Noise and Vibration Assessment

Willyama High School Demolition Works
Radium Street
Broken Hill, NSW

Prepared for: Barker Ryan Stewart
March 2025
MAC252351-01RP1V1

Muller Acoustic Consulting

Document Information

Noise and Vibration Assessment

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Radium Street

Broken Hill, NSW

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CONTENTS

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1 Introduction

Muller Acoustic Consulting Pty Ltd (MAC) has been commissioned by Barker Ryan Stewart (BRS), on behalf of the NSW Department of Education (DOE), to prepare a Noise and Vibration Assessment (NVA) for the demolition of Willyama High School located at Radium Street, Broken Hill, NSW (the project).

The purpose of the NVA is to quantify potential environmental noise emissions associated with the project and provide recommendations for potential noise mitigation and management measures, where impacts are identified.

This assessment has been undertaken in accordance with the following documents:

- NSW Environment Protection Authority (EPA), Noise Policy for Industry (NPI), 2017;
- NSW Department of Environment and Climate Change (DECCW) – NSW Interim Construction Noise Guideline (ICNG), July 2009;
- School Infrastructure NSW (SINSW), 2023, Noise, Vibration and Traffic Factsheet;
- NSW Environment Protection Authority (EPA), Approved Methods for the measurement and analysis of environmental noise in NSW, 2022; and
- Australian Standard AS 1055:2018 - Acoustics - Description and measurement of environmental noise - General Procedures.

A glossary of terms, definitions and abbreviations used in this report is provided in **Appendix A**.

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2 Project Description

2.1 Project Overview

The work under this project is for the demolition of Willyama High School located at Radium Street, Broken Hill, NSW.

The project site is bounded by Radium Street, Murton Street and McGowen Lane, Broken Hill, NSW (refer to **Figure 1**).

The objectives of this project are to safely demolish, remove and responsibly dispose all existing infrastructure on the Willyama High School site, excluding Block B, Block C and Shade Shelters SS7, SS8 and SS(, but including the following:

- Buildings - Blocks A;
- All covered walkways (CW1 to CW3 inclusive);
- Shade shelters SS1 to SS6 inclusive;
- All carpark and pavement slabs, excluding the slabs under Shade Shelters SS7, SS8 and SS9;
- All fencing (other than the site perimeter fence);
- All underground services (excluding any town services); and
- All contents, equipment, and sundry items (loose and/or fixed) with-in the buildings and/or on the site.

At the completion of the demolition works, the site is to be remediated, including the supply, installation and compaction of all necessary clean fill (VENM or ENM) to achieve a clean, free draining site ready for the future building of a new school on the site.

2.2 Proposed Work Hours

All works will be scheduled during the recommended standard hours for construction work, as per the NSW Interim Construction Noise Guideline (ICNG), being:

- Monday to Friday 7am to 6pm;
- Saturday 8am to 1pm; and
- No work on Sunday or public holidays.

The project is anticipated to take 20 weeks to complete, and the estimated maximum number of personnel on site would be 25 workers during soft demolition works and hazardous materials removal.

2.3 Receiver Review

The area surrounding the project site is typically zoned R1 (General Residential) to the east, south and west, and C2 (Environmental Protection Zone) to the north. There are small areas of RE1 (Public Recreation) (Broken Hill Regional Aquatic Centre) and E1 (Local Centre) (Broken Hill IGA and Broken Hill Post Office) located within the wider residential area.

The nearest residential receivers are located on Brooks Street (Noise Catchment Area (NCA) 1), McGowan Street (NCA 2) and Fisher Street (NCA 3), about 30m to west, east and south of the project boundary respectively. The nearest non-residential receivers are identified as the Broken Hill IGA, about 120m to the southeast of the project site, and the Broken Hill Regional Aquatic Centre, about 200m to the west of the project site.

The locality plan identifying the position of the potentially affected receivers is provided in **Figure 2**.

FIGURE 1

PROPOSAL SITE

MAC252351-01

WILLYAMA HS DEMOLITION

KEY

- Project Site
- Site Compound
- Hardstand Areas
- Structures to be Removed
- Structures to be Retained
- Mobile Crusher

0 20 40 60 80 m

N

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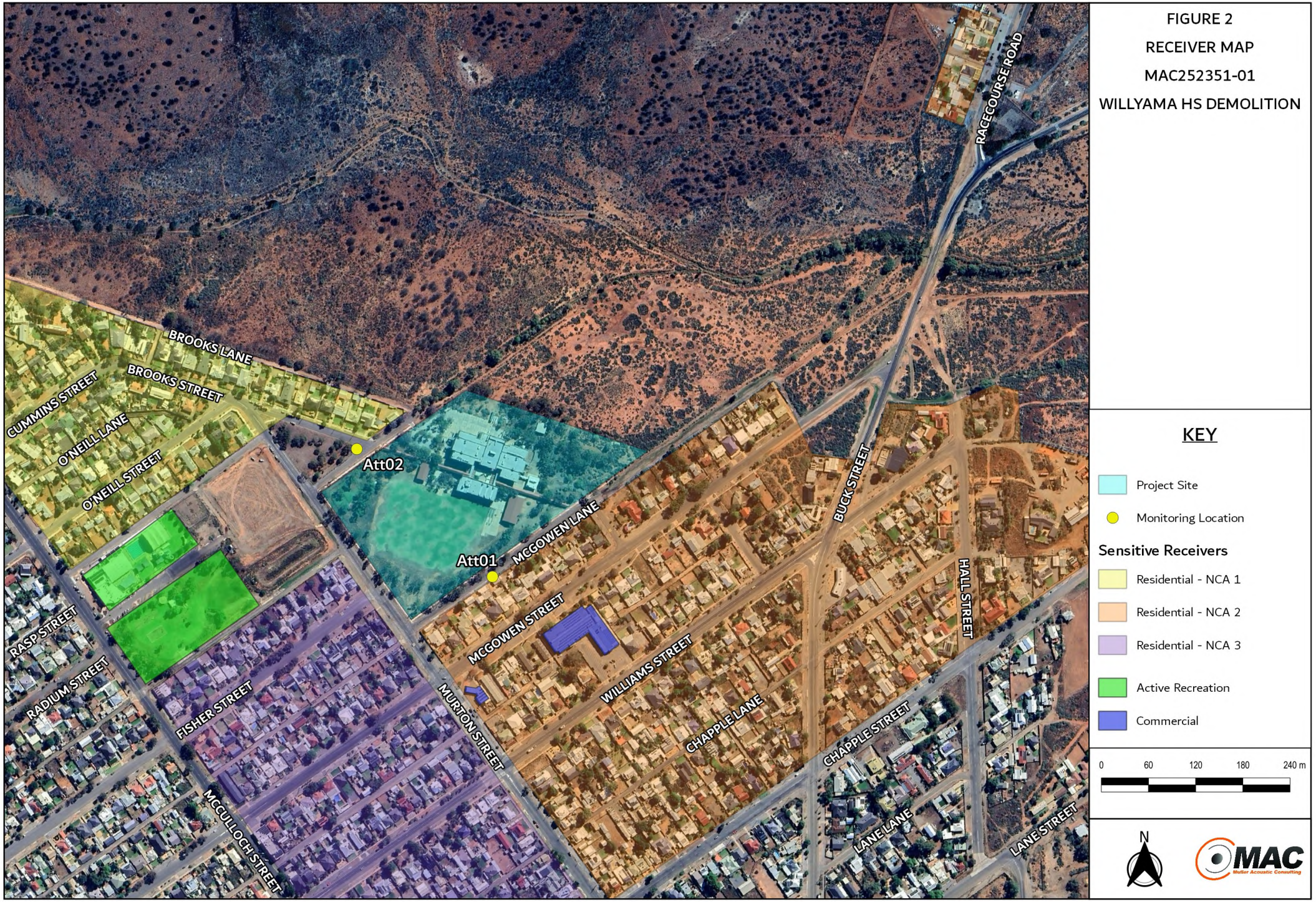


FIGURE 2
RECEIVER MAP
MAC252351-01
WILLYAMA HS DEMOLITION
KEY
Project Site
Monitoring Location
Sensitive Receivers
Residential - NCA 1
Residential - NCA 2
Residential - NCA 3
Active Recreation
Commercial
0
60
120
180
240 m
N
MAC
Muller Acoustic Consulting
Att01
Att02
BROOKS LANE
BROOKS STREET
CUMMINS STREET
O'NEILL LANE
O'NEILL STREET
MCGOWEN LANE
MCGOWEN STREET
BUCK STREET
HALL STREET
WILLIAMS STREET
CHAPPLE LANE
CHAPPLE STREET
LANE LANE
LANE STREET
RACECOURSE ROAD
MURTON STREET
RASP STREET
RADIUM STREET
FISHER STREET
MCCULLOCH STREET

3 Noise and Vibration Policy and Guidelines

3.1 Interim Construction Noise Guideline

The ICNG sets out procedures to identify and address the impacts of construction noise on residences and other sensitive land uses. This section provides a summary of noise objectives that are applicable to the assessment. The ICNG provides two methodologies for the assessment of construction noise emissions:

- quantitative, which is suited to major construction projects with typical durations of more than three weeks; and
- qualitative, which is suited to short term infrastructure maintenance (< three weeks).

This CNA has adopted a quantitative assessment approach, which includes identification of potentially affected receivers, derivation of the construction Noise Management Levels, quantification of potential noise impact at receivers via predictive modelling and, provides management and mitigation recommendations.

3.1.1 Standard Hours for Construction

Table 1 presents the ICNG recommended standard hours for construction works.

Table 1 Recommended Standard Hours for Construction

Daytime	Construction Hours
Monday to Friday	7am to 6pm
Saturdays	8am to 1pm
Sundays or Public Holidays	No construction

These recommended hours do not apply in the event of direction from police, or other relevant authorities, for safety reasons or where required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm.

Construction activities are anticipated to be undertaken during standard construction hours only.

3.1.2 Construction Noise Management Levels

Section 4 of the ICNG details the quantitative assessment method involving predicting noise levels and comparing them with the Noise Management Levels (NMLs) and are important indicators of the potential level of construction noise impact. **Table 2** reproduces the ICNG Noise Management Level (NML) for residential receivers. The NML is determined by adding 10dB (standard hours) or 5dB for OOH to the Rating Background Level (RBL) for each specific assessment period.

Table 2 Noise Management Levels

Time of Day	Management Level LAeq(15min)[1]	How to Apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays.	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq(15min) 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 work to be carried out, the expected noise levels and duration, as well as contact details.
	Highly Noise Affected 75dBA (HNA)	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 times identified by the community when they are less sensitive to noise such as before and after school for work near schools, or mid-morning or mid-afternoon for work near residences; and 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 strong justification would typically be required for work 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 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Note 1: The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the construction noise management levels for noise assessment purposes and is the median of the ABL's.

3.2 NSW Vibration Guideline

Department of Environment and Conservation (DEC) 2006, *Assessing Vibration: A Technical Guideline* (the guideline) provides guidance on determining effects of vibration on buildings occupants. The guideline does not address vibration induced damage to structures, blast induced vibration effects or structure borne noise effects.

British Standard BS 7385:Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2", gives guidance on the levels of vibration which building structures could be damaged. BS7385 also takes into consideration the frequency of the vibration which is critical when assessing the likelihood of building damage.

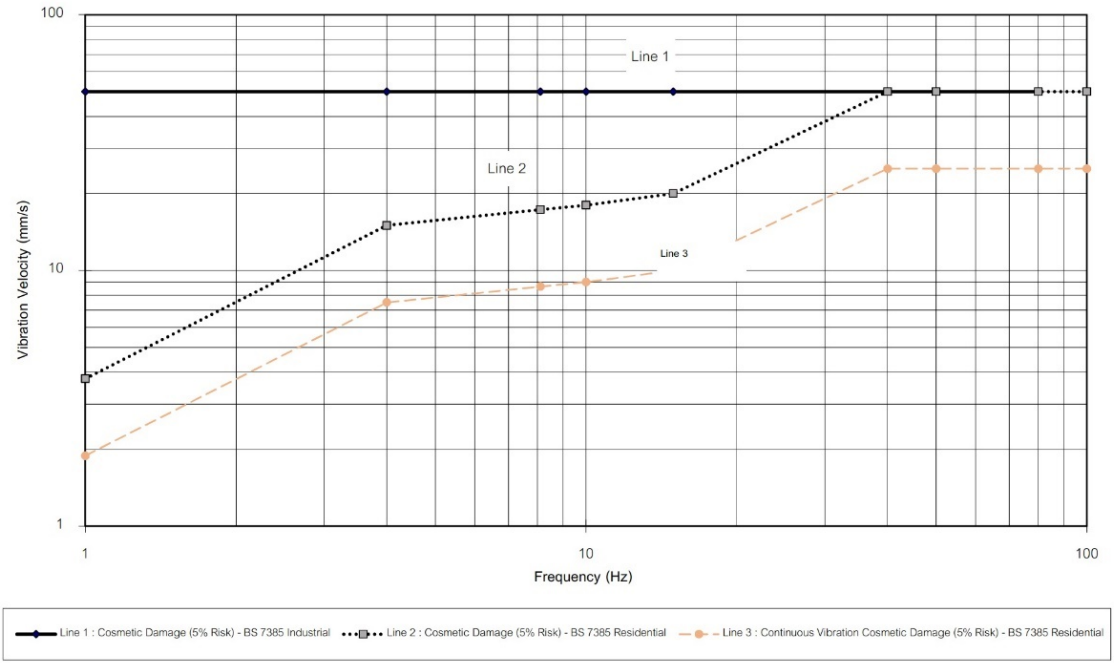
Guide values are set for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to result in a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and heavy commercial/industrial buildings are presented in **Table 3**, with a visual representation presented in **Figure 3**. Where sources of continuous vibration may give rise to dynamic magnification due to resonance, the values provided in **Table 3** should be reduced by 50%, this is especially the case with respect to Peak Particle Velocity (PPV) at lower frequencies.

Table 3 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4Hz to 15Hz	15Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

Figure 3 – Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage



3.2.1 Human Comfort – Assessing Vibration a Technical Guideline

Humans are far more sensitive to vibration than is commonly realised and may detect vibration levels which are well below levels that may cause damage to buildings or structures. Assessing vibration: a technical guideline was published in February of 2006 by the DECC and is based on guidelines contained in BS 6472 – 1992, Evaluation of human exposure to vibration in buildings (1-80 Hz) and provides guidance on assessing vibration against human comfort.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.

Table 4 Examples of types of vibration (from Table 2.1 of the guideline)		
Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)	Infrequent: Activities that create up to three distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990)	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

3.2.2 Continuous Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to continuous vibration (1-80Hz), the criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. **Table 5** reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 5 Criteria for Exposure to Continuous Vibration			
Place	Time[1]	Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working Areas (e.g. hospital operating theatres, precision laboratories)	Day or Night	0.14	0.28
Residences	Day	0.28	0.56
	Night	0.20	0.40
Offices	Day or Night	0.56	1.1
Workshops	Day or Night	1.1	2.2

Note: rms velocity (mm/s) and vibration velocity value (dB re 10^{-9} mm/s) values given for most critical frequency >8Hz assuming sinusoidal motion.

Note 1: Daytime is 7am to 10pm and Night-time is 10pm to 7am.

3.2.3 Impulsive Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to impulsive vibration (1-80Hz), these criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. Impulsive vibration (as defined in Section 2.1 of the guideline) is generally associated with infrequent activities that create up to three (3) distinct vibration events in an assessment period e.g. occasional dropping of heavy equipment, occasional loading and unloading. **Table 6** reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 6 Criteria for Exposure to Impulsive Vibration

Place	Time[1]	Assessment Criteria	
		Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working Areas (e.g. hospital operating theatres, precision laboratories)	Day or Night-time	0.14	0.28
Residences	Daytime	8.6	17.0
	Night-time	2.8	5.6
Offices	Day or Night-time	18.0	36.0
Workshops	Day or Night-time	18.0	36.0

Note 1: Daytime is 7am to 10pm and Night-time is 10pm to 7am.

3.2.4 Intermittent Vibration

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Intermittent vibration is representative of activities such as impact hammering, rolling or general excavation work (such as an excavator tracking).

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of Vibration Dose Values (VDV) which requires the measurement of the overall weighted RMS (root mean square) acceleration levels over the frequency range 1-80 Hz. To calculate VDV the following formula (refer section 2.4.1 of the guideline) was used:

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, a (t) is the frequency-weighted RMS of acceleration in m/s^2 and T is the total period of the day (in seconds) during which vibration may occur.

The Acceptable Vibration Dose Values (VDV) for Intermittent Vibration is reproduced in **Table 7**.

Table 7 Acceptable Vibration Dose Values (VDV) for Intermittent Vibration				
Location	Daytime		Night-time	
	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$
Critical Areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Note: Daytime is 7am to 10pm and Night-time is 10pm to 7am

Note: These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

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4 Assessment Criteria

4.1 Existing Acoustic Environment

To quantify the existing acoustic environment and determine construction noise management levels (NMLs), a series of short term (15 minute) operator attended noise measurements were conducted at the nearest potentially affected receivers.

The attended noise survey was conducted in general accordance with the procedures described in Australian Standard AS 1055:2018, "Acoustics – Description and Measurement of Environmental Noise" and Fact Sheet A: Determining existing noise levels (NPI, 2017).

The acoustic instrumentation used carries current NATA calibration and complies with AS/NZS IEC 61672.1-2019-Electroacoustics - Sound level meters - Specifications. Calibration of all instrumentation was checked prior to and following measurements. Drift in calibration did not exceed ±0.5dBA. All equipment carries appropriate and current NATA (or manufacturer) calibration certificates with records of all calibrations maintained by MAC as per the EPA's Approved Methods for the measurement and analysis of environmental noise in NSW (EPA, 2022).

The attended noise monitoring was conducted using one Svantek 971 noise analyser at the site (see **Figure 2**) on Wednesday 22 January 2025 to quantify ambient background noise levels.

The attended measurement identified that environmental noise (wind through vegetation and bird calls) was the dominant source, with domestic noise and traffic noise also contributing to the acoustic environment. The results of the short-term noise measurement and observations are summarised in **Table 8**.

Table 8 Operator-Attended Noise Survey Results

Date/Time (hrs)	Noise Descriptor (dB re 20µPa)			Meteorology	Description and SPL, dBA
	L_{Amax}	L_{Aeq}	L_{A90}		
Location Att01 – McGowen Lane					
22/01/2025 10:46	64	40	35	WD: SW WS: 2.5m/s 31°C	Wind-blown Vegetation 32-48 Domestic Noise 30-50 People Talking 40-64
Location Att02 – Radium Street					
22/01/2025 11:06	58	45	39	WD: SW WS: 2.5m/s 31°C	Wind-blown Vegetation 36-45 Traffic 33-58 Birds 33-45

4.2 Construction Noise Management Levels

The relevant NMLs for standard construction hours are presented in **Table 9**. The NMLs for all residential receivers were derived from the most conservative L_{A90} noise level of the monitoring locations (Location 1).

Table 9 Construction Noise Management Levels

Receiver ID	Assessment Period[1]	Adopted RBL dB L_{A90}	NML dB $L_{Aeq(15min)}$
All residential	Standard Hours	35	45 (RBL+10dBA)
Commercial	When in use	n/a	70
Active Recreation	When in use	n/a	65

Note 1: Refer to **Table 1** for Standard Recommended Hours for Construction.

4.3 Vibration Criteria

The recommended limits for transient vibration to ensure minimal risk of cosmetic damage to residential buildings are presented in **Table 10**.

Table 10 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4Hz to 15Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

The Acceptable Vibration Dose Values (VDV) for Intermittent Vibration is reproduced in **Table 11**. Vibration criteria is also presented as a peak velocity in mm/s, in accordance with Appendix C of the guideline, to provide ease of comparison with transient vibration guide values for cosmetic damage. It is noted that assessment of intermittent vibration for human comfort should consider the vibration dose values, with strong justification required for assessment against the peak velocity criteria.

Table 11 Acceptable Vibration Values for Intermittent Vibration

Location	Vibration Dose Values (VDV)		Peak Velocity[1]	
	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$	Preferred Value mm/s	Maximum Value mm/s
Residences	0.20	0.40	8.6	17.0

Note: These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

Note 1: Alternate values for peak velocity, as per Appendix C of the guideline provided as a guide. Sufficient justification required for the use of peak velocity approach

5 Modelling Methodology

A computer model was developed to quantify project noise emissions to neighbouring receivers using DGMR (iNoise, Version 2024.21) noise modelling software. iNoise is an intuitive and quality assured software for industrial noise calculations in the environment. 3D noise modelling is considered industry best practice for assessing noise emissions from projects.

The model incorporated a three-dimensional digital terrain map giving all relevant topographic information used in the modelling process. Additionally, the model uses relevant noise source data, ground type, attenuation from barrier or buildings and atmospheric information to predict noise levels at the nearest potentially affected receivers. Where relevant, modifying factors in accordance with Fact Sheet C of the NPI have been applied to calculations.

The model calculation method used to predict noise levels was in accordance with ISO 9613:1 and ISO 9613:2 including corrections for meteorological conditions using CONCAWE[1]. The ISO 9613 standards are the most used noise prediction method worldwide. Many countries refer to ISO 9613 in their noise legislation. However, the ISO 9613 standard does not contain guidelines for quality assured software implementation, which leads to differences between applications in calculated results. In 2015 this changed with the release of ISO/TR 17534-3. This quality standard gives clear recommendations for interpreting the ISO 9613 method. iNoise fully supports these recommendations. The models and results for the 19 test cases are included in the software.

5.1 Construction Noise Assessment Methodology

Noise emissions were modelled for the following scenarios:

- Site establishment / decommissioning;
- Soft demolition, including removal of loose and fixed furniture, fixtures and equipment, and removal of hazardous materials; and
- Structural demolition.

Noise emission data and assumptions for each construction scenario modelled in this assessment are summarised in **Table 12**. The noise emission data was typically sourced from the Transport for NSW Construction and Maintenance Noise Estimator Tool (CMNET).

[1] Report no. 4/18, "the propagation of noise from petroleum and petrochemical complexes to neighbouring communities", Prepared by C.J. Manning, M.Sc., M.I.O.A. Acoustic Technology Limited (Ref.AT 931), CONCAWE, Den Haag May 1981

Table 12 Acoustically Significant Sources - Sound Power Levels dBA (re 10^{-12} Watts)				
Item	Sound Power Levels[3] dB LAeq(15min)	Scenario		
		Establishment	Soft Demo	Structural Demo
Road Trucks	104	X	X	X
Mobile Crane	108	X		
Excavator (5t)	100	X	X	X
Excavator (20t)	105	X	X	X
Excavator (30t)	109			X
Excavator (45t)	113			X
Bobcat	104	X	X	X
Elevated Work Platform	98		X	
Power Tools	102		X	
Water Cart	101			X
Mobile Crusher (x2)[1,2]	109			X
Total Fleet SWL		**112**	**111**	**115 (117)**

Note 1: Where crushing is done on site, then a mobile crusher will be utilised.

Note 2: Crushing of building materials to be undertaken within a suitably made temporary enclosure.

Note 3: SWL for each individual item of equipment.

5.2 Vibration Assessment

Table 5 provides the minimum working distances for the use of various generic vibration intensive sources to nearby receivers. It is important to note that the minimum working distances are indicative and will vary depending on the particular item of equipment and local geotechnical conditions.

A review of equipment list for the proposal indicates that the demolition works would not require the use of vibration intensive plant and equipment, with works typically undertaken using excavators with sheer cutters or pulverisers. The demolition works would not require the use of any pneumatic hammers, rock breakers or vibratory rollers, or other significant vibration generating equipment. It is noted that during structural demolition works, a mobile crusher may be utilised on site. A review of aerial imagery indicates that the nearest residential receiver is located more than 150m from the proposed location of the mobile crusher. Hence, it is anticipated that the works would not generate vibration levels to cause human annoyance or cosmetic damage to structures to residential receivers.

Notwithstanding, where the demolition works require the use of vibration intensive equipment, a review of safe working distances should be undertaken.

Table 13 Acoustically Significant Sources - Sound Power Levels dBA (re 10^{-12} Watts)				
Equipment Item	Rating / Description	Minimum Working Distances		
		Cosmetic Damage BS 7385)	Heritage Item (DIN 4150)	Human Response (OH&E)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5m	10m	15m to 20m
	< 100 kN (Typically 2-4 tonnes)	6m	12m	20m
	< 200 kN (Typically 4-6 tonnes)	12m	24m	40m
	< 300 kN (Typically 7-13 tonnes)	15m	30m	100m
	> 300 kN (Typically 13-18 tonnes)	20m	40m	100m
	> 300 kN (> 18 tonnes)	25m	50m	100m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2m	4m	7m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	14m	23m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet piles	2m to 20m	up to 40m	20m
Pile Boring	≤ 800 mm	2m (nominal)	4m	4m
Jackhammer	Hand held	1m (nominal)	2m	2m
Profiler	Wirtgen W210	4m	8m	n/a
Asphalt Paver	Vogele Super 1800-3	1m	2m	n/a
Oscillating Roller	Hamm HD70 (Oscillating)	2m	4m	n/a
Static Roller	Hamm HD70 (Static)	1m	2m	n/a

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6 Noise Assessment Results

6.1 Construction Noise Assessment

Table 14 and **Table 15** summarise the predicted noise level range and number of potentially noise affected receivers for each of the assessed scenarios. The potentially affected areas, that is, areas where noise levels are predicted to be above the NMLs, are presented in **Figure 4** to **Figure 7.**

Table 14 Predicted Range of Construction Noise Levels for Nearby Sensitive Receivers

Receiver	Predicted Noise Level Range, dB $LA_{eq(15min)}$[1]				NML dB $LA_{eq(15min)}$
	Site Establishment	Soft Demo	Structure Demo	Structural Demo with Crushing	
Residential – NCA 1	**<30 – 53**	**31 – 56**	**33 – 63**	**34 – 64**	45
Residential – NCA 2	**<30 – 51**	**34 – 51**	**32 – 58**	**37 – 59**	45
Residential – NCA 3	**<30 – 53**	**<30 – 48**	**32 – 54**	**33 – 55**	45
Active Recreation	≤42	≤42	≤48	≤50	65
Commercial	≤44	≤45	≤48	≤51	70

Note: Predicted construction noise levels above the NMLs are highlighted and shown in **bold**.

Note 1: Noise levels from construction activities vary due to their position across the project site with respect to surrounding receivers.

Table 15 Number of Potentially Noise Affected Receivers

Receiver	Affected Distance[1] (m)	Number of Potentially Affected Receivers			
		Site Establishment	Soft Demo	Structure Demo	Structural Demo with Crushing
Residential – NCA 1	500	~15	~15	~25	~45
Residential – NCA 2	665	~15	~20	~45	~70
Residential – NCA 3	440	~20	~10	~35	~60
Active Recreation	n/a	0	0	0	0
Commercial	n/a	0	0	0	0

Note 1: Potentially affected distance from the site boundary.

The results of the predictive noise modelling demonstrates that construction noise levels are anticipated to exceed the NMLs for residences surrounding the project site during each of the proposed work stages, with noise levels of up to 19dB $LA_{eq(15min)}$ above the NML for the nearest residential receivers on Brooks Street during structural demolition works.

Noise levels are not expected to exceed the NMLs for non-residential receivers or the highly affected noise level of 75dB $LA_{eq(15min)}$ during any of the proposed work stages.

FIGURE 4

Noise contours

Scenario 1 - Site Establishment

MAC252351-01

WILLYAMA HS DEMOLITION

KEY

LAeq(15min) Noise Contours

- 45dB
- 50dB
- 55dB
- 60dB
- 65dB
- 70dB
- 75dB

0 60 120 180 240 m

N

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FIGURE 5

Noise contours

Scenario 2 - Soft Demolition

MAC252351-01

WILLYAMA HS DEMOLITION

KEY

LAeq(15min) Noise Contours

- 45dB
- 50dB
- 55dB
- 60dB
- 65dB
- 70dB
- 75dB

0 60 120 180 240 m

N

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FIGURE 6

Noise contours

Scenario 3 - Structural Demolition

MAC252351-01

WILLYAMA HS DEMOLITION

KEY

LAeq(15min) Noise Contours

- 45dB
- 50dB
- 55dB
- 60dB
- 65dB
- 70dB
- 75dB

0 60 120 180 240 m

N

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FIGURE 7

Noise contours

Scenario 3 - Structural

Demolition with Crushing

MAC252351-01

WILLYAMA HS DEMOLITION

KEY

LAeq(15min) Noise Contours

- 45dB
- 50dB
- 55dB
- 60dB
- 65dB
- 70dB
- 75dB

0 60 120 180 240 m

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7 Construction Noise Recommendations (Standard Mitigation Measures)

The results of the assessment indicate that the noise emissions during the demolition works are anticipated to exceed the relevant NMLs at nearby residential receivers by up to 8dB $LA_{eq(15min)}$ during site establishment works, up to 11dB $LA_{eq(15min)}$ during soft demolition works, and up to 19dB $LA_{eq(15min)}$ during structural demolition works. Therefore, in accordance with the ICNG, where noise from construction works is above the NMLs, the contractor should apply feasible and reasonable work practices to minimise noise.

To minimise the potential impacts of noise emissions to nearby sensitive receivers, it is recommended that the mitigation strategies in **Table 16**, as per the ICNG and AS2436, are considered. Employing these strategies could result in a conservative noise level reduction of up to 10dBA.

When determining the best mix of work practices, the contractor needs to consider what measures are feasible and what measures can be reasonably implemented. Not all standard mitigation measures are applicable to each project and should be considered on a case-by-case basis. Furthermore, the management of construction noise should be flexible, with the effectiveness of measures reviewed throughout the construction period.

Table 16 Construction Noise Mitigation Measures	
Mitigation Level	Mitigation Measures
Standard Mitigation	▪ Toolbox and induction of personnel prior to shift to discuss noise control measures that may be implemented to reduce noise emissions to surrounding receivers; ▪ Training (of employees to conduct quieter work practices); ▪ Avoid shouting, and minimise loud talking where neighbours can be affected; ▪ Equipment which is used intermittently is to be shut down when not in use; ▪ Where possible, machinery will be located/orientated to direct noise away from the closest sensitive receivers; ▪ Undertake regular maintenance of machinery to minimise noise emissions. Maintenance will be confined to standard daytime construction hours and where possible, away from noise sensitive receivers; ▪ The quietest suitable machinery reasonably available will be selected for each work activity; ▪ Avoid queuing of vehicles adjacent to any receivers; ▪ Where practicable, ensure noisy plant/machinery are not working simultaneously in close proximity to receivers; ▪ Where possible, all plant are to utilise a broad band reverse alarm in lieu of the traditional hi-frequency type reverse alarm; and ▪ Minimising the need for reversing or movement alarms.
Level 1 Mitigation (Including Standard Mitigation Level)	▪ Scheduling of construction activities to minimise the number of work fronts and simultaneous activities occurring along the boundary to minimise noise levels; ▪ Reduce throttle setting and turn off equipment when not being used; ▪ Wherever possible, subject to feasibility and reasonability, the quietest plant and equipment should be utilised in combination with management measures to minimise noise impacts; ▪ Where vehicle queuing is required, for example due to safety reasons, engines are to be switched off to reduce their overall noise impacts on receivers; ▪ Where available, use temporary site buildings and materials stockpiles as noise barriers; and ▪ Use mobile noise screens (which can achieve noise reductions of up to 8dBA), optimise the positioning of plant and equipment to minimise line of site to receivers or substitute noisy equipment to reduce the noise level at nearby receivers for these activities.

8 Discussion and Conclusion

Muller Acoustic Consulting Pty Ltd (MAC) has completed a Noise and Vibration Assessment (NVA) for the demolition of Willyama High School located at Radium Street, Broken Hill, NSW.

The results of the NVA indicate that the noise emissions are anticipated to exceed the relevant NMLs at nearby residential receivers by up to 8dB $L_{Aeq(15min)}$ during site establishment works, up to 11dB $L_{Aeq(15min)}$ during soft demolition works, and up to 19dB $L_{Aeq(15min)}$ during structural demolition works. Therefore, it is recommended that the contractor applies all feasible and reasonable work practices to minimise noise.

Noise levels are not expected to exceed the relevant NMLs for non-residential receivers or the highly affected noise level of 75dB $L_{Aeq(15min)}$ at any receivers during the proposed demolition works.

Recommendations have been provided to minimise the potential noise impacts from the demolition works, albeit of a temporary nature during standard construction hours.

A review of equipment list for the proposal indicates that the demolition works would not require the use of vibration intensive plant and equipment. Where a mobile crusher is utilised on site during structural demolition works, it is noted that the nearest residential receivers are located more than 150m from the proposed location of the mobile crusher and are unlikely to experience vibration levels above the human annoyance or cosmetic damage criteria. Notwithstanding, where the demolition works require the use of vibration intensive equipment, a review of safe working distances should be undertaken.

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Appendix A – Glossary of Terms

A number of technical terms have been used in this report and are explained in **Table A1**.

Table A1 Glossary of Acoustical Terms

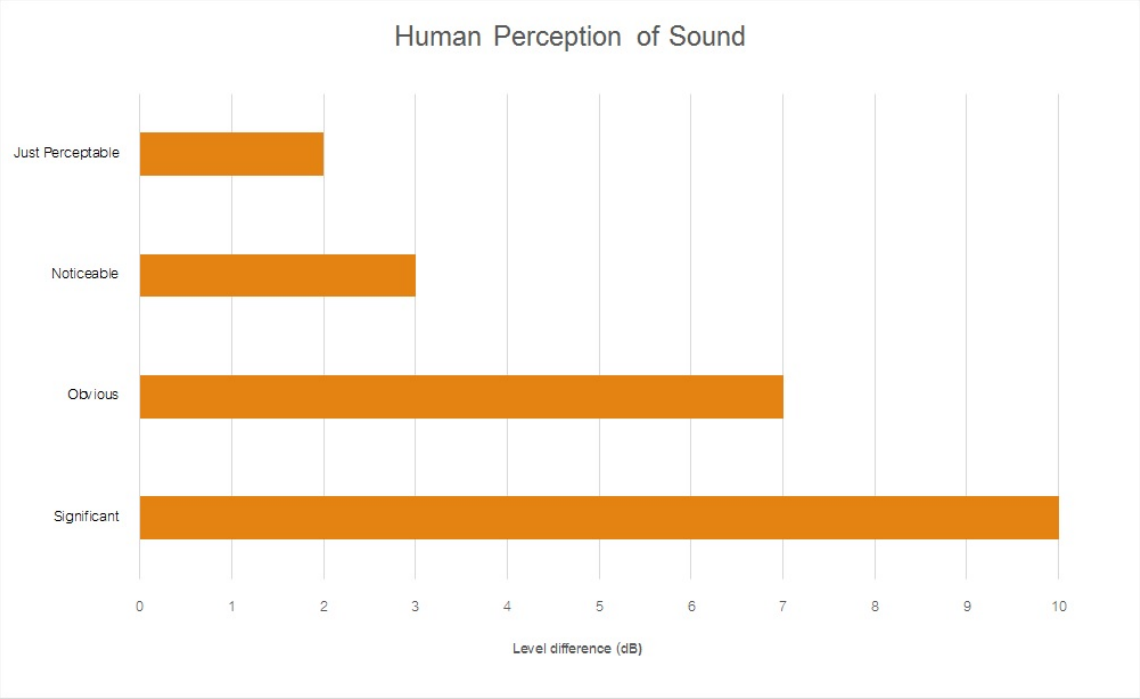
Term	Description
1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment Background Level (ABL) is defined in the NPI as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Ambient Noise	The total noise associated with a given environment. Typically, a composite of sounds from all sources located both near and far where no particular sound is dominant.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to sound.
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is usually represented by the LA90 descriptor
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(Z), dB(L)	Decibels Z-weighted or decibels Linear (unweighted).
Extraneous Noise	Sound resulting from activities that are not typical of the area.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
LA10	A sound level which is exceeded 10% of the time.
LA90	Commonly referred to as the background noise, this is the level exceeded 90% of the time.
LAeq	Represents the average noise energy or equivalent sound pressure level over a given period.
LAmax	The maximum sound pressure level received at the microphone during a measuring interval.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.
RBL	The Rating Background Level (RBL) as defined in the NPI, is an overall single figure representing the background level for each assessment period over the whole monitoring period. The RBL, as defined is the median of ABL values over the whole monitoring period.
Sound Power Level (Lw or SWL)	This is a measure of the total power radiated by a source in the form of sound and is given by 10.log10 (W/Wo). Where W is the sound power in watts to the reference level of 10^{-12} watts.
Sound pressure level (Lp or SPL)	the level of sound pressure; as measured at a distance by a standard sound level meter. This differs from Lw in that it is the sound level at a receiver position as opposed to the sound 'intensity' of the source.

Table A2 provides a list of common noise sources and their typical sound level.

Table A2 Common Noise Sources and Their Typical Sound Pressure Levels (SPL), dBA

Source	Typical Sound Pressure Level
Threshold of pain	140
Jet engine	130
Hydraulic hammer	120
Chainsaw	110
Industrial workshop	100
Lawn-mower (operator position)	90
Heavy traffic (footpath)	80
Elevated speech	70
Typical conversation	60
Ambient suburban environment	40
Ambient rural environment	30
Bedroom (night with windows closed)	20
Threshold of hearing	0

Figure A1 – Human Perception of Sound



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