HEGGIES
AUSTRALIA

REPORT 10-5678-R1
Revision 1

Rosedale Residential Development
Traffic Noise and Construction Noise Assessment

PREPARED FOR

Marsim (trading as Nature Cost Developments)
62 New South Head Road
Edgecliffe NSW 2027

15 AUGUST 2007

Rosedale Residential Development
Traffic Noise and Construction Noise Assessment

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EXECUTIVE SUMMARY

Marsim proposes to construct a future residential development on 187ha of land at Rosedale, situated 13km south of Batemans Bay, NSW. The proposal involves the creation of residential lots with associated community spaces. Heggies Pty Ltd (Heggies) has been commissioned by Marsim to provide acoustic input regarding road traffic noise and construction noise to existing residences, and the road traffic noise impact and mitigation to future residences in the proposed development at Rosedale.

The Director General's environmental assessment requirements for a concept plan of the proposed development specify in relation to noise, that potential road impacts on future residences be addressed and appropriate mitigation measures be identified; and potential impacts of demolition, construction and operational noise be addressed. The traffic noise impact of the proposed development and earthworks and construction noise has been assessed in accordance with guidelines from the NSW Department of Environment and Climate Change (DECC) (formerly the DEC).

Acoustic Terminology and a Glossary and Abbreviations are provided to assist the reader. The study findings are summarised in the following paragraphs :

- The DECC's Environmental Criteria for Road Traffic Noise (ECRTN) was adopted for the assessment of traffic noise for future residences within the development.
- Within the development two types of roads, being "collector" and "local were identified. A computer model was developed to predict noise levels in accordance with the ECRTN criteria. The model was based on traffic flow data provided by Colston Budd Hunt & Kafes Pty Ltd. Predicted noise levels indicate the ECRTN criteria is exceeded at the collector road residences and also at the local road residences during both daytime and night-time.
- Consideration to noise mitigation of road traffic noise should be investigated for affected residences in accordance with the project objectives. The project urban design objectives preclude the use of noise walls and barriers and the noise mitigation would include consideration of internal dwelling layouts and/or architectural treatments.
- The DECC's Environmental Noise Control Manual (ENCM) was adopted for the assessment of earthworks and construction noise at existing receivers. Heggies previously conducted an ambient noise survey in report 10-3192-R1 "*Rosedale Residential Development Noise Impact Assessment*" which assessed the impact of the nearby Sewerage Treatment Plant. The ambient noise survey results were used to set construction noise criteria in accordance with the ENCM.
- Noise levels for earthworks and construction were predicted at the nearest receivers based on preliminary construction information. Predicted noise levels indicate construction noise criteria will be exceeded when activities are conducted at the closest road locations to existing residences to the west, south and east. Consideration of operational and noise control strategies are recommended.

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1 INTRODUCTION

Marsim proposes to construct a future residential development on 187ha of land at Rosedale, situated 13km south of Batemans Bay, NSW. The proposal involves the creation of residential lots with associated community spaces.

Heggies Pty Ltd (Heggies) has been commissioned by Marsim to provide acoustic input regarding road traffic noise and construction noise to existing residences, and the road traffic noise impact and mitigation to future residences in the proposed development at Rosedale.

The essential elements of the study are:

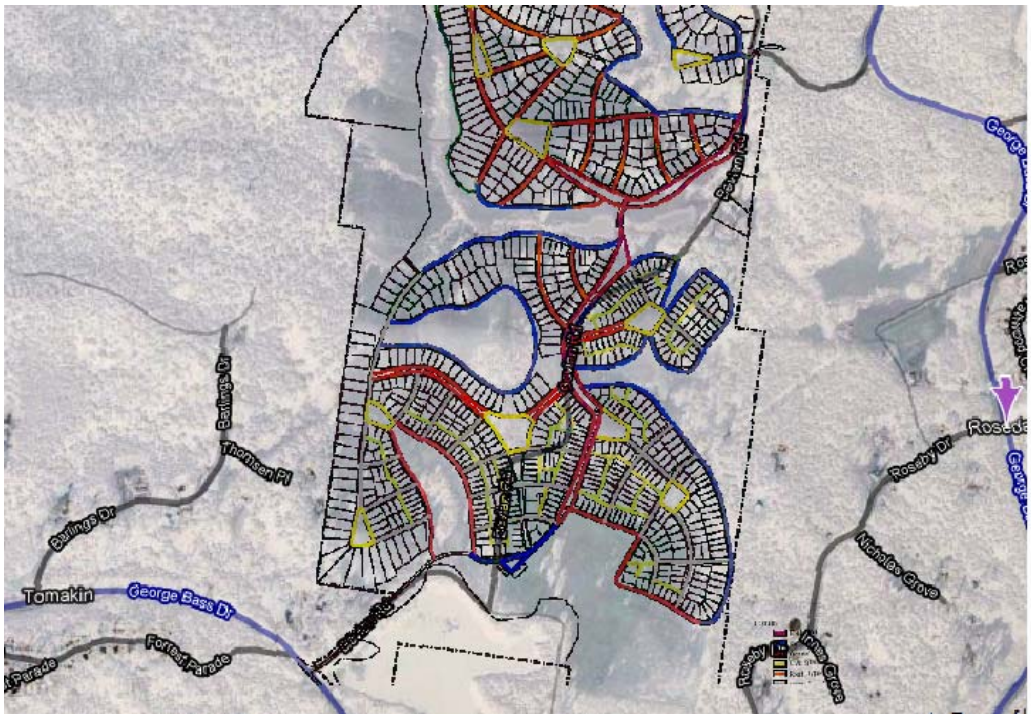
- Establishment of noise criteria for road traffic noise in accordance with the Department of Environment and Climate Change (DECC) (formerly the DEC) Environmental Criteria for Road Traffic Noise (ECRTN).
- Undertake noise modeling of the site and immediate area.
- Assess the impact of road traffic noise on future receivers within the development.
- Establishment of construction noise criteria in accordance with the DECC Environmental Noise Control Manual (ENCM) and assessment at existing receivers.

It is planned to revise this study in the future to include an assessment of the traffic noise impact associated with the development to existing residences, when classified traffic counts proposed to be conducted on George Bass Drive are completed.

2 SITE DESCRIPTION

Marsim proposes to construct a future residential development on 187ha of land at Rosedale, situated 13km south of Batemans Bay on the NSW south coast. The proposed development is to be located east of Barling Drive and on the north and western side of Georges Bass Drive, Rosedale as illustrated in **Figure 1**. Within the development there will be different categories of road, with the main access road (which roughly follows the existing alignment of Bevian Road) classified as a "collector" road and other roads "local" roads

Figure 1 Site Layout and Location



3 ROAD TRAFFIC NOISE CRITERIA

3.1 NSW Road Traffic Noise Policy

The NSW *Environmental Criteria for Road Traffic Noise* (ECRTN May 1999) presents guidelines for the assessment of road traffic noise arising from new or redeveloped roads. The policy document provides road traffic noise guidelines for a range of road or residential developments, as well as guidelines that apply for other nominated sensitive land uses. For residential developments, the noise criteria are external, at 1 m from the potentially most affected facade of the residential buildings.

The road traffic guidelines recommended in the policy document are based on the functional categories of the subject roads, as applied by the RTA.

The functional categories are as follows:

- Arterial roads (including freeways) carrying predominantly through-traffic from one region to another, forming principal avenues of communication for urban traffic movements.
- Sub-arterial roads connecting the arterial roads to areas of development and carrying traffic from one part of a region to another. They may also relieve traffic on arterial roads in some circumstances.
- Collector roads connecting the sub-arterial roads to the local road system in developed areas.
- Local roads, which are the subdivisional roads within a particular developed area. These are used solely as local access roads.

Table 1 presents the relevant ECRTN noise guidelines that have been applied during the course of this assessment. These guidelines are applicable to this project

It is noted that the noise criteria presented within the ECRTN noise policy document are guidelines and as such, are non-mandatory.

In achieving compliance with the noise criteria, consideration needs to be given to feasibility and reasonableness, aesthetics, cost implications, equity, community preferences and practicality of potential noise controls.

Table 1 Road Traffic Noise Criteria for Residential Land Uses

Type of Development	Criteria		
	Day 7am - 10pm (dBA)	**Night 10pm - 7am (dBA)**	**Where Criteria are Already Exceeded**
Criteria for Existing Residences fronting Sub-arterial Roads			
Land use developments with potential to create additional traffic on existing freeways/arterials	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers or acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dBA.
Criteria for Existing Residences fronting Collector Roads			
Land use developments with potential to create additional traffic on collector road	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dBA.
Criteria for New Residences fronting Collector Roads			
New residential land use developments affected by collector traffic noise	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA	Where feasible and reasonable, existing noise levels should be reduced to meet the noise criteria via judicious design and construction of the development. Locations, internal layouts, building materials and construction should be chosen to minimise noise impacts.
Criteria for New Residences fronting Local Roads			
New residential land use developments affected by traffic noise from local roads	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria for occupants via judicious design and construction of the development. Relevant strategies will include optimum location and orientation of buildings on the site; planning internal layouts carefully; choosing the most appropriate building materials and using good construction techniques.

4 CONSTRUCTION NOISE ASSESSMENT CRITERIA

4.1 Construction Noise Guidelines

When dealing with noise emanating from construction works, the DECC recognises that higher levels of noise are likely to be tolerated by people in view of the relatively short duration of the works. As a result, the *"Environmental Noise Control Manual"* (ENCM) presents the DEC's recommended guidelines for the control of construction works noise.

Chapter 171-1 of the ENCM recommends the following approaches to mitigating adverse noise impacts from construction sites:

4.1.1 Noise Emission Objectives

The ENCM recommends that the $L_{A10(15minute)}$ noise levels arising from a construction site and measured within the curtilage of an occupied noise-sensitive premises (ie at boundary or within 30 m of dwelling, whichever is the lesser) should not exceed the noise levels indicated in **Table 2**. These noise goals are consistent with community reaction to construction noise.

Table 2 DEC-Recommended Noise Goals for Construction Works

Period of Noise Exposure	$L_{A10(15minute)}$ Construction Noise Goal
Cumulative noise exposure period not exceeding 4 weeks	$L_{A90(15minute)}$ plus 20 dBA
Cumulative noise exposure period of between 4 weeks and 26 weeks	$L_{A90(15minute)}$ plus 10 dBA
Cumulative noise exposure period longer than 26 weeks	$L_{A90(15minute)}$ plus 5 dBA

It is noted the time for roadworks and then residential construction will exceed 26 weeks, resulting is a design goal of $L_{A90(15minute)}$ plus 5 dBA.

Heggies previously conducted an ambient noise survey in report 10-3192-R1 "*Rosedale Residential Development Noise Impact Assessment"* which assessed the impact of the nearby Sewerage Treatment Plant. Ambient $L_{A90(15minute)}$ or Rated Background Levels of 34 dBA during the daytime and 33 dBA during the evening and night-time were recorded, and based on these for construction during standard daytime hours the design goal is 39 dBA at existing residences.

4.1.2 Preferred Hours of Construction

The DEC guidelines recommend confining permissible work times as outlined in **Table 3**.

Table 3 Preferred Daytime Construction Hours

Day	Preferred Construction Hours
Monday to Friday	7.00 am to 6.00 pm
Saturdays	7.00 am to 1.00 pm (if inaudible at residences) Otherwise, 8.00 am to 1.00 pm.
Sundays or Public Holidays	No construction

4.1.3 Works Undertaken Outside of Preferred Construction Hours

Where it is necessary for construction works to be undertaken outside the DEC's preferred daytime construction hours, the condition normally applied is that:

- $L_{A10(15minute)}$ noise levels emitted by the works should not exceed the L_{A90} level during the relevant evening or night-time period by a margin of more than 5 dBA, *independent* of the duration of the construction activity.

Silencing

All practical measures should be used to silence construction equipment, particularly in instances where extended hours of operation are required.

Impulsive and/or Tonal Noise

For plant or operations with impulsive or tonal noise characteristics, such as rock hammers, a noise penalty of up to 5 dBA (depending on degree of impulsiveness or tonality) should be added to measured or predicted $L_{A10(15minute)}$ noise levels when comparing L_{A10} noise levels from construction works to the limits presented in **Table 2**.

Sleep Disturbance

In order to minimise the risk of sleep disturbance during night-time construction activities, the ENCM recommends that:

The LA1(60second) noise level outside a bedroom window should not exceed the LA90 background noise level by more than 15 dBA. The LA1(60second) noise level may conservatively be estimated by the typical maximum level of noise emission.

General Comment on DEC Construction Noise Criteria

In the case of major demolition, excavation and construction projects in close proximity to residential and even commercial buildings, it can be difficult to comply with the DEC's ENCM construction noise criteria (refer Table 2). However, the following is noted:

- The criteria nominated in the ENCM are adopted as *"noise design goals"*. Where these goals cannot be achieved in practice, DEC recommends the use of best practice measures and management measures in order to minimise the risk of potential noise impacts.

The essence of the ENCM-based approach then is that:

- The potential for residential (and other receiver) disturbance should firstly be established, regardless of the practicality of achieving the resulting noise goals in specific instances; and
- Once potential exceedances are identified, all possible measures should be investigated to minimise the risk of adverse impacts.

5 ROAD TRAFFIC NOISE MODELLING

5.1 Road Traffic Noise Calculation Algorithm

Road traffic noise predictions were undertaken through computer modelling based on information provided by the client as design input. Traffic Noise modelling was carried out using the UK Department of Transport, "*Calculation of Road Traffic Noise*" (CORTN 1988) algorithm. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, ground absorption and shielding from ground topography and physical noise barriers.

In the case of NSW DECC guidelines, the CoRTN algorithm has been modified to calculate the relevant L_{Aeq} road traffic noise emission descriptors, as required. Based on the measured data and consistent with default conversions, a modifying factor of -3 dBA has been used to convert L_{A10} to L_{Aeq} in the noise prediction model.

All reported noise levels are "facade-corrected". The predicted noise levels have been adjusted upwards to include a notional 2.5 dBA reflection within the noise model computation, as required in CORTN calculations.

The predicted levels are for ground floor residential receivers at a height of 1.8 m above ground level (based on a receiver height of 1.5 m and nominal foundations of 0.3 m).

5.2 Road Traffic Modelling Parameters

The peak hourly traffic volumes, percentage heavy vehicles and speed used in the model are presented in **Table 4** :

Table 4 Traffic Volume Details for the Proposed Roads in the residential area

Road Section	Traffic flow (Vehicles/hour) [1]		Percentage Heavy Vehicles [1]		Traffic Speed (km/h) [1]
	Daytime [1]	Night-time [2]	Daytime [1]	Night-time [2]	
Boulevard	280	140	2	2	50
Main street	280	140	2	2	50
Avenue	280	140	2	2	50
Road 1, Road 2	100	50	2	2	40

Notes 1. Source Transport Report for Proposed Residential Subdivision, Rosedale - Colston Budd Hunt and Kafes Pty Ltd.
2. Night-time hourly peak volumes are assumed to be 50% of the daytime (6 am to 7 am compared to 8 am to 9 am), based on traffic counts conducted on sub-arterial roads on the NSW South Coast.

6 TRAFFIC NOISE ASSESSMENT

6.1 Assessment at Proposed Residences Near the Different Street Types

Single point receiver (SPR) calculations were carried out at representative and potentially most affected noise-sensitive receptors within the residential development. All calculations assume Dense Graded Asphalt (DGA) road surfacing and the traffic parameters volume details summarised in **Table 4**.

As presented in the "*Urban Design Guideline*" the main thoroughfare through the development has three street types being "Main Street", "Boulevard" and "Avenue". The traffic noise model has been based on parameters from the Code for the Main Street and Boulevard and Avenue including lane and median strip widths, and kerb to facade distances of 7 m.

For local roads within the development that connect to the main thoroughfare the Code has "Road 1" and "Road 2" types. Similarly to the main thoroughfare the traffic noise model has been based on parameters from the Code including lane and median strip widths, and kerb to facade distances of 8.5 m to 17.2 m.

Predicted noise levels for different road types are presented in **Table 5** and **Table 6**.

Table 5 Predicted Noise Levels - Main Thoroughfare or Collector Road

Residential Street Location	Daytime LAeq(1hr) (dBA)	Criteria	Night-time LAeq(1hr) (dBA)	Criteria
Main street	64	60	60	55
Boulevard	65		61	
Avenue	65		61	

Table 6 Predicted Noise Levels - Local Road

Residential Street Location	Daytime LAeq(1hr) (dBA)	Criteria	Night-time LAeq(1hr) (dBA)	Criteria
Road 1	57	55	54	50
Road 2	60		56	

6.1.1 Discussion of Results

A review of **Table 5** and **Table 6** shows the daytime criterion exceeded by 4 dBA to 5 dBA at the collector road residences and by 2 dBA to 5 dBA at the local road residences. During night-time the criterion is exceeded by 5 dBA to 6 dBA at the collector road residences and by 4 dBA to 6 dBA at the local road residences.

6.1.2 Operational Road Traffic Noise - Available Mitigation Treatments

The above computer model predictions suggest that future noise levels at the potentially most affected residences collector and the main local roads within the development exceed the ECRTN noise goals.

This suggests that where feasible and reasonable, noise mitigation should be investigated during detailed design for affected residences in accordance with the project objectives.

In broad terms, noise mitigation options available include the following:

- Operational treatments.
  These would include an improved quieter road surface, limits on vehicle speed, etc. In this particular case, vehicle speed is already modest at 50 km/hr. Further more, quieter road surfaces are only considered effective when the speed exceeds 70 km/hr, and are not suitable for roads with intersections due to the high road surface wear incurred.
- Noise walls.
  Noise reductions are possible for noise walls devoid of large gaps. Fences nominally 2 m high at the residential boundary have the potential to attenuate noise at the residential facades. Earth berms can also form adequate noise barriers where aesthetic consideration precludes the use of a solid vertical wall. Earth berms require a relatively large footprint which is directly related to the batter and height of the berm. However, solid fences and or earth berms are not in accordance with the urban design objectives for the project.
- Location of habitable rooms to the rear of the residence, with non habitable areas such as bathrooms, laundries facing the road.
- Architectural treatments.
  These aim to ensure that satisfactory internal noise levels are achieved, as a minimum. Potential architectural treatments generally provided are limited to:
    - Fresh air ventilation systems that meet Building Code of Australia requirements with the windows and doors shut.
    - Standard glazing. (Note given the exceedances of the criteria are less than 10 dBA, standard glazing in conjunction with good seals is considered adequate).
    - Quality window and door seals (ie no gaps).
    - The sealing of wall vents and the underside of eaves.

6.2 Assessment at Existing Residences

There are several existing residences on or near George Bass Drive and Bevian Drive in the vicinity of the George Bass Drive and Bevian Road intersection. These receivers experience traffic noise as a result of existing movements on these two roads, and there will potentially be a change to these existing traffic noise levels as a result of the development.

The appropriate ECRTN criteria for assessment is presented in **Table 1** - Road Traffic Noise Criteria for Residential Land Uses. For residences fronting George Bass Drive the appropriate criteria is that for Sub-arterial Roads and for Bevian Road that for Collector Roads. Note if the Bevian Road residence is relatively close to the George Bass Alignment, (such that the noise environment is dominated by George Bass Drive traffic) then the Sub-arterial Road criteria would apply.

In accordance with the ECRTN and the Sub-arterial road category applicable to the George Bass Drive residences, and also the near Bevian Road residence(s), the prediction of existing and future (with development) noise levels is required. The predicted noise levels are then assessed against the ECRTN baseline criteria and 2 dBA allowance goal.

The prediction of these noise levels requires classified traffic counts on George Bass Drive (which provide inter alia 15 hour day and 9 hour night-time flows) to calculate existing noise levels, and future noise levels. The classified counts are proposed in the future and it is anticipated this report will be updated with a traffic noise assessment at the existing residences when this data is available.

7 CONSTRUCTION NOISE ASSESSMENT

7.1 Construction Noise Emissions

The proposal is conceptual at this stage and final (detailed design) road plans have yet to be prepared. Accordingly details of specific construction plant and equipment, methodology or programming are unavailable at this early stage. Details of the construction program and activities will be formulated following approval of the project and following engagement of a contractor to carry out the works.

The total development is expected to be completed over a several year period, with initial earthworks, services and road construction followed by buildings. Earthworths and road construction is expected to take of the order of one year to complete. The following preliminary construction information is however provided:

- Earthworks for the development using the following equipment:
    - Typical bulldozer and scraper;
    - Grader and various vehicles including dump trucks and water tankers would also be involved;
    - Excavator and backhoe for services
- Road construction using:
    - Various vehicles including dump and concrete trucks;
    - Vibrating rollers.
    - Compressors

Typical maximum expected noise levels of construction plant measured at a distance of 7 m with the units operating at maximum load are shown in **Table 7**.

Table 7 Noise Level of Construction Plant Items (L_{Amax} at 7 m).

Plant Item	L_{Amax} Noise Level at 7m (dBA)
Scraper	86
Bulldozer	85
Grader	84
Vibrating Roller	82
Backhoe	83
Excavator	80
Concrete Vibrators	87
Concrete Pumps	84
Dump Truck	83
Water Tanker	84
Compactor	85
Compressor	75
Hand Tools	68 to 73

The noise levels shown in **Table 7** are maximum noise levels. The difference between the L_{Amax} and L_{A10} noise levels for large construction projects is generally between 5 dBA and 10 dBA depending on the intensity and type of operation. For the purpose of this assessment, a conservative noise reduction of 5 dBA has been applied to convert L_{Amax} noise levels to L_{A10} levels for comparison with the L_{A10} construction noise objectives.

The following are three main groups of construction and excavation plant utilised in the ensuing calculations, for the purpose of assessment:

Group 1: Bulldozer
Scraper
Grader
Dump truck

Group 2: Excavator
Backhoe
Concrete Vibrator
Dump truck

Group 3: Dump truck
Compressor
Water Tanker
Hand Tools

7.2 Construction Noise Predictions

There are a number of existing residences to the west, south east and north of the development. Calculations are for the worst case condition during road construction operations when closest to the assessment point which corresponds to the nearest residence in each direction.

Table 8 presents the calculated L_{A10} noise emission at the these potentially most affected noise-sensitive receiver locations in comparison with the corresponding construction noise emission objectives.

Table 8 Construction Noise Emission and Noise Emission Objectives

Address or Location [1]	Distance to Works	L_{A10} Noise Emission (dBA)			L_{A10} Noise Objectives (dBA)
		Group 1	Group 2	Group 3	Over 26 Weeks
Closest Western resident	80 m	53	50	43	39
Closest Southern resident	160 m	43	40	33	
Closest Eastern resident	75 m	54	51	44	
Closest Northern resident	390 m	24	21	14	

Notes 1. We have also assumed 5 dBA per 100 m ground absorption in addition to geometric spreading.

When reviewing the noise emission levels in **Table 8** it is necessary to consider the following:

The receiver noise levels were calculated for the worst case condition of all plant and equipment operating at the closest potential location to the receivers. This is conservative for the purpose of this assessment as for most of the time, equipment will generally be operated further away, resulting in lower noise emission at the receiver locations. For large periods of time, in particular when all plant items are not operating simultaneously, noise levels are likely to be lower than the calculated levels shown in **Table 8**.

7.3 Noise Mitigation of Construction Activities

Given the potential for the predicted noise exceedances indicated in **Table 8,** noise mitigation strategies should be implemented wherever feasible during the construction works. Wherever possible, subject to feasibility and reasonability, the quietest plant and equipment should be utilised in combination with management measures to minimise the noise impact on the local community.

Australian Standard AS 2436-1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"* sets out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on this proposed upgrade are listed below, including the typical noise level reduction achieved, where applicable.

Operational Strategies:

- An important aspect of the mitigation of noise impacts during all construction phases would be adherence to the DEC's recommended standard daytime construction hours (refer **Section 4.1.2**).
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers would also result in reduced noise emissions.
- Where practicable, the offset distance between noisy plant items and nearby noise sensitive receivers should be as great as possible.
- As far as possible, maintenance work on all construction plant should be carried out away from noise sensitive receivers and confined to standard daytime construction hours.
- Regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than normal.

Source Noise Control Strategies:

- Engines and exhausts are typically the dominant noise sources on mobile plant such as bulldozers, cranes, graders, excavators, trucks, etc. In order to reduce noise emissions, more efficient silencers or exhausts could be fitted potentially providing additional attenuation.
- Low noise "silenced" generators should be used on the project where feasible.
- Regular maintenance of all plant and machinery used for the project will assist in minimising noise emissions.

8 CONCLUSION

Marsim proposes to construct a future residential development on 187ha of land at Rosedale, situated 13km south of Batemans Bay, NSW. The proposal involves the creation of residential lots with associated community spaces. Heggies Pty Ltd (Heggies) has been commissioned provide acoustic input regarding road traffic noise and construction noise to existing residences, and the road traffic noise impact and mitigation to future residences in the proposed development at Rosedale.

The results and findings of the study are summarised in the following points:

- The Director General's environmental assessment requirements specify in relation to noise that potential road impacts on future residences be addressed and appropriate mitigation measures be identified; and potential impacts of demolition, construction and operational noise be addressed.
- The DECC's Environmental Criteria for Road Traffic Noise (ECRTN) was adopted for the assessment of traffic noise for future residences within the development.
- Within the development two types of roads, being "collector" and "local were identified. ECRTN criteria is exceeded at the collector road residences and also at the local road residences during both daytime and night-time.
- Consideration to noise mitigation of road traffic noise should be investigated for affected residences in accordance with the project objectives. The project urban design objectives preclude the use of noise walls and barriers and the noise mitigation would include consideration of internal dwelling layouts and/or architectural treatments.
- The DECC's Environmental Noise Control Manual (ENCM) was adopted for the assessment of construction noise at existing receivers.
- Construction noise criteria will be exceeded when activities are conducted at the closest road locations to existing residences to the west, south and east. Consideration of operational and noise control strategies are recommended.

ACOUSTIC TERMINOLOGY USED IN THE REPORT

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.

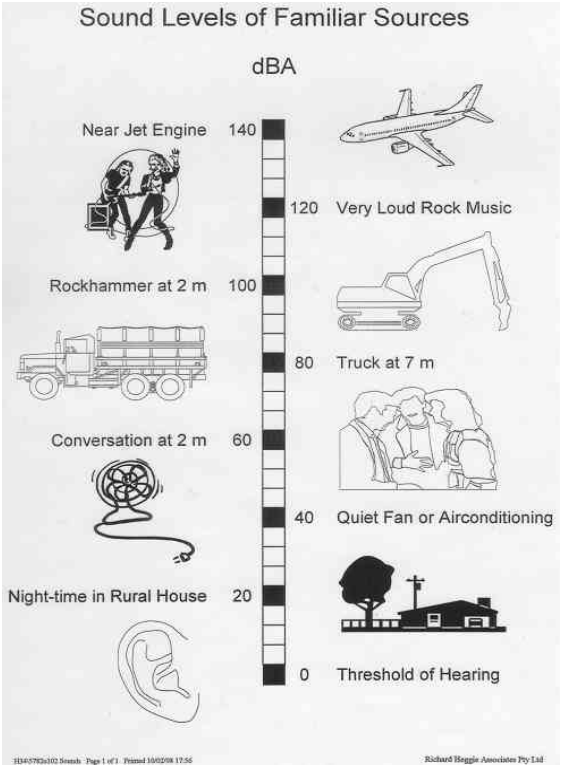
The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

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



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.

2 Sound Power Level

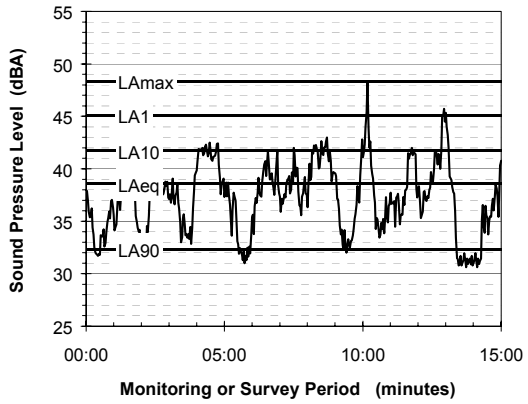
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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.

3 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 L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} 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:

L_{AMax} The maximum noise level of the 15 minute interval.

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} 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.

L_{Aeq} 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.

ACOUSTIC TERMINOLOGY USED IN THE REPORT

This method produces a level representing the "repeatable minimum" L_{A90} noise level over the daytime and night-time measurement periods, as required by the DEC. In addition the method produces mean or "average" levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

4 Tonality

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

5 Impulsiveness

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

6 Frequency Analysis

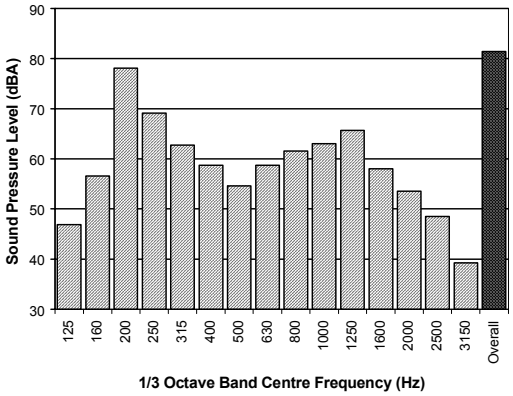
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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.



7 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_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

8 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.

9 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.

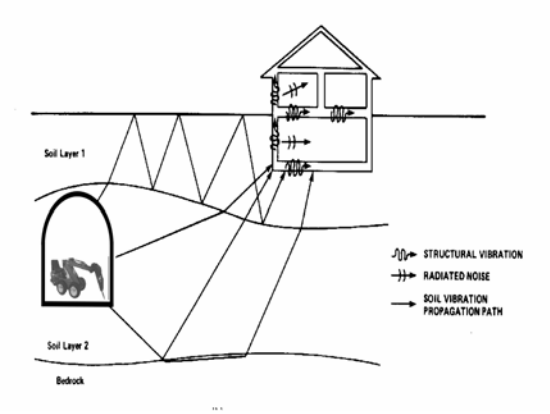
10 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed "structure-borne noise", "ground-borne noise" or "regenerated noise". This 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 ground-borne or structure-borne 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 ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnell.

ACOUSTIC TERMINOLOGY USED IN THE REPORT



The term “regenerated noise” is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

GLOSSARY AND ABBREVIATIONS

ABL	Assessment Background Level - In accordance with the INP, the single figure background noise level representing each assessment period - day, evening and night. The ABL noise level is determined by calculating the lower 10 percentile level of all $L_{A90(15minute)}$ samples for each assessment period.
Ambient Noise	The all-encompassing noise associated with a given environment. It is the composite of sounds from many sources, both near and far.
Amenity Noise Criteria	Industrial noise level within each INP time period (day, evening and night) deemed acceptable by the INP Policy for specific to land use and area useage.
AS	Australian Standard
Attenuation	The reduction of noise level.
A-weighting	Adjustment carried out to the 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. This is described using the L_{A90} statistical noise descriptor.
Compliance	Where noise levels meet noise level goals, noise criteria, or noise requirements.
Concept design	Initial functional layout of a concept, such as a road or road system, providing a level of understanding leading to later establishment of detailed design parameters.
CORTN	Calculation Of Road Traffic Noise - United Kingdom Department of Transport guidelines for the calculation of road traffic noise.
Day	For industrial noise, in accordance with the INP, it is the period from 07.00 am to 6.00 pm (Monday to Sunday).
DECC	NSW Department of Environment and Climate Change formerly known as the Department of Environment and Conservation (DEC) and the Environment Protection Authority (EPA)
DIPNR	NSW Department of Infrastructure, Planning and Natural Resources.
dB	Abbreviation for decibel - a unit of sound measurement. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.
dBA	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.

GLOSSARY AND ABBREVIATIONS

ECRTN	Environmental Criteria for Road Traffic Noise NSW Government's policy in relation to the assessment of road traffic noise impacts.
EIS	Environmental Impact Statement - A study that assesses potential environmental and social impacts associated with the construction and operation of a project.
EPA	Environment Protection Authority, now known as the Department of Environment and Conservation.
Evening	For industrial noise, in accordance with the INP, it is the period from 6.00 pm to 10.00 pm (Monday to Sunday).
Feasible and Reasonable	Terms used in relation to noise mitigation measures: Feasibility relates to engineering considerations and what is practical to achieve in terms of mitigation. Reasonableness relates to the application of judgement in arriving at a decision.
Guideline	Information intended to provide advice on a procedure. Guidelines are non-mandatory.
Heavy Vehicle	A truck, transport or other vehicle with a gross vehicle weight above a specified level (for example over 8 tonnes).
Heggies	Heggies Pty Ltd
INP	Industrial Noise Policy (INP)- the NSW Government's INP is administered by the DECC. The policy provides a framework and process for assessment of industrial noise including deriving noise limits, conditions for consents and licenses that will enable the DECC to regulate premises.
Intrusive Noise Criteria	Noise level for each INP time period (day, evening and night) above which the industrial noise contribution from a particular industrial noise source is expected to clearly noticeable and potentially objectionable. The noise criteria are dependant on the underlying background noise level.
L_{Amax}	Maximum noise level measured at a given location.
L_{AN}	L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period
L_{A1}	The A-weighted sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{A10}	The sound pressure level that is just exceeded for 10% of the time for which the given sound is measured. This descriptor is often referred to as the average maximum noise level. During a 15 minute survey, it would represent the loudest 90 seconds.

GLOSSARY AND ABBREVIATIONS

L_{A90}	The A-weighted sound pressure level that is just exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise. This descriptor is often referred to as the average minimum noise level. During a 15 minute survey, it would represent the quietest 90 seconds.
L_{Aeq}	Equivalent A-weighted sound pressure level - the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level occurring over that period.
$L_{Aeq(15minute)}$	The L_{Aeq} noise level over a 15 minute period. In accordance with the NSW INP's intrusive criteria, $L_{Aeq(15minute)}$ from industry is assessed against the RBL + 5 dBA.
$L_{Aeq(period)}$	The L_{Aeq} noise level over the relevant assessment period. Based on the NSW 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 INPs amenity criteria, $L_{Aeq(period)}$ from industry is assessed against the appropriate day/evening/night amenity goal.
Level	The level of noise, usually expressed in dBA, as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dBA gives a close indication of the subjective loudness of the noise.
Mitigation	Measure to manage and minimise noise impacts.
Night	For industrial noise, in accordance with the INP, it is the period from 10.00 pm to 6.00 am (Monday to Sunday).
Noise Level Goal or Noise Level Objective	A noise level that should be adopted for planning purposes as the highest acceptable noise level for the specific area, land use and time of day.
Noise Logger	An electronic sound level logging device which continuously monitors the ambient noise and stores L_{AN} statistical noise levels over a given pre-set sample time period.
RBL	A single statistical noise descriptor describing the L_{A90} background noise level of the relevant assessment period. In accordance with the INP, the Rating Background Level (RBL) for each assessment period is obtained by calculating the median values of the relevant day/evening/night assessment background levels (ABLs), for each day of the survey. For example, for a weeks worth of monitoring, the night RBL is the median of the seven ABLs.
RTA	Roads and Traffic Authority