturnal noise and amphibians in tropical rainforests of the Kuranda Range in Northern Queensland, (Goosem *et al* 2007), a decline in population densities of at least one frog species was attributed to road noise, with impacts up to 200 m from the road. Noise levels near the road were approximately 60 dB.

While specific noise levels, which may result in amphibians abandoning habitats or being injured, are not available in the literature, observations and experience indicate that amphibians are very sensitive to noise. Even the minor noises of researchers approaching habitats where amphibians are calling can cause a cessation of calling by individuals in close proximity. Conversely, it is common to find some frog species calling in ponds immediately adjacent to roads or railway lines.

### **9.1.3 Reptiles**

Sound perception appears to be subordinate in importance to vision and chemoreception in the activities of most reptiles. However, studies have shown that certain desert reptiles are sensitive to low-intensity sound (Mancini *et al* 1988). Noise may be of more adaptive significance for nocturnal species because full use cannot be made of vision. Critical

environmental sounds are often of relatively low intensity (for example, the movement of insect prey and predators such as snakes and owls).

Some studies reviewed by Mancini *et al* (1988) indicate hearing damage to some lizard species after exposure to steady noise levels above 95 dB.

### 9.1.4 Birds

Measures of absolute auditory sensitivity in a wide variety of bird species show a region of maximum sensitivity between 1 kHz – 5 kHz, with a rapid decrease in sensitivity at higher frequencies. The data suggest that in this frequency range, birds show a level of hearing sensitivity that is similar in most respects to that found for the most sensitive mammals, with avian performance clearly inferior above and below this range of frequencies (Mancini *et al* 1988).

The general conclusion of the US FHWA review (2004) is that some (although not all) bird species are sensitive to road traffic noise (at least during breeding), and that the distances over which this effect is observed can vary considerably (from a few metres to more than 3 km away). Observations also include reduced bird diversity and density of bird life near roads, and in some cases this is associated with average noise levels above 50 dBA.

Dawe and Goosem (2008) state that:

*‘Anthropogenic noise can also trigger flight and alert responses in birds and altered behaviour after the noise disturbance, which can lead to reduced breeding success, at noise levels ranging from 65–85 dB(A). Complete habituation to such disturbance does not always occur, even in less noise-sensitive species’*

An investigation by the US Fish and Wildlife Service (USFWS) (2004) provides some relevant data for the effects of noise on the Marbled Murrelet and the Northern Spotted Owl (reproduced in **Table 16**). The former is an oceanic feeder and nests in old-growth forests, and the latter strictly occupies forests. As there is very little information specific to Australian birds, the noise thresholds from the USFWS have been used to inform this study.

Table 16: Noise thresholds for responses by North American birds (Modified from USFWS 2004)

Effect threshold	Defined as	Noise level
Detectability	Where the noise is detectable but a Murrelet or Spotted Owl does not show any reaction.	4 dB above baseline noise level
Alert	Where the Murrelet or Spotted Owl shows apparent interest by turning its head or extending its neck.	‘could not be documented with any precision’ therefore ‘subjectively placed between the detectability and harassment/injury threshold’ Alert – 57 dBA L <sub>max</sub>
Disturbance	Where the Murrelet or Spotted Owl shows avoidance of the noise by hiding, defending itself, moving the wings or body, or postponing a feeding.	‘could not be documented with any precision’ therefore ‘subjectively placed between the detectability and harassment/injury threshold’ Disturbance – 70 dBA L <sub>max</sub>
Harassment/injury	Where the Murrelet or Spotted Owl is injured, defined as an adult flushed from the nest or the young missing a feeding.	92 dBA L <sub>max</sub>

A further study (Awbrey *et al* 1995) determined that Californian Gnat-catchers (with a call of approximately 50 dB) had a masking distance of 15.2 m from the edge of the road, and did not occur where the road noise was greater than 69 dB. However, this species also successfully bred near an airport with noise levels in excess of 70 dB.

A study of road noise in Victoria (Parris and Schneider 2008) revealed reductions in populations of the Grey Shrike-thrush and Grey Fantail adjacent to busy roads, with those species becoming undetectable at sites with road noise levels of 67 and 72 dB respectively.

As mentioned previously, it has been reported that jet fighter over-flights had no substantial effect on egrets in Florida (Black *et al* 1984), and that aircraft noise levels of 85 dB(A) were required to elicit escape behaviour in the Crested Tern (Brown 1990).

### **9.1.5 Mammals**

Manci *et al* (1988) state that:

*'Sound levels above about 90 dB are likely to be adverse to mammals and are associated with a number of behaviours such as retreat from the sound source, freezing, or a strong startle response. Sound levels below about 90 dB usually cause much less adverse behaviour. Laboratory studies of domestic mammals have indicated that behavioural responses vary with noise types and levels, and that domestic animals appear to acclimate to some sound disturbances'*

The US FHWA review notes that some mammals avoid roads and that in some cases this avoidance behaviour has been attributed to noise.

## **9.2 POTENTIAL RANGER 3 DEEPS NOISE IMPACTS**

### **9.2.1 Noise Disturbances**

With respect to the impacts of noise on terrestrial fauna, although there is a substantial body of research and observations, there are no clear or well-defined thresholds for species' tolerance, even on an individual species basis. While there are many observations with respect to the responses of breeding and non-breeding birds to aircraft over-flights, as well as a number of studies relating to bird densities in proximity to roads, these studies are inconclusive with respect to specific thresholds at which different responses are elicited in different species. Furthermore, many of those observations and studies have been unable to differentiate between the impacts of noise itself and the other associated impacts of the movement of vehicles, aircraft or people.

There are a number of considerations with respect to noise disturbances which would result from construction and operation of the proposed Ranger 3 Deeps including:

- the types of noise emitted – continuous noise (for example, ventilation fans and generators) and episodic or short duration and/or intermittent noise (for example, mobile plant during construction works);
- the types of response elicited – ranging from the masking of calls, to a scale of responses from alert to avoidance (or abandonment) of habitats;
- variations in the responses of different species, and even of individuals within a single species, to different noise disturbances; and
- the interactions between noise disturbances and bird activities.

### **9.2.2 Types of Noise**

The responses of terrestrial fauna to noise disturbances will vary depending upon the type of noise. Generally continuous noise, i.e. noise produced by ventilation fans and generators while operating, is more readily tolerated by terrestrial fauna (particularly birds) than episodic noise disturbances – for instance, haul trucks moving about the site). For example, where a wetland bird has become habituated to the continuous (background) noise of generators, the

episodic noise of a haul truck passing by may still elicit an adverse response. Obviously, the levels of noise are also relevant in identifying the likely responses of terrestrial fauna.

It is also relevant to consider the period of the noise impact when addressing the likely responses and thresholds for terrestrial fauna. With respect to steady state noise sources such as generators and compressors, the most notable impact is likely to occur at start-up, when the equipment transitions from a quiet phase into the continuous noise of on-going activities. In that instance, initiation of the equipment may trigger an alert reaction from terrestrial fauna nearby, while the continuous noise of the equipment may be more readily tolerated by the same terrestrial fauna at the same distance.

Another relevant consideration is that terrestrial fauna are not adapted solely to a quiet environment. Heavy rainfall and thunderstorms can potentially generate noise levels in excess of those likely from the construction and operation of the Ranger 3 Deeps project, and the terrestrial fauna present in the locality is clearly adapted to those circumstances. Conversely, construction of the Project will impose additional noise stimuli as well as noise stimuli over longer periods than those natural weather events.

Notwithstanding this, a high density of birds has been identified in the riparian zone, RP1 and Georgetown Billabong which are all near the existing Ranger mine operations (Eco Logical Australia 2014). These areas are subjected to existing noise events from the current mining operations, and the continuing use of impacted areas demonstrates the adaptability of many bird species and/or their tolerance of noise events typical of the projects.

### 9.2.3 Responses to Noise Events

There are two relevant elements to the responses of terrestrial fauna to noise events:

- masking – where noise affects communication between individuals of a species; and
- individual reactions – ranging from a mild alert response through to avoidance (or abandonment) of habitat including the possibility of nests being abandoned due to novel noise impacts.

The effects of masking are likely to be extremely varied. In general, it can reasonably be assumed that small forest or grassland songbirds and smaller wetland bird species, as well as many amphibians, will be adversely affected by masking to a greater degree than larger and/or more solitary species. For many of these species, vocal communications are vital, and the smaller species at least would have difficulty calling at sufficient volumes to overcome masking when the noise stimuli are at high levels and/or are of long duration.

Individual responses to noise events, as noted above, will vary from a mild alert response (to relatively low noise events) through to avoidance or the abandonment of otherwise suitable habitat. The individual responses, summarised in **Table 17**, will vary between species and groups, as well as between individuals within a single species.

Table 17: Likely responses of terrestrial fauna (birds and amphibians) to noise stimuli

Response	Birds	Amphibians
Alert	Looks briefly at source Turns head.	Briefly ceases calling
Alarm	Looks intently at source Changes position Shows intent to flee.	Ceases calling for a long period
Flight	Moves a short distance from source. Ceases feeding of young and/or foraging.	Temporarily moves away from source
Avoidance	Permanently vacates area or abandons nests.	Permanently vacates area

### 9.2.4 Bird activities

The likely responses of individual birds to the noise events which will arise from construction and operation of the Ranger 3 Deeps project will depend in part on the timing of noise in relation to the bird activities.

As discussed widely in the literature, and as regularly observed, many species become habituated to noise disturbances, particularly continuous noise such as that created by the ventilation fans. There is, however, as discussed above, likely to be some initial alert or alarm response to the start-up of continuous noise sources.

For example, the high densities of birds identified at Retention Pond 1, Georgetown Billabong and the riparian zone (Eco Logical Australia 2014), near the existing mine operations, demonstrate this habituation response. Existing operating noise levels have not prevented species from using these locations.

## 9.3 RANGER 3 DEEPS PROPOSED NOISE CRITERIA

Based on the information presented above, the noise criteria identified in **Table 18** indicate the likely effects on terrestrial fauna of noise levels experienced as a result of construction and operation of the Project. As discussed above, the scientific and published literature is inconclusive with respect to the thresholds or threshold criteria for terrestrial fauna with respect to noise impacts. The thresholds identified in **Table 18** involve a combination of published information (as discussed above), observations and extrapolation. Although derived predominantly from studies of birds, the nominated thresholds in **Table 18** are considered relevant to all terrestrial fauna present in the vicinity of the Ranger 3 Deeps project area.

Table 18: Likely effects on terrestrial fauna as a result of the construction and operation of the Project

Disturbance effect	Steady or continuous noise sources LAeq(15min) (dBA)	Episodic (single event or short-term) noise sources LAmax (dBA)	Typical bird activities potentially impacted
Occasional (Alert) – minor impacts on habitat use for most species	50 to 65	45 to 60	Nesting
Frequent (Alarm or Flight) – moderate impacts on habitat use	65 to 85	60 to 80	Nesting Roosting
Avoidance of area – by most of the population of some species	≥85	≥80	Nesting Roosting Foraging

Note: Masking impacts, particularly on smaller songbirds, may occur at noise levels of approximately the alert threshold right up until the point of avoidance.  
LAmax limits have been specifically set below the LAeq limits in recognition of considerations related to startle responses.

Variations will doubtless exist in individual responses (as noted above), and a combination of those variations in tolerance to noise between individuals of a species, as well as habituation to noise impacts, meaning that the thresholds identified in **Table 18** may be somewhat conservative. Therefore, some individuals from several of the species affected will become at least partially habituated to the noise over time, and potentially recolonise areas that had initially been abandoned. The continuing use of the Georgetown Billabong, Retention Pond 1 and riparian zones near the existing Ranger mine operations by high densities of wetland birds at times demonstrates the adaptability of many of these species.

Conversely, as discussed above and in several of the reports on wildlife and noise previously cited, the noise tolerances and thresholds of different species of birds (and of other animals) vary considerably. As a consequence, it is possible some species are more sensitive than

suggested by the values in **Table 18**, and individuals of some species may vacate habitat close to the noisiest work sites.

In this regard, an initial effect when construction first commences in a new area is likely, causing individuals of a number of species in near proximity to move away or abandon the area altogether. However, over time, equilibrium is likely to be ultimately reached between more noise-tolerant specimens of the same species and longer term operational work areas. It is anticipated individuals of a number of species which would probably move some distance away during initial construction activities will return to disturbance areas, up to a point.

## 9.4 FAUNA NOISE IMPACT ASSESSMENT

Predicted steady state ( $L_{Aeq(15minute)}$ ) and episodic ( $L_{Amax}$ ) noise levels have been calculated to the representative ecologically sensitive receiver locations presented in **Figure 3** for construction and operation of the proposed Ranger 3 Deeps project.

In addition, the noise contour plot presented in **Appendix C** has been analysed to assess potential operational noise impacts. From the emission contours, it is possible to interpret predicted noise levels at any given location surrounding the Ranger mine. This is important for identifying potential impacts on ecologically sensitive areas since, unlike residential and public receptors, terrestrial fauna will tend to move about the project area.

### 9.4.1 Construction

#### Steady or continuous noise sources $L_{Aeq(15minute)}$ (dBA)

$L_{Aeq(15minute)}$  noise levels have been modelled to the nearest ecologically sensitive receivers as per the construction noise modelling scenario presented in **Section 8.3.3**.

The predicted  $L_{Aeq(15minute)}$  noise levels for Ranger 3 Deeps construction activities (only) at the nearest ecologically sensitive receptors are presented in **Table 19**. Noise levels have been predicted under worst case meteorological conditions presented in **Table 1** to provide a conservative assessment approach.

Table 19: Predicted Construction Noise Levels at Ecologically Sensitive Receptors

Location	Period	Predicted Noise Level $L_{Aeq(15minute)}$ (dBA)	Disturbance effect	
		Worst-case (source to receiver winds)	Occasional	Frequent
Georgetown Billabong	All periods (daytime, evening and night-time)	49	50-65	65-80
Retention Pond 1		32		
Magela Creek		58		

As presented in **Table 19**, steady or continuous noise sources associated with Ranger 3 Deeps construction activities are predicted to be 58 dBA at Magela Creek due to construction of exhaust point 1. In accordance with the criteria presented in **Table 18** this noise level may result in occasional disturbance effects and is likely to have a minor impact on habitat use for most species.

As described in **Section 4.2.8** the anticipated timeframe for the construction of each ventilation raise is up to 130 days and as such, impacts in the vicinity of each raise will be relatively short term.

#### Episodic (single event or short-term) noise sources $L_{Amax}$ (dBA)

In assessing episodic noise sources from construction activities,  $L_{Amax}$  noise levels of acoustically significant plant and equipment to be used were input to the noise model. The

maximum anticipated noise level from the construction of the ventilation raises is likely to be associated with trackslap or blade bangs from the dozer conducting initial earthworks.

The considered acoustically significant plant and equipment and the associated L<sub>Amax</sub> levels are provided in **Table 20**. L<sub>Amax</sub> noise level predictions were made at the nearest ecologically sensitive areas under adverse weather conditions.

Table 20: Maximum Sound Power Levels

Source	L <sub>Amax</sub> (dBA)
Dozer	124

Maximum noise levels up to L<sub>Amax</sub> 54 dBA and 62 dBA may occur at Georgetown Billabong and Magela Creek respectively during construction activities under these circumstances. In accordance with the criteria presented in **Table 18** this noise level may result in occasional disturbance effects and is likely to have a minor impact on habitat use for most species.

At all other ecologically sensitive receptor locations, predicted L<sub>Amax</sub> construction noise levels are well below the occasional disturbance noise level of 50 dBA.

### 9.4.2 Operation

Following construction of the Project, the main noise sources adjacent to the ecologically sensitive receiver areas will be the ventilation fans. These are generally steady state or continuous noise sources. Episodic noise sources are unlikely to change from those associated with existing Ranger mine operations.

The predicted L<sub>Aeq(15minute)</sub> noise levels for the existing Ranger mine operations and the cumulative existing and proposed Project operations at the nearest ecologically sensitive receptors are presented in **Table 21** together with the proposed disturbance criteria.

Predicted L<sub>Aeq(15minute)</sub> outer envelope (worst case) noise contours for the cumulative operation of the proposed Ranger 3 Deeps project with existing Ranger mine operations are provided in **Appendix C**. The 50 dBA noise contour indicates the lower limit of the occasional disturbance criteria identified for the Project (refer **Table 18**). As such this noise contour indicates the extent to where noise impacts may occur from Ranger mine operations including Ranger 3 Deeps.

Table 21: Predicted Operational Noise Levels at Ecologically Sensitive Receptors

Location	Period	Predicted Noise Level L <sub>Aeq(15minute)</sub> (dBA)		Disturbance effect L <sub>Aeq(15minute)</sub> (dBA)	L <sub>Aeq(15minute)</sub> (dBA)
		Worst-case (source to receiver winds)			
		Existing	Cumulative Ranger 3 Deeps and existing	Occasional	Frequent
Georgetown Billabong	All periods (daytime, evening and night-time)	45	51	50-65	65-80
Retention Pond 1		43	43		
Magela Creek		45	58		

As presented in **Table 21**, noise levels associated with the operation of the Ranger 3 Deeps project are predicted to be within the occasional disturbance noise zone at the nearest ecologically sensitive receivers of Georgetown Billabong and Magela Creek.

As presented in **Table 21**, the Project is likely to introduce an incremental increase in noise levels of up to 13 dBA at the ecologically sensitive receivers to the east of the site.

Notwithstanding this, noise levels remain well below the frequent disturbance criteria identified for the Project.

**Appendix D** presents the incremental increase in the area predicted to experience noise levels above the occasional disturbance criteria of 50 dBA between existing and proposed Ranger 3 Deeps operations. As presented in **Appendix D**, the operation of the Project is predicted to result in approximately a 182 Hectare (Ha) increase in the area experiencing noise levels above 50 dBA in comparison with existing operations.

**Appendix E** presents the incremental increase in the area predicted to experience noise levels above the frequent disturbance criteria of 65 dBA between existing and proposed Ranger 3 Deeps operations. As presented in **Appendix E**, the operation of the Project is predicted to result in approximately a 39 Ha increase in the area experiencing noise levels above 65 dBA in comparison with existing operations.

### 9.4.3 Discussion

Initially, construction of the Ranger 3 Deeps ventilation raises may result in alterations in the behaviour of some of the fauna which inhabit the ecologically sensitive receivers, particularly those individuals in closest proximity to the new facilities.

Following the initial stages of construction (for example, earthworks and drilling), equilibrium is likely to be reached, involving:

- likely changes in species composition near the Project, with less noise-tolerant species moving further away;
- selection for more noise-tolerant individuals within the populations of species close to the Project; and
- habituation of some species and individuals to the noise impacts as currently displayed by some species near existing operations.

It is clear that noise can have adverse effects on terrestrial fauna, with different species being more or less sensitive to noise. Extremely high noise levels can result in hearing damage or other physiological effects, although fauna generally avoid exposure to such impacts wherever possible. At lower noise levels, terrestrial fauna will generally avoid anthropogenic noise sources and prefer to occupy areas further from noise sources.

Generally, terrestrial fauna will avoid areas where very high noise levels (sufficient to cause injury or damage) occur. It is anticipated that noise levels in excess of 100 dBA, over extensive periods, would be required to create physical damage or injury. It is unlikely that any terrestrial fauna would remain in any area affected by noise levels of this order. Indeed, it is noted that the construction and operation of the Ranger 3 Deeps facilities will not include plant and equipment capable of generating noise levels required to cause such damage, even in very close vicinity to the plant and equipment.

As presented in **Appendix D** and **Appendix E**, the area exposed to noise levels above the occasional and frequent disturbance criteria will increase to the north east of the Ranger mine site due to the Ranger 3 Deeps project in comparison to existing operations. The area experiencing noise levels above the frequent disturbance criteria of 65 dBA are increased by approximately 39 Ha. Given that this is in relatively close proximity to the Ranger 3 Deeps infrastructure it is likely that any noise sensitive species will relocate to areas further away from the operations.

## 10 VIBRATION IMPACT ASSESSMENT

### 10.1 UNDERGROUND BLASTING

#### 10.1.1 Blasting Design Goals

Section 4.2 of the Rio Tinto Environment Standard Noise and Vibration Control Guidance Note provides the following references for assessing the impacts of blasting:

- ANZECC guidelines
- Australian Standard 2187.2-2006
- British Standard 7385: Part 2 1993
- British Standard 6472-1992 Appendix C

The ground vibration and airblast levels which cause concern or discomfort to residents are generally lower than the relevant building damage limits.

The ANZECC guidelines are the most commonly used guideline for assessing potential residential disturbance arising from blast emissions. The ANZECC guidelines provide assessment criteria with the aim of minimising annoyance from noise and vibrations caused by blasting activities and are as follows:

- The recommended maximum level for airblast is 115 dB Linear. This level may be exceeded for up to 5% of the total number of blasts over a 12 month period but should not exceed 120 dB Linear at any time.
- The recommended maximum for ground vibration is a Peak Vector Sum (PVS) vibration velocity of 5 mm/s. This level may be exceeded for up to 5% of the total number of blasts over a 12 month period but should not exceed 10 mm/s at any time.
- Blasting should generally only be permitted during the hours of 9.00 am to 5.00 pm Monday to Saturday. Blasting should not take place on Sundays and public holidays.
- Blasting should generally take place no more than once per day.

Australian Standard 2187.2-2006 "Explosives - Storage, Transport and Use Part 2: Use of Explosives" gives criteria for the maximum levels of ground vibration for human comfort and for control of damage to structures. These criteria are given in Table 22 and **Table 23** respectively.

Table 22: Ground vibration limits for human comfort chosen by some regulatory authorities (AS 2187.2 2006)

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site *	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply.
	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply.
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect equipment operation.

\* A sensitive building includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

Table 23: Recommended ground vibration limits for control of damage to structures (AS 2187.2 2006)

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction	All blasting	Frequency-dependent damage limit criteria
Unoccupied structures of reinforced concrete or steel construction	All blasting	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology

NOTE: Table 22 and **Table 23** do not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations that might occur within the structure. Particular attention should be given to the response of suspended floors.

Furthermore AS 2187.2 2006 states the following with respect to damage from airblast:

*From Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dBA. The probability of damage increases as the airblast levels increase above this level. Windows are the building element currently regarded as the most sensitive to airblast, and damage to windows is considered as improbable below 140 dBL.*

*A limit of 133 dBL is recommended as a safe level that will prevent structural/architectural damage from airblast.*

There are no current government policies or widely accepted guidelines as to vibration criteria for cultural heritage sites. However, a number of previous environmental assessments and project approvals have identified and adopted ground vibration criteria for different cultural heritage sites.

Criteria adopted for these sites are presented in **Table 24**.

Table 24: Adopted Vibration Criteria for Cultural Heritage Sites

Type	Vibration Criteria	Airblast Criteria
Stone arrangements	3 mm/s <sup>1</sup>	N/A
Grinding groove	80 mm/s <sup>2</sup>	N/A
Rock shelter	40 mm/s <sup>1</sup>	N/A

1 Source - Hunter Expressway Alliance (2011)  
2 Source – DP&I (2007).

### 10.1.2 Site Specific Blasting Criteria

Based on the preceding, the Ranger mine blast design goals are provided in **Table 25**.

Table 25: Site Specific Blast Criteria

Location	Ground Vibration Peak component particle velocity (mm/s)	Airblast Peak sound pressure level (dBL)
Nearest sensitive receivers and residences	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply.	115 dBL for 95% blasts per year. 120 dBL maximum unless agreement is reached with the occupier that a higher limit may apply.
Sensitive structures and buildings	25 mm/s	133 dBL
Mount Brockman (rock shelter)	40 mm/s	N/A
R34 (grinding groove)	80 mm/s	N/A
Tree Snake Dreaming	N/A <sup>1</sup>	N/A

1 Cultural heritage criteria outlined in **Table 24** not applicable in this area.

### 10.1.3 Blasting Parameters

Underground blasting will be required for mine and stope development. Typical blast parameters for the Project have been provided by ERA and are presented in **Table 26**.

Table 26: Blast Parameters for access, lateral and stope development

Blast Parameter	Access and lateral development	Stope development
Explosive density	1.05	1.05
Blast hole diameter (mm)	46	87
Charge length (m)	3	20
Charge weight per hole (kg)	5	125
Holes per delay	1	1
Charge weight per delay (MIC kg)	5	120

### 10.1.4 Ground Vibration Site Law

It is noted that the blasting associated with the development and stoping is underground. Therefore, airblast levels will be negligible and this assessment has only considered the ground vibration criteria defined in **Table 25**.

Site law formulas provide specific relationships between the level of blast emissions and scaled distance. The scaled distance is a fundamental relationship between distance and the maximum instantaneous explosive charge mass (MIC). Assessment of blast emissions involves the statistical analysis of large amounts of recorded blast events in order to develop a site-specific relationship between scaled distance, MIC and blast emissions.

Blast emissions have been predicted using the Ranger mine ground vibration site law developed for the site based on 2009 blast monitoring data from open cut operations. It is noted that blast monitoring has been undertaken in 2013 at the R34 cultural site for the

underground decline development to its current depth and location. However, blast induced vibration at the surface has not been discernible above existing background vibration. As such, the site law prepared based on the 2009 open cut blast emissions data will provide a conservative prediction methodology.

The Ranger mine site law is as follows:

**Ground Vibration**

$$PVS (95\%) = 3453 (SD)^{-1.57} \text{ (mm/sec)}$$

where PVS (95%) is the levels of ground vibration (Peak Vector Sum - mm/s), above which 5% of the total population (of data points) will lie, assuming that the population has the same statistical distribution as the underlying measured sample. This is sometimes called the “5% exceedance” line which is utilised since the criteria advocated by the ANZECC cater for the inherent variation in emission levels from a given blast design by allowing a 5% exceedance of a general criterion.

SD is the ‘scaled distance’, where:  $SD = \frac{D}{\sqrt[3]{MIC}}$ .

where D is the distance from the blast site to the monitoring location and MIC is the maximum explosive charge mass (kg) detonated in any 8ms interval.

**10.1.5 Predicted Blasting Emissions**

Based on the blast parameters provided by ERA and the ground vibration site law above, **Table 27** presents the predicted ground vibration levels at the nearest vibration sensitive receivers to the proposed mine development and stope.

Table 27: Predicted Ground Vibration Levels

Receptor Location and Estimated Closest Distance to Blast (m)	Predicted Peak component particle velocity (mm/s)		Site Specific Blast Criteria Peak component particle velocity (mm/s)
	Mine Development	Stope	
R34 - 340m	0.9	4.5	80
Mount Brockman – 4500m	0	0.1	40
Tree Snake Dreaming – 1500m	0.1	0.4	N/A
Ranger mine village (contractor camp) – 3500m	0	0.1	5

As presented in **Table 26**, there is a difference in the required charge weights per hole between the exploration decline and the trial stope. This variability has produced the differing blast vibration levels at each receiver presented in **Table 27**. As presented in **Table 27** predicted ground vibration levels are well below the relevant site specific blast criteria at all the potentially affected receiver locations.

**10.1.6 Blast Monitoring**

As noted in **Section 10.1.4**, the vibration monitoring programme undertaken at the R34 cultural heritage site for the underground decline development has not recorded any surface vibration associated with blasting to its current depth and location. Blast monitoring will continue at this location to ensure that no vibration impacts are experienced due to blasting from the Project.

## 10.2 SURFACE FACILITY CONSTRUCTION VIBRATION

The main vibration generating activities during the construction of the surface facilities will be associated with the operation of mobile equipment such as the dozer and trucks and the drilling of ventilation raises.

The amplitude of vibrations from construction equipment diminishes with distance from the source. This attenuation of vibration is due to both geometrical spreading and dissipation of energy within the ground. *Construction Vibrations and Their Impact on Vibration-Sensitive Facilities* (Amick & Gendreau, ASCE, 2000) provides a common generic model of vibrations as a function of distance developed by Wiss (1981), as shown in **Figure 5**.

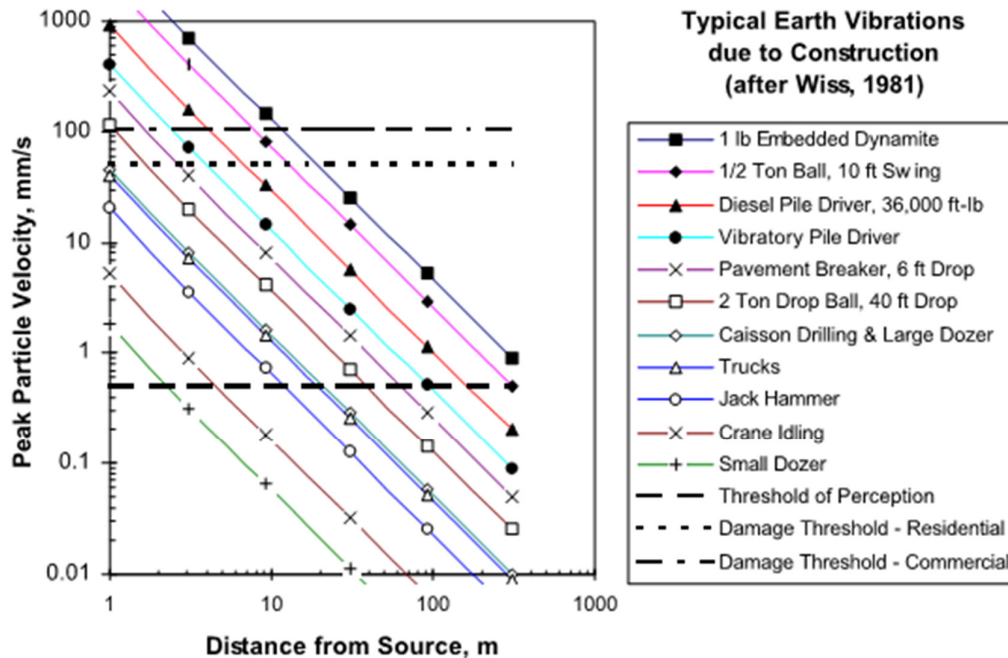


Figure 5: Construction Vibration as a Function of Distance (Amick and Gendreau 2000)

Given the minimum separation distance of approximately 100 m between surface construction operations and the nearest vibration sensitive cultural locations (R34 cultural heritage site), **Figure 5** indicates that vibration levels from the plant and equipment utilised for the construction of the Project infrastructure will be well below the threshold of perception of 0.5 mm/s and will be negligible.

Further, the minimum separation distance between construction activities and the nearest potentially affected residential and public locations is approximately 3 km. At this distance, vibration levels from these activities would be negligible and well below levels of human perception at the nearest receivers.

## 11 SUMMARY

SLR has conducted a noise and vibration impact assessment for the proposed Ranger 3 Deeps project at the Ranger mine located at Jabiru, Northern Territory.

The main objective of the assessment was to identify the incremental change to the noise and vibration profile associated with the Project relative to existing Ranger operations and to assess the noise impacts with respect to relevant criteria at the nearest noise and vibration sensitive receptors.

Construction and operational noise levels were predicted using a computer model developed for the subject site. Noise levels were predicted under calm and acoustically adverse meteorological conditions.

The predicted noise level increase at the nearest affected residential and public receivers due to the construction and operation of the project is insignificant (<1 dBA) and therefore any potential noise impacts are negligible.

The predicted cumulative noise levels from existing operations and the additional infrastructure associated with the Project are at or below the operational project specific noise criteria at all residential and public receiver locations.

There is predicted to be an incremental increase in noise levels due to the operation of the Project at the Georgetown Billabong and Magela Creek ecologically sensitive receivers. Noise levels at these locations are predicted to be above the occasional disturbance noise criteria of 50 dBA but below the frequent disturbance criteria of 65 dBA.

The area experiencing noise levels above the occasional disturbance criteria of 50 dBA is predicted to increase by approximately 182 Ha due to the Project. The area experiencing noise levels above the frequent disturbance criteria of 65 dBA is predicted to increase by approximately 39 Ha due to the Project.

It is considered unlikely that significant noise impacts will be experienced in the nearest ecologically sensitive areas and equilibrium will be reached involving:

- likely changes in species composition near the Project, with less noise-tolerant species moving further away;
- selection for more noise-tolerant individuals within the populations of species close to the Project; and
- habituation of some species and individuals to the noise impacts as currently displayed by some species near existing operations.

The potential impacts attributable to vibration associated with blasting and construction on the nearest vibration sensitive receivers are negligible.

## 12 REFERENCES

AMEC Americas Limited (July 2005) *Mackenzie Gas Project Effects of Noise on Wildlife* prepared for Imperial Oil Resources Ventures Limited.

Amick, H. and Gendreau, M (2000). *Construction Vibrations and Their Impact on Vibration-Sensitive Facilities*.

ANZECC (1990). *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, Australia and New Zealand Environment and Conservation Council.

AS1055:1997 (1997). *Description and Measurement of Environmental Noise*, Standards Australia, Sydney.

AS 2187.2-2006 (2006). *Explosives - Storage and use - Use of explosives*.

Awbrey, F.T., D. Hunsacker, and R. Church. 1995. Abstract: *Acoustical responses of California Gnatcatchers to traffic noise*. Inter-Noise 95: 971–974. Newport Beach.

Black, Barbara and Collopy, Michael W. and Percival, H. Franklin and Tiller, Anita A. and Bohall, Petra G. (1984) *Effects of low level military training flights on wading bird colonies in Florida*. Gainesville, FL, Florida Cooperative Fish and Wildlife Research Unit, University of Florida, (Technical Report – Florida Cooperative Fish and Wildlife Research Unit, 7)

Brown A.L. 1990. *Measuring the effect of aircraft noise on sea birds* School of Australian Environmental Studies, Griffith University, Nathan, Brisbane, 4111, Australia

Brown, L. (2001) *Overview of research on the effects of noise on wildlife* in Proceedings of the Effects of Noise on Wildlife Conference, Happy Valley-Goose Bay, Labrador.

Dawe, G. and M. Goosem (2008) *Noise Disturbance along Highways: Kuranda Range Road Upgrade Project*. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns (157pp.).

DEC (2006). *Assessing Vibration a Technical Guideline*, NSW Department of Environment and Conservation, Sydney.

DECC (2009). *Interim Construction Noise Guideline*, NSW Department of Environment and Climate Change, Sydney.

DP&I (2007). *Moolarben Coal Mines Pty Limited Project Approval*. <https://majorprojects.affinitylive.com/public/8071514cbc0e997772dc28a394c57859/Project%20Approval.pdf>. Accessed 23 April 2014.

Eco Logical Australia (2014). *Vegetation and fauna assessment, for the proposed Ranger 3 Deeps underground mine*. Prepared for Energy Resources Australia Ltd.

EPA (1994). *Environmental Noise Control Manual*, NSW Environmental Protection Authority, Sydney.

EPA (2000). *Industrial Noise Policy*, NSW Environmental Protection Authority, Sydney.

Goosem, M., Hoskin, C. and Dawe, G. (2007). *Nocturnal noise levels and edge impacts on amphibian habitats adjacent to the Kuranda Range Road*. Report to Queensland Department of Main Roads and Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre, Cairns.

Heggies (2010). *Ranger Uranium Mine Noise and Vibration Impact Assessment*. Prepared for Energy Resources Australia Ltd.

Hunter Expressway Alliance (2011). *Hunter Expressway – Stage 2 construction noise and vibration management sub plan*. Prepared for NSW Roads and Maritime Services.

IEC 61672.1-2004 (2004). *Electroacoustics – Sound Level Meters – Specifications*

Larkin, R.P., D. Margoliash, J.A. Kogan (1996) *Recognition of the utterances of terrestrial wildlife: a new approach*. The Journal of the Acoustical Society of America, 99(4 pt. 2): 2532.

Manci, K.M., D.N. Gladwin, R. Vilella, and M.G. Cavendish (1988) *Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis*. U.S. Fish and Wildlife Service. National Ecology Research Center, Ft. Collins, CO. NERC–88/29. 88 pp.

NTEPA (2013) *Guidelines for the Preparation of an Environmental Impact Statement – Ranger 3 Deeps Underground Mine*.

Ocean Studies Board (OSB) (2003). *Ocean Noise and Marine Mammals*. National Research Council, Division on Earth and Life Studies. The National Academies Press, Washington, DC.

Parris K.M and Schneider A. 2008. *Impacts of traffic noise and traffic volume on birds of roadside habitats*. Ecology and Society 14(1): 29.

RET (2009). *Airborne Contaminants, Noise and Vibration – Leading Practice Sustainable Development Program for the Mining Industry*.

RTA (2001). *Environmental Noise Management Manual*. NSW Roads and Traffic Authority, Sydney.

US FWS. 2004. *Estimates of distances at which incidental take of murrelets and spotted owls due to harassment are anticipated from sound-generating, forest-management activities in Olympia National Forest*. US Fish and Wildlife Service, Lacey, WA.

US Department of Transportation Federal Highway Administration (US FHWA) (September 2004) *Synthesis of Noise Effects on Wildlife Populations*. Publication No. FHWA–HEP–06–016

Woinarski, JCZ, Armstrong, M, Brennan, K, Fisher, A, Griffiths, AD, Hill, B, Milne, DJ, Palmer, C, Ward, S, Watson, M, Winderlich, S, & Young, S 2010. *Monitoring indicates rapid and severe decline of native small mammals in Kakadu National Park, northern Australia*. Wildlife Research 37: 116–126.

## 13 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Energy Resources of Australia Ltd. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

### 1 Sound Level or Noise Level

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2E-5 Pa.

### 2 “A” Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an “A-weighting” filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120 110	Heavy rock concert Grinding on steel	Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerbside of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to quiet
40 30	Inside private office Inside bedroom	Quiet to very quiet
20	Unoccupied recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as “linear”, and the units are expressed as dB(lin) or dB.

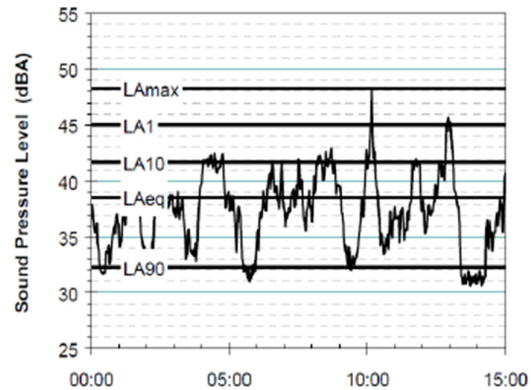
### 3 Sound Power Level

The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 1E-12 W. The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

### 4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

- LA1 The noise level exceeded for 1% of the 15 minute interval.
- LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.
- LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.
- LAeq The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the “repeatable minimum” LA90 noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or “average” levels representative of the other descriptors (LAeq, LA10, etc).

### 5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than “broad band” noise.

### 6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

### 7 Frequency Analysis

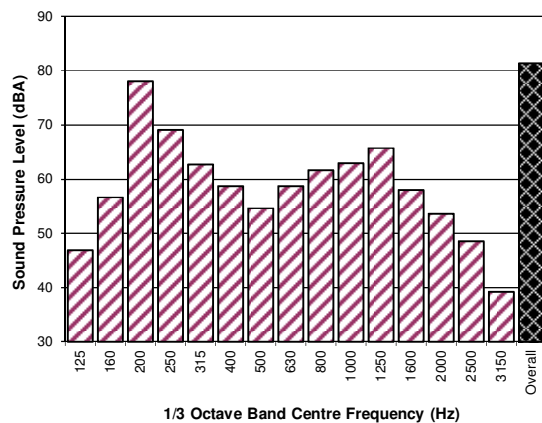
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



### 8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of “peak” velocity or “rms” velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as “peak particle velocity”, or PPV. The latter incorporates “root mean squared” averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula  $20 \log (V/V_0)$ , where  $V_0$  is the reference level (1E-6 mm/s). Care is required in this regard, as other reference levels are used by some organizations.

### 9 Human Perception of Vibration

People are able to “feel” vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual’s perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as “normal” in a car, bus or train is considerably higher than what is perceived as “normal” in a shop, office or dwelling.

### 10 Over-Pressure

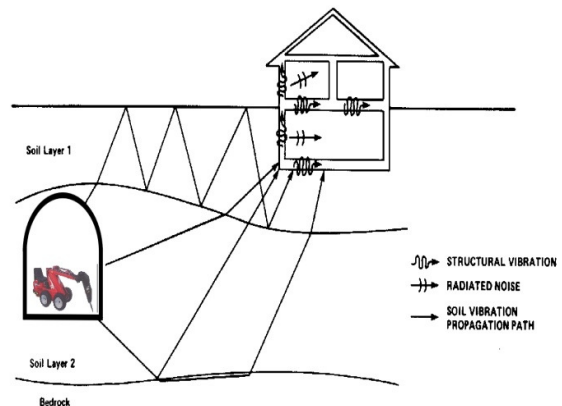
The term “over-pressure” is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

### 11 Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed “regenerated noise”, “structure-borne noise”, or sometimes “ground-borne noise”. Regenerated noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of regenerated noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and regenerated noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.

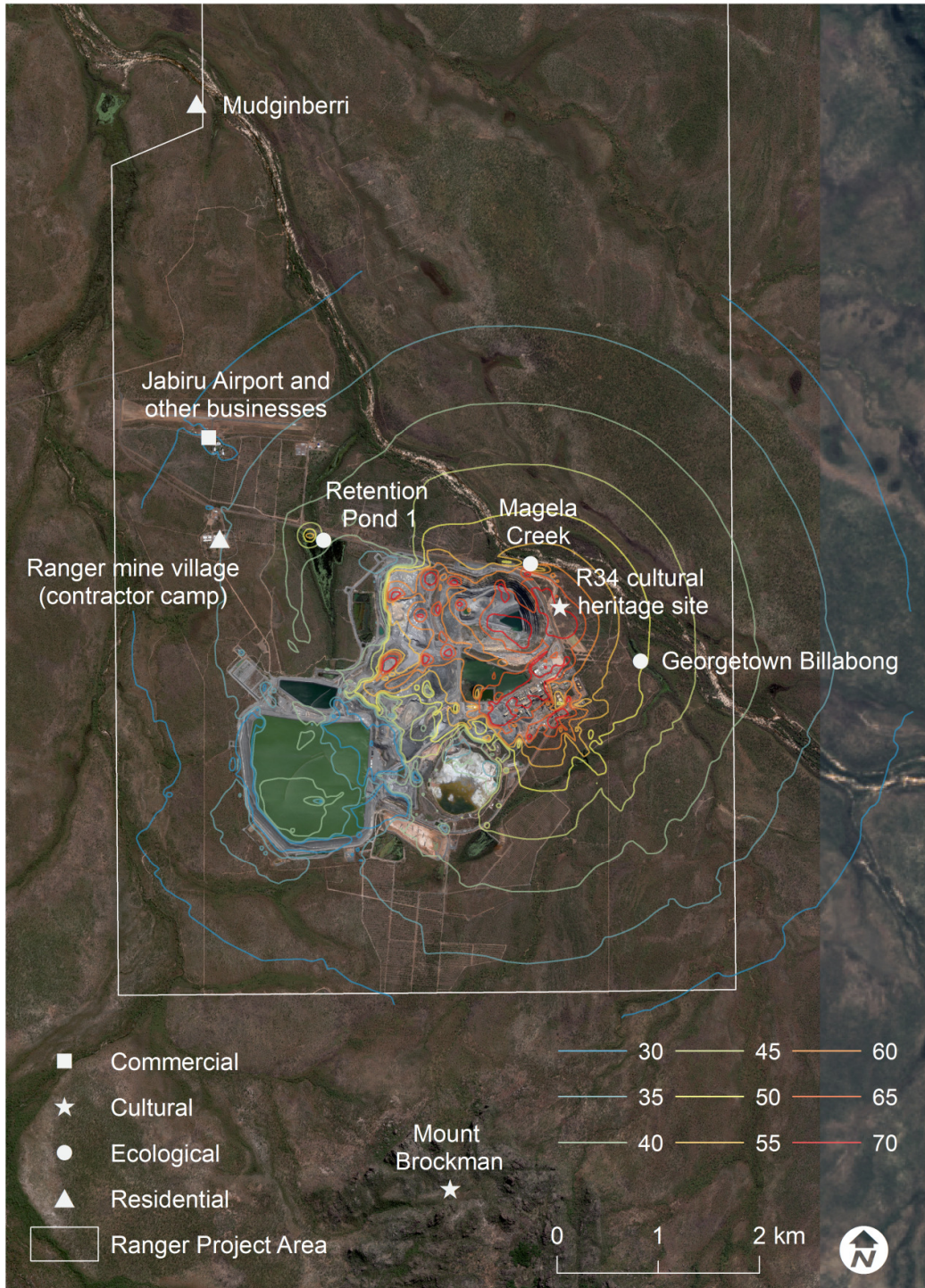


The term “regenerated noise” is also used to describe other types of noise that are emitted from the primary source as a different form of energy. One example would be a fan with a silencer, where the fan is the energy source and primary noise source. The silencer may effectively reduce the fan noise, but some additional noise may be created by the aerodynamic effect of the silencer in the airstream. This “secondary” noise may be referred to as regenerated noise.

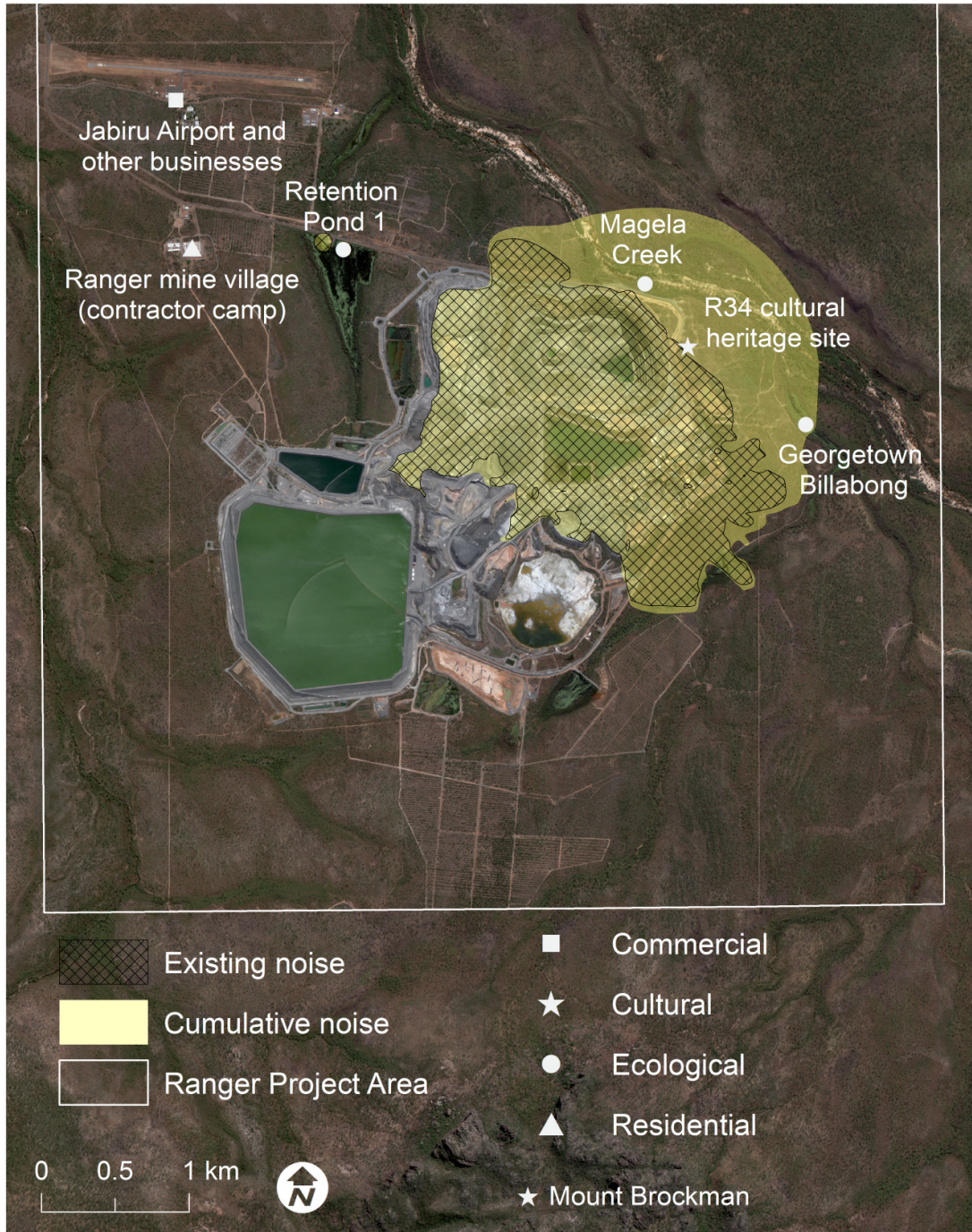
**Appendix B:** outer envelope (worst case) noise contours – existing Ranger mine operations



**Appendix C:** outer envelope (worst case) noise contours – cumulative existing and Ranger 3 Deeps operations



**Appendix D:** Incremental increase in occasional (alert) zone due to Ranger 3 Deeps operations (>50 dBA)



**Appendix E:** Incremental increase in frequent (alarm or flight) zone due to Ranger 3 Deeps operations (>65dBA)

