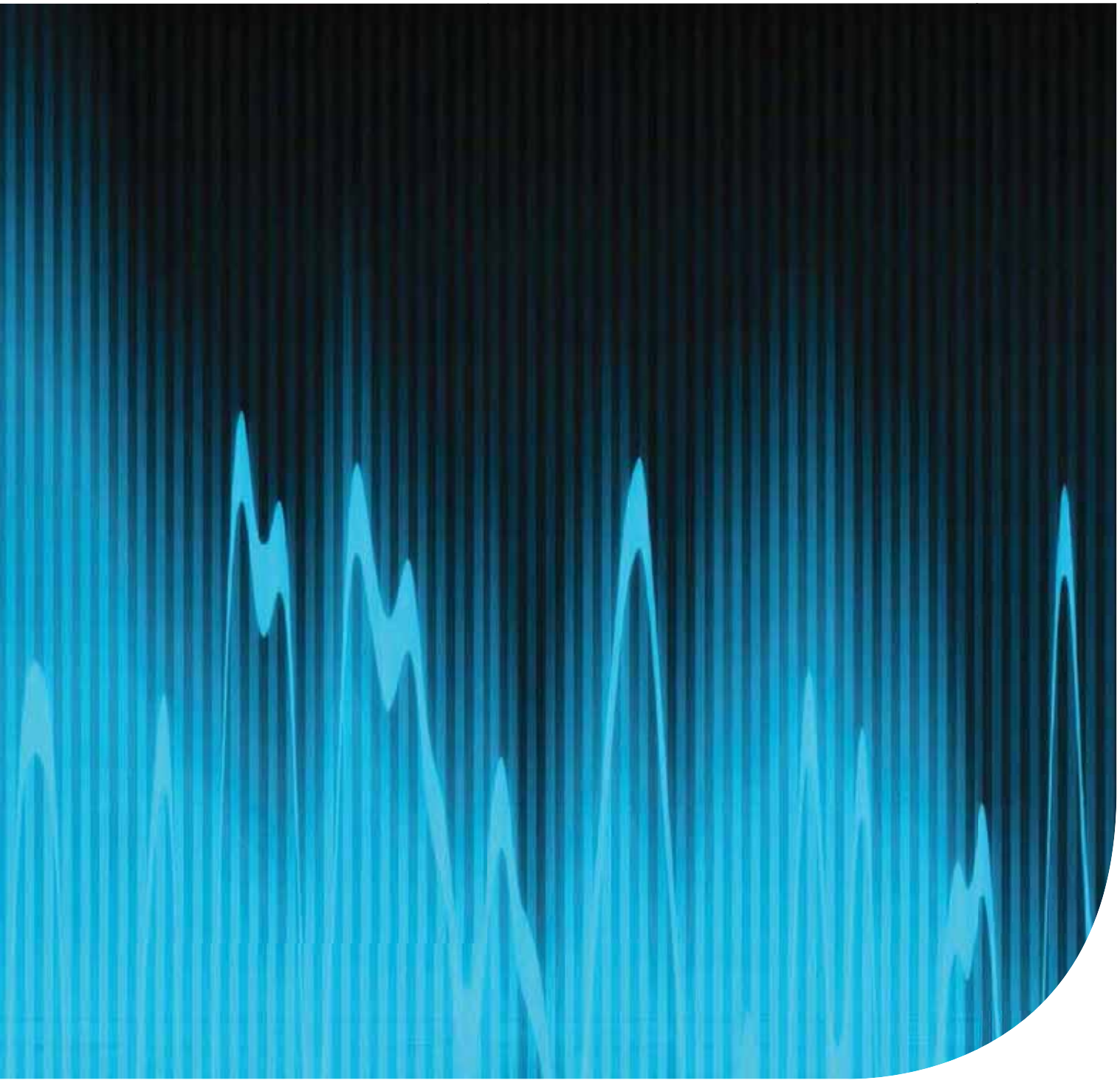
Appendix K

Noise and vibration assessment

Gunlake Quarry Extension Project

Noise and vibration assessment

Prepared for Gunlake Quarries Pty Limited | 11 February 2016



Gunlake Quarry Extension Project

Noise and vibration assessment

Prepared for Gunlake Quarries Pty Limited | 11 February 2016

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Gunlake Quarry Extension Project

Final

Report J14119RP1 | Prepared for Gunlake Quarries Pty Limited | 11 February 2016

Prepared by	**Teanuanua Villierme**	Approved by	**Najah Ishac**
Position	Acoustic Consultant	Position	Director
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Date	11 February 2016	Date	11 February 2016

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Document Control

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1 Introduction

Gunlake Quarry is a hard rock quarry operated by Gunlake Quarries Pty Ltd (Gunlake). It is located approximately 5 kilometres (km) north-west of Marulan in the Goulburn Mulwaree local government area (LGA) (Figure 1.1).

Gunlake Quarry currently operates under New South Wales (NSW) project approval 07-0074 issued by the Minister for Planning in September 2008 under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The project approval has been modified on three occasions. The current development consent permits the production of 750,000 tonnes of saleable product per year for 30 years. Gunlake Quarry produce material suitable for use in a wide range of applications, including concrete and sealing aggregates, rail ballast, manufactured sand and road base.

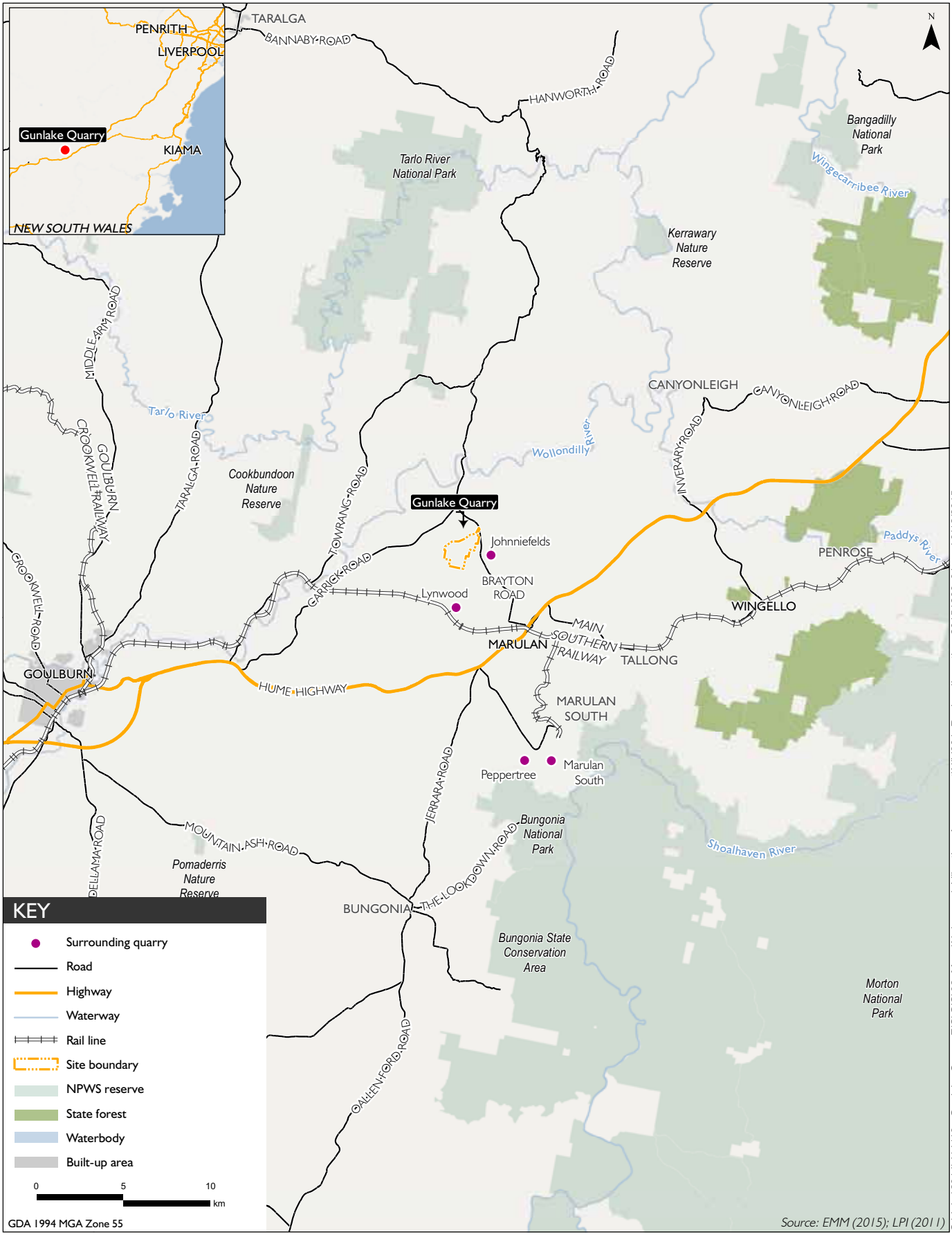
EMM consulting Pty Limited (EMM) has been engaged by Gunlake to prepare a Noise and Vibration Assessment (NVA), which forms part of the Environmental Impact Statement (EIS) prepared to accompany the application to expand the current operations at Gunlake Quarry.

The NVA has been prepared with reference to the following policies, standards and guidelines:

- NSW Environment Protection Authority (EPA) (2000) *NSW Industrial Noise Policy* (INP);
- NSW Department of Environment, Climate Change and Water (DECCW) (2011) *NSW Road Noise Policy* (RNP);
- Australian Standard (AS) 1055-1997, Acoustics - Description and Measurement of Environmental Noise;
- AS 2187-2-2006, *Explosives – Storage and Use Part 2: Use of Explosives*;
- Technical Services (1995) *Imperial Chemical Industries (ICI) Explosives Blasting Guide*; and
- the revised Secretary Environmental Assessment Requirements (SEARs) issued on 13 October 2015.

A noise and vibration assessment (Pacific Environment 2014) was prepared for the previous modification of project approval 07-0074. The previous assessment identified that noise emissions from the quarry satisfied the relevant project approval criteria. Hence, this NVA has been prepared to assess the potential noise and blasting impact at the nearest sensitive receivers from the proposed Gunlake extension project.

A number of technical terms are required for the discussion of noise and blasting. These are explained in Appendix A.



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Regional context

Gunlake Quarry
Noise and Vibration Assessment

Figure 1.1

2 Project description

2.1 Existing site operations

The components of the quarry are:

- a quarry pit with hard rock resource;
- overburden and excess product emplacement areas;
- drilling and blasting to release the rock material;
- crushing and screening of the quarried rock;
- truck loading and transport of hard rock; and
- ancillary infrastructure to support operations including offices, amenity buildings and other minor infrastructure.

2.1.1 Extraction

Quarry extraction has progressed from north to south. The quarry pit is accessed by a haul road from the north of the quarry pit. This haul road continues to the processing plant. Quarrying is currently being carried out on the first bench of the pit. Overburden has been transported to a permanent overburden emplacement bund on the east of the site and provides acoustic and visual screening to surrounding land users. The overburden emplacement bund currently covers 4.5 ha. The intention is to extend the north and south extents of the bund as quarrying continues.

Once the overburden is removed, conventional drill and blast techniques are used to quarry the rock faces to a height of approximately 13 m. Blasting occurs approximately once a fortnight.

2.1.2 Processing

Following extraction, quarried rock is transported to the processing area north of the quarry pit. The processing area comprises the following components:

- primary crusher and screens;
- secondary crusher and screens;
- tertiary crusher and screens;
- interconnecting conveyors; and
- product stockpiles.

A front-end loader (FEL) loads products into road trucks for transportation to customers.

2.1.3 Transportation

Gunlake Quarry currently has approval for 82 laden truck movements per day. This equates to 3.4 truck movements per hour, on average.

All saleable products from Gunlake quarry are transported by road to Sydney and other markets north and south of Marulan. Transportation starts from the quarry access road and turning right and southbound onto Brayton Road. Brayton Road is part of the transport route linking the quarry to the Hume Highway.

Products for markets north of Marulan are transported along Brayton Road and a purpose built Bypass Road connecting to Red Hills Road and eventually the Hume Highway. For transportation of product south of Marulan, road trucks use Brayton Road, through the northern edge of Marulan and access the Hume Highway via the Brayton Road southbound ramp. All road trucks return to the quarry via Red Hills Road, the Bypass Road and northbound onto Brayton Road. It is noted that there are also a small number of additional vehicle movements associated with employee travel, fuel deliveries and service vehicles.

2.1.4 Operating hours

The hours of operation as per the project approval 07-0074 are provided in Table 2.1.

Table 2.1 Hours of operations

Operation	Current approved hours
Overburden material	7 am to 6 pm Monday to Saturday. None on public holidays.
Drilling	7 am to 6 pm Monday to Saturday.
Blasting	9 am to 5 pm Monday to Friday.
Quarrying and processing	Primary and secondary crusher and associated equipment: 7 am to 6 pm.Monday to Saturday. None on Sundays and public holidays.
	Tertiary crusher: 24 hours between 6 am Monday to 7 pm Saturday.
Maintenance	Anytime Monday to Saturday.
Truck loading and haulage	Bypass road: 24 hours except 6 pm Saturday to 2 am Monday.
	Brayton Road to Marulan: 6 am to 7 pm Monday to Saturday.

2.2 Proposed extension project summary

Gunlake seeks to increase the current approved rate of extraction at the quarry to assist in meeting the demand for construction materials for the local area and Sydney markets. Production of 2 million tonnes per annum (Mtpa) of saleable product for 30 years is proposed. Therefore, Gunlake seeks a new development consent that permits:

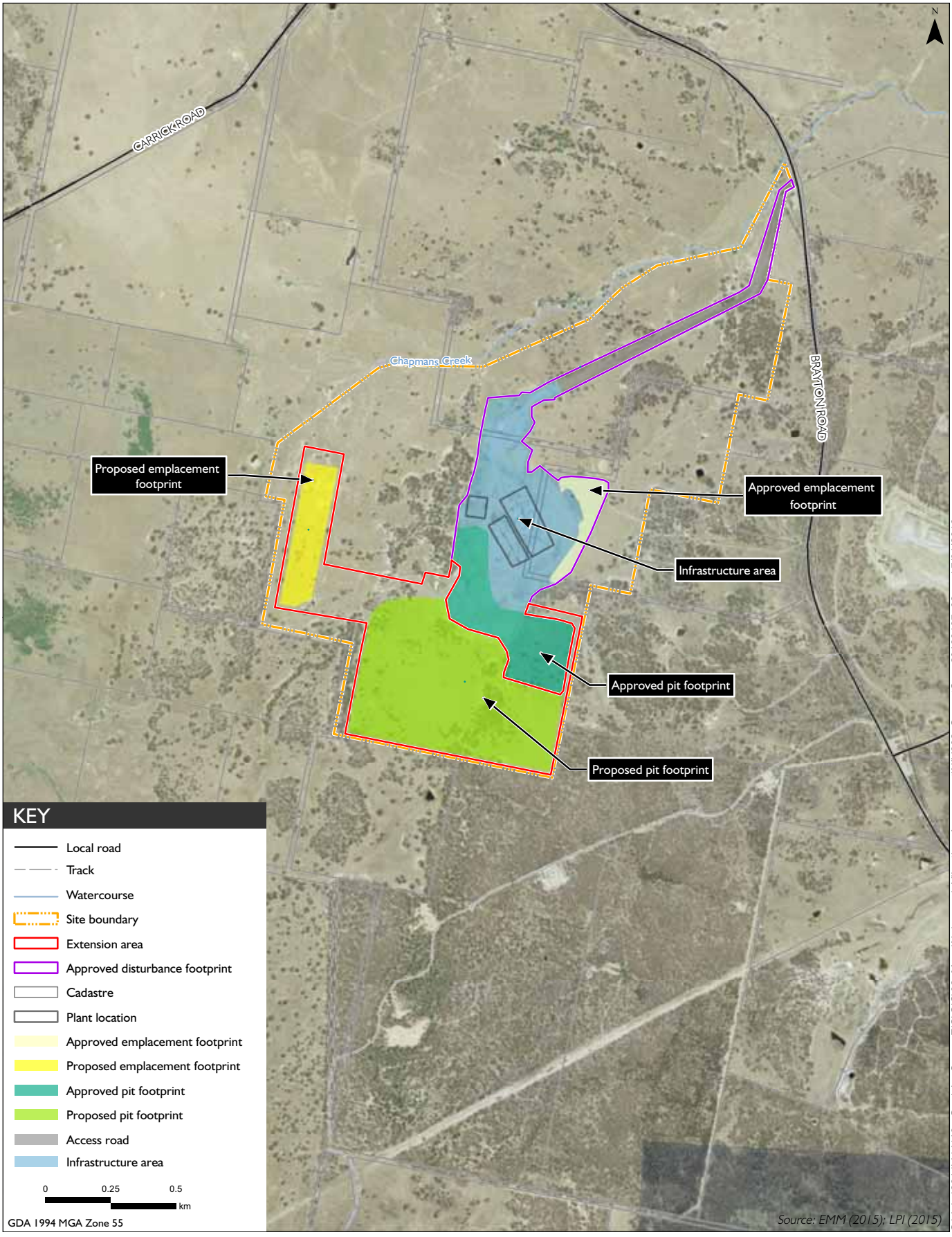
- 2 Mtpa of saleable products to be produced;
- an increase in truck movements to an average of 440 movements per day;
- an extension of the quarry pit footprint to approximately 49 hectares (ha);
- 24 hour per day primary and secondary crushing;
- upgraded tertiary processing plant (fixed);

- additional overburden emplacement to accommodate the increase in production; and
- blasting twice weekly.

In addition, Gunlake seeks to maintain the approval for all other aspects of existing quarry operations under project approval 07-0074. The quarry's approved disturbance area and proposed extension area are shown in Figure 2.1.

2.3 Extension project requirements

Gunlake Quarry produces material suitable for use in a wide range of applications, including concrete and sealing aggregates, rail ballast, manufactured sand and road base. These products are used in its own operations in Sydney as well as for other markets. Gunlake is in the process of establishing concrete plants in the Sydney region with three plants in operation. Under the current project approval 07-0074, 19.25 Mt of saleable product will be quarried at Gunlake Quarry over the project life. This is a small proportion of the 180 Mt of hard rock resource identified at the site. The increase in production from the allowable maximum 750,000 tpa to a maximum of 2 Mtpa will permit Gunlake to meet the identified demand for construction materials using the identified resource.



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Current and proposed operations

Gunlake Quarry
Noise and Vibration Assessment

Figure 2.1

2.4 Approved operations

Gunlake Quarry currently operates under project approval 07-0074 issued by the Minister for Planning in September 2008 under Part 3A of the EP&A Act. The project approval has been modified on three occasions:

- Modification 1 – Stage 2 southbound access;
- Modification 2 – Quarry expansion; and
- Modification 3 – Truck movements.

Modifications 1 and 3 were minor modifications to alter transport routes and truck numbers related to the quarry. Modification 2 included expansion of the quarry pit and overburden emplacement, an increase in truck movements equivalent to 750,000 tpa of saleable product and alteration of the approved hours of operation.

A summary of the current approved Gunlake operations (approved under project approval 07-0074, as last modified) is provided in Table 2.2 together with a comparison to the proposed extension project.

Table 2.2 Current approval and proposed extension project

Aspect	Current approval	Proposed extension project
Quarrying method	Hard rock quarrying by open cut methods.	No change.
Resource	Approximately 180 million tonnes.	No change.
Disturbance area	As shown in Figure 2.1.	Extension of pit footprint to approximately 63 ha (shown in Figure 2.1).
Saleable product	750,000 tpa.	Increase to 2 Mtpa.
Quarry life	30 years.	30 years from approval. There is sufficient resource (180 Mt) for quarrying to continue at 2 Mtpa for 90 years.
Beneficiation	Onsite crushing and stockpiling of quarried rock.	Increase in processing capacity ie upgraded processing plant.
Product transport	An average of 164 truck movements per day.	Increase truck movements to an average of 440 movements per day.
Operational workforce	25 on-site employees and 25 to 38 truck drivers (full-time equivalent).	Increase of approximately 27 on-site employees and truck drivers.
Hours of operation	6 am Monday to 6 pm Saturday, including crushing between 7 am and 6 pm, Monday to Saturday and maintenance at any time, Monday to Saturday.	Modify existing hours of operation to allow crushing 24 hours a day (except Sundays and public holidays) and maintenance anytime (including Sundays and public holidays).
Capital investment value	-	$3.2 million

3 Existing environment

3.1 Existing site noise emissions

Gunlake Quarry is located in a rural setting and is surrounded by undulating terrain. Elevations within the site boundary range from approximately 640 m AHD at the northern end to 700 m AHD at the southern end. A topographic ridge lies between the quarry and residences on Brayton Road, and hence provides a visual and acoustic screen from quarry operations at these residences. The nearest residence to the north-west of the site on Carrick Road has line of sight to the quarry. Isolated parts of surrounding properties also have long distant views of the site. However, these are generally at least 5 km from the quarry.

Site noise emissions and blasting are currently managed in accordance with the approved Noise and Blast Management Plan (Heggies 2009) which includes operator-attended noise monitoring on a yearly basis. A review of historical monitoring results showed that noise from quarry operations satisfied the noise criteria specified in project approval 07-0074 at all receiver locations.

Blast emissions are monitored at two nearest residential properties to the quarry, R1 and R3, which are owned by Gunlake. There have been 85 blasts at the quarry between July 2011 and July 2015. During this time, the ground vibration criterion (5 mm/s) has been met on all occasions, whereas the airblast overpressure criterion (115 dB, Lin Peak) has been marginally exceeded on two occasions at location R3 by 0.6 dB and 2.1 dB, in April 2012 and June 2013 respectively. Notwithstanding, these exceedances satisfy the allowable exceedance limit of 5% per total number of blasts over a period of 12 months. Furthermore, no blasts exceeded the upper criterion of 120 dB, Lin Peak.

The proposed extension project will involve the extension of the pit area to the south and the construction of an additional overburden area west of the current pit area, and hence will have the potential to generate noise emissions at potentially sensitive receivers.

3.2 Assessment locations

3.2.1 Quarry noise

There are four residences within 1.5 km of the site, three residences to the east of the site on Brayton Road (R1, R2 and R3) and one residence to the north-west on Carrick Road (R4). Two of the residences to the east of the site (R1 and R3) are owned by Gunlake and therefore noise criteria do not apply at these residences. These location numbers are consistent with the previous noise and vibration assessment (Pacific Environment 2014) and the current project approval 07-0074.

Four additional assessment locations, further away from quarry operations, have been included in this assessment as quarry operations are moving further south and north-west of the currently approved footprint. Additional assessment locations R5 and R6 are sensitive receivers to the north-west of the site and nearest to R4. Additional assessment locations R7 and R8 are sensitive receivers to the south-east of the site and nearest to R3. The noise assessment locations are presented in Table 3.1 and shown on Figure 3.1.

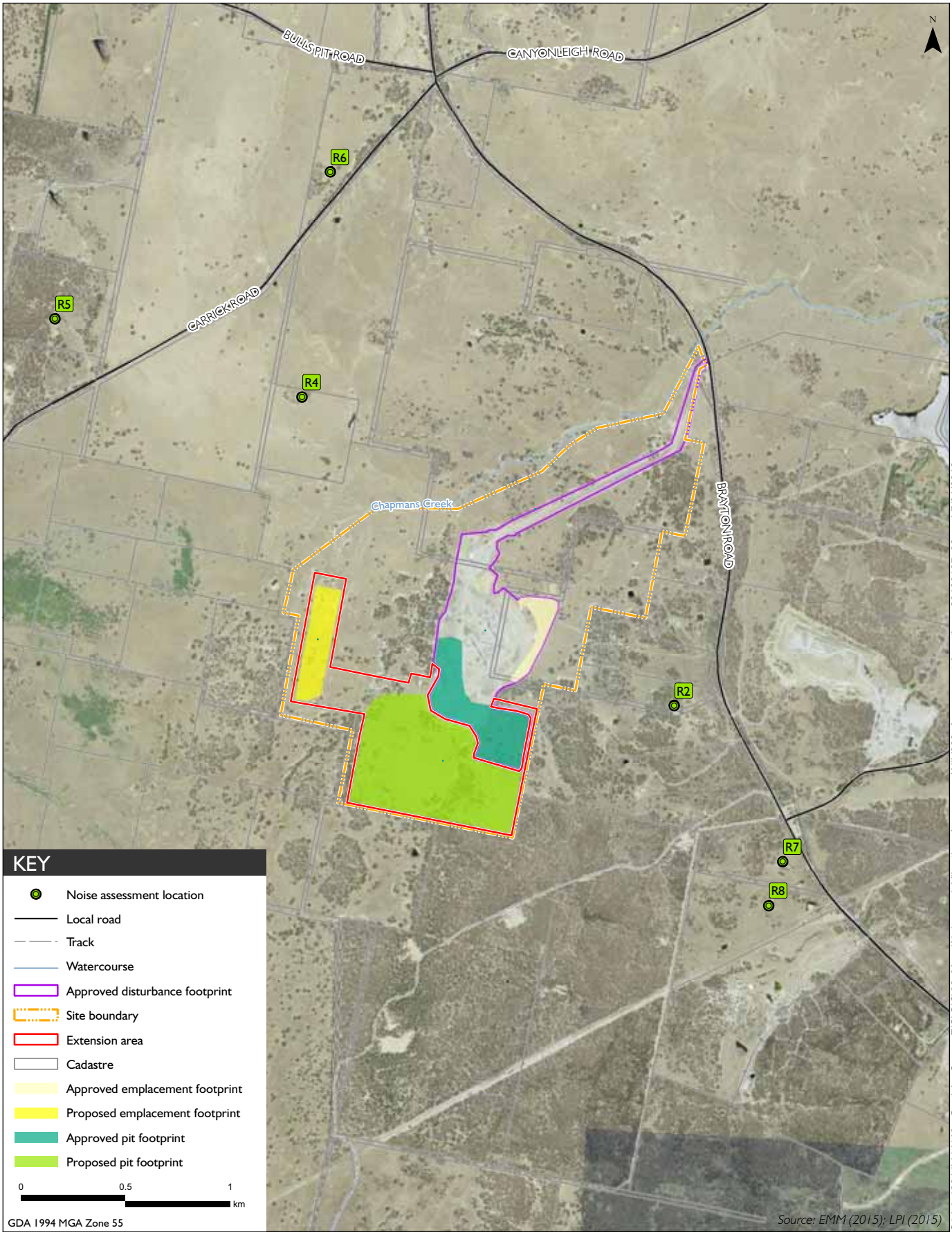
Table 3.1 Assessment locations

Assessment location ID	Locality	MGA coordinates	
		Easting	Northing
R2	Brayton Road	772839	6159046
R4	Carrick Road	771060	6160520
R5	Carrick Road	769878	6160894
R6	Carrick Road	771195	6161595
R7	Brayton Road	773358	6158300
R8	Brayton Road	773291	6158091

Adherence with noise criteria at these locations would indicate that noise criteria will be met at other surrounding noise-sensitive locations.

3.2.2 Road traffic noise

Several residences are located along the road transport route including on Brayton Road southbound of the quarry access road, Brayton Road through Marulan and Red Hills Road to the Hume highway. These residences have the potential to be impacted by road traffic noise resulting from the proposed increase in transport volumes from the quarry. The product transport route and residences potentially impacted by road traffic noise are shown in Figure 3.2.



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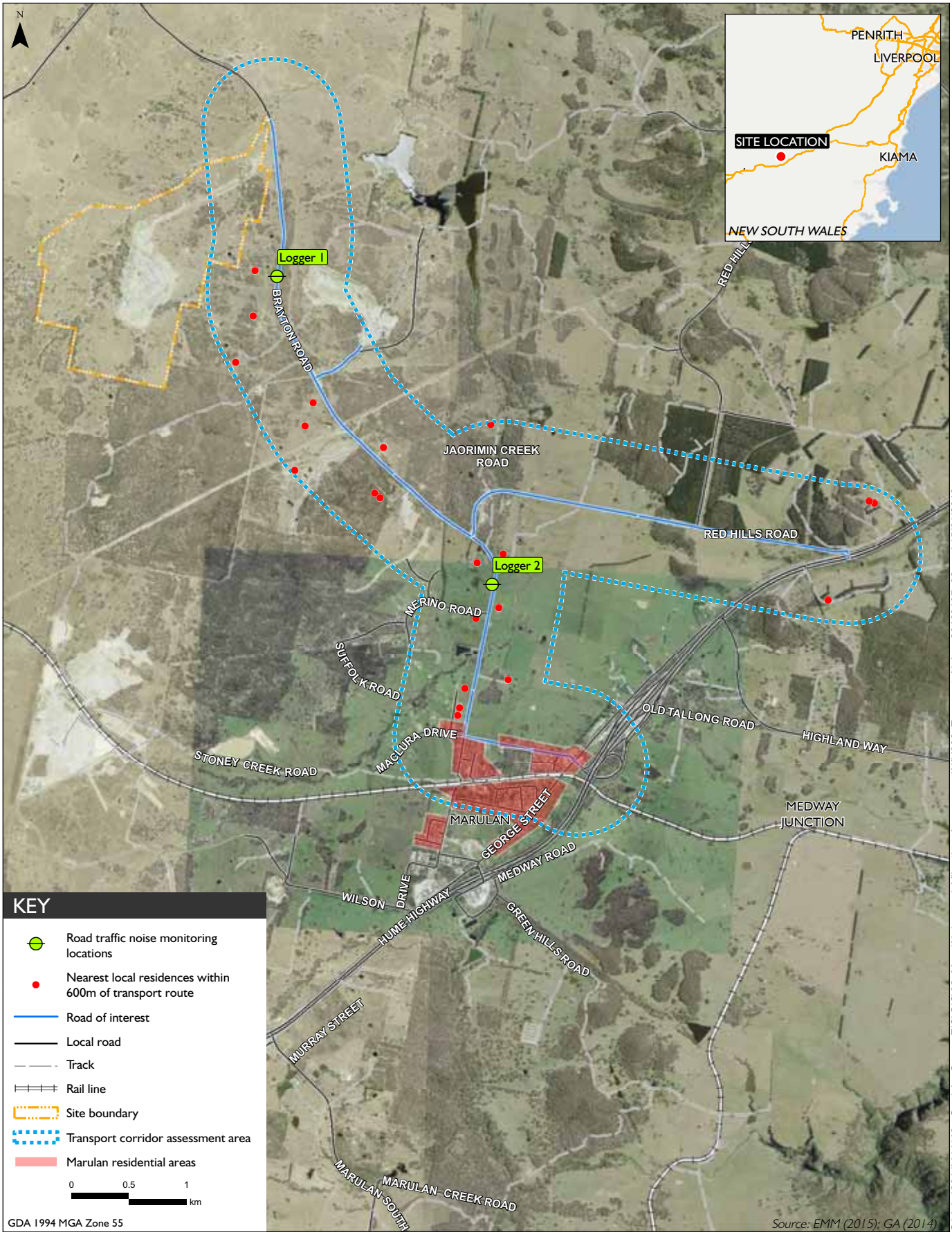
Quarry noise assessment locations

Gunlake Quarry
Noise and Vibration Assessment

Figure 3.1



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Primary transport route and noise monitoring locations

Gunlake Quarry
Noise and Vibration Assessment

Figure 3.2

3.3 Background noise levels

A key element in assessing environmental noise impact from industry is to quantify the existing background acoustic environment, including any existing industrial noise where present.

A review of historical long-term unattended noise data from the previous noise and vibration assessment (Pacific Environment 2014) identified a rating background level (RBL) of less than the INP's minimum 30 dB(A) default for day, evening and night periods at locations R3 and R4.

To verify the background noise levels at these locations, EMM conducted two short-term operator-attended noise measurements near R2 on Brayton Road and near R4 on Carrick Road. The quarry was not operating during the background noise monitoring and consequently did not contribute to measured L_{A90} noise levels at these monitoring locations. Long-term background noise monitoring locations (consistent with the previous noise and vibration assessment (Pacific Environment 2014)) and EMM's short-term background noise monitoring locations are shown in Figure 3.3.

The attended noise surveys were conducted using a Brüel and Kjær Type 2250 one-third octave hand-held sound level meter (s/n 2759405). Field calibration of the instrument was undertaken before and after the survey using a Brüel and Kjær type 4230 calibrator with the variation in calibrated levels not greater than ±0.5 dB. Attended measurements were conducted in general accordance with Australian Standard (AS) 1055-1997 *Description and Measurement of Environmental Noise,* Parts 1, 2 and 3. Meteorological conditions throughout the attended surveys generally consisted of clear skies and winds at ≤2 m/s from the north-east to north-west. There were no winds above 5 m/s or rain events during the attended surveys.

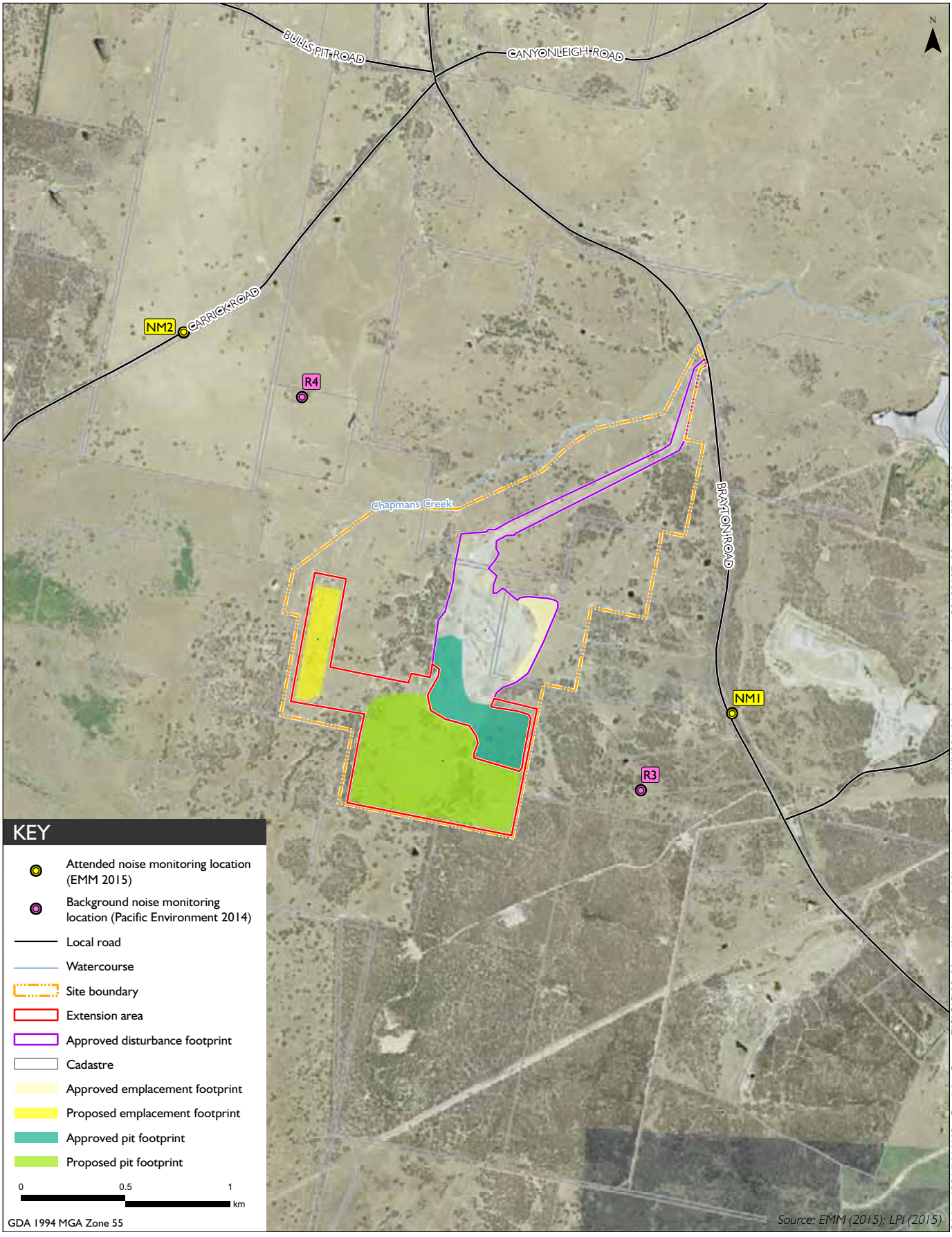
A summary of the results of the attended measurements is presented in Table 3.2.

The short-term attended noise monitoring results confirm that the background (L_{A90}) noise levels at residences on Carrick Road (near R4) are below the INP default RBL of 30 dB. The background (L_{A90}) noise level at residences on Brayton Road (near R2) was measured at 33 dB. However, after filtering insect noise and other extraneous noise sources with high frequency characteristics (ie frequencies above 1.25 kHz), which are commonly considered atypical to annual background noise trends from the data, the L_{A90} noise level at these residences was calculated to be 30 dB. Therefore, an RBL of 30 dB has been adopted for the nearest sensitive receivers.

Table 3.2 Attended noise monitoring summary

Location	Date	Start time/ period	Measurement result, dB			Comments
			L_{Aeq}	L_{A90}	L_{Amax}	
NM1	2/9/15	15:10	62	33	84	Traffic passbys frequent
Brayton Road (near R2)		Day		(30)[1]		Insects and birds constant
						Plane audible for one minute
						Other quarry (unrelated to Gunlake) audible for five minutes
NM2	2/9/15	16:30	47	26	74	Traffic passby on one occasion and distant traffic
Carrick Road (near R4)		Day				Insects and birds constant
						Gunlake operations inaudible

Notes: 1. L_{A90} noise level after filtering of insect noise and other sources containing higher frequencies above 1.25 kHz.



Quarry noise monitoring locations

Gunlake Quarry
Noise and Vibration Assessment

Figure 3.3

3.4 Meteorology

Noise propagation over distance can be significantly affected by the weather conditions. Of most interest are source to receiver winds, the presence of temperature inversions and drainage flow effects, as these conditions can enhance received noise levels. To account for these phenomena, the INP specifies meteorological analysis procedures to determine the prevalent weather conditions that enhance noise propagation in a particular area, with a view to determining whether they can be described as a feature of the project area.

3.4.1 Wind

Wind has the potential to increase noise impacts at a receiver when it is light and stable, and blows from the direction of the noise source. As the wind strength increases, the noise produced by the wind usually obscures noise from most industrial and transport sources.

The INP requires that winds of speeds up to 3 m/s with an occurrence greater than or equal to 30% of the time during any period (day, evening or night) in any season be assessed.

Detailed analysis of winds was undertaken using weather data from the Gunlake Quarry weather station located on the north of the site.

The prevailing winds analysis was undertaken in accordance with INP methods and considered weather data over a two year period (November 2013 to October 2015). The analysis determined that prevailing winds were present during the night period ranging from the north to east-south-east (22.5° to 112.5° from north).

3.4.2 Temperature inversions

Temperature inversions, when they occur, have the ability to increase noise levels by focusing sound waves. Temperature inversions generally occur during the night-time and early morning periods during the winter months. A temperature inversion needs to occur for approximately 30% of the total night-time during winter, or about two nights per week, for it to be a significant characteristic of the area and require consideration in accordance with the INP (EPA 2000).

The frequency of temperature inversions was determined based on sigma-theta data obtained from the Gunlake on-site weather station. Analysis of the data found that F class temperature inversions may occur for greater than 30% of the night-time period and, as such, has been considered in the prediction and assessment of noise emissions from Gunlake quarry operations. This is consistent with past studies undertaken in the area.

3.4.3 Drainage winds

Topography around the quarry is undulating with a gentle uphill slope in most directions. The INP states that a default wind drainage value should be applied where sources are at a higher altitude than the assessment location with no intervening topography. Drainage winds were considered but found to be irrelevant at the site area as assessment locations are higher than the noise sources or there is intervening topography.

3.4.4 Modelled meteorological conditions

Predicted noise levels from proposed quarry operations at the assessment locations have been calculated based on the meteorological parameters shown in Table 3.3. Prevailing conditions (winds and inversion) based on the detailed weather data analysis described previously have been considered.

Table 3.3 Weather conditions considered in noise modelling

Assessment period	Meteorological condition	Air temperature	Relative humidity	Wind speed[1]	Stability category (temperature gradient)
Day	Calm	20°C	70%	0 m/s	D class
Evening/Night	Calm	10°C	90%	0 m/s	D class
Night	Wind	10°C	90%	2.3 m/s(2)	D class
Night	Temperature inversion	10°C	90%	0 m/s	F class

Notes: 1. Based on the 10th percentile wind speed of all winds present for 30% of the time during the relevant period.

2. Wind directions considered are 0°, 22.5°, 45°, 67.5°, 90°, 112.5° from north (0°) based on data from the Gunlake Quarry weather station.

It is noted that the previous noise assessment (Pacific Environment 2014) utilised a different set of prevailing weather conditions for the purpose of predicting noise emissions levels. These included calm conditions (no prevailing winds) during the day, evening and night period, and F class temperature inversions during the night period.

4 Criteria

4.1 Operational noise criteria

4.1.1 Project approval 07-0074

Noise criteria for assessment locations R2 and R4 exist for Gunlake quarry operations are specified in Condition 2, Schedule 3 of the current Project Approval (07-0074) and are reproduced in Table 4.1.

Table 4.1 Project Approval noise criteria

Location	Noise criteria, dB			
	Day	Evening	Night	
	$L_{Aeq(15\text{-}min)}$	$L_{Aeq(15\text{-}min)}$	$L_{Aeq(15\text{-}min)}$	$L_{A1(1\text{-}min)}$
R2	35	35	35	47
R4	35	35	35	45

Condition 4 and 4A of Schedule 3, relating to operating conditions and noise management plan requirements are:

> Operating Conditions
>
> 4. The Proponent shall:
>
> (a) implement best practice management to minimise the operational and road transportation noise of the project;
>
> (b) minimise the noise impacts of the project during meteorological conditions when the noise limits in this approval do not apply (see notes to Table 1 in Condition 2 above);
>
> (c) carry out regular monitoring to determine whether the project is complying with the relevant conditions of this approval;
>
> (d) regularly assess noise monitoring data and modify and/or stop operations on site to ensure compliance with the relevant conditions of this approval; and
>
> (e) ensure all reasonable and feasible measures are employed to reduce noise from the tertiary crusher at night, to the satisfaction of the Secretary.
>
> Noise Management Plan
>
> 4A. The Proponent shall prepare and implement a Noise Management Plan for the project to the satisfaction of the Secretary. This plan must:
>
> (a) be prepared in consultation with the EPA and submitted to the Secretary for approval by 31 August 2015;
>
> (b) describe the measures that would be implemented to ensure:
>
> compliance with the noise criteria in this approval;
>
> best management noise minimisation practice is employed on site; and

the noise impacts of the project are minimised during any meteorological conditions when the noise limits in this approval do not apply; and

(c) detail a monitoring program that will be put in place to measure noise from the project against the noise criteria in Table 2, and which evaluates and reports on the effectiveness of the noise management system on site.

4.1.2 Project specific noise criteria

Industrial sites in NSW are regulated by the local council, DP&E and/or the EPA. Noise limits are normally derived from operational noise criteria applied at assessment locations based on INP guidelines (EPA 2000) or noise levels that can be achieved at a specific site following the application of all feasible and reasonable noise mitigation.

The INP guidelines for assessing industrial facilities have been used for this assessment. With respect to the criteria, the guidelines state:

> They are not mandatory, and an application for a noise producing development is not determined purely on the basis of compliance or otherwise with the noise criteria. Numerous other factors need to be taken into account in the determination. These factors include economic consequences, other environmental effects and the social worth of the development.

Assessment criteria depend on the existing amenity of areas potentially affected by the subject development. Noise assessment criteria for industry are based on the following objectives:

- protection of the community from excessive intrusive noise; and
- preservation of amenity for specific land uses.

To ensure these objectives are met, the EPA provides two separate criteria: intrusiveness criteria and amenity criteria. A fundamental difference between the intrusiveness and the amenity criteria is the period they relate to:

- intrusiveness criteria — apply over 15 minutes in any period (day, evening or night); and
- amenity criteria — apply to the entire assessment period (day, evening or night).

i Intrusiveness

The intrusiveness criteria require that $L_{Aeq(15\text{-}min)}$ noise levels from site during the relevant operational periods (ie day, evening and night) do not exceed the RBL by more than 5 dB. The adopted RBL utilised for determination of the intrusive criteria are based on the background noise monitoring results presented in the previous noise and vibration assessment (Pacific Environment 2014) and reproduced in Table 3.2, as further verified by EMM in Section 3.3. The RBL are lower than the INP minimum threshold of 30 dB for all assessment periods and therefore a RBL of 30 dB has been adopted for all assessment locations.

Table 4.2 presents the intrusive noise criteria determined for the assessment locations. These are the current project noise criteria at R2 and R4 (Table 4.1).

Table 4.2 Intrusive noise criteria

Assessment location	Period[1]	Adopted RBL, dB	Intrusive criteria, $L_{Aeq(15\text{-}min)}$, dB
R2, R7, R8 - Brayton Road	Day	30	35
	Evening	30	35
	Night	30	35
R4, R5, R6 - Carrick Road	Day	30	35
	Evening	30	35
	Night	30	35

Note: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; evening: 6 pm to 10 pm; night: all remaining periods.

ii Amenity

The assessment of amenity is based on noise criteria specific to the land use. The criteria relate only to industrial noise and exclude road or rail noise. Where the measured existing industrial noise approaches recommended amenity criteria, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise.

Residential assessment locations have been categorised in the INP (EPA 2000) rural amenity category in accordance with the INP definition of a rural receiver type, ie an area with an acoustical environment that is dominated by natural sounds, and generally characterised by low background noise levels. The corresponding recommended amenity criteria for Gunlake Quarry are given in Table 4.3.

Table 4.3 Amenity criteria

Assessment location	Indicative area	Time period	Recommended noise level, $L_{Aeq(period)}$, dB	
			Acceptable	Maximum
R2, R7, R8 - Brayton Road	Rural	Day	50	55
		Evening	45	50
		Night	40	45
R4, R5, R6 - Carrick Road	Rural	Day	50	55
		Evening	45	50
		Night	40	45

Source: INP (EPA 2000).

iii Project specific noise level

The project-specific noise levels (PSNLs) are generally the more stringent of either the intrusive or amenity criteria. However, where the amenity criteria is lower than the intrusive criteria it does not automatically follow that the amenity criteria would be more stringent due to the relative time periods over which they apply. Where this situation arises it is necessary to demonstrate that both the amenity and intrusive criteria can be achieved.

The PSNLs determined for the extension project for all relevant assessment periods are the relevant intrusive criteria and are shown in 'bold' text in Table 4.4.

Table 4.4 Project specific noise levels

Assessment Location	Period[1]	Intrusive criteria, $L_{Aeq(15\text{-}min)}$, dB	Amenity criteria, $L_{Aeq(period)}$, dB
R2, R7, R8 - Brayton Road	Day	**35**	50
	Evening	**35**	45
	Night	**35**	40
R4, R5, R6 - Carrick Road	Day	**35**	50
	Evening	**35**	45
	Night	**35**	40

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; evening: 6 pm to 10 pm; night is the remaining periods.

4.1.3 Voluntary Land Acquisition and Mitigation Policy

The NSW Government has developed the *Voluntary Land Acquisition and Mitigation Policy* (VLAMP) (NSW Government 2014). The VLAMP has been formally adopted by the NSW Government and seeks to balance acquisition and mitigation obligations for extractive industry development operators that provide appropriate protections for landholders, where impacts are potentially significant.

Figure 4.1 provides the general decision making process that will be applied by consent authorities at the development application stage when assigning voluntary mitigation and acquisition obligations.

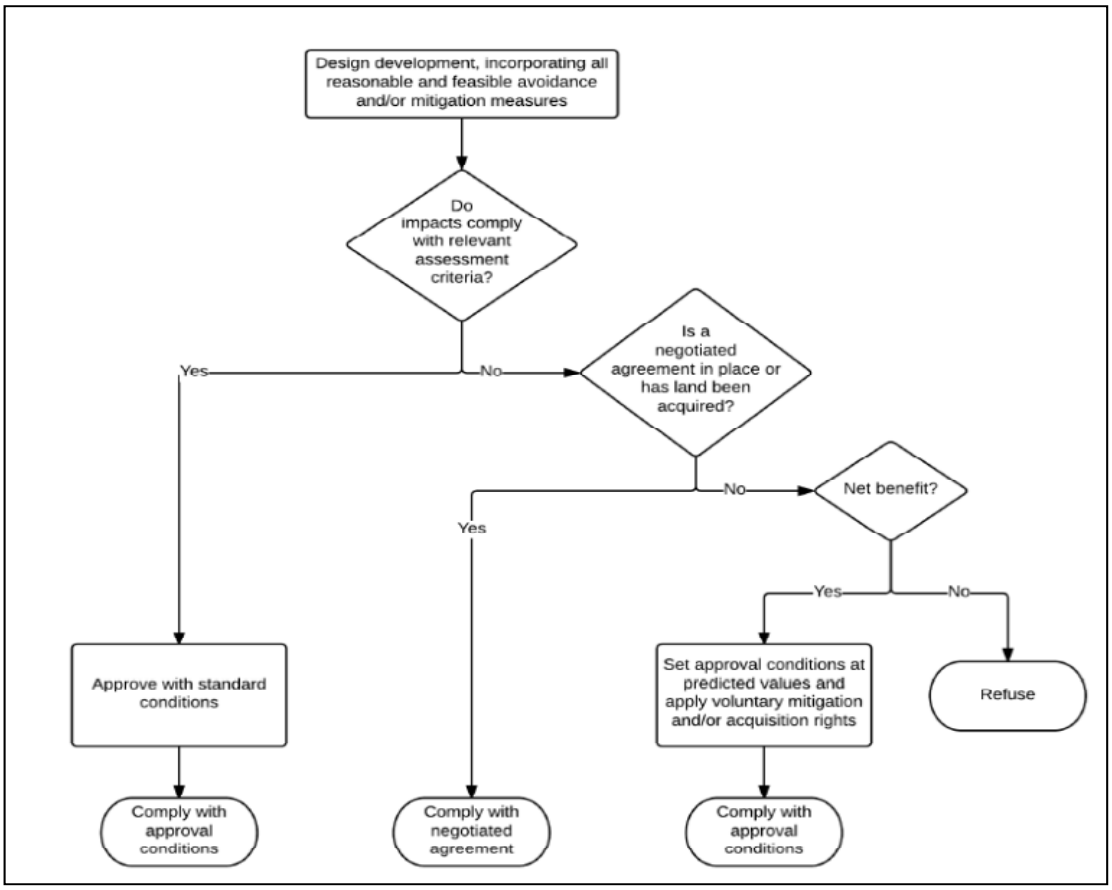


Figure 4.1 General approach to decision making during the assessment process

i VLAMP application

The VLAMP states:

> This policy is to be applied by consent authorities when assessing and determining development applications and modification applications for mining, petroleum and extractive industry developments subject to the State significant development provisions of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

According to the above application clause, the VLAMP applies to the proposed Gunlake extension project as it is a State significant development.

Furthermore the VLAMP states:

> A consent authority can apply voluntary mitigation and voluntary land acquisition rights to reduce:
>
> - operational noise impacts of a development on privately owned land; and
> - rail noise impacts of a development on privately owned land near non-network rail lines (private rail lines), on or exclusively servicing industrial sites (see Appendix 3 of the Rail Infrastructure Noise Guideline (RING) (EPA 2013);
>
> But not:
>
> - construction noise impacts, as these impacts are shorter term and can be controlled;
> - noise impacts on the public road or rail network; or
> - modifications of existing developments with legacy noise issues, where the modification would have beneficial or negligible noise impacts. In such cases, these legacy noise issues should be addressed through site-specific pollution reduction programs under the Protection of the Environment Operations Act 1997.

Irrespective of the above, Section 1.4.5 and Section 1.4.8 of the INP (EPA 2000) include procedures in regards to mitigation or acquisition of properties based on similar principles as contained in the VLAMP. Hence, residents are afforded the same or similar rights under the INP as they would with the more recent VLAMP.

ii Characterisation of noise impacts

Voluntary mitigation and acquisition rights in the VLAMP are assigned to privately owned dwellings based on the level of predicted noise above the current project approval noise criteria, or the PSNL. This is explained in Table 4.5.

Table 4.5 Characterisation of noise impacts and potential treatments

Residual noise exceeds INP criteria by	Characterisation of impacts	Potential treatment
0–2 dB(A) PSNL	Impacts are considered to be **negligible**	The exceedances would not be discernible by the average listener and therefore would not warrant receiver based treatments or controls.
3–5 dB(A) above the PSNL in the INP but the development would contribute less than 1 dB to the total industrial noise level	Impacts are considered to be **marginal**	Provide mechanical ventilation/comfort condition systems to enable windows to be closed without compromising internal air quality/amenity.
3–5 dB(A) above the PSNL in the INP and the development would contribute more than 1 dB to the total industrial noise level	Impacts are considered to be **moderate**	As for marginal impacts but also upgraded facade elements like windows, doors, roof insulation, etc., to further increase the ability of the building façade to reduce noise levels.
>5 dB(A) above the PSNL in the INP	Impacts are considered to be **significant**	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions.

iii Acquisition of privately owned land

The VLAMP provides noise acquisition criteria for privately owned land parcels. The policy assigns acquisition rights if the noise generated by a development contributes to an exceedance of the recommended maximum noise levels in Table 2.1 of the INP (EPA 2000) on more than 25% of any privately owned land, where a dwelling could be built on the land under existing planning controls.

The VLAMP defines land as "...the whole of a lot, including contiguous lots owned by the same landowner".

For the proposed Gunlake operations, this results in acquisition criteria of 55 dB, 50 dB and 45 dB ($L_{Aeq, period}$) for the day, evening and night periods, respectively, on more than 25% of any privately owned land.

4.1.4 Sleep disturbance

Gunlake Quarry currently operates during the night period and sleep disturbance ($L_{A1(1\text{-}min)}$) noise limits exist for R2 and R4 in the current project approval (Table 4.1). Gunlake Quarry will continue to operate during the night period (from 10 pm to 7 am) and therefore the current noise limits will be adopted in this assessment as the criteria for R2 and R4.

For all other assessment locations (ie R5, R6, R7 and R8), assessment of sleep disturbance is also required in accordance with the INP and associated Application Notes. The INP Application Notes recognise that the current sleep disturbance criterion is not ideal. The assessment of potential sleep disturbance is complex and poorly understood and the EPA believes that there is insufficient information to determine a suitable alternative criteria.

In the interim, the INP guideline suggests that the $L_{A1(1\text{-}min)}$ level of 15 dB above the RBL is a suitable screening criteria for sleep disturbance for the night-time period. Guidance regarding potential for sleep disturbance is also provided in the NSW Road Noise Policy (RNP). The RNP calls upon a number of studies that have been conducted into the effect of maximum noise levels on sleep. The RNP acknowledges that, at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance. However, the RNP provides the following conclusions from the research on sleep disturbance:

- maximum internal noise levels below 50 to 55 dB are unlikely to awaken people from sleep; and
- one or two noise events per night (for example, excavator unloading rock into an empty haul truck tray), with maximum internal noise levels of 65 to 70 dB, are not likely to affect health and wellbeing significantly.

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade including a partially open window will reduce external noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB calculated at the facade of a residence are unlikely to cause sleep disturbance affects. Furthermore, the World Health Organisation (WHO) *Guidelines for Community Noise* (WHO 1999) suggests that levels below 45 dB inside homes are unlikely to wake sleeping occupants.

The descriptors L_{Amax} and $L_{A1(1\text{-}min)}$ may be considered interchangeable which is accepted by the EPA.

Sleep disturbance for assessment locations R5, R6, R7 and R8 are based on the adopted RBLs as presented in Table 4.6.

Table 4.6 Sleep disturbance criteria

Assessment location	Period[1]	Adopted RBL, dB(A)	Sleep disturbance $L_{A1(1\text{-}min)}$ criteria, dB	Project approval (07-0074) $L_{A1(1\text{-}min)}$ criteria, dB
R2	Night	n/a	n/a	47
R4	Night	n/a	n/a	45
R5-R6	Night	30	45	n/a
R7-R8	Night	30	45	n/a

Notes: 1. Night: 10 pm to 7 am Monday to Saturday; 10 pm to 8 am Sundays and public holidays.

4.2 Construction noise

Construction noise is assessed under the Interim Construction Noise Guidelines (ICNG), however there is no proposed construction period. Noise generated during the overburden emplacement construction will be assessed as operational noise due to the similar type of plant and equipment used for Gunlake general quarrying operations. In EMM's experience, this method is considered suitable and commonly accepted by the EPA.

4.3 Cumulative noise

To limit continuing increases in industrial noise within a particular area, combined industrial noise should not exceed the amenity criteria levels specified in Table 2.1 from Section 2.2 of the INP (EPA 2000). Holcim (Australia) Pty Ltd (Holcim) Johnniefelds Quarry is situated on Brayton Road approximately 1.2 km east of Gunlake Quarry and currently only operates during day-time and evening periods. Operational noise from Johnniefelds Quarry has the potential to impact residences R2, R7 and R8 during the daytime and evening periods. Cumulative operational noise during the day-time and evening periods has been considered for these residences and compared against the relevant INP acceptable and recommended maximum amenity criteria levels. This assessment has adopted the rural type amenity criteria for all residences (Table 4.3).

It is noted that Holcim Lynwood Quarry is a development currently under construction in the area, and is approximately 3 km south of the quarry and 4 km west of Marulan. Lynwood Quarry is expanding further north of the currently approve footprint. It is noted however that Lynwood Quarry's infrastructure area, which includes the processing plant, is located approximately 3 km from the site's southern boundary. Therefore, given the distance between Lynwood Quarry and the nearest assessment locations (R7 and R8), it is anticipated that additional industrial noise emissions would not increase cumulative noise levels to above the relevant amenity criteria. This is discussed further in Section 5.6.

4.4 Blasting

The limits adopted by EPA for blasting are provided in the Australian and New Zealand Environment Conservation Council (ANZECC 1990) guidelines, *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*.

The blasting limits address two main effects of blasting:

- airblast noise overpressure; and
- ground vibration.

It is noted that airblast and ground vibration criteria exist for Gunlake quarry operations as specified in Condition 6 and Condition 7, Schedule 3 of the current Project Approval (07-0074). These are consistent with the ANZECC (1990) guidelines as discussed in the following sections. Blasting currently occurs approximately once a fortnight, and as part of the extension project is proposed to occur twice weekly.

4.4.1 Airblast

The recommended maximum vibration level for airblast is 115 dB linear peak. The vibration level of 115 dB may be exceeded on up to 5% of the total number of blasts over 12 months. However, the level should not exceed 120 dB linear peak at any time. A summary of airblast limits are provided in Table 4.7.

Table 4.7 Airblast overpressure

Airblast overpressure level dB(L_{peak})	Allowable exceedance
115	5% of the total number of blasts over 12 months
120	0%

4.4.2 Ground vibration

Peak particle velocity (PPV) from ground vibration should not exceed 5 mm/s for more than 5% of the total number of blasts over 12 months. However, the maximum level should not exceed 10 mm/s at any time. A summary of ground vibration limits are provided in Table 4.8.

Table 4.8 Ground vibration limits

PPV (mm/s)	Allowable exceedance
5	5% of the total number of blasts over 12 months
10	0%

4.5 Road traffic

4.5.1 Assessment criteria

The road traffic noise assessment has been conducted in accordance with the NSW EPA *Road Noise Policy* (RNP) (EPA 2011). The RNP identifies several noise assessment criteria according to road categories and land uses. The freeway/arterial/sub-arterial road type was adopted for residential land uses on Brayton Road (north and south of the Bypass Road), the Bypass Road/Red Hills Road and the Hume Highway, which are existing quarry product transportation road. It is noted that there will be no increase in transport truck numbers along Brayton Road south of Bypass Road as a result of the proposed extension, as additional traffic volumes from the quarry will use the Bypass Road/Red Hills Road.

The road traffic noise assessment criteria from Table 3 of the RNP (EPA 2011) relevant to residential land uses are reproduced in Table 4.9. It is noted that the road traffic movements on the site access road and internal haul roads are within the quarry boundary and therefore are assessed as operational noise.

Table 4.9 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria, dB	
		Day (7 am to 10 pm)	Night (10 pm to 7 am)
Freeway/arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{Aeq(15\text{-}hr)}$ 60 (external)	$L_{Aeq(9\text{-}hr)}$ 55 (external)

Additionally, the RNP states where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to 2 dB, which is generally accepted as the threshold of perceptibility to a change in noise level.

4.5.2 Relative increase criteria

In addition to meeting the assessment criteria, any significant increase in total traffic noise at residences must be considered. Residences experiencing increases in total traffic noise levels above those presented in Table 4.10 should be considered for mitigation. It should be noted that the relative increase criterion does not apply to local roads, as per Section 2.4 of the RNP (EPA 2011).

Table 4.10 Relative increase criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase, dB	
		Day (7 am to 10 pm)	Night (10 pm to 7 am)
Freeway/arterial/sub-arterial roads and transit ways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{Aeq(15\text{-}hr)}$+12 dB (external)	Existing traffic $L_{Aeq(9\text{-}hr)}$+ 12 dB (external)

5 Operational noise modelling and assessment

5.1 Overview

The extension project will involve the increase in product production, the extension of the pit area to the south, the development of an overburden emplacement to the west of the pit area, and the increase in site-related road traffic (mainly transportation). These aspects have the potential to change noise emissions at sensitive receivers. Hence, noise emissions from Gunlake Quarry operations have been quantitatively reviewed to provide a contemporary assessment of approved operations, incorporating the proposed extension.

5.2 Noise modelling methodology

5.2.1 Modelling software and calculation method

This section presents the methods and assumptions used to model noise emissions from existing and proposed Gunlake Quarry operations.

Noise modelling was based on three-dimensional digitised ground contours of the surrounding land. Noise predictions were carried out using Brüel and Kjær Predictor Version 10.10 noise prediction software. 'Predictor' calculates total noise levels at assessment locations from the concurrent operation of multiple noise sources. The model has considered factors such as:

- the lateral and vertical location of plant;
- source to assessment location distances;
- ground effects;
- atmospheric absorption;
- topography of the Project site and surrounding area; and
- applicable meteorological conditions (refer to Section 3.4).

Validation of the noise model was completed using attended measurements undertaken during the site visit. Furthermore, off-site measurements results along with weather data recorded by Gunlake weather station at the time of the measurements were used to calibrate the noise model.

5.2.2 Modelling scenarios

The modelling includes existing and proposed operations at the quarry. Plant and equipment were modelled at locations and heights representing activities during quarry operations, including all adopted feasible and reasonable noise management and mitigation discussed in more detail in Section 5.2.3 and Section 7.

Current processing operations at the quarry consist of primary, secondary, tertiary and quaternary crushers as well as multiple screens. However, to meet the proposed production rate of 2 Mtpa, the processing plant (fixed) will need to be upgraded including the addition of two tertiary crushers, an impact crusher and screens.

EMM conducted a site visit on 2 September 2015 to undertake noise measurements at Gunlake Quarry for the purpose of determining sound power levels of relevant equipment items. It is noted that it was not possible to effectively measure all on-site equipment as some equipment was not operating on the day of monitoring. Where direct measurement was not possible, sound power data has been obtained from previous site surveys when the site was fully operational (Pacific Environment 2014) or from EMM's sound power database. Sound power data adopted for each noise modelling scenario is provided in Table 5.1. The noise modelling conservatively assumed that all plant and equipment will be operating concurrently. Assumed locations of acoustically significant plant and equipment during each stage of the extension project are provided graphically in Appendix B.

Table 5.1 Operational plant and equipment sound power levels

Plant and equipment	Sound power level (L_w), dB	Current operations			Extension project Year 1 to Year 30		
		Day	Evening	Night	Day	Evening	Night
Existing processing plant							
Primary crusher	112[1]	✓	x	x	✓	✓	✓
Secondary crusher	115[1]	✓	x	x	✓	✓	✓
Primary screens	112[1]	✓	x	x	✓	✓	✓
Tertiary crusher and impact crusher	115[1]	✓	✓	✓	✓	✓	✓
Secondary screens	109[1]	✓	✓	✓	✓	✓	✓
Quaternary crusher	105[1]	✓	✓	✓	✓	✓	✓
Upgraded processing plant – future							
Tertiary crusher x 2 and impact crusher	118[1]	x	x	x	✓	✓	✓
Tertiary screens	109[1]	x	x	x	✓	✓	✓
Mobile plant and equipment							
Front-end loader (FEL) – loading road truck in sales area	112[1]	✓	✓	✓	✓	✓	✓
Excavator (Hitachi 450LC)	104[1]	✓	✓	✓	✓	✓	✓
Excavator (CAT 345B)	107[3]	✓	x	x	✓	x	x
Dozer (Komatsu)	112[3]	✓	x	x	✓	x	x
Front-end loader (FEL) – pit area	115[3]	✓	✓	✓	✓	✓	✓
Haul truck x 2 (CAT 769D)	114[3]	✓	✓	✓	✓	✓	✓
Drill	116[3]	✓	x	x	✓	x	x
Grader	104[3]	✓	x	x	✓	x	x
Watercart	102[2]	✓	✓	✓	✓	✓	✓
Road truck (loaded)	103[3]	✓	x	x	✓	✓	✓
Road truck (empty)	105[3]	✓	x	x	✓	✓	✓
Light vehicle	76[3]	✓	✓	✓	✓	✓	✓

Notes: *1.Obtained from direct measurement by EMM.*

2. Obtained from the previous modification noise assessment report (Pacific Environment 2014).

3. Obtained from EMM database of similar equipment.

During the site visit, it was identified that the noise sources most likely to cause sleep disturbance were from the FEL loading the road trucks and the haul trucks unloading material into the Primary crusher bin. The maximum noise level from a haul truck unloading material into the hopper bin measured by EMM was L_{Amax} 124 dB. This L_{Amax} noise level was used as input to the computer model for both maximum noise level events (FEL operation or haul trucks unloading material). Predictions were made at the assessment locations under calm and F class inversion conditions during the night-time period.

5.2.3 Noise management and mitigation

A range of feasible and reasonable noise mitigation measures have been adopted by Gunlake Quarry which have been included in noise modelling. These include:

- extending the north and south extents of the emplacement bund to the east of the site; and
- reducing mobile fleet during the evening and night periods.

These measures along with other investigated feasible mitigation measures are described further in Section 6.

5.3 Noise modelling results and discussion

5.3.1 Operational noise levels

Predicted noise emission levels from Gunlake quarrying operations at all assessment locations are provided in Table 5.2.

Noise levels have been predicted based on the meteorological conditions provided in Table 3.3.

Noise emission levels predicted to be above the existing project approval limits and PSNLs are indicated by shading.

The accuracy of the noise model has been verified through a noise model calibration exercise. Noise model calculations for existing operations were compared to quarry noise levels measured both on-site and off-site during attended measurements completed during the September 2015 site visit. During these measurements, key acoustically significant plant and equipment (eg crushers) were switched on and off to allow an accurate individual noise level contribution to be derived. The noise model was calibrated accordingly to reflect the difference in measured and modelled noise levels. Quarry noise levels measured both on-site and off-site during attended measurements were similar to levels calculated from the calibration model, and differences in levels were in the order of ±1 dB. The existing and future noise level predictions presented in Table 5.2 are therefore considered accurate in representing noise from Gunlake Quarry operations.

Table 5.2 Predicted operational noise levels

Assessment location	Predicted operational $L_{Aeq(15\text{-}min)}$ noise levels, dB				Noise criteria $L_{Aeq(15\text{-}min)}$, dB
	Day	Evening/ Night	Night	Night	
	Calm	Calm	Prevailing winds[1]	Inversion[2]	PA limit/PSNL
Existing quarry operations					
R2	40	38	40	40	35
R4	39	37	39	39	35
R5	28	25	28	28	35
R6	29	27	29	29	35
R7	33	31	34	34	35
R8	32	30	33	33	35
Year 1 quarry operations					
R2	41	42	44	45	35
R4	41	42	45	45	35
R5	29	31	34	34	35
R6	31	32	35	35	35
R7	34	35	37	38	35
R8	33	34	37	37	35
Year 5 quarry operations					
R2	41	42	44	45	35
R4	41	42	45	45	35
R5	30	31	34	34	35
R6	31	32	35	35	35
R7	34	35	38	38	35
R8	33	34	37	37	35
Year 10 quarry operations					
R2	41	42	44	45	35
R4	41	42	45	45	35
R5	29	31	34	34	35
R6	31	32	35	35	35
R7	34	35	38	38	35
R8	33	34	37	37	35
Year 20 quarry operations					
R2	41	42	44	44	35
R4	41	42	45	45	35
R5	30	31	34	34	35
R6	31	32	35	35	35
R7	34	35	38	38	35
R8	33	34	37	37	35

Table 5.2 Predicted operational noise levels

Assessment location	Predicted operational $L_{Aeq(15\text{-}min)}$ noise levels, dB				Noise criteria $L_{Aeq(15\text{-}min)}$, dB
	Day	Evening/ Night	Night	Night	
	Calm	Calm	Prevailing winds[1]	Inversion[2]	PA limit/PSNL
	Year 30 quarry operations				
R2	41	42	44	44	35
R4	41	42	45	45	35
R5	29	31	34	34	35
R6	31	32	35	35	35
R7	34	35	38	38	35
R8	33	34	37	37	35

Notes: 1. Maximum predicted level based on wind speed of 2.3 m/s and wind directions from 360° to 112.5° (22.5° increments) from north (0°) based on data from the Gunlake Quarry weather station.

2. F class temperature inversion.

A discussion of results including residual noise levels above PSNLs relevant to each assessment area is provided as follows:

- **R2**:
  - current operations: noise levels are modelled to be up to 5 dB above the PSNLs (and current approval conditions) during the daytime and night-time periods (during worst case winds and F class temperature inversion). This level of noise is considered to produce moderate impact according to the VLAMP.
  - Extension project, Year 1 to Year 30: day-time noise levels are predicted up to 6 dB above the PSNLs. Evening and night-time noise levels are predicted up to 10 dB above the PSNLs between Year 1 and Year 20. Between Year 20 and Year 30, evening and night-time noise levels are predicted up to 9 dB above the PSNLs. This level of noise is considered to produce significant impact, and entitles this location to voluntary acquisition upon request in accordance with the VLAMP. Discussion with regard to land acquisition is discussed further in Section 6.
- **R4**:
  - current operations: noise levels are modelled to be up to 4 dB above the PSNLs during the daytime and night-time periods (during worst case winds and F class temperature inversion). This level of noise is considered to produce moderate impact according to the VLAMP.
  - Extension project, Year 1 to Year 30: day-time noise levels are predicted up to 6 dB above the PSNLs. Evening and night-time noise levels are predicted up to 10 dB above the PSNLs. This level of noise is considered to produce significant impact, and entitles this location to voluntary acquisition upon request in accordance with the VLAMP. Discussion with regard to land acquisition is discussed further in Section 6.

- **R5–R6**:
  - current operations: noise levels are modelled to satisfy the PSNLs during all assessment periods.
  - Extension project, Year 1 to Year 30: noise levels are predicted to satisfy the PSNLs during all assessment periods.
- **R7:**
  - current operations: noise levels are modelled to satisfy the PSNLs during all assessment periods.
  - Extension project, Year 1 to Year 30: day-time noise levels are predicted to satisfy the PSNLs. Evening and night-time noise levels during calm weather conditions are predicted to satisfy the PSNLs. Night-time noise levels during worst case winds and F class temperature inversion are predicted to be up to 3 dB above the PSNLs. This is considered to be a moderate level of noise impact (during worst case night-time meteorological conditions only) and entitles this location to mitigation upon request in accordance with the VLAMP. Discussion with regard to mitigation is discussed further in Section 6.
- **R8**:
  - current operations: noise levels are modelled to satisfy the PSNLs during all assessment periods.
  - Extension project, Year 1 to Year 30: day-time noise levels are predicted to satisfy the PSNLs. Evening and night-time noise levels during calm weather conditions are predicted to satisfy the PSNLs. Night-time noise emission levels during worst case winds and F class temperature inversion are predicted up to 2 dB above the PSNLs. This is considered to be a negligible level of noise impact and would not warrant receiver based mitigation according to the VLAMP.

Predicted site noise levels above the criteria at worst affected locations are mainly as a result of noise emissions from the processing plant items. Notwithstanding, noise levels from the extension project would be lower at receivers further from the quarry (in particular the processing area). Noise levels at these further away receivers are predicted to satisfy the criteria during worst case meteorological conditions for all stages of the project.

5.3.2 Sleep disturbance assessment

Predicted L_{Amax} noise levels from relevant Gunlake Quarry operations at all assessment locations are provided in Table 5.3.

The highest predicted L_{Amax} noise level (from FEL loading or haul truck unloading operations) was 46 dB during F class temperature inversion at assessment location R2. This satisfies the current project approval limit and adopted criterion at this location. The highest predicted L_{Amax} noise levels at all other assessment locations (R4 to R8) ranged between 36 dB and 43 dB during F class temperature inversion, and satisfy the EPA's strict background plus 15 dB screening target.

Table 5.3 Predicted L_{Amax} noise levels

Assessment location	Night-time predicted operational L_{Amax} noise levels, dB		Relevant noise criteria, dB
	Calm	Inversion[2]	
R2	42–43	44–46	47
R4	31–39	34–42	45
R5	30–33	33–36	45
R6	29–34	31–36	45
R7	33–40	36–43	45
R8	30–40	33–43	45

Notes: 1. Maximum predicted level based on wind speed of 2.3 m/s and wind directions from 360° to 112.5° (22.5° increments) from north (0°) based on data from the Gunlake weather station.

2. F class temperature inversion.

5.4 Cumulative noise assessment

Potential cumulative noise impacts from existing and successive developments are considered by the INP procedures by ensuring that the appropriate noise criteria are established with a view to maintaining acceptable noise amenity levels. Therefore, the cumulative impact of the proposed extension project with existing industrial noise sources has been assessed to determine the acceptable and recommended maximum amenity levels at the relevant assessment locations.

The operating Johnniefelds Quarry is situated east of Brayton Road approximately 1.2 km east of Gunlake Quarry (Figure 1.1). Johnniefelds Quarry only operates during the day-time and evening periods and has the potential to impact the nearest sensitive receivers R2, R7 and R8 during these periods. It is noted that predicted or existing noise levels from Johnniefelds Quarry are not documented in the public domain. Potential noise levels from Johnniefelds Quarry have therefore been qualitatively reviewed along with the predicted operational noise levels from the proposed Gunlake Quarry in this report.

The site $L_{Aeq(15\text{-}min)}$ noise levels predicted at assessment locations R2, R7 and R8 during the day period range from 33 dB to 41 dB. Typically, site $L_{Aeq(day)}$ noise levels would be at least 3 dB lower, and therefore range from 30 dB to 38 dB for these properties. The INP acceptable recommended level of 50 dB is unlikely to be exceeded at these locations as contributions from the Johnniefelds Quarry would not be dissimilar to that from the subject development, given relative proximities. For example, adding two noise levels of 38 dB $L_{Aeq(day)}$ each results in a combined level of 42 dB. Similarly, given site $L_{Aeq(15\text{-}min)}$ noise levels predicted at assessment locations R7 and R8 during the evening period (34–35 dB), it is anticipated that site $L_{Aeq(evening)}$ noise levels would satisfy the INP acceptable recommended level of 45 dB at these locations.

Holcim (Australia)'s Lynwood Quarry is located south of the extension project. Holcim (Australia) is seeking to modify the quarry consent (Modification 4) to expand further north of the currently approved footprint. The noise assessment prepared for Lynwood Quarry Modification 4 (Umwelt 2015) predicts that noise levels from the proposed modification at residences north-east of Lynwood Quarry (south of the extension project eg R7 and R8) would be less than 30 dB for all stages of the modification during worst-case meteorological conditions. Therefore, potential noise contributions from Lynwood Quarry (Modification 4) would not increase cumulative noise levels above the INP amenity criteria at all assessment locations for the extension project.

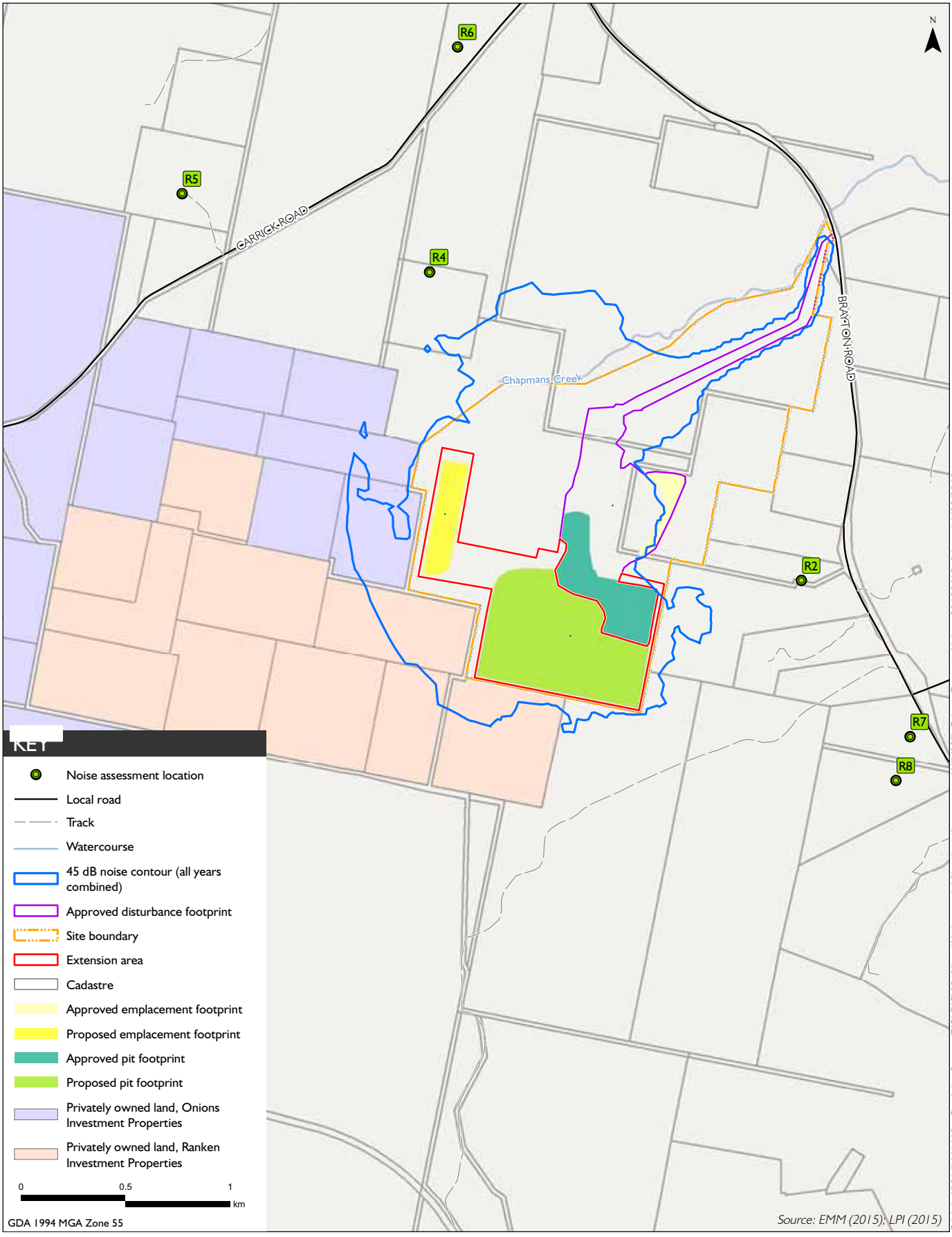
In summary, cumulative noise from the extension project and surrounding developments is anticipated to satisfy the amenity criteria at all assessment locations.

5.5 Privately owned lands assessment

Several privately owned lands were identified surrounding the Gunlake Quarry consent boundary that could potentially be exposed to noise from the extension project and other industrial developments in the area. As discussed in the previous section, cumulative noise from the extension project and other surrounding quarries will not impact on privately owned residences in the area. However, the VLAMP requires further assessment of cumulative noise levels over privately owned land parcels. Acquisition rights are assigned to land owners if total combined industrial noise levels from all projects exceed the recommended maximum noise levels in Table 2.1 of the INP (EPA 2000) on more than 25% of any privately owned land, where a dwelling could be built on the land under existing planning controls. The subject development's contribution to any such exceedance needs to be determined.

The $L_{Aeq,period}$ noise contour derived from all five modelled operational stages for worst case meteorological conditions is presented in Figure 5.1. The night-time noise contour has been provided as this represents the worst case operating period. Only the subject site's contribution is included and the $L_{Aeq,period}$ 45 dB contour is shown (ie equivalent to the VLAMP night-time 25% land acquisition criterion). As discussed earlier, night-time operations from other operations would not alter this level (ie Johnniefelds Quarry does not operate at night and Lynwood Quarry is documented to contribute at less than 30 dB).

The VLAMP defines privately owned land as "...the whole of a lot, including contiguous lots owned by the same landowner". This is important and relevant to the subject assessment which shows predicted noise levels over the entire privately owned land parcel, including all contiguous lots, is less than 25% and therefore does not trigger acquisition rights during worst case night-time F class temperature inversion conditions (Refer Figure 5.1). Furthermore, Gunlake currently has negotiated agreements in place with the relevant landowners of properties to the immediate south and south-west.



Predicted noise levels on privately owned land parcels - all years LAeq(night) dB

Gunlake Quarry
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Figure 5.1

5.6 Blasting

Blast design will be managed by site personnel and the blasting contractor to control the airblast overpressure and ground vibration. Notwithstanding a quantitative assessment of blast overpressure and vibration levels has been prepared using the method given in the *AS2187-2-2006: Explosives – Storage and Use Part 2: Use of Explosives and the Imperial Chemical Industries (ICI) Explosives Blasting Guide* (ICI Technical Services 1995), as applicable to blasting in hard rock. This formula has been shown to be conservative in calculating overpressure and vibration.

The relevant formulae are as follows:

PVS = $K (R/Q ^{0.5})^{-1.6}$

dB = $164.2 - 24(\log_{10} R - 0.33 \log_{10} Q)$

Where,

PVS = peak vector sum ground vibration level (mm/s)

dB = peak airblast level (dB Linear)

K = factor applied according to blasting type

R = distance between charge and residence (m)

Q = charge mass per delay (kg) or maximum instantaneous charge (MIC)

It should be noted that a K factor of 500 (hard or highly structured rock) was used to calculate levels associated with blasting during the extraction process.

This assessment provides blast overpressure and ground vibration levels at several distances away from blast locations at the quarry during the extension project. The results are provided in Table 5.4. The results convey that a large range of MICs can be adopted based on the distance from the blast to the nearest assessment locations, along with other standard blasting practices as determined throughout the blast design process. A review of the quarry plans and proposed active quarry area shows that blasting may occur at 700 m from the nearest assessment location and a respective MIC of 290 kg along with other appropriate blast design practices will satisfy ANZECC limits. Conversely, where blasts are distanced further from assessment locations, a higher MIC along with other appropriate blast design practices can be adopted whilst still satisfying ANZECC limits.

As mentioned in Section 3.1 Gunlake has successfully managed blast emission from the site and will continue to do so as part of the approved Noise and Blast Management Plan (Heggies 2009) or as modified for the extension project.

Table 5.4 Blast overpressure and ground vibration results

Phase	Activity	Distance from blast location (m)	Highest allowable MIC (kg)	Overpressure criteria (dB(L)peak)	Ground vibration criteria PPV (mm/s)	Highest allowable MIC (kg) to satisfy criteria
All years	Hard rock extraction	700	290	≤115	≤5	290
		900	600	≤115	≤5	600
		1,100	1,150	≤115	≤5	1,150
		1,300	1,900	≤115	≤5	1,900

5.7 Road traffic noise

There are two main routes used by road trucks to travel to and from the quarry. Road trucks leaving and returning to the quarry use Brayton Road east of the site access road. Road trucks travelling north of Marulan (mostly to Sydney markets) turn left onto the Bypass Road/Red Hills Road before reaching the Hume Highway. Road trucks travelling south of Marulan drive through the town of Marulan before connecting to the Hume Highway using the southbound ramp. All road trucks return to the quarry using the Red Hills Road/Bypass Road and turn right onto Brayton Road (northbound). The transport route and road traffic noise monitoring locations are shown on Figure 3.2.

Under the current project approval, the average daily truck movements from and to the quarry is 164 (82 truck loads). The proposed extension project will increase average daily truck movements to 440 (220 truck loads), with a potential maximum daily truck movements of 690 (345 truck loads).

To quantify existing total traffic movements on the transport route, tube traffic count surveys were undertaken by EMM in August 2015 at two locations. The existing average daily traffic movements (all traffic) recorded during the traffic count survey in August 2015 provided in Table 5.5.

Table 5.5 Existing average daily traffic movements - August 2015

Road section	Existing average daily traffic movements (including Gunlake Quarry)		
	Total – all vehicles	Heavy vehicles	% heavy vehicles
Gunlake Quarry access road	238	168	71%
Brayton Rd - west of Bypass Rd	720	326	45%
Bypass/Red Hills Rd	398	221	56%
Brayton Rd - east of Bypass Rd	448	99	22%
Brayton Rd - east of Bypass Rd (Marulan)	448	99	22%

Two noise loggers (Class 1) were deployed at two locations on Brayton Road to measure road traffic noise from existing traffic movements at the same time as the tube traffic count surveys. One logger was placed between the site access road and the Johnniefelds Quarry access road, and the second logger was placed on Brayton Road east of Bypass Road. The loggers were placed at the nearest residential property boundary to the roads and were used to calibrate road traffic noise predictions back to the nearest residential facade location. Unattended noise monitoring results from the two loggers are provided in Table 5.6.

Table 5.6 Unattended road traffic noise monitoring results

Location	Road section	Logging period	Assessment period	Measured noise level, dB	RNP criteria, dB
Logger 1	Brayton Rd - between site access road and Johnniefelds Quarry access road	17/8/15 to 2/9/15	Day	63 $L_{Aeq(15\text{-}hr)}$	60 $L_{Aeq(15\text{-}hr)}$
			Night	59 $L_{Aeq(9\text{-}hr)}$	55 $L_{Aeq(9\text{-}hr)}$
Logger 2	Brayton Rd - east of Bypass Rd	17/8/15 to 2/9/15	Day	59 $L_{Aeq(15\text{-}hr)}$	60 $L_{Aeq(15\text{-}hr)}$
			Night	53 $L_{Aeq(9\text{-}hr)}$	55 $L_{Aeq(9\text{-}hr)}$

The Calculation of Road Traffic Noise (CORTN) (UK Department of Transport) method was used to calculate the total existing traffic noise emissions and predict future traffic noise emissions at the nearest privately owned receivers for each road section of the transport route for the day and night assessment periods. The calculations account for differences in driving speed along different road sections of the transport route.

It was assumed that 85% and 15% of all existing traffic volume on the section of Brayton Road west of the Bypass/Red Hills Road occur during RNP day and night periods, respectively. On the section of Brayton Road east of the Bypass/Red Hills Road, it was assumed that 90% and 10% of all existing traffic volume occur during RNP day and night periods, respectively. On the Bypass/Red Hills Road, 80% of the existing traffic volume was assumed to occur during the RNP day period, and 20% during the RNP night period. These are consistent with the traffic volume data recorded during the surveys on these sections of Brayton Road.

For the proposed extension project, it was assumed that 65% and 35% of all additional Gunlake Quarry traffic volumes would occur during the RNP day and night periods, respectively.

The results of the road traffic noise calculations for each road section of the transport route are presented in Table 5.8 for the nearest privately owned receivers. It is noted that the unattended monitoring data from the loggers was used to validate the calculated existing traffic noise levels.

Table 5.7 Road traffic noise levels

Road section	Distance to nearest receiver (m)	Driving speed (km/h)	Existing total traffic noise (including Gunlake Quarry), dB(A)	Calculated extension project traffic noise, dB(A)	Future total traffic noise, dB(A)	Criteria, dB(A)	Difference between existing and future total traffic noise, dB
Day period							
Brayton Rd - west of Bypass Rd	108	100	47	45	49	60	2
Bypass/Red Hills Rd	400	100	38	38	41	60	3
Brayton Rd - east of Bypass Rd	62	100	47	43[1,2]	48[1,2]	60	1
Brayton Rd - east of Bypass Rd (Marulan)	16	50	50	44[1,2]	51[1,2]	60	1
Night period							
Brayton Rd - west of Bypass Rd	108	100	42	44	46	55	4
Bypass/Red Hills Rd	400	100	34	37	39	55	5
Brayton Rd - east of Bypass Rd	62	100	39	43[1,2]	44	55	5
Brayton Rd - east of Bypass Rd (Marulan)	16	50	43	44[1,2]	47	55	4

Notes: *1. Includes light vehicles only, as additional Gunlake heavy vehicles will leave and return to the quarry using the Bypass/Red Hills Road.*

2. It was assumed that half of the additional Gunlake light vehicle traffic will be travelling within a single hourly period.

The predicted future (total) road traffic noise levels satisfy the RNP day and night criteria at all nearest privately owned receivers for each section of the transport routes. During the RNP day period, the increase in road traffic noise level on Bypass/Red Hills Road is predicted to be 3 dB at the nearest privately owned receivers. Road traffic noise levels on the section of Brayton Road west of the Bypass/Red Hills Road and east of the Bypass/Red Hills Road (including in Marulan) are predicted to marginally increase by 2 dB and 1 dB, respectively.

During the RNP night period, the increase in road traffic noise level on Brayton Road (all sections including in Marulan) and the Bypass/Red Hills Road is predicted to be 4 to 5 dB at the nearest privately owned receivers, however noise levels will be below the relevant criteria. The increase in road traffic noise level for each section of the transport route also satisfies the relative increase criterion of 12 dB.

Therefore, road traffic noise resulting from the proposed extension project is predicted to satisfy the relevant criteria at all privately owned receivers for each section of the transport route.

6 Mitigation, land acquisition and noise management

6.1 Current noise management and recommendations

Gunlake currently undertakes operational noise and blast monitoring in accordance with the approved Noise and Blast Monitoring Program (Heggies 2009). Operator-attended monitoring to quantify noise contribution from the quarry at the nearest residences is completed on a yearly basis. Noise monitoring is undertaken at the nearest residence R1 (owned by Gunlake), and noise data is used to determine compliance at all other surrounding sensitive receivers.

Blast monitoring is undertaken for all blast events at the nearest potentially affected residence. It is noted that all landowners within 2 km of the quarry are notified prior to a blast event.

A review of noise monitoring reports for the previous three years found that noise emissions from the quarry are typically inaudible at the nearest residential locations or, if they are audible, are below the relevant noise limits.

To evaluate the environmental noise performance of Gunlake Quarry, it is recommended that the noise monitoring program is continued and includes night-time noise monitoring to quantify the 24 hours operation of the processing plant.

6.2 Additional feasible and reasonable management and mitigation

As part of the proposed extension project the proponent has committed to reducing the mobile fleet during the evening and night periods which are represented in the noise model results.

Early noise model iterations identified the existing and upgraded processing plant to be the main contributor to offsite noise levels at assessment locations R2 and R4. Feasible mitigation measures were subsequently investigated including the construction of a 5 m earth bund west of the upgraded processing plant. The reduction in total offsite noise levels at assessment location R4 was in the order of 1 dB. This measure was therefore deemed unreasonable and not considered further.

The noise benefit from adding sheet metal enclosures around the existing and upgraded processing plant and equipment was also reviewed. The overall reduction in total offsite noise levels with this mitigation in place was in the order of 4 to 5 dB at R2, R4 and R7. This reduction was evaluated along with other economic and social factors and was deemed unreasonable for the project due to:

- the reduction is of most benefit to two assessment locations, and of moderate benefit to a further one assessment location;
- the significant overall cost to implement the measure along with ongoing maintenance restrictions would potentially deem the project economically unfeasible; and
- entering into an amenity agreement, or, offering voluntary acquisition rights for two locations and voluntary mitigation rights for one location would likely present a more economically sustainable outcome for the project.

6.3 Voluntary mitigation

Operational noise levels at assessment location R7 from the proposed extension project are predicted to moderately exceed (by 3 dB, ie between 3 to 5 dB) the current project approval limits and PSNLs during worst case meteorological conditions. This entitles the landowner to voluntarily mitigation upon request in accordance with the VLAMP. Potential mitigation would include receiver based treatment, for example, upgrade of the dwelling facade elements. Gunlake is committed to provide potential mitigation to assessment location R7 upon request from the relevant landowner, unless an alternate amenity agreement can be made.

6.4 Voluntary land acquisition

Operational noise levels at assessment locations R2 and R4 from the proposed extension project are predicted to significantly exceed (by more than 5 dB) project approval limits and the PSNLs during the night-time period. Furthermore, the assessment identified that the implementation of other feasible mitigation measures would not achieve the required reduction to warrant this measure economically reasonable. Therefore, this entitles assessment locations R2 and R4 to voluntary acquisition rights upon request in accordance with the VLAMP. It is noted that an agreement has recently been negotiated between Gunlake and the landowner of assessment location R4, and therefore voluntary land acquisition is no longer relevant at this location.

Gunlake is committed to provide land acquisition upon request to the landowner of R2, if an alternate amenity agreement with the landholder cannot be made.

7 Conclusion

EMM has completed a noise and vibration assessment for the proposed extension of Gunlake Quarry.

A noise model was developed to assess noise levels from currently approved and proposed operations. The model adopted sound power levels of key acoustically significant plant and equipment from site measurements conducted by EMM, the noise assessment completed for the previous modification or from a database of similar equipment.

Operational noise levels for the proposed extension project are predicted to be above the current project approval limits and PSNLs at most assessment locations (R2, R4, R7 and R8). The proposed extension project is predicted to have a moderate to significant residual noise impact at locations R2, R4 and R7. Locations R2 and R4 are predicted to experience significant residual noise level impacts of up to 9 dB and 10 dB above the current project approval limits and the PSNLs, respectively, during worst case F class temperature inversions during the night-time period. Assessment locations where significant noise level impacts are predicted (R2 and R4) are entitled to voluntary land acquisition upon request in accordance with the VLAMP (NSW Government 2014) after all feasible and reasonable mitigation has been applied and if an alternate amenity agreement cannot be made. Gunlake has recently negotiated an agreement with the landowner of assessment location R4 and therefore voluntary land acquisition is only relevant to assessment location R2. Assessment location R7, where a moderate residual noise level impact is predicted, is entitled to voluntary mitigation upon request in accordance with the VLAMP (NSW Government 2014) after all feasible and reasonable mitigation has been applied and if an alternate amenity agreement cannot be made. Gunlake is committed to provide potential receiver based mitigation to this property upon request of the relevant landowner.

Potential sleep disturbance impacts from operational maximum noise level events have been assessed and are expected to satisfy the relevant criteria for all assessment locations.

Cumulative noise from the extension project and other developments is likely to satisfy the relevant amenity criteria.

The privately owned lands assessment demonstrates that the predicted noise levels over the entire privately owned land parcel, including all contiguous lots, is less than 25% and therefore does not trigger the VLAMP acquisition rights during worst case night-time F class temperature inversion conditions. Furthermore, Gunlake currently has negotiated agreements with the relevant landowners of properties to the immediate south and south-west.

Predicted operational road traffic noise levels satisfy the relevant RNP noise criteria and guidelines at all nearest assessment locations for all road sections of the transport route.

Blast overpressure and ground vibration levels from the proposal are predicted to satisfy relevant EPA guidelines. Notwithstanding, the proponent will continue to actively manage and monitor blast overpressure and vibration in accordance with the site's blast management plan.

References

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World Health Organization (1999) *Guidelines for Community Noise*.

Appendix A

Acoustic terminology

Several technical terms are discussed in this report. These are explained in Table A.1.

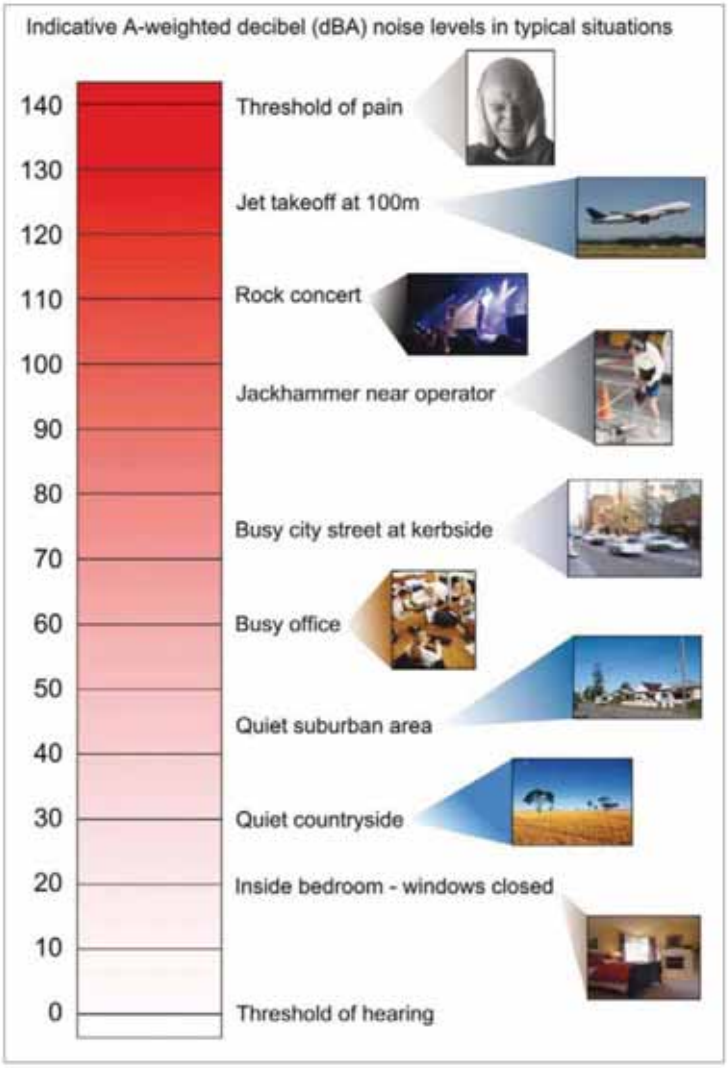
Table A.1 Glossary of acoustic terms

Term	Description
Amenity criteria	The amenity criteria relate to all industrial noise. Where industrial noise approaches base amenity criteria, then noise levels from new industries need to demonstrate that they will not be an additional contributor to existing industrial noise.
ANZECC	Australian and New Zealand Environment Conservation Council
Day period	Monday – Saturday: 7 am to 6 pm, on Sundays and Public Holidays: 8 am to 6 pm.
dB	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
DP&E	Department of Planning and Environment (NSW government)
EA	Environmental assessment
EPA	NSW Environment Protection Authority
EP&A Act	Environmental and Planning Assessment Act 1979 (NSW)
Evening period	Monday – Saturday: 6 pm to 10 pm, on Sundays and Public Holidays: 6 pm to 10 pm.
INP	Industrial Noise Policy (NSW EPA 2000)
Intrusive criteria	The intrusive criteria refers to noise that intrudes above the background level by more than 5 dB. The intrusiveness criterion is described in detail in this report.
$L_{A1(1\text{-}min)}$	The 'A-weighted' noise level exceeded for 1% of the specified time period of 1 minute.
L_{A10}	The 'A-weighted' noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise level.
L_{A90}	Commonly referred to as the background noise level. The 'A-weighted' noise level exceeded 90% of the time.
L_{Aeq}	The energy average noise from a source. This is the equivalent continuous 'A-weighted' sound pressure level over a given period. The $L_{Aeq(15\text{-}min)}$ descriptor refers to an L_{Aeq} noise level measured over a 15 minute period.
L_{Amin}	The minimum 'A-weighted' noise level received during a measuring interval.
L_{Amax}	The maximum root mean squared 'A-weighted' sound pressure level (or maximum noise level) received during a measuring interval.
Linear peak	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.
Night period	Monday – Saturday: 9 pm to 7 am (as per agreement with DP&E), on Sundays and Public Holidays: 10 pm to 8 am.
PSNL	The project-specific noise level (PSNL) are criteria for a particular industrial noise source or industry. The PSNL is the lower of either the intrusive criteria or amenity criteria.
RBL	The Rating Background Level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period.
RNP	Road Noise Policy
Sound power level (Lw)	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude.
Vibration	A motion that can be measured in terms of its displacement, velocity or acceleration. The common unit for velocity is millimetres per second (mm/s).

It is useful to have an appreciation of decibels (dB), the unit of noise measurement. Table A.2 gives an indication as to what an average person perceives about changes in noise levels. Examples of common noise levels are provided in Figure A.1.

Table A.2 Perceived change in noise level

Change in sound level (dB)	Perceived change in noise
1–2	typically indiscernible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud

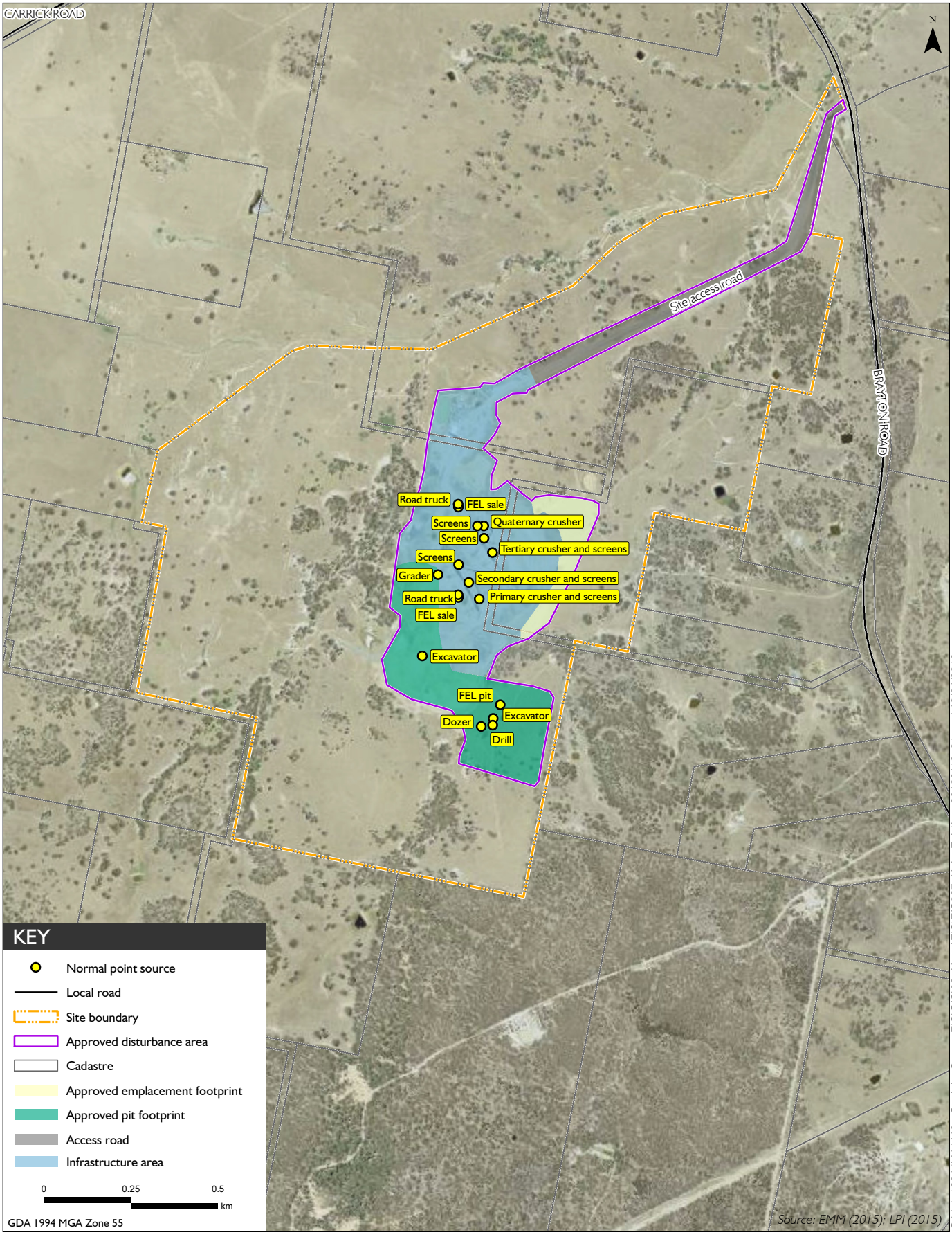


Source: Road Noise Policy (Department of Environment, Climate Change and Water 2011).

Figure A.1 Common noise levels

Appendix B

Modelled plant and equipment locations



Modelled plant and equipment locations – Existing operations

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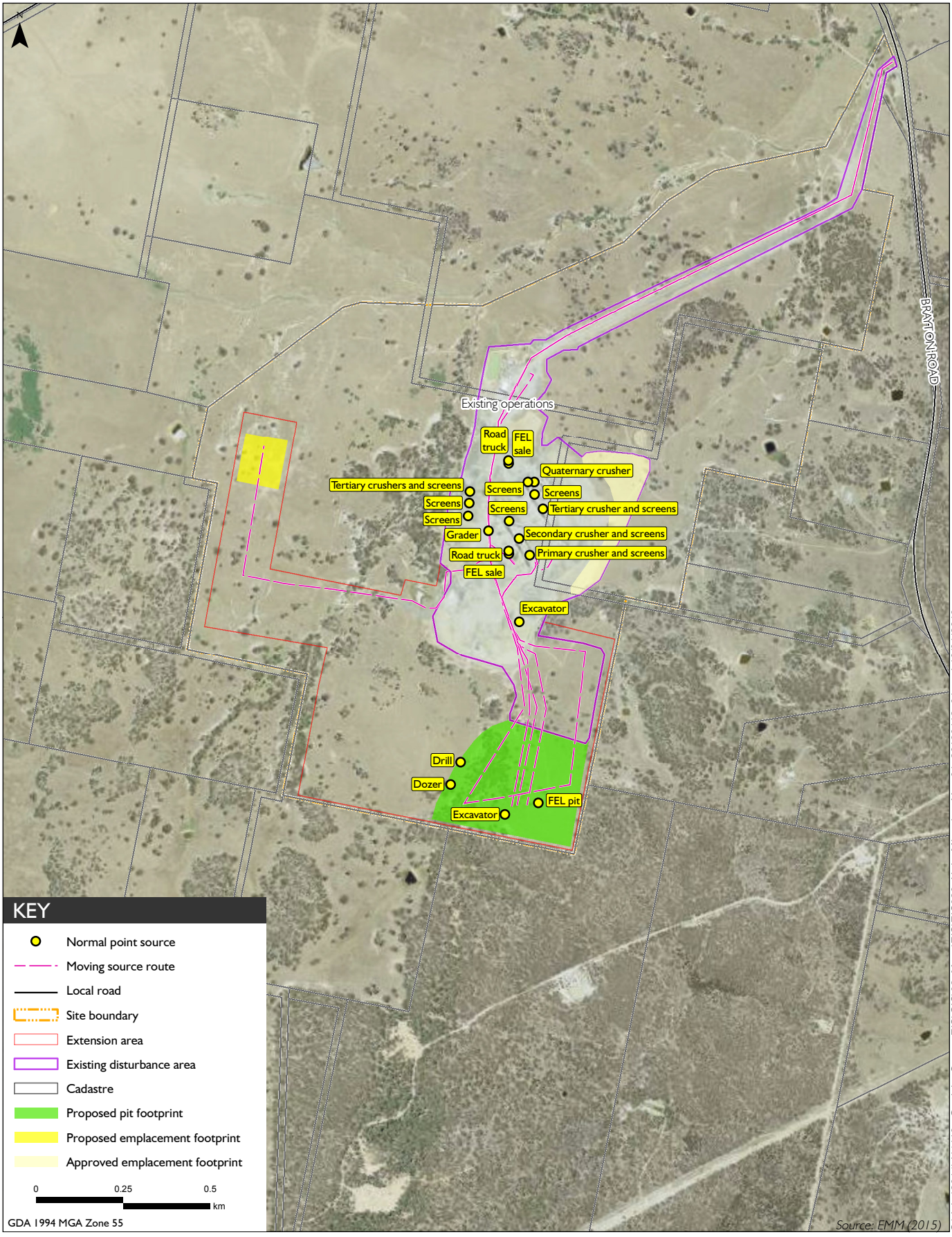
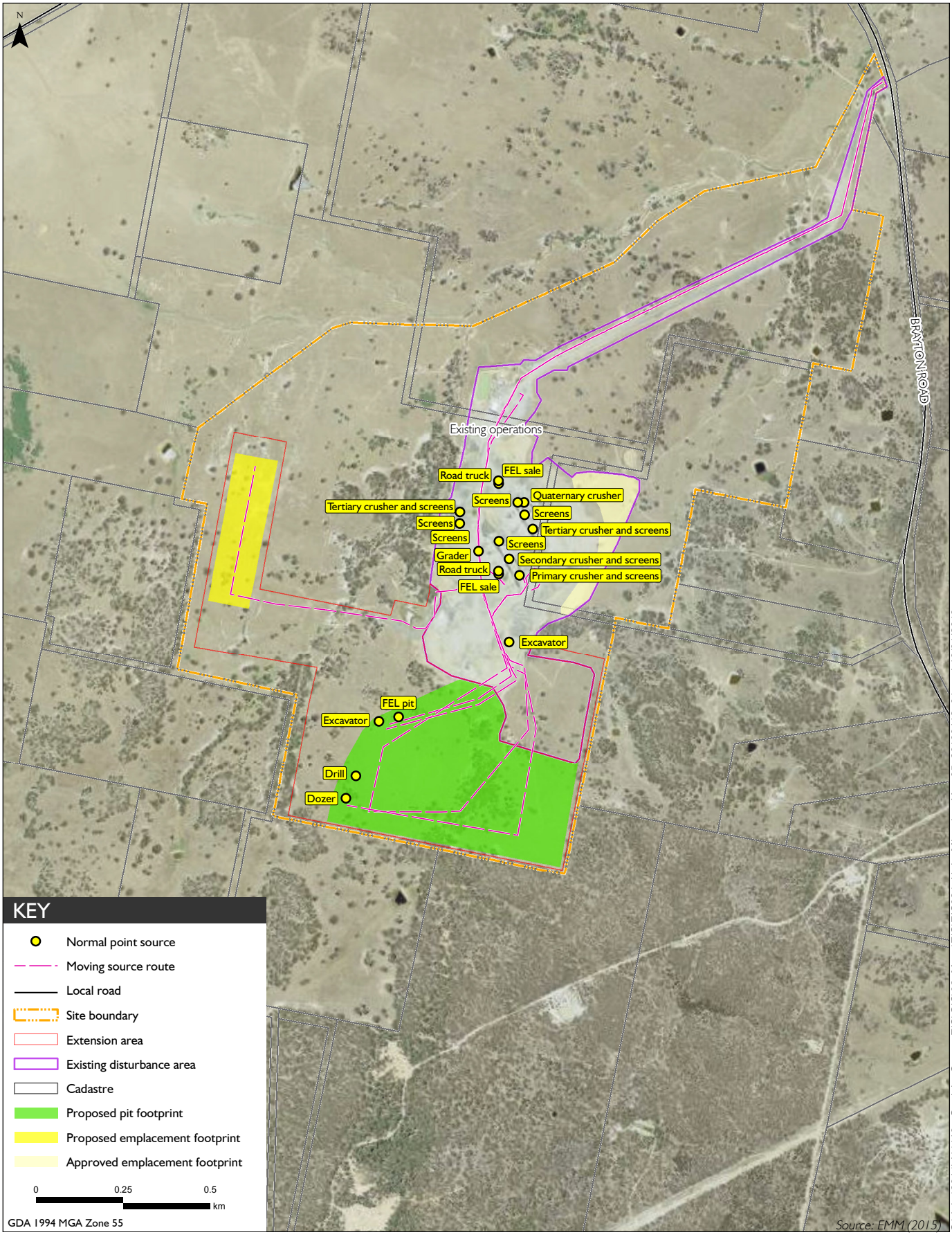
Figure B1



Modelled plant and equipment locations – Year 1

Gunlake Quarry
Noise and Vibration Assessment

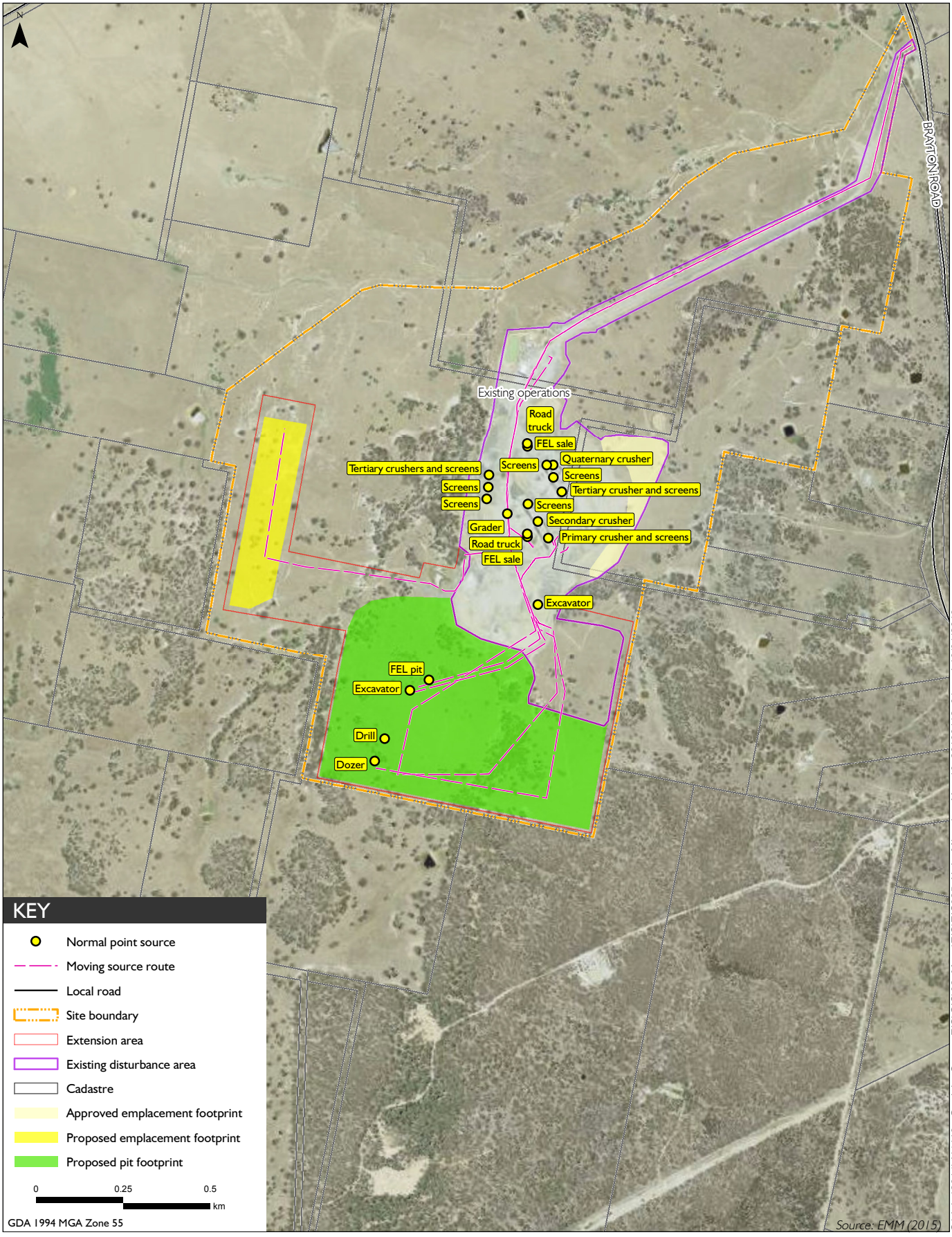
Figure B2



Modelled plant and equipment locations – Year 5

Gunlake Quarry
Noise and Vibration Assessment

Figure B3



Modelled plant and equipment locations – Year 10

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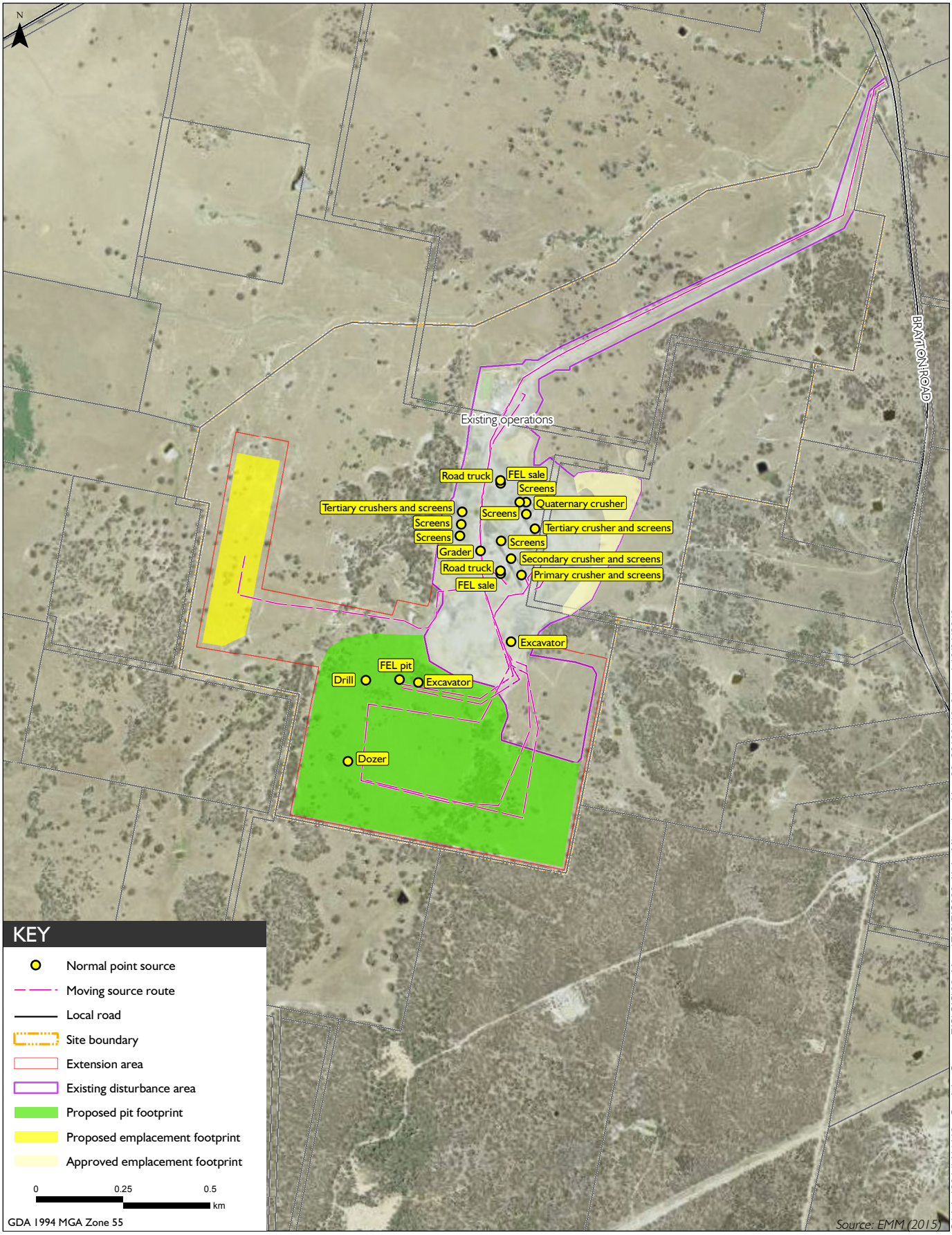
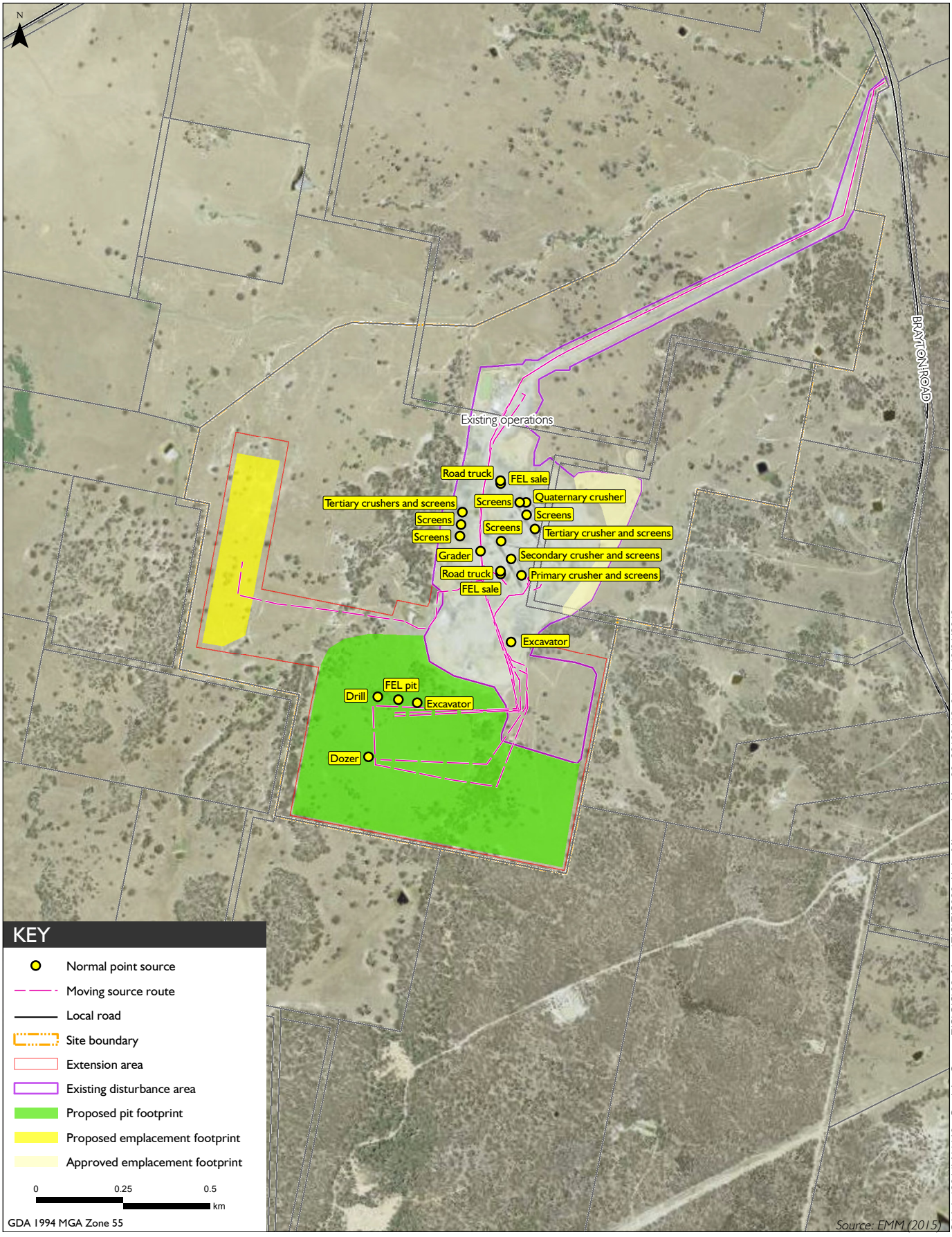
Figure B4



Modelled plant and equipment locations – Year 20

Gunlake Quarry
Noise and Vibration Assessment

Figure B5



Modelled plant and equipment locations – Year 30

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Figure B6

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