Appendix F

Noise and vibration assessment

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ALFORDS POINT ROAD UPGRADE

NOISE AND VIBRATION ASSESSMENT

TF553-01F02 (REV 8) NOISE AND VIBRATION ASSESSMENT

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Roads and Maritime Services

Member of the Association of Australian Acoustical Consultants

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1 INTRODUCTION

Renzo Tonin & Associates were engaged to conduct an environmental noise and vibration assessment for the proposed upgrade of Alfords Point Road, between the Alfords Point Bridge southern abutment and Brushwood Drive, Alfords Point.

It is proposed to widen Alfords Point Road for approximately 2.1km in length, upgrading the existing undivided 4 lane road to a 6 lane divided carriageway. F-type barriers are proposed between the carriageways, and also adjacent to the southbound carriageway.

Other associated works include increasing the width of the northbound on ramp locally to accommodate a dedicated off carriageway bus stop, constructing a formalised truck inspection bay near the Old Illawarra Road overpass, and the inclusion of a 3m shared path adjacent to the southbound carriageway.

Noise emissions from road traffic have been calculated and assessed at the potentially most affected residential receivers in accordance with the NSW Road Noise Policy (RNP).

Noise and vibration caused by construction activity associated with the upgrade has also been assessed.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

2 EXISTING ACOUSTIC ENVIRONMENT

2.1 Noise Sensitive Receivers

The project study area extends from the Alfords Point Bridge southern abutment in the north, to Brushwood Drive in the south. There are noise sensitive receivers on both sides of Alfords Point Road.

The receivers potentially most affected by the proposed upgrade are the residences immediately adjacent to the road corridor on both the eastern and western sides of Alfords Point Road. These are located from Stringybark Place to Brushwood Drive on the western side and Maxwell Close to Brushwood Drive on the eastern side. All potentially affected receivers have been considered in this assessment.

To facilitate the assessment of noise impacts from the proposed Alfords Point Road upgrade, residential areas along the route have been divided into Noise Catchment Areas (NCAs). NCAs are areas that are likely to have similar noise exposures, on the basis of factors such as topography, road design (cuttings, embankments, intersections etc), setbacks and types of residences or other noise receptors. A description of the NCAs is provided in Table 1 and they are also presented in Figures 1 and 2 below.

Table 1 - Description of NCAs

NCA	Description
1	Stringybark Place to Nallada Road. Western side of road corridor. Elevated from road. No existing noise barrier.
2a	Tallowwood Close to Jarrah Close. Western side of road corridor. Similar elevation to road. No existing noise barrier.
2b	Watergum Place to Ribbon Gum Close. Western Side of Road Corridor. Behind existing noise barrier. Similar elevation to road.
3	Shore Close to Sand Place. Eastern side of road corridor. Similar elevation to road.
4	Mariner Road to Maxwell Close. Similar to lower elevation than road.

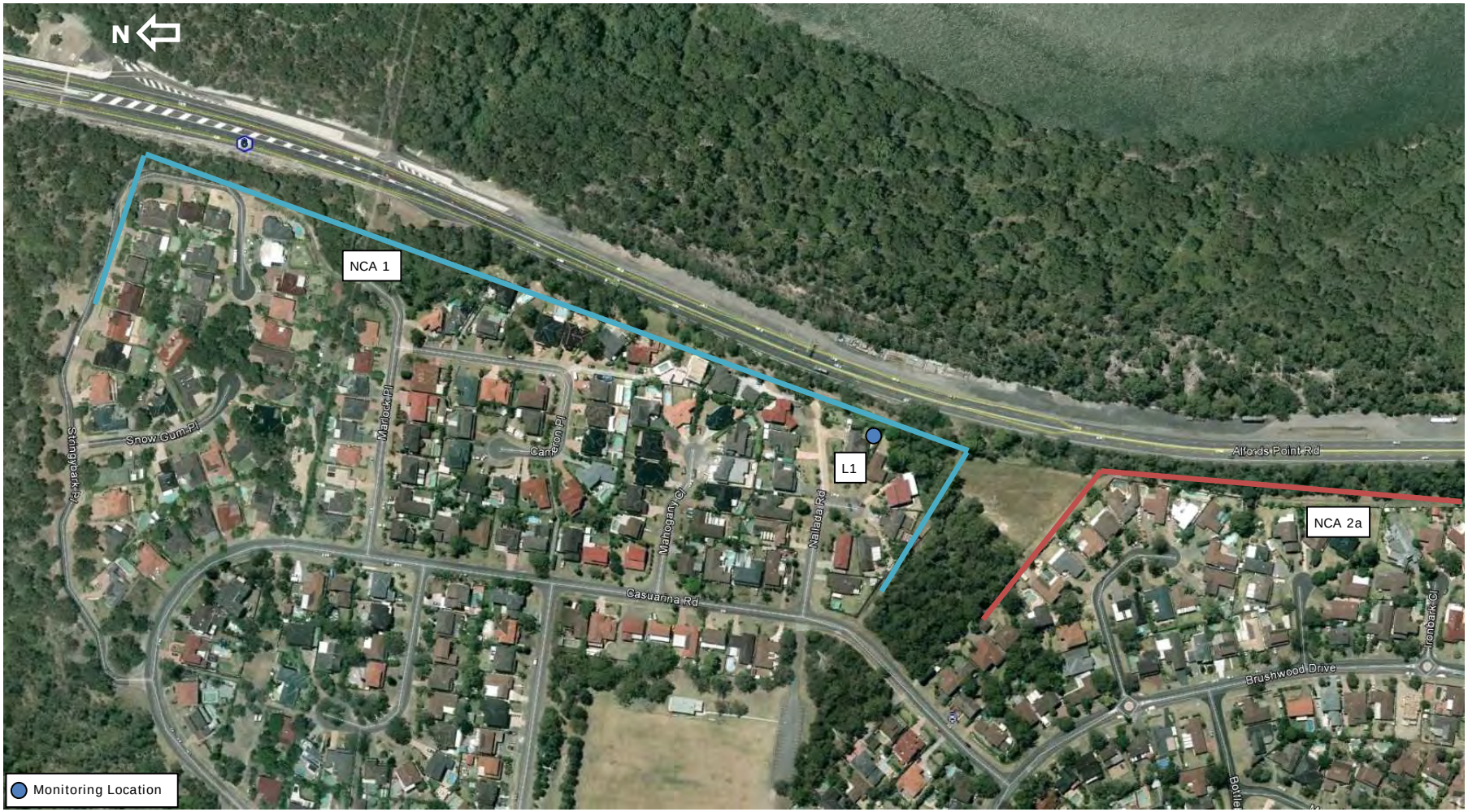


Figure 1 - Site Map and Monitoring Locations (Alfords Point Bridge to Ironbark Close)

Figure 2 - Site Map and Monitoring Locations (Ironbark Close to Brushwood Drive)

2.2 Long-term Noise Monitoring

From site inspections, ambient noise on site at the time was dominated by traffic noise from Alfords Point Road. Long-term noise surveys were conducted to quantify ambient noise levels.

Long-term noise monitoring was initially conducted in November 2011. Three noise monitoring locations were selected as representative of the different groups of receivers along the project route. The following locations were selected:

1. **2 Nallada Road** – Located towards the northern end of the project area on the western side of Alfords Point Road. Houses in this area are elevated approximately 15m above Alfords Point Road. Line of sight to the road is partially obstructed due to the road being in cutting.
2. **26 Lemongum Place** – Located towards the southern end of the project area on the western side of Alfords Point Road. This receiver is behind the existing noise barrier that runs along the north bound on ramp and roadway from Brushwood Drive to Jarrah Close.
3. **76 Sylvan Ridge Drive** – Located on the eastern side of Alfords Point Road. Receivers in the area have similar elevation to the road and have a wide angle of view to the road.

The data obtained at 76 Sylvan Ridge Drive seemed inconsistent with the other locations, and therefore re-monitoring was conducted at 76 Sylvan Ridge Drive and 88 Sylvan Ridge Drive, in early June 2012 to provide additional data for calibration of the noise model.

The noise monitoring methodology is described in Appendix B. A summary of the long-term noise monitoring results are in Table 2 below, and the graphical outputs from the noise monitors are presented in Appendix C.

Some rainfall occurred during the monitoring period and therefore monitoring was extended from the minimum 7 days to 12 days. During analysis of the data, the days least affected by rain were used to determine the 7-day noise levels, with any rain and wind affected data being excluded.

Table 2 – Results of Long Term Noise Monitoring

	Monitoring Location	L_{Aeq} Traffic Noise Levels		L_{A90} Background Noise Levels		
		Day	Night	Day	Evening	Night
L1	2 Nallada Road	65	62	56	52	37
L2	26 Lemongum Place	59	56	50	47	46
L3	76 Sylvan Ridge Drive	59	56	52	46	31
L4	88 Sylvan Ridge Drive	62	58	57	52	35

Noise monitoring is used to establish:

1. existing traffic noise levels for validation of the operational noise model, and
2. background noise levels for the setting of construction noise goals for the project.

For this length of road the final four noise monitoring locations are considered sufficient to allow the appropriate validation and calibration of the operational noise model.

3 ROAD TRAFFIC NOISE ASSESSMENT

3.1 Traffic Noise Criteria

The NSW Road Noise Policy (RNP) came into effect in July 2011 and replaces the NSW Environmental Criteria for Road Traffic Noise (ECRTN). This report assesses road traffic noise impact in accordance with the RNP and the RTA's 'Environmental Noise Management Manual' (ENMM).

The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impact and determining mitigation measures for developments that are potentially affected by road traffic noise, with the aim of preserving the amenity appropriate to the land use.

3.1.1 Residential Land Uses

Roads are generally defined as arterial, sub-arterial or local depending on their function. Alfords Point Road is an arterial road in that it handles through traffic bound for another locality and has characteristically heavy and continuous traffic flows.

The major component of this project involves upgrading Alfords Point Road from a four-lane to a six-lane road between Alfords Point Bridge and Brushwood Drive. According to the ENMM, this project does not constitute a 'new road traffic noise source' because the road is not new and does not produce noise to receptors from a different direction. The project is entirely within the existing same-category road corridor. The purpose of the project is to accommodate existing and increase the future traffic carrying capacity of the road. Therefore, the 'redeveloped road' criteria for residential type receivers, as set out in Table 3 of the RNP, apply for all NCAs and are presented in the table below.

Table 3 - Road Traffic Noise Assessment Criteria for Residential Land Uses

Road category	Type of project/land use	Assessment Criteria, dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Freeway/ arterial/ sub-arterial roads	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	$L_{Aeq,15\ hour}$ 60 (external)	$L_{Aeq,9\ hour}$ 55 (external)

Where feasible and reasonable, noise levels from existing roads would be reduced to meet the noise criteria. In many instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulations of in-service vehicles, greater use of public transport, and alternative methods of freight haulage.

The criteria set out in Table 3 above are the noise levels that the road redevelopment project will aim to achieve. All reasonable and feasible noise mitigation measures will be considered in the design of the project.

3.1.2 Sensitive Land Use Developments

The RNP also sets guidelines for the assessment of traffic noise on sensitive land uses such as schools, hospitals, places of worship and recreation areas. During the site inspection the following sensitive land use developments were identified:

- Alfords Point Pre School - 2 Hickory Close, NCA 2b.
- Alfords Point Primary School - 2C Brushwood Drive, NCA 2b.
- Sir Thomas Mitchell Aged Care – 351 Fowler Road, in NCA 4

Based on the above sensitive land use developments and the requirements of the RNP, the applicable road traffic noise criteria are presented in Table 4 below.

Table 4 - Road Traffic Noise Criteria for Sensitive Land Use Developments

Type of Development	Assessment Criteria, dB(A)	
	Day (7am – 10pm)	**Night (10pm – 7am)**
School classrooms	$L_{Aeq(1\ hour)}$ = 40[1] when in use	–
Open space (passive use)[3]	$L_{Aeq(15\ hour)}$ = 55[2] when in use	–
Open space (active use)	$L_{Aeq(15\ hour)}$ = 60[2] when in use	–
Aged care facility	60[4]	55[4]

Notes:
1. *Internal noise criteria*
2. *External noise criteria*
3. *Passive open spaces applicable to school playgrounds*
4. *External criteria, same as residential land use criteria*

It is generally accepted that most buildings provide a noise reduction of at least 10dB(A) when windows are left 20% open, without providing additional treatment. Therefore for a conservative assessment, a minimum of 10dB(A) reduction from external noise levels to internal noise levels has been adopted.

3.1.3 Relative Increase Criteria

According to the NSW RNP, the traffic noise impact from the proposed road redevelopment would need to also comply with the 'Relative Increase Criteria' as discussed in Section 2.4 of the RNP. The relative increase criteria as set out in the RNP applicable to this project are reproduced below.

Table 5 – Relative Increase Criteria

Type of Development	Total Traffic Noise Level Increase, dB(A)
Redevelopment of existing road	Existing Traffic $L_{Aeq(period)}$ + 12 dB (external)

Notes: 1. 'Existing traffic' refers to the traffic noise levels for the relevant 'no build' option

Since this project is an upgrade of an existing road, receivers are already exposed to traffic noise and therefore there are no locations where the project will cause an increase of more than 12dB over the existing noise levels. The project complies with this relative increase criteria.

3.2 Traffic Flow and Composition Summary

Traffic data has been provided by the Roads and Maritime Services (RMS) for future years 2016 and 2026 in the form of AADT, as shown in Table 6. The 2016 (year of opening) and 2026 (design year) data were used as the basis for noise modelling.

Table 6 - AADT Data

Road/Ramp	2016	2026
Alfords Point Road North of Brushwood Ramps	52,479	55,831
Alfords Point Road South of Brushwood Ramps	37,223	39,949
Alfords Point Road on ramp from Brushwood Dr	8,147	8,384
Alfords Point Road off ramp to Brushwood Dr	7,474	7,891
Brushwood Dr west of Alfords Point Road on ramp	6,194	6,414

Since the project is a road redevelopment essentially involving the addition of lanes within the existing road corridor, whether the project is built or not will not change the volume of traffic on the road. Therefore the noise models for both the 'build' and 'no build' options utilise the same traffic data.

The AADT data provided by RMS does not include the day/night proportions, heavy vehicle proportions or vehicle speeds. Therefore this data was obtained from traffic counts conducted as part of this study during the noise monitoring phase. The counted data from 2011 is shown in Table 7.

Table 7 – 2011 Traffic Counts

Road	Day (7:00 – 22:00)			Night (22:00 – 7:00)		
	% of AADT	HV %	Speed km/h	% of AADT	HV %	Speed km/h
Alfords Pt Rd @ bridge NB	81	7.9	94	19	10	95
Alfords Pt Rd @ bridge SB	88	7.8	85	12	6.5	86
Alfords Pt Rd @ Brushwood NB	81	11.8	95	19	14.5	97
Alfords Pt Rd @ Brushwood SB	93	8	90	7	9.8	90
On-ramp NB	81	4.1	75	19	3.6	77
Off-ramp SB	92	4.3	79	8	3.3	81

3.3 Road Traffic Noise Prediction Modelling

Noise predictions are based on a method developed by the United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)" known as the CoRTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board and as a result it is recognised and accepted by the NSW Environment Protection Authority. The model predicts noise levels for steady flowing traffic and noise from high truck exhausts is also taken into account.

The CoRTN algorithms are contained within the 'CadnaA' noise modelling software which has been used to calculate traffic noise levels at receivers. The noise prediction model takes into account the following inputs.

Table 8 - Summary of Modelling Inputs

Input Parameters	Data Acquired From
Traffic volumes and mix	Based on AADT forecast data from RMS and traffic counts
Vehicle speed	Based on measured speeds during traffic counting
Gradient of roadway	Topographic data provided by RMS
Source height	0.5 metre for car exhaust, 1.5 metres for car and truck engines and 3.6 metres for truck exhaust and detailed within CORTN88
Ground topography at receiver and road	2m Ground Contours
Angles of view from receiver	Contained within model
Reflections from existing barriers, structures and cuttings on opposite side of road	Calculated in CadnaA through CoRTN algorithm
Air and ground absorption	0.5 [can vary between 0 (hard surface) to 1 (soft ground)]
Receiver Heights	1.5 metre above ground level for ground floor and 4.5 metre above ground level for 1st floor
Facade correction	+2.5dB(A)
Correction for Australian conditions	-1.7 dB(A) for 'at facade' conditions from Australian Road Research Board (ARRB) Transport Research (Saunders et al 1983)
Acoustic properties of road surfaces	Dense graded asphalt – no corrections applied
Noise mitigation measures	Nil

3.4 Model Validation

The noise model was validated using the long-term noise monitoring results. Table 9 below summarises the results of the validation, providing a comparison of the modelled traffic noise levels for existing conditions compared to the measured traffic noise levels.

Table 9 - Noise Model Validation

Location	$L_{Aeq,15hr}$ Daytime Noise Level			$L_{Aeq,9hr}$ Night time Noise Level		
	Measured	Modelled	Variation	Measured	Modelled	Variation
2 Nallada Road (NCA 1)	65.0	66.6	-1.6	61.6	61.6	0.0
26 Lemongum Place (NCA 2a and 2b)	59.0	60.7	-1.7	56.4	56.2	0.2
76 Sylvan Ridge Drive (NCA 4)	61.8	62.6	-0.8	58.1	57.3	0.8
88 Sylvan Ridge Drive (NCA 4)	59.2	61.1	-1.9	55.6	55.9	-0.3
Mean Variation			***-1.5***			***0.2***

The noise model validation results presented above show that the noise model predicts results that are fairly consistent with the noise monitoring and within acceptable tolerances.

The mean variations shown in the table for the day and night have been applied to the model outputs for all receivers.

3.5 Noise Model Prediction Results

Operational noise modelling has been conducted based on the traffic volumes presented in Section 3.2 and the modelling inputs in Section 3.3. Table 10 below presents the results of noise modelling where:

- **'Opening Year' noise levels** are the levels produced by the 2016 traffic volumes for both the 'build' and 'no build' options,
- **'Design Year' noise levels are** the predicted noise levels for 2026 for both the 'build' and 'no-build' options.

The outcomes of noise modelling are:

- Existing noise levels at many properties already exceed the RNP criteria of 60dB(A) $L_{Aeq,15h}$ and/or 55dB(A) $L_{Aeq,9h}$,
- The increase in noise levels between the design year 'no build' and 'build' options is not more than 2dB(A) at any residence and therefore the impact of the project is considered to be 'not significant'.

- Existing and design year noise levels were found to be 'acute' at a number of residential receivers, particularly at the upper level of double storey residences. The 'acute' properties are identified in Table 10 and Appendix D.

- Although the road is being widened to the east, noise levels are predicted to reduce slightly at some properties in Sylvan Ridge Drive as a result of the project. This is due to the addition of an F-type barrier along the southbound carriageway between the road and the shared path. Although this barrier is low in height, the residences are also lower than the road and therefore this small barrier does provide some noise mitigation.

- There are two properties in NCA 4 where noise levels are predicted to be acute, being 88 and 90 Sylvan Ridge Drive. The reason for the acute levels here is mainly due to there being no rear boundary fence at 88 Sylvan Ridge Drive, and 90 Sylvan Ridge Drive is a battle-axe block located close to the road.

Further noise mitigation should be considered where design year noise levels are acute, that is greater than or equal to $L_{Aeq,15hr}$ 65dB(A) or $L_{Aeq,9hr}$ 60dB(A), or where noise levels exceed the RNP criteria and have increased 'significantly' [ie by more than 2dB(A)] as a result of the project.

Properties where further noise mitigation should be considered are identified in Table 10 and a discussion of possible noise mitigation options is presented in Section 3.8. The figures in Appendix D are a pictorial representation of the properties identified for consideration of further mitigation in Table 10.

The primary school and pre-school within NCA2b are set well back from the road. While noise predictions indicate that noise levels could exceed the 50dBA external criteria, this is an existing impact and noise levels remain virtually unchanged as a result of the project. No noise mitigation is required.

Noise Contours

The $L_{Aeq,15hr}$ Day and $L_{Aeq,9hr}$ Night noise contours for the 2026 'Build' and 'No Build' scenarios are presented in Appendix E. The noise contours assume no noise mitigation measures have been incorporated into the road development (other than existing noise barriers and boundary fences). The noise contours are produced by interpolation from a series of calculations to specific points within a regularly spaced grid, 1.5 metres above ground level. It is noted that the noise contours are estimates of the predicted noise levels, and that contour values may differ slightly from equivalent spot calculations.

Table 10 – Operational Noise Predictions (without Noise Mitigation)

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
1	21 Stringybark Pl	G	59	56	59	56	59	56	59	56	0.0	0.0	60	55	NO	NO	NO
1	23 Stringybark Pl	G	59	55	59	55	60	56	59	56	-0.2	-0.2	60	55	NO	NO	NO
1	25 Stringybark Pl	G	61	57	61	57	61	58	61	58	0.1	0.1	60	55	NO	NO	NO
1	27 Stringybark Pl	G	62	58	62	59	62	59	63	59	0.2	0.2	60	55	NO	NO	NO
1	29 Stringybark Pl	G	55	52	56	53	56	52	57	53	0.9	0.9	60	55	NO	NO	NO
1	41 Stringybark Pl	G	55	51	55	52	55	52	56	52	0.3	0.3	60	55	NO	NO	NO
1	43 Stringybark Pl	G	58	54	58	54	58	54	58	55	0.4	0.4	60	55	NO	NO	NO
1	45 Stringybark Pl	G	61	57	61	57	61	57	62	58	0.4	0.5	60	55	NO	NO	NO
1	18 Marlock Pl	G	58	55	59	55	59	55	59	56	0.4	0.4	60	55	NO	NO	NO
1	1A Cameron Pl	G	62	58	61	58	62	59	62	58	-0.3	-0.2	60	55	NO	NO	NO
1	1 Cameron Pl	G	62	58	61	58	62	58	62	58	-0.2	-0.2	60	55	NO	NO	NO
1	3 Cameron Pl	G	58	55	58	55	59	55	59	55	0.0	0.1	60	55	NO	NO	NO
1	5 Cameron Pl	G	65	62	65	62	66	62	66	62	-0.2	-0.2	60	55	YES	YES	YES
1	9 Cameron Pl	G	60	57	61	57	61	57	61	58	0.6	0.7	60	55	NO	NO	NO
1	11 Cameron Pl	G	63	59	63	60	63	59	64	60	0.7	0.8	60	55	NO	YES	YES
1	13 Cameron Pl	G	60	56	60	57	60	56	60	57	0.4	0.5	60	55	NO	NO	NO
1	15 Cameron Pl	G	57	53	57	53	57	53	57	54	0.2	0.4	60	55	NO	NO	NO
1	17 Cameron Pl	G	62	58	62	59	62	58	63	59	0.4	0.5	60	55	NO	NO	NO
1	14 Nallada Pl	G	60	57	61	57	61	57	61	58	0.4	0.5	60	55	NO	NO	NO
1	12 Nallada Pl	G	62	58	63	59	62	59	63	60	1.0	0.9	60	55	NO	YES	YES
1	2 Nallada Rd	G	65	61	65	61	65	61	65	62	0.4	0.4	60	55	YES	YES	YES

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
1	4 Nallada Rd	G	66	62	65	62	66	63	65	62	-0.4	-0.4	60	55	YES	YES	YES
1	5 Nallada Rd	G	63	60	63	60	64	61	63	60	-0.6	-0.5	60	55	NO	YES	YES
1	6 Nallada Rd	G	66	62	65	62	66	63	65	62	-0.9	-0.7	60	55	YES	YES	YES
2a	10 Tallowwood Cl	G	62	58	61	58	62	59	61	58	-1.0	-0.8	60	55	NO	NO	NO
2a	12 Tallowwood Cl	G	61	58	59	57	61	58	60	57	-1.5	-1.2	60	55	NO	NO	NO
2a	14 Tallowwood Cl	G	62	59	60	57	62	59	60	58	-2.1	-1.8	60	55	NO	NO	NO
2a	14 Tallowwood Cl	1	64	61	62	59	64	61	62	60	-1.7	-1.5	60	55	NO	YES	YES
2a	16 Tallowwood Cl	G	62	59	60	58	63	60	60	58	-2.1	-1.9	60	55	NO	NO	NO
2a	16 Tallowwood Cl	1	64	61	62	60	64	62	63	60	-1.8	-1.7	60	55	NO	YES	YES
2a	18A Tallowwood Cl	G	64	61	61	59	64	62	62	59	-2.6	-2.5	60	55	NO	NO	NO
2a	17 Tallowwood Cl	G	62	60	60	58	63	60	61	58	-2.1	-2.1	60	55	NO	NO	NO
2a	15 Tallowwood Cl	G	62	60	60	58	63	60	61	58	-2.0	-2.0	60	55	NO	NO	NO
2a	15 Tallowwood Cl	1	65	63	63	61	66	63	64	61	-2.0	-2.0	60	55	NO	YES	YES
2a	13 Tallowwood Cl	G	62	59	60	57	62	60	60	58	-1.9	-1.9	60	55	NO	NO	NO
2a	11 Tallowwood Cl	G	61	58	59	56	61	58	59	57	-1.5	-1.4	60	55	NO	NO	NO
2a	6 Callistemon Cl	G	60	57	58	56	60	58	59	56	-1.7	-1.6	60	55	NO	NO	NO
2a	6 Callistemon Cl	1	63	60	61	59	63	60	62	59	-1.6	-1.5	60	55	NO	NO	NO
2a	8 Callistemon Cl	G	62	60	61	58	63	60	61	58	-1.6	-1.6	60	55	NO	NO	NO
2a	8 Callistemon Cl	1	65	62	63	61	65	62	64	61	-1.6	-1.4	60	55	NO	YES	YES
2a	9 Callistemon Cl	G	63	60	62	59	63	61	62	59	-1.5	-1.5	60	55	NO	NO	NO
2a	7 Callistemon Cl	G	63	60	62	59	63	61	62	59	-1.4	-1.3	60	55	NO	NO	NO
2a	7 Callistemon Cl	1	65	63	64	61	66	63	64	61	-1.6	-1.4	60	55	NO	YES	YES
2a	6 Ironbark Cl	G	63	60	61	59	63	60	62	59	-1.5	-1.4	60	55	NO	NO	NO

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
2a	8 Ironbark Cl	G	64	61	62	59	64	61	62	60	-1.4	-1.3	60	55	NO	YES	YES
2a	7 Ironbark Cl	G	65	62	64	61	65	62	64	61	-1.2	-1.1	60	55	NO	YES	YES
2a	5 Ironbark Cl	G	64	61	63	60	65	62	63	61	-1.3	-0.9	60	55	NO	YES	YES
2a	10 Turpentine Cl	G	66	63	65	62	67	63	65	62	-1.3	-1.0	60	55	YES	YES	YES
2a	12 Turpentine Cl	G	68	65	67	64	68	65	67	64	-1.1	-0.9	60	55	YES	YES	YES
2a	14 Turpentine Cl	G	69	65	68	65	69	66	68	65	-0.9	-0.6	60	55	YES	YES	YES
2a	16 Turpentine Cl	G	66	63	66	62	66	63	66	63	-0.4	-0.3	60	55	YES	YES	YES
2a	16 Turpentine Cl	1	68	65	68	65	69	65	68	65	-0.7	-0.5	60	55	YES	YES	YES
2a	18 Turpentine Cl	G	66	63	66	62	66	63	66	63	-0.2	-0.1	60	55	YES	YES	YES
2a	18 Turpentine Cl	1	68	65	68	65	69	66	68	65	-0.7	-0.5	60	55	YES	YES	YES
2a	17 Turpentine Cl	G	65	61	64	61	65	61	65	61	-0.1	0.0	60	55	YES	YES	YES
2a	17 Turpentine Cl	1	68	65	67	64	69	65	68	65	-0.7	-0.6	60	55	YES	YES	YES
2a	15 Turpentine Cl	G	60	57	60	57	60	57	61	57	0.3	0.3	60	55	NO	NO	NO
2a	15 Turpentine Cl	1	64	61	64	60	64	61	64	61	-0.3	-0.3	60	55	NO	YES	YES
2a	12 Blueberry Pl	G	65	62	65	62	65	62	65	62	-0.1	0.0	60	55	YES	YES	YES
2a	14 Blueberry Pl	G	66	62	65	62	66	62	66	62	-0.3	-0.2	60	55	YES	YES	YES
2a	14 Blueberry Pl	1	69	66	69	65	70	66	69	66	-0.9	-0.7	60	55	YES	YES	YES
2a	15 Blueberry Pl	G	67	64	67	63	67	64	67	64	-0.4	-0.3	60	55	YES	YES	YES
2a	15 Blueberry Pl	1	70	66	69	65	70	67	69	66	-1.0	-0.8	60	55	YES	YES	YES
2a	13 Blueberry Pl	G	63	59	63	59	63	60	63	60	-0.4	-0.3	60	55	NO	YES	YES
2a	13 Blueberry Pl	1	65	62	65	61	66	62	65	62	-0.9	-0.8	60	55	YES	YES	YES
2a	22 Jarrah Cl	G	67	64	66	63	67	64	67	63	-0.7	-0.5	60	55	YES	YES	YES
2a	23 Jarrah Cl	G	65	62	65	62	66	62	65	62	-0.5	-0.3	60	55	YES	YES	YES

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
2a	21 Jarrah Cl	G	63	59	63	59	63	60	63	60	-0.3	-0.2	60	55	NO	YES	YES
2a	21 Jarrah Cl	1	69	65	68	64	69	66	68	65	-1.1	-0.8	60	55	YES	YES	YES
2a	19 Jarrah Cl	G	64	61	64	60	64	61	64	61	-0.4	-0.4	60	55	NO	YES	YES
2a	19 Jarrah Cl	1	69	65	68	65	69	66	68	65	-1.1	-0.8	60	55	YES	YES	YES
2a	17 Jarrah Cl	G	64	61	64	60	64	61	64	61	-0.4	-0.3	60	55	NO	YES	YES
2a	15 Jarrah Cl	G	64	60	63	60	64	61	64	61	-0.4	-0.3	60	55	NO	YES	YES
2a	15 Jarrah Cl	1	69	66	68	65	69	66	68	65	-0.9	-0.7	60	55	YES	YES	YES
2a	13 Jarrah Cl	G	65	61	64	61	65	62	65	61	-0.3	-0.3	60	55	YES	YES	YES
2a	11 Jarrah Cl	G	60	57	60	57	60	57	60	57	-0.1	-0.1	60	55	NO	NO	NO
2a	11A Jarrah Cl	G	60	56	60	56	60	57	60	57	-0.1	0.0	60	55	NO	NO	NO
2b	14 Watergum Pl	G	60	56	60	56	60	57	60	57	-0.2	-0.1	60	55	NO	NO	NO
2b	16 Watergum Pl	G	60	56	60	56	60	57	60	57	-0.1	0.0	60	55	NO	NO	NO
2b	18 Watergum Pl	G	60	56	60	57	60	57	60	57	0.0	0.1	60	55	NO	NO	NO
2b	18 Watergum Pl	1	64	60	64	61	65	61	65	61	0.0	0.2	60	55	YES	YES	YES
2b	20 Watergum Pl	G	60	56	60	56	60	56	60	56	-0.1	0.0	60	55	NO	NO	NO
2b	10 Lemongum Pl	G	60	57	60	57	61	57	60	57	-0.2	-0.1	60	55	NO	NO	NO
2b	12 Lemongum Pl	G	60	56	60	56	60	57	60	57	-0.1	0.0	60	55	NO	NO	NO
2b	14 Lemongum Pl	G	60	56	60	56	60	57	60	57	-0.1	0.0	60	55	NO	NO	NO
2b	16 Lemongum Pl	G	60	56	60	56	60	57	60	57	-0.1	-0.1	60	55	NO	NO	NO
2b	18 Lemongum Pl	G	59	56	59	56	60	56	60	56	0.0	0.0	60	55	NO	NO	NO
2b	18 Lemongum Pl	1	63	60	63	60	64	60	64	60	0.0	-0.1	60	55	NO	YES	YES
2b	20 Lemongum Pl	G	60	56	59	56	60	56	60	56	-0.1	0.0	60	55	NO	NO	NO
2b	20 Lemongum Pl	1	63	59	63	59	63	60	63	60	0.0	0.0	60	55	NO	YES	YES

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
2b	22 Lemongum Pl	G	59	56	59	56	60	56	60	56	0.0	-0.1	60	55	NO	NO	NO
2b	22 Lemongum Pl	1	63	59	63	59	64	60	64	60	-0.1	0.0	60	55	NO	YES	YES
2b	24 Lemongum Pl	G	59	56	59	56	60	56	60	56	-0.1	0.0	60	55	NO	NO	NO
2b	24 Lemongum Pl	1	68	65	68	65	68	65	68	65	0.0	0.0	60	55	YES	YES	YES
2b	26 Lemongum Pl	G	60	57	60	57	60	57	60	57	0.0	0.0	60	55	NO	NO	NO
2b	26 Lemongum Pl	1	70	67	70	67	71	67	71	67	-0.1	-0.1	60	55	YES	YES	YES
2b	28 Lemongum Pl	G	62	59	62	59	63	59	63	59	0.0	0.0	60	55	NO	NO	NO
2b	28 Lemongum Pl	1	69	66	69	66	70	66	70	66	-0.1	0.0	60	55	YES	YES	YES
2b	12 Eucalyptus St	G	59	56	59	56	60	56	60	56	0.0	0.0	60	55	NO	NO	NO
2b	12 Eucalyptus St	1	64	60	64	60	64	60	64	60	0.0	-0.1	60	55	NO	YES	YES
2b	2 RibbonGum Cl	G	64	61	64	61	64	61	64	61	0.1	0.1	60	55	NO	YES	YES
2b	2 RibbonGum Cl	1	72	69	72	69	72	69	72	69	0.0	0.2	60	55	YES	YES	YES
2b	4 RibbonGum Cl	G	62	59	62	59	63	59	63	59	0.0	0.1	60	55	NO	NO	NO
2b	6 RibbonGum Cl	G	64	60	64	60	64	61	64	61	0.1	0.0	60	55	NO	YES	YES
2b	6 RibbonGum Cl	1	68	65	68	65	69	66	69	66	0.0	0.0	60	55	YES	YES	YES
2b	8 RibbonGum Cl	G	63	60	63	60	64	61	64	61	0.0	0.0	60	55	NO	YES	YES
2b	8 RibbonGum Cl	1	69	66	69	66	70	66	69	66	-0.1	0.0	60	55	YES	YES	YES
2b	10 RibbonGum Cl	G	64	61	64	61	64	61	64	61	0.0	0.0	60	55	NO	YES	YES
2b	12 RibbonGum Cl	G	64	61	64	61	64	61	64	61	0.0	0.0	60	55	NO	YES	YES
2b	14 RibbonGum Cl	G	64	61	64	61	64	61	64	61	0.0	0.1	60	55	NO	YES	YES
3	Sir Thomas Mitchell Aged Care Front	G	63	57	63	57	63	57	63	57	-0.1	-0.1	60	55	NO	NO	NO

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
3	Sir Thomas Mitchell Aged Care Front	G	64	58	64	57	64	58	64	58	0.0	-0.1	60	55	NO	NO	NO
3	Sir Thomas Mitchell Aged Care Front	G	64	58	64	58	65	59	64	59	-0.1	-0.1	60	55	NO	NO	NO
3	Sir Thomas Mitchell Aged Care Front	G	62	57	62	57	62	57	63	57	0.1	0.1	60	55	NO	NO	NO
3	4 Shore Cl	G	57	53	57	53	58	53	58	53	0.1	0.1	60	55	NO	NO	NO
3	9 Shore Cl	G	60	55	60	56	61	56	61	56	0.2	0.1	60	55	NO	NO	NO
3	6 Shore Cl	G	62	57	62	57	63	58	62	57	-0.2	-0.2	60	55	NO	NO	NO
3	7 Shore Cl	G	61	57	61	57	61	57	61	57	-0.1	-0.1	60	55	NO	NO	NO
3	5 Shore Cl	G	61	57	61	57	61	57	61	57	-0.1	0.0	60	55	NO	NO	NO
3	3 Shore Cl	G	61	57	61	57	62	58	62	58	-0.1	-0.1	60	55	NO	NO	NO
3	4 Sand Pl	G	61	57	61	57	61	57	61	57	-0.1	-0.1	60	55	NO	NO	NO
3	3 Sand Pl	G	62	58	61	57	62	58	62	58	-0.2	-0.3	60	55	NO	NO	NO
-	Primary School	G	54	-	54	-	54	-	54	-	-0.2		50[1]	-	NO	-	NO
-	Pre-School	G	54	-	54	-	54	-	54	-	0.0		50[1]	-	NO	-	NO
4	17 Mariner Rd	G	59	55	59	55	60	56	59	55	-0.3	-0.4	60	55	NO	NO	NO
4	15 Mariner Rd	G	60	56	59	55	60	56	60	56	-0.3	-0.3	60	55	NO	NO	NO
4	13 Mariner Rd	G	60	56	59	55	60	56	60	56	-0.3	-0.3	60	55	NO	NO	NO
4	11 Mariner Rd	G	62	58	61	57	63	58	62	57	-1.0	-1.0	60	55	NO	NO	NO
4	9 Mariner Rd	G	62	58	61	57	62	58	61	57	-1.2	-1.3	60	55	NO	NO	NO
4	7 Mariner Rd	G	61	57	60	55	61	57	60	56	-1.5	-1.4	60	55	NO	NO	NO
4	5 Mariner Rd	G	61	57	59	55	61	57	60	55	-1.6	-1.5	60	55	NO	NO	NO
4	3 Mariner Rd	G	60	56	59	54	61	56	59	55	-1.3	-1.4	60	55	NO	NO	NO

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
4	1 Mariner Rd	G	60	56	59	54	61	56	59	55	-1.6	-1.6	60	55	NO	NO	NO
4	54 Sylvan Ridge Rd	G	61	56	59	55	61	57	59	55	-1.7	-1.7	60	55	NO	NO	NO
4	56 Sylvan Ridge Rd	G	60	56	58	54	60	56	58	54	-1.9	-1.8	60	55	NO	NO	NO
4	58 Sylvan Ridge Rd	G	61	57	59	55	62	57	60	55	-2.2	-2.0	60	55	NO	NO	NO
4	60 Sylvan Ridge Rd	G	62	58	60	56	63	58	61	56	-2.1	-2.0	60	55	NO	NO	NO
4	62 Sylvan Ridge Rd	G	61	57	60	56	61	57	60	56	-1.3	-1.3	60	55	NO	NO	NO
4	64 Sylvan Ridge Rd	G	63	59	62	58	63	59	62	58	-1.2	-1.0	60	55	NO	NO	NO
4	66 Sylvan Ridge Rd	G	61	57	61	57	62	58	61	57	-0.5	-0.4	60	55	NO	NO	NO
4	68 Sylvan Ridge Rd	G	62	58	62	58	63	59	62	58	-0.6	-0.5	60	55	NO	NO	NO
4	70 Sylvan Ridge Rd	G	62	59	62	58	63	59	63	59	-0.1	-0.2	60	55	NO	NO	NO
4	72 Sylvan Ridge Rd	G	61	58	62	58	62	58	62	58	0.1	0.1	60	55	NO	NO	NO
4	74 Sylvan Ridge Rd	G	63	59	63	59	63	59	63	59	0.1	0.1	60	55	NO	NO	NO
4	76 Sylvan Ridge Rd	G	61	57	61	58	61	58	62	58	0.2	0.2	60	55	NO	NO	NO
4	78 Sylvan Ridge Rd	G	61	58	61	58	61	58	62	58	0.3	0.3	60	55	NO	NO	NO
4	80 Sylvan Ridge Rd	G	62	58	62	59	62	59	63	59	0.3	0.2	60	55	NO	NO	NO
4	82 Sylvan Ridge Rd	G	62	58	62	59	62	59	63	59	0.3	0.2	60	55	NO	NO	NO
4	84 Sylvan Ridge Rd	G	62	58	62	58	62	58	62	59	0.3	0.3	60	55	NO	NO	NO
4	86 Sylvan Ridge Rd	G	61	58	62	58	62	58	62	58	0.2	0.2	60	55	NO	NO	NO
4	88 Sylvan Ridge Rd	G	63	59	63	60	63	60	64	60	0.4	0.4	60	55	NO	YES	YES
4	90 Sylvan Ridge Rd	G	64	60	64	60	64	60	64	61	0.4	0.4	60	55	NO	YES	YES
4	92 Sylvan Ridge Rd	G	60	57	60	57	61	57	61	57	0.1	0.1	60	55	NO	NO	NO
4	94 Sylvan Ridge Rd	G	59	55	59	55	59	56	59	56	0.1	0.0	60	55	NO	NO	NO
4	2 Maxwell Cl	G	58	54	58	54	58	54	58	55	0.0	0.1	60	55	NO	NO	NO

NCA	Receiver	Floor	2016 'No Build'		2016 'Build'		2026 'No Build'		2026 'Build'		Increase ('Build - No Build')		RNP Noise Criteria		Exposed to Acute Noise Levels		Consider Noise Mitigation (YES/NO)
			DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	
			dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	
4	4 Maxwell Cl	G	58	54	58	54	58	55	58	55	0.0	0.0	60	55	NO	NO	NO
4	6 Maxwell Cl	G	57	54	57	54	58	54	58	54	0.1	0.1	60	55	NO	NO	NO
4	8 Maxwell Cl	G	58	55	58	55	58	55	58	55	0.0	0.1	60	55	NO	NO	NO
4	12 Maxwell Cl	G	61	58	61	58	61	58	62	58	0.4	0.3	60	55	NO	NO	NO
4	14 Maxwell Cl	G	59	56	60	56	60	56	60	56	0.4	0.4	60	55	NO	NO	NO

Notes: 1. 50dB(A) is the equivalent external noise level based on internal noise goal of 40dB(A)for school classrooms and 10dB(A) noise reduction through open window

3.6 Maximum Noise Level Assessment

The NSW RNP does not specify a night-time L_{max} noise limit or noise goal. This is primarily because research conducted to date in this field has not been definitive and the relationship between maximum noise levels, sleep disturbance and subsequent health effects is not currently well defined.

According to the policy however, the likely maximum or peak noise levels are to be broadly assessed and reported for the night-time period, which is considered by the EPA as being 10 pm to 7 am.

Taking guidance from Practice Note iii of RMS's Environmental Noise Management Manual, we have used the following methodology for assessing maximum noise levels. This project is a road redevelopment that does not involve interruptions to the traffic flow or changes to the traffic mix.

- Collate external L_{max} and L_{eq} noise levels from the monitored existing noise levels between 10 pm and 7 am based on 15minute stored data at all four monitoring locations.
- Calculate the $L_{max} - L_{eq}$ range from the monitored existing noise levels at each location.
- Predict the future L_{max} noise levels based on the proposed road design and distance corrections.
- Analyse L_{max} noise levels based on 1 second stored data at 76 Sylvan Ridge Drive to determine the number of maximum noise events per hour during the night period.
- Evaluate whether maximum noise impacts will reduce or increase for the design year.

Long term unattended noise monitoring carried out at the monitoring locations along Alfords Point Road indicated L_{max} traffic noise levels at night as shown in Table 11. Maximum noise levels at night have been predicted using existing L_{max} noise level data and taking into consideration the proposed road design. It is noted that the assessment of maximum noise levels are only applicable to residential receivers.

Table 11 - Maximum Lmax Night-Time Levels at Monitoring Locations, dB(A)

Monitoring Location	Current L_{max} Range[1]	Predicted L_{max} Range	$L_{max} - L_{eq}$ Range	Average Lmax events
2 Nallada Road	67 - 85	67 – 85	15 - 26	16 per night (approx. 2 per hour)
26 Lemongum Place	66 - 91	66 – 91	15 - 33	
76 Sylvan Ridge Drive	65 - 78	66 - 79	15 - 25	
88 Sylvan Ridge Drive[2]	65 - 78	66 - 79	15 - 25	

Notes: 1. Night-time L_{max} values are shown only where $L_{max} > 65dB(A)$ and where $L_{max} - L_{eq} \geq 15dB(A)$
2. Results for 88 Sylvan Ridge Drive based on data captured at 76 Sylvan Ridge Dr

Due to only a minor change in the overall road width and therefore the distances from vehicles to residences, L_{max} noise levels are not expected to change significantly between the present and future. L_{max} noise levels may increase by around 1dB(A) at residences within NCA 3 and NCA 4 due to the road widening to the east, however no significant change is predicted in other NCAs.

Since the upgrades involve widening of the road within the same road corridor, the change in distance from road to receiver as a result of the project will be minor and therefore L_{max} noise levels in the future will remain similar to current levels and therefore no change to current maximum noise level impacts are expected.

The number of maximum noise events occurring on any night would be proportional to the volume of trucks on the road, and therefore they too are not expected to change as a result of the project.

3.7 Relocation of Bus Stop

The existing bus stop located near 14 Eucalyptus Street is to be relocated south near 6 and 8 Ribbongum Close. In terms of L_{Aeq}, the noise from a bus stopping or accelerating away from the new bus stop is considered unlikely to be louder than a heavy vehicle passby on the main carriageway or ramp. However depending on bus timetables, the frequency of busses could increase the number of L_{max} events during the night period (before 7am and after 10pm).

3.8 Road Traffic Noise Mitigation Options

Although the project is not expected to cause any significant increase in noise levels (not more than 2dB), some residences within the project area are already exposed to 'acute' noise levels, as identified in Appendix D, therefore an assessment of feasible and reasonable noise mitigation options is required.

This project is still at 'concept design phase' and final noise mitigation treatments will not be decided until the 'detailed design phase' to allow for all design changes to be considered in the noise assessment. Nonetheless, the following recommendations provide in-principle noise control solutions to reduce noise impacts to residential receivers. The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

It is noted that in accordance with Section 3.4.1 of the RNP the following is stated:

> *"…identify feasible and reasonable mitigation measures in the following order of priority:*
>
> *i. Road design and traffic management*
>
> *ii. Quieter pavement surfaces*
>
> *iii. In-corridor noise barriers/mounds*
>
> *iv. At-property treatments or localised barriers/mounds"*

We confirm that all reasonable and feasible traffic management and road design opportunities to reduce road traffic noise have been considered in the concept design. Therefore, the following sections assess the feasible and reasonableness of the remaining mitigation options in accordance with the order of priority stated above.

3.8.1 Quieter Pavements

The RTA's 'Environmental Noise Management Manual' (ENMM) gives guidance on appropriate treatment of dwellings affected by traffic noise. 'Quiet' road pavement surfaces such as Stone Mastic Asphalt (SMA) and Open Graded Asphaltic Concrete (OGAC) could be laid along the proposed realignment as part of the road redevelopment. At speeds of greater than 80 km/h, this treatment can provide a 2-4dB(A) noise reduction at the source compared to standard pavements, although noise reductions are less for speeds less than 80km/h.

The posted speed limit for the proposed realignment would remain at 80 km/h. There are also no intersections along the proposed upgrade that would provide complications for maintenance. With this in mind, using a quieter pavement may be considered in the detail design.

3.8.2 Noise Barriers

Noise barriers are most feasible where residences are closely grouped, where the barriers do not cause access difficulties to properties, and where they are visually acceptable. Where driveway access is required it is preferred not to use noise barriers as the overall noise reduction provided by the barrier is compromised by the need to install an access gate.

Site inspections have revealed that there is an existing noise barrier on western side of the road corridor between Brushwood Drive and Jarrah Close. This noise barrier varies in height and is typically between 2.7m – 4m. The location of the noise barrier is shown below.

Figure 3 – Location of Existing Noise Barrier

The feasibility of constructing additional noise barriers to mitigate residences with acute noise levels will be conducted at the detailed design stage of the project. At this stage we note that:

- Dwellings within NCA 1 sit at higher elevation than the road above a rock cutting. It is not likely to be feasible to construct a noise barrier at this location due to the topography. A noise barrier at the top of the cutting would also have visual impacts to resident by blocking views. At-property treatment would be more appropriate for acute properties within this catchment.
- In NCA 2a noise barriers may be feasible as residences back onto Alfords Point Road and there are no driveways or other obstructions.
- In NCA 2b there is already an existing noise barrier. Portions of this barrier may need to be relocated or adjusted as a result of the road works at the on ramp. If required, a barrier analysis will be undertaken at the detailed design stage of the project to determine the optimum barrier height and at-property treatments considered where the existing barrier does not achieve the noise goals.
- Noise barriers are not reasonable for NCAs 3 and 4 as there are only two residences in NCA 4 that have acute noise levels. These residences can be treated with 'at-property' measures.

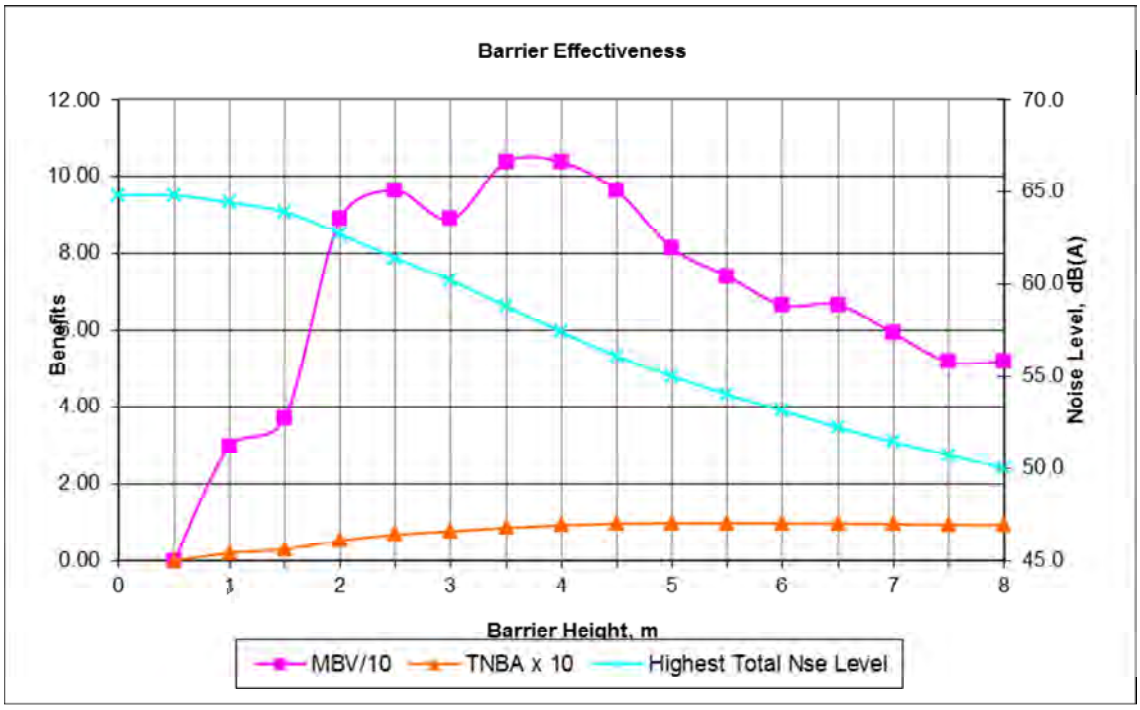
NCA 2a is the only area where noise barriers are feasible. To assist with the ongoing discussion and consideration of noise barriers, a preliminary noise barrier analysis was conducted in accordance with RMS procedures to determine the 'target' and 'assessed' barriers, where;

- **Target Barrier (TB)** is the barrier that meets the RNP noise goals.
- **Assessed Barrier (AB)** is the barrier that provides the greatest marginal noise reduction benefit and the greatest benefit per unit area of barrier. This is the most cost-effective barrier.

The barrier will be most effective when located on the roadside rather than at the residential property boundary as receiver levels are below the road level at the northern end of NCA 2a. Table 12 shows noise barrier performance when the noise barrier is located on the roadside, approximately 2m from the nearside lane to allow space for landscaping. The noise barrier analysis has been conducted at the most affected receiver within the NCA, and using the night time model as this is the worst case scenario. A graph of the noise barrier effectiveness analysis is also shown.

Table 12 – NCA2a Noise Barrier Performance

Noise Barrier at Roadside		
Noise Barrier Height	**Night Time Noise Level**	**Noise Reduction**
0	65	
0.5	65	0
1	64	0
1.5	64	1
2	63	2
2.5	61	3
3	60	5
3.5	59	6
4	57	7
4.5	56	9
5	55	10
5.5	54	11
6	53	12
6.5	52	13
7	51	13
7.5	51	14
8	50	15



The results show that:

- The target barrier height is 5m.
- The assessed barrier height is 4m

Should a 5m noise barrier be installed along NCA 2a, no dwellings would require at-property treatment. However, should a 4m noise barrier be installed, then the balance of the dwellings remaining which are found to exceed the project noise goals, should be considered for at-property noise mitigations.

During the detailed design phase stage of the proposal, further investigation of all feasible and reasonable noise mitigation options would be undertaken for the receivers requiring noise mitigation measures. All feasible and reasonable noise mitigation treatments would be considered for the impacted receivers in accordance with the RNP, and in consultation with their respective landowners to reduce traffic noise level to within the applicable noise goals.

3.8.3 At-Property Treatment

At-property treatment would only be considered for dwellings where other noise mitigation measures are either exhausted or are not feasible or cost effective.

The RNP's noise criteria are external noise goals, and building treatment only reduces noise levels inside a dwelling. Therefore, any building treatment would be designed to achieve the internal noise levels that would have been achieved had the project complied with the RNP criteria externally.

It is generally accepted that most buildings provide a noise reduction of at least 10dB(A) when windows are left 20% open, without providing additional treatment. This equates to an RNP

internal criteria of $L_{Aeq(15\ hour)}$ 50dB(A) and $L_{Aeq(9\ hour)}$ 45dB(A) for residences along the road upgrade.

The following noise control options are generally available according to the level of noise reduction required.

- **Option 1** *<5 dB(A) reduction*

  Mechanical ventilation only

  Where external noise levels are less than 5dB(A) above the RNP noise criteria, the internal 'base' criteria may be achieved with windows closed. A light framed building with single glazed windows would provide a minimum noise reduction of up to 15dB(A) from outside to inside when windows are closed. If the noise criteria can only be achieved with windows closed, then mechanical ventilation or air conditioning must be provided to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.

  The estimated cost for providing the above treatment is in the order of $5,000 - $10,000 per dwelling.

- **Option 2** *5-10 dB(A) reduction*

  Mechanical ventilation and sealing of wall vents

  Where external noise levels are less than 10dB(A) above the RNP noise criteria, the internal criteria may be achieved with windows closed. A light framed building with single glazed windows would provide a minimum noise reduction of up to 20dB(A) from outside to inside (ENMM p20) when windows are closed and wall vents are sealed. If the RNP internal noise criteria can only be achieved with windows closed, then mechanical ventilation or air conditioning must be provided to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.

  It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.

  The estimated cost for providing the above treatment is in the order of $5,000 - $15,000 per dwelling (ENMM p111 sets a limit of $15,000 per residence).

- **Option 3** *10-12 dB(A) reduction*

  Upgraded seals for windows and doors

  Where external noise levels are only slightly greater than 10dB(A) above the RNP noise criteria, then additional to installing mechanical ventilation systems (Option 1), special acoustic grade seals would be installed on windows and perimeter doors exposed to road traffic noise to enable the internal noise criteria to be achieved with

windows and doors shut.

The estimated cost for providing the combined treatment of both Options 1 and 2 is in the order of $10,000 - $20,000 per dwelling (ENMM p111 sets a limit of $20,000 per residence).

- **Option 4**
  >12 dB(A) reduction

  Upgraded windows, glazing and doors

  Where the predicted external noise level exceeds the RNP noise criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors would be required on the facades exposed to the proposed upgrade, in addition to the mechanical ventilation described in Option 1. Note that these upgrades are only suitable for masonry buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.

  The estimated cost for providing the above treatment is in the order of $25,000 - $30,000 per dwelling.

4 CONSTRUCTION NOISE ASSESSMENT

4.1 Construction Noise Criteria

4.1.1 Interim Construction Noise Guideline

The NSW 'Interim Construction Noise Guideline' (ICNG) is the EPA's standard policy for assessing construction noise.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the substantial scale of the construction works proposed for the Alfords Point Road upgrade, a quantitative assessment is carried out herein, consistent with the ICNG's requirements.

4.1.2 Residences

Table 13 below (reproduced from Table 2 of the ICNG) sets out the noise management levels and how they are to be applied for residential receivers. The guidelines intend to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 13 – Noise at Residences Using Quantitative Assessment

Time of Day	Management Level $L_{Aeq\ (15\ min)}$*	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of Day	Management Level $L_{Aeq\ (15\ min)}$*	How to Apply
public holidays	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB(A)	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 of the *NSW Interim Construction Noise Guideline*.

** Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

Based on the noise levels measured for this project, the management levels applicable to residences are summarised below.

Table 14 - Construction Noise Management Levels for Residences

Time of Day	Management Level $L_{Aeq(15min)}$	Base Management Level $L_{Aeq(15min)}$				
		NCA 1	NCA 2a	NCA 2b	NCA 3	NCA 4
During recommended standard hours (day)	RBL + 10dB(A)	66	60	60	62	62
Outside recommended standard hours (evening)	RBL + 5dB(A)	57	52	52	51	51
Outside recommended standard hours (night)	RBL + 5dB(A)	42	51	51	36	36

4.1.3 Sensitive Land Uses

Table 15 below (reproduced from Table 3 of the ICNG) sets out the noise management levels for sensitive land uses within the study area.

Table 15 – Noise at Other Sensitive Land Uses Using Quantitative Assessment

Land use	Management level, $L_{Aeq\ (15\ min)}$
Classrooms at Schools[1]	Internal noise level = 45 dB(A)
Places of Worship	Internal noise level = 45 dB(A)
Passive recreation areas (such as outdoor grounds used for teaching)[2]	External noise level = 60 dB(A)

Notes: 1. Applicable for the internal teaching areas of Primary School and Pre School in NCA 2b
2. Applicable for outdoor play areas of schools

It is noted that as a general rule, building structures would typically provide a minimum of 10dB(A) reduction from external noise levels to internal noise levels. Therefore, the equivalent external management noise level for the internal areas of the schools is 55dB(A). Furthermore, the outdoor play areas of the schools are classified as passive recreation areas with a management level of 60dB(A) in accordance with the above table.

4.1.4 Sleep Disturbance

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the assessment should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL. The ICNG takes guidance from the NSW Environmental Criteria for Road Traffic Noise (ECRTN, Environment Protection Authority 1999) for recommended night time noise goals to minimise potential impacts and preserve acoustic amenity within receivers:

- Maximum internal noise levels below 50-55dB(A) are unlikely to cause awakening reactions.
- One or two events per night with maximum internal noise levels of 65-70dB(A) are not likely to affect health and wellbeing.

Based on the above, an upper external noise limit of L_{Amax} 65dB(A) is set as the noise management level (NML) for the purposes of this assessment.

4.2 Construction Activities

4.2.1 Road Upgrade Works

It is anticipated that the project will be constructed in two main stages (although this will be broken into a number of sub-stages). Stage one will be to construct the new carriageway on the eastern side of Alfords Point Road whilst traffic remains in its current location.

When completed, all traffic will be switched from the existing road onto the new stage one works. Following the traffic switch, stage two will be to reconstruct the existing carriageway. Ramp construction, bus stops and construction of the vehicle inspection station will be included at some convenient point in these two stages.

Construction work would generally be carried out during daytime hours whenever practicable; however, some night works would be required for certain activities to minimise traffic impacts at the different stages of construction. It is estimated that both pre-construction activities such as utility adjustments and full road work construction may take between 18-24 months to complete and would require the use of conventional construction equipment.

The following table lists construction activities and the associated plant and equipment likely to be used by the contractor to carry out the necessary construction work for this project. Should noise wall construction be required, the noise levels produced would be similar to that for drainage works since similar equipment would be used.

Table 16 - Construction Activity & Equipment List

Activity	Plant/ Equipment
Clearing	Chain Saw Tracked Excavator Dump Truck Bull Dozer
Utility Adjustment	Tracked Excavator Dump Truck Mobile Crane
Concrete pavement demolition	Road saw Tracked Excavator Front end loader Dump Truck
Concrete pavement demolition (hydraulic hammers)	Tracked Excavator Dump Truck Rock Breaker
Bulk earthworks including excavation in rock(hydraulic hammers)	Tracked Excavator Dump Truck Rock Breaker Bull Dozer Front end loader Backhoe
Sub grade ripping(in rock) and compaction	Tracked Excavator Dump Truck Bull Dozer Front end loader Compactor
Material processing(crushers) and screening operations	Rock Crushing Rock screening Dump Truck Tracked Excavator
Drainage	Tracked Excavator Drilling Rig Dump Truck Front end loader Backhoe

Activity	Plant/ Equipment
Pavement and concrete barrier construction	Mobile Crane Concrete Truck Concrete pump Grader Pavement Laying Machine Roller Generator
Noise Wall Construction	Piling Drilling Rig Concrete Truck Mobile Crane Tracked Excavator
Street lighting	Mobile Crane
Signposting and line marking	Mobile Crane Truck

4.2.2 Construction Site Compounds

Two site compounds are proposed to be setup during the construction phase to store equipment and materials, site sheds and storage containers. The two proposed locations are:

- Compound 1 – Between Alfords Point Road main carriageway and Brushwood Drive southbound off ramp; and
- Compound 2 – South of the project area between Old Illawarra Road and Alfords Point Road, near Rosewall Drive.

The proposed hours of use for the compounds are:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- No work on Sundays and public holidays

During the period of road construction the activities associated with the compounds are likely to include:

- light and heavy vehicles accessing the compounds,
- deliveries through heavy vehicles,
- maintenance of plant and equipment,
- mechanical plant associated with the site amenities, and
- people talking.

4.3 Construction Noise Sources

The following table lists the sound power levels of the plant and equipment likely to be used by the contractor to carry out the necessary construction work for this project.

Table 17 - Typical Construction Equipment & Sound Power Levels, dB(A)

Works/ Stage	Plant Description	L_{Aeq} Sound Power Levels, dB(A) re 1pW
Road Upgrade Works	Rock Breaker	117
	Concrete Saw	115
	Rock Screening Unit (recycling)	114
	Piling / Drilling Rig	111
	Mobile Crane	110
	Rock Crusher (recycling)	110
	Compactor	110
	Front End Loader	110
	Pavement Laying Machine	109
	Bulldozer	109
	Tracked Excavator	107
	Grader	107
	Concrete Truck	106
	Dump Trucks	105
	Rollers	104
	Truck (>20tonne)	103
	Concrete Pump	102
	Backhoe	101
	Power Generator	100
Construction Compounds	Typical diesel engine machine warming up	110
	Delivery Truck	108
	Dump Trucks	108
	Water Cart	107
	Truck (>20tonne)	106
	Light commercial vehicles (eg 4WD)	103
	Person talking loudly	76

The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 "Guide to Noise Control on Construction, Demolition and Maintenance Sites", OEH's ICNG, information from past projects and information held in our library files.

4.4 Predicted Construction Noise Levels

4.4.1 Road Upgrade Works

Representative first row and second row receivers have been nominated for this construction noise assessment in each NCA.

For the concrete pavement demolition activity, it has been assumed that rock breaking and concrete sawing will not occur concurrently and as such have been listed as separate activities.

Based on the activities, equipment and noise levels described above, the highest L_{Aeq} noise levels likely to be experienced at the nominated receivers during each phase of work are presented in the following table.

Noise levels were calculated taking into consideration attenuation due to distance and shielding from surrounding buildings and other structures. As an indication of potential night time impacts (where night time construction may occur), **bold** numbers indicate an exceedance of Australian Standards AS2107 recommend maximum internal noise level of 40dB(A) for sleeping areas near major roads, assuming a 25dB reduction through the facade with windows closed.

Table 18 – Predicted Construction Phase Noise Levels, dB(A)

Activity		NCA Representative Receiver									
		NCA1 R1	NCA1 R2	NCA2a R1	NCA2a R2	NCA2b R1	NCA2b R2	NCA3 R1	NCA3 R2	NCA4 R1	NCA4 R2
External Criteria	*Day*	*66*	*66*	*60*	*60*	*60*	*60*	*62*	*62*	*62*	*62*
	Evening	*57*	*57*	*52*	*52*	*52*	*52*	*51*	*51*	*51*	*51*
	Night	*42*	*42*	*51*	*51*	*51*	*51*	*36*	*36*	*36*	*36*
Clearing		**66**	52	**66**	61	**66**	61	65	58	**66**	59
Utility adjustments		62	48	62	57	62	57	61	54	62	55
Concrete pavement demolition		**67**	53	**67**	61	**67**	62	**66**	58	**67**	60
Concrete pavement demolition (hydraulic hammers)		**68**	54	**67**	62	**68**	62	**67**	59	**67**	61
Bulk earthwork (hydraulic hammers)		**69**	55	**69**	63	**69**	64	**68**	60	**69**	62
Sub grade ripping and compaction		65	51	65	60	65	60	64	57	65	58
Material processing and screening operations		**67**	52	**66**	61	**67**	61	65	58	**66**	60
Drainage		65	51	65	59	**65**	60	64	57	65	58
Pavement and concrete barrier construction		65	51	65	59	65	60	64	56	65	58
Potential noise wall construction at NCA2a		-	-	65	59	-	-	-	-	-	-
Street lighting		60	46	59	54	60	54	59	51	59	53
Signposting and line marking		61	46	60	55	61	55	59	52	60	54

Table 19 – ICNG Construction Noise Criteria Exceedance

Activity	NCA Representative Receiver									
	NCA1 R1	NCA1 R2	NCA2a R1	NCA2a R2	NCA2b R1	NCA2b R2	NCA3 R1	NCA3 R2	NCA4 R1	NCA4 R2
Exceedance During Recommended Standard Hours (Day)										
Clearing	0	-	6	1	6	1	3	-	4	-
Utility adjustments	-	-	2	-	2	-	-	-	-	-
Concrete pavement demolition	1	-	7	1	7	2	4	-	5	-

Activity	NCA Representative Receiver									
	NCA1 R1	NCA1 R2	NCA2a R1	NCA2a R2	NCA2b R1	NCA2b R2	NCA3 R1	NCA3 R2	NCA4 R1	NCA4 R2
Concrete pavement demolition (hydraulic hammers)	2	-	7	2	8	2	5	-	5	-
Bulk earthwork (hydraulic hammers)	3	-	9	3	9	4	6	-	7	0
Sub grade ripping and compaction	-	-	5	-	5	0	2	-	3	-
Material processing and screening operations	1	-	6	1	7	1	3	-	4	-
Drainage	-	-	5	-	5	-	2	-	3	-
Pavement and concrete barrier construction	-	-	5	-	5	-	2	-	3	-
Potential noise wall construction at NCA2a	-	-	5	-	-	-	-	-	-	-
Street lighting	-	-	-	-	-	-	-	-	-	-
Signposting and line marking	-	-	0	-	1	-	-	-	-	-
Exceedance Outside Recommended Standard Hours (Evening)										
Clearing	9	-	14	9	14	9	14	7	15	8
Utility adjustments	5	-	10	5	10	5	10	3	11	4
Concrete pavement demolition	10	-	15	9	15	10	15	7	16	9
Concrete pavement demolition (hydraulic hammers)	11	-	15	10	16	10	16	8	16	10
Bulk earthwork (hydraulic hammers)	12	-	17	11	17	12	17	9	18	11
Sub grade ripping and compaction	8	-	13	8	13	8	13	6	14	7
Material processing and screening operations	10	-	14	9	15	9	14	7	15	9
Drainage	8	-	13	7	13	8	13	6	14	7
Pavement and concrete barrier construction	8	-	13	7	13	8	13	5	14	7
Potential noise wall construction at NCA2a	-	-	13	7	-	-	-	-	-	-
Street lighting	3	-	7	2	8	2	8	0	8	2
Signposting and line marking	4	-	8	3	9	3	8	1	9	3
Exceedance Outside Recommended Standard Hours (Night)										
Clearing	24	10	15	10	15	10	29	22	30	23
Utility adjustments	20	6	11	6	11	6	25	18	26	19
Concrete pavement demolition	25	11	16	10	16	11	30	22	31	24
Concrete pavement demolition (hydraulic hammers)	26	12	16	11	17	11	31	23	31	25
Bulk earthwork (hydraulic hammers)	27	13	18	12	18	13	32	24	33	26
Sub grade ripping and compaction	23	9	14	9	14	9	28	21	29	22
Material processing and screening operations	25	10	15	10	16	10	29	22	30	24
Drainage	23	9	14	8	14	9	28	21	29	22

Activity	NCA Representative Receiver									
	NCA1 R1	NCA1 R2	NCA2a R1	NCA2a R2	NCA2b R1	NCA2b R2	NCA3 R1	NCA3 R2	NCA4 R1	NCA4 R2
Pavement and concrete barrier construction	23	9	14	8	14	9	28	20	29	22
Potential noise wall construction at NCA2a	-	-	14	8	-	-	-	-	-	-
Street lighting	18	4	8	3	9	3	23	15	23	17
Signposting and line marking	19	4	9	4	10	4	23	16	24	18

4.4.1.1 Recommended Standard Hours Exceedance

Based on the predicted construction noise levels presented in the table above, the daytime construction noise management levels are generally exceeded for first row receivers. These exceedance vary and are predicted up to 9dB. Second row receivers are generally either not in exceedance or slightly exceeded, by up to 4dB. It is noted that predicted noise levels at all receivers are below the 75dB(A) 'highly noise affected' noise management level.

4.4.1.2 Works Outside Recommended Standard Hours

Outside the recommended standard hours construction noise management levels are generally exceeded for both first and second row receivers. These exceedances are predicted up to 18dB for evening works, and up to 33dB for night works. The extent of noise exceedances predicted are conservative, based on the worst case that typical 'standard hours' construction works will be carried out during the outside standard hours.

It is recommended that further assessment of works be carried out outside standard hours be completed where these works are to extend over more than two consecutive nights, when the extent, duration and type of works to be undertaken can be quantified in more detail.

A reasonable and feasible approach to noise management will be required to reduce noise levels as much as possible to manage impacts from construction noise. Construction noise management measures are discussed in Section 4.5 below.

4.4.1.3 Sleep Disturbance

Based on the construction activities and equipment described in this report, a sleep disturbance assessment has been conducted as presented in the table below.

Table 20 – Predicted L_{Amax} Construction Noise Levels, dB(A)

Activity	NCA Representative Receiver									
	NCA1 R1	NCA1 R2	NCA2a R1	NCA2a R2	NCA2b R1	NCA2b R2	NCA3 R1	NCA3 R2	NCA4 R1	NCA4 R2
Sleep Disturbance Upper Limit	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*65*
Clearing	67	53	67	62	67	62	66	59	67	60
Utility adjustments	65	51	65	60	65	60	64	57	65	58

Activity	NCA Representative Receiver									
	NCA1 R1	NCA1 R2	NCA2a R1	NCA2a R2	NCA2b R1	NCA2b R2	NCA3 R1	NCA3 R2	NCA4 R1	NCA4 R2
Concrete pavement demolition	68	54	68	62	68	63	67	59	68	61
Concrete pavement demolition (hydraulic hammers)	75	61	74	69	75	69	74	66	74	68
Bulk earthwork (hydraulic hammers)	75	61	75	69	75	70	74	66	75	68
Sub grade ripping and compaction	68	54	68	63	68	63	67	60	68	61
Material processing and screening operations	77	62	76	71	77	71	75	68	76	70
Drainage	74	60	74	68	74	69	73	66	74	67
Pavement and concrete barrier construction	65	51	65	59	65	60	64	56	65	58
Potential noise wall construction at NCA2a	65	51	64	59	65	59	64	56	64	58
Street lighting	66	51	65	60	66	60	64	57	65	59
Signposting and line marking	67	53	67	62	67	62	66	59	67	60
Exceedance During Night (10pm to 7am)										
Clearing	2	-	2	-	2	-	1	-	2	-
Utility adjustments	0	-	-	-	0	-	-	-	-	-
Concrete pavement demolition	3	-	3	-	3	-	2	-	3	-
Concrete pavement demolition (hydraulic hammers)	10	-	9	4	10	4	9	1	9	3
Bulk earthwork (hydraulic hammers)	10	-	10	4	10	5	9	1	10	3
Sub grade ripping and compaction	3	-	3	-	3	-	2	-	3	-
Material processing and screening operations	12	-	11	6	12	6	10	3	11	5
Drainage	9	-	9	3	9	4	8	1	9	2
Pavement and concrete barrier construction	0	-	-	-	0	-	-	-	-	-
Potential noise wall construction at NCA2a	-	-	-	-	-	-	-	-	-	-
Street lighting	1	-	0	-	1	-	-	-	0	-
Signposting and line marking	2	-	2	-	2	-	1	-	2	-

4.4.2 Construction Compounds

Noise levels from site compound activity have been predicted to the nearest residential receivers to each compound. The construction noise goals that apply are based on background noise levels measured for this project in similar residential areas.

Table 21 – Predicted Noise Levels from Site Compounds

Compound	side of road	Receiver	Distance to Compound (m)	Day Noise Goal RBL + 10	Predicted L_{Aeq} Noise Level dB(A)	Exceedance
1	east	5 Shore	60	60	61	1
	west	14 Ribbon Gum Cl	45	60	61	1
2	east	57 Jervis Dr	100	60	54	-
	west	1 Goolagong Pl	65	60	59	-

Receivers nearest to Compound 1 are shielded by existing noise walls, boundary fences, and the Brushwood Drive off ramp. The receivers to the east of Compound 2 are shielded in part from the compound by the natural ground topography. In all cases there is a major traffic carriageway between the site compound and the receiver.

The exceedances shown here are generally less than the exceedances predicted for the L_{Aeq} night time assessment in Table 19. Reasonable and feasible noise management measures should be implemented to reduce noise levels as much as possible.

4.5 Construction Noise Mitigation Options

The following recommendations provide in-principle noise control solutions to reduce noise impacts to residential receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

4.5.1 Standard Noise and Vibration Management Measures

Table 22 sets out standard noise and vibration mitigation, as outlined in the ENMM (Section 5), to be implemented on the Project as required.

Table 22 – Standard Mitigation Measures to Reduce Construction Noise and Vibration

Action Required	Applies to	Details
Management Measures		
Implement community consultation measures – inform community of construction activity and potential impacts	Airborne noise Ground-borne vibration	Incorporate into Community Liaison Plan

Action Required	Applies to	Details
Site inductions	Airborne noise Ground-borne vibration	All employees, contractors and subcontractors are to receive a Project induction. The environmental component may be covered in toolboxes and should include: • all relevant project specific and standard noise and vibration mitigation measures; • relevant licence and approval conditions; • permissible hours of work; • any limitations on high noise generating activities; • location of nearest sensitive receivers; • construction employee parking areas; • designated loading/unloading areas and procedures; • site opening/closing times (including deliveries); and • environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height where practicable, throwing of metal items and slamming of doors.
Monitoring	Airborne noise Ground-borne vibration	See Section 4.5.2.3
Site specific attended vibration measurements	Ground-borne Vibration	As required
Source Controls		
Construction hours and scheduling	Airborne noise Ground-borne vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods if practicable.
Construction respite period	Airborne noise Ground-borne vibration	Noise and vibration generating activities with impulsive, tonal or low frequency characteristics (such as jack hammering, rock breaking, rock hammering, vibratory rolling) should only be carried out: • in continuous blocks, up to but not exceeding 3 hours each; and • with a minimum respite period of one hour between each block.
Equipment selection	Airborne noise Ground-borne vibration	Use quieter and less noise/ vibration emitting construction methods where feasible and reasonable. Where vibration intensive equipment is used within the minimum working distances identified, determine whether alternative construction methodology or less vibration intensive equipment can be used, e.g. when piling is required, use bored piles rather than impact-driven piles.
Maximum noise levels	Airborne noise	All plant and equipment to be appropriately maintained to ensure optimum running conditions, with periodic monitoring.
Use and siting of plant	Airborne noise Ground-borne vibration	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be limited/ avoided where possible. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised where practicable. Plant used intermittently to be throttled down or shut down when not in use where practicable. Noise-emitting plant to be directed away from sensitive receivers where possible.

Action Required	Applies to	Details
Plan worksites and activities to minimise noise and vibration	Airborne noise Ground-borne vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) should be fitted and used on all construction vehicles and mobile plant regularly used on site for periods of over two months where practicable.
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise	Ensure all deliveries occur during standard construction hours.
Path Controls		
Shield sensitive receivers from noisy activities	Airborne noise	Where reasonable and feasible, use structures to shield residential receivers from noise such as: • site shed placement; • earth bunds; • temporary noise screens (where practicable) • enclosures to shield fixed noise sources such as pumps, compressors, fans etc screens (where practicable); and • consideration of site topography when situating plant.

4.5.2 Additional Noise Mitigation and Management

4.5.2.1 Noise Control Measures

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 "Guide to Noise Control on Construction, Demolition and Maintenance Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 23 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 23 – Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	20	20

Noise Control Method	Practical Examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	5 to 10	5 to 10	15	15
Engine Silencing	Residential class mufflers	15 to 25	10 to 20	50	30
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and would be referred to in preference to those of AS2436, for this assessment.

Table 24 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 24 – Noise Control Measures for Likely Construction Plant

Plant Description	Screening	Acoustic Enclosures	Silencing	Alternative Process
Pneumatic Hand Tools (general)	✔	✔	✔	✔
Excavator/Compactor/Rollers	✔	✖	✔	✖
Pavement Laying Machine	✔	✖	✔	✖
Trucks (>20 tone)	✔	✖	✔	✖
Water Cart	✔	✖	✔	✖

A construction noise and vibration management plan should be implemented to avoid adverse noise and vibration disturbance to affected residences.

4.5.2.2 Work Outside Standard Hours

Receivers in NCAs 1, 2, 3 and 4 found to be impacted by works outside standard hours should be notified by letterbox drop. The notification should explain the type and duration of the activities to be carried out and that noise levels generated by these activities may be audible. The notification should also inform residents of the complaints handling procedure.

4.5.2.3 Regular Periodic Noise Monitoring

The following approach would be adopted with regard to noise monitoring procedures during the construction works.

- Where potential noise impacts are predicted to be within 10 to 15dB(A) of the noise management level, the potential construction noise nuisance is considered to be moderate. Noise monitoring should be carried out to confirm predicted noise impacts within two weeks of commencement of construction. Reasonable and feasible noise reduction measures would be investigated, where necessary.

- Where potential noise impacts are predicted to be more than 15dB(A) above the noise management levels, the potential construction noise nuisance is considered to be high. All reasonable and feasible noise control measures should be implemented prior to the commencement of construction works. Noise compliance monitoring for all major equipment and activities on the sites should be undertaken prior to their commencement of work on site. Finally, noise levels during construction should be monitored and where exceeded, further noise reduction measures (where reasonable and feasible) should be implemented eg. restrict working hours, use silencing equipment.

4.5.2.4 Construction Site Compounds

Noise levels from construction compounds are predicted to generally comply with the set noise goals, with the potential for only minor exceedances. The following general noise management measures should be considered for Compound 1 to minimise noise levels.

- Buildings and sheds on site should be located so that they provide additional noise shielding for residences.
- All personnel (including sub-contractors) working on site shall be site inducted. The site induction shall their responsibilities with regard to noise management.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when operating plant and turn off equipment when not in use.

4.5.2.5 Complaints Handling Procedure

In addition to the noise mitigation measures outlined above, it is recommended that a management procedure be put in place to deal with noise complaints that may arise from the construction works. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.

5 CONSTRUCTION VIBRATION ASSESSMENT

5.1 Vibration Criteria

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of vibration, are all important aspects in both the annoyances caused and the strains induced in structures.

The effects of ground vibration on buildings near construction sites may be broadly defined by the following three categories:

1. Disturbance to building occupants (human comfort) - Vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,
2. Effects on building contents - Vibration where the building contents may be affected, and,
3. Effects on building structures - Vibration in which the integrity of the building or structure itself may be prejudiced.

Category 1 – Human Comfort

For disturbance to human occupants of buildings, we refer to *'Assessing Vibration; a technical guideline'*, published by DECC in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*.

Vibration sources are defined as Continuous, Impulsive or Intermittent. Section 2 of the technical guideline defines each type of vibration as follows:

- **Continuous** vibration continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).
- **Impulsive** vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at about the same amplitude, providing that the duration is short, typically less than 2 seconds.
- **Intermittent** vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude.

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'

Preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced below.

Table 25 – Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- & y-axis	z-axis	x- & y-axis
Continuous vibration					
Critical areas[2]	Day or night	0.005	0.0036	0.010	0.0072
Residences[3]	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions & places of worship	Day or night	0.020	0.014	0.040	0.028
Workshops	Day or night	0.04	0.029	0.080	0.058
Impulsive vibration					
Critical areas[2]	Day or night	0.005	0.0036	0.010	0.0072
Residences[3]	Day	0.30	0.21	0.60	0.42
	Night	0.10	0.071	0.20	0.14
Offices, schools, educational institutions & places of worship	Day or night	0.64	0.46	1.28	0.92
Workshops	Day or night	0.64	0.46	1.28	0.92

Notes:
1. *Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am*
2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992*
3. *The criteria for residences also applies to aged care facilities*

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 2.4 of the guideline and are reproduced below.

Table 26 – Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$)

Location	Daytime Values[1]		Night-time Values[1]	
	Preferred	Maximum	Preferred	Maximum
Critical areas[2]	0.10	0.20	0.10	0.20
Residences[3]	0.20	0.40	0.13	0.26

Location	Daytime Values[1]		Night-time Values[1]	
	Preferred	Maximum	Preferred	Maximum
Offices, schools, educational institutions & places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:
1. *Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am*
2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992*
3. *The criteria for residences also applies to aged care facilities*

Category 2 – Effects on building contents

The typical frequency range of road and bridge construction induced ground vibration is around 8 Hz to 100 Hz. Over this range the threshold of visible movement of building contents such as plants, pictures, blinds etc is around 0.5 mm/s. At vibration levels higher than 0.9 mm/s, audible rattling of loose objects such as crockery can be expected.

Category 3 – Structural Damage to Buildings

There is currently no Australian Standard for assessment of building damage caused by vibrational energy. However, the British Standard 7385: Part 2 "Evaluation and measurement of vibration in buildings", can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The German standard DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures", also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum 'safe limit' of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (eg historical with preservation orders etc), it is 3mm/s. These limits increase as the frequency content of the vibration increases.

These values are presented in Table 27 and are generally recognised to be conservative.

Table 27 – Structural Damage Criteria - Safe Limits for Building Vibration

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation At Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation At Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

5.2 Construction Vibration Sources

Typical vibration levels from construction equipment most likely to cause significant vibration are summarised below. The information was sourced from a variety of reference materials available in the Renzo Tonin & Associates library.

Table 28 – Typical Ground Vibration Generated by Construction Plant

Activity	Typical Ground Vibration
Excavators / Bulldozers	Typical ground vibration from excavators and bulldozers range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s.
Rock Hammers	Typical ground vibration levels at various distances from rock-breakers operating in hard sandstone range from 4.5 mm/s at 5 m, 1.3 mm/s at 10 m, 0.4 mm/s at 20 m and 0.2 mm/s at distances greater than 30 m. At distances greater than 50m, vibration are usually below 0.1 mm/s.
Compactor	Compactors typically generate 20mm/s at distances of approximately 5m, 2mm/s at distances of 15m. At distances greater than 30m, vibration are usually below 0.3mm/s.
Vibratory rollers	Ground vibration caused by vibratory rollers can range up to 1.5mm/s at distances of 25m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground/structure. Machinery should therefore not be brought to rest when in the vicinity of susceptible buildings, especially dwellings. Higher levels could occur at closer distances, however, no damage would be expected for any building at distances greater than approximately 12m (for a medium to heavy roller).
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels in the range of 0.01 - 0.2mm/s at the footings of buildings located 10 - 20m from a roadway. Very large surface irregularities can cause levels up to five to ten times higher. In general, ground vibration from trucks is usually imperceptible in nearby buildings. The rattling of windows and other loose fittings that is sometimes reported is more likely to be caused by airborne acoustic excitation from very low frequency (infrasonic) noise radiated by truck exhausts and truck bodies. While this may cause concern to the occupants, the phenomenon is no different from the rattling caused by wind or people walking or jumping on the floor and fears of structural damage or even accelerated ageing are usually unfounded.

5.3 Predicted Vibration Levels

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of vibration, are all important aspects in both the annoyances caused and the strains induced in structures.

Vibration generated by construction plant was estimated at various distances and expected vibration impacts are shown in Table 29 below.

Table 29 – Potential Vibration Impact Assessment

Approx. Distance	Assessment on Potential Vibration Impacts		
	Structural Damage Risk	**Human Disturbance**	**Vibration Monitoring**
≤5 m	**Medium** risk of structural damage as a result of vibratory rollers, compactors	**High** risk of adverse comment as a result of excavator, rockhammer, bulldozer, rollers and compactors	Vibration monitoring may be required
5m to <20 m	**Low** risk of structural damage	**Medium** risk of adverse comment as a result of excavator, rockhammer, bulldozer, rollers and compactors	Vibration monitoring may be required
20m to <30 m	**Low** risk of structural damage	**Low** risk of adverse comment	Vibration monitoring may be required
30m to <60 m	**Very Low** risk of structural damage	**Very Low** risk of adverse comment	Not required
>60 m	**Very Low** risk of structural damage	**Very Low** risk of adverse comment	Not required

The nearest sensitive receivers are in NCA 2b and are generally 10-20m from the north bound on ramp and bus bay works. The nearest residences are those in Lemongum Place near the merger of the northbound onramp with the main carriageway. Due to the nature of works being carried out, the risk of structural damage is assessed as being low risk. However, there is medium risk of adverse comment at these receivers as a result of vibration generated by excavator, rock hammer, bulldozer, rollers and compactors as the occupants may feel some vibration.

Recommendations for reducing potential vibration impacts, including minimum working distances for construction plant are provided in Section 5.4 below.

5.4 Vibration Mitigation

5.4.1 Recommended Minimum Buffer Distances

The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific. Accordingly, based on our database containing vibration measurements from past projects and library information, Table 30 below presents the recommended safe working distances for high vibration generating plant.

Table 30 - Recommended Minimum Working Distances for Vibration Intensive Plant

Plant Item	Rating / Description	Minimum Working Distance	
		Cosmetic Damage	Human Response
Vibratory Roller[1]	< 50 kN (Typically 1-2 tonnes)	5 m	15m – 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	< 300 kN (Typically 13-18 tonnes)	20 m	100 m
	< 300 kN (Typically > 18 tonnes)	25 m	100 m
Compactors[2]	-	15 m	100 m
Dozer[1]	(D810) with ripper	2 m (nominal)	10 m
Excavators[2]	≤ 30 Tonne (travelling/ digging)	10 m	15 m
Grader[1]	<= 20 tonne	2 m (nominal)	10 m
Loaders[2]	-	-	5 m
Small Hydraulic Hammer[2]	300kg (5-12 tonne excavator)	2 m	7 m
Medium Hydraulic Hammer[2]	900kg (12-18 tonne excavator)	7 m	23 m
Large Hydraulic Hammer[2]	1600kg (18-34 tonne excavator)	22 m	73 m
Jackhammer[2]	Hand held	1 m (nominal)	Avoid contact with structure
Truck Movements[2]	-	-	10 m

Notes: 1. TCA Construction Noise Strategy (Rail Projects) November 2011
2. Renzo Tonin & Associates project files, databases & library

Site specific buffer distances should be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on site. Where construction activity occurs in close proximity to sensitive receivers, minimum buffer distances to affected receivers should be determined by site measurements and maintained in order to comply with relevant vibration limits.

5.4.2 Vibration Management Measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort and structural damage vibration limits:

1. A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding

the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Where construction activity occurs in close proximity to sensitive receivers, vibration testing of actual equipment on site would be carried out prior to their commencement of site operation to determine acceptable buffer distances to the nearest affected receiver locations.

4. Dilapidation surveys should be conducted at all buildings within the distances identified in the last column of Table 30. These distances are set to address potential community concerns that perceived vibration may have caused damage to property.

6 TRUCK INSPECTION BAY

6.1 Site Description

There is currently an informal truck inspection bay on the east side of Alford's Point Road, just north of NCA 4. As part of the project it is proposed to create a formal truck inspection bay further south, under the Old Illawarra Road overpass.

The hours of operation for the inspection bay are generally 6am to 6pm Monday to Saturday, although there may be ad-hoc inspections outside these hours.

Figure 4 shows the location of the inspection bay and nearby receivers. The nearest residential receivers to the inspection bay have been identified as follows:

R1 – residences in Gerald Road and Lee Place to the east of the inspection bay.

R2 – residence to the north located between Alfords Point Road and Old Illawarra Road.

R3 – residences to the west in Travis Place.

R4 – new residences to the north (some still under construction) in Bachli Place.

Figure 4 – Truck Inspection Bay and Receivers

6.2 Noise Monitoring

Additional noise monitoring was conducted to establish existing noise levels in the vicinity of the proposed inspection bay. To quantify the existing ambient noise environment, long-term (unattended) noise monitoring was conducted over a one week period in December 2012 in the rear yard of 7 Lee Place. This was the nearest location to the proposed inspection bay where permission to monitor was obtained, whilst avoiding properties with pool pumps and air conditioners that could potentially affect the monitoring results. The noise monitor was positioned outdoors in the open (away from building facades).

The monitoring data was analysed and the background noise levels for the day, evening and night period were determined in accordance with the NSW 'Industrial Noise Policy' (INP) procedures. The INP requires that the level of background noise be assessed separately for the daytime, evening and night-time periods. These periods are defined as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

Table 31 – Measured Existing Background Noise Levels, dB(A)

Location	L_{90} Background Noise Levels		
	Day	Evening	Night
7 Lee Place	48	44	31

6.3 Operational Noise Criteria

There are no specific criteria for addressing noise from truck inspection bays. Therefore for the purpose of this assessment, it is appropriate to assess its potential impact on the general noise amenity surrounding the site based on the NSW INP and the OEH's sleep arousal guidelines.

6.3.1 NSW INP

The assessment procedure in terms of the NSW 'Industrial Noise Policy' (INP, Environment Protection Authority 2000) has two components:

- Controlling intrusive noise impacts in the short term for residences; and
- Maintaining noise level amenity for residences and other land uses.

Intrusiveness Criteria

In order to assess the intrusiveness impact of the inspection bay in accordance with the INP, the applicable noise intrusiveness criterion is as follows:

$L_{Aeq,15min}$ ≤ rating background level plus 5 dB(A)

Amenity Criteria

Assessment of the operation of the inspection bay against the amenity criteria is not suitable as noise events are short duration and only occur infrequently within the day, evening and night periods. The few short duration noise events that do occur within these periods would have no impact on the noise amenity of the surrounding area.

6.3.2 Sleep Disturbance Noise Criteria

Noise emanating from the inspection bay after 10pm and before 7am has the potential for creating sleep disturbance. The INP does not address the issue of sleep disturbance. A number of other publications produced by the EPA however make the general observation that a person's sleep can be significantly disrupted by noise and provide guidance on this matter.

Guidance for assessing sleep disturbance resulting from short-duration high-level noises which occur between 10pm and 7am is taken from the OEH's policy with respect to sleep disturbance as follows:

> *"Peak noise level events, such as reversing beepers, noise from heavy items being dropped or other high noise level events, have the potential to cause sleep disturbance. The potential for high noise level events at night and effects on sleep should be addressed in noise assessments for both the construction and operational phases of a development. The INP does not specifically address sleep disturbance from high noise level events.*
>
> *OEH reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*
>
> *From the research, OEH recognised that current sleep disturbance criterion of an LA1, (1 minute) not exceeding the LA90, (15 minute) by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, OEH will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*
>
> *The detailed analysis should cover the maximum noise level or LA1, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:*
>
> - *how often high noise events will occur*
> - *time of day (normally between 10pm and 7am)*

- *whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*

The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response. OEH will accept analysis based on either LA1, (1 minute) or LAMax).”

The policy states that a sleep disturbance criterion of $L_{A1(1min)} \leq L_{A90(15min)} + 15dB(A)$, should be used as a first step ‘guide’ as it is ‘not ideal’ and ‘where it is not met, a more detailed analysis is required’. That detailed analysis includes a reference to the research material contained in the NSW ‘Environmental Criteria for Road Traffic Noise’ (ECRTN) in the assessment of the subject proposal.

Appendix B of the NSW ‘Environmental Criteria for Road Traffic Noise’ (ECRTN), 1999 summarises the findings of world-wide research undertaken on sleep disturbance from noise up until the time when this publication was produced. It summarises all of the research with the following statement:

“Considering all of the foregoing information the following conclusions can be drawn:

- *Maximum internal noise levels below 50-55dB(A) are unlikely to cause awakening reactions.*
- *One or two noise events per night, with maximum internal noise levels of 65-70dB(A), are not likely to affect health and wellbeing significantly.”*

Therefore, from the above research a 50-55 dB(A) maximum internal noise level would be equivalent to approximately 65-70 dB(A) maximum noise level outside a bedroom window. These external noise limits are in line with the noise limits described by Griefahn (ref. Acoustics Australia vol 20 No 2 August 1992 pp 43-47) and the NSW ECRTN policy which addresses sleep disturbance.

In summary, the sleep disturbance criteria described in policies presented above are used for the purpose of noise impact assessment for this study. However, due consideration is also given to the ECRTN’s research findings in setting an appropriate ‘upper’ limit.

6.4 Operational Noise Sources

Typical noise sources for truck inspection bays were obtained from measurements and data in the Renzo Tonin & Associates’ library and are summarised in the Table 32. The data includes individual sound power levels for a variety of sources associated with trucks, allowing for the assessment of noise impacts against the NSW INP. L_{Amax} source noise levels are also provided as they are to be used to assess the potential for sleep disturbance impact. These levels are used to predict noise levels at the potentially most affected residences.

Table 32 – Sound Power Levels for Truck Inspection Bay Activities

Activity	Sound Power Level, dB(A) re. 1pW	
	L_{eq}	L_{max} / L_1
Truck entering inspection bay	102	–
Truck exiting inspection bay	108	–
Truck idling and refrigerator condenser units on	96	–
Truck reverse signal	–	107
Truck air brake release	–	116

6.5 Predicted Noise Levels & Assessment

6.5.1 Operational Noise

Noise emissions from typical activities at the inspection bay were determined by modelling the noise sources, receiver locations and topographical features of the surrounding area.

We are advised that a typical truck inspection takes approximately five minutes, and generally only one truck is inspected at a time. Allowing time for changeover between the conclusion of one inspection and the beginning of the next, the 'worst-case' scenario for any 15-minute period was assumed to be:

- 2 trucks entering the inspection bay;
- 2 trucks idling continuously with mounted refrigeration equipment on and in use; and
- 2 trucks exiting the inspection bay.

Based on the above worst-case scenario, the predicted operational noise levels at the nearest affected receivers during the day and night time periods are presented below. The inspection bay is located within a deep cutting underneath the Old Illawarra Road overpass and the cutting itself provides noise shielding to residences, particularly to residences on the eastern side of the road.

Table 33 – Predicted L_{Aeq} Truck Inspection Bay Noise Levels

Receiver	Criteria			Predicted Noise Level, $L_{Aeq,15min}$
	Day	Evening	Night	
R1- Gerald Rd	53	49	36	36
R2 – Old Illawarra Rd				40
R3 – Travis Pl				39
R4 – Bachli Pl				42

Noise levels from the operation of the proposed truck inspection bay are predicted to comply with the day and evening criteria. Therefore operation of the bay between 7am and 10 pm is permissible.

The inspection bay is also proposed to operate between 6am and 7am. This shoulder period has background noise levels similar to daytime levels due to high levels of traffic during the morning peak. Therefore noise emissions from the inspection bay between 6am and 7am would also comply and operation during this period is also permissible.

The night time noise goal of 36dB(A) is determined from the low background noise levels measured in the middle of the night between about 1am and 4am. It would only be during this period where noise from the inspection bay would potentially exceed the noise goals.

The operational hours of the inspection bay are proposed to be generally 6am to 6pm Monday to Saturday. This noise assessment shows that operation during these proposed hours is permissible and no adverse noise impacts are expected during these hours.

While there may also be ad-hoc inspections outside these hours, provided that use of the bay is avoided during the quietest part of the night period between about 1am and 4am, then no adverse noise impacts are expected.

6.5.2 Sleep Disturbance

For any use of the inspection bay during the night between 10pm and 7am, sleep disturbance should be considered. For the assessment of sleep disturbance the following worst-case scenario during the night time period was assumed:

- 1 truck releasing air brakes on site; and
- 1 truck reversing with beeping alarm on site.

Based on the above worst-case scenario, the predicted maximum noise levels at the receiver locations are as follows:

Table 34 – Predicted Truck Inspection Bay Maximum Noise Levels

Receiver	Criteria	Predicted L_{Amax}
R1- Gerald Rd	31 + 15 = **46** (screening test)	59
R2 – Old Illawarra Rd		60
R3 – Travis Pl	**65** (upper limit)	57
R4 – Bachli Pl		62

Maximum noise levels from the operation of the inspection bay are predicted to exceed the 'background + 15' criteria during the night time period. However the predicted noise levels are below the upper limit of 65dB(A), which relates to an equivalent internal limit where noise levels are unlikely to cause awakening reactions. Therefore activities within the truck inspection bay are predicted to comply with the sleep disturbance requirements.

7 CONCLUSION

Renzo Tonin & Associates have completed a noise and vibration assessment of the proposed upgrade Alfords Point Road, between Alfords Point Road Bridge and Brushwood Drive, Alfords Point. Noise from the operation of the upgraded road has been assessed, along with noise and vibration associated with the project construction activities.

The findings of this study are:

- Traffic noise levels at the design year for the 'build' option are predicted to be within 2dB(A) of the 'no build' option and therefore the project is assessed as not causing any 'significant' noise impact with regard to operational noise.
- Existing and future traffic noise levels are 'acute' at some residential receivers and therefore according to the assessment procedures, these properties must be considered for noise mitigation. The properties to be considered for noise treatment have been identified and possible noise mitigation options have been discussed. Since the project is still in concept phase, final noise mitigation treatments will not be decided until the 'detailed design phase' to allow for all design changes to be considered.
- Construction noise is likely to exceed the construction noise goals during all periods for first row receivers, and impacts will be greatest during any night time work. All reasonable and feasible noise mitigation should be applied during the construction phase. Possible noise mitigation measures and their effectiveness have been discussed.
- The risk of structural damage during construction is assessed as being low risk. There is medium risk of adverse comments from the nearest receivers for felt vibration. Vibration mitigation measures and appropriate buffer distances have been provided.
- Noise from the proposed new truck inspection bay located under the Old Illawarra Road overpass is not predicted to cause any adverse noise impacts during the proposed general hours of use between 6am and 6pm Monday to Saturday.