New Primary School in Mulgoa Rise

Review of Environmental Factors – Noise & Vibration Assessment Report

School Infrastructure NSW
Level 8, 259 George Street
Sydney NSW 2000

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1 INTRODUCTION

A new primary school, namely the New Primary School in Mulgoa Rise (NPSMR), is to be located at 1-23 Forestwood Drive, Glenmore Park, NSW. As part of the response to the Secretary's Environmental Assessment Requirements (SEARs) in relation to this new development; an acoustic assessment is required. Therefore, Pulse White Noise Acoustics (PWNA) has been engaged to undertake this acoustic assessment.

Consequently, this report discusses the findings obtained from the acoustic assessment. This assessment addresses the impacts from typical operational activities and construction activities.

A list of acoustic terminology used in this report is included in Appendix A of this report.

1.1 Project Description

This acoustic assessment addresses the proposed development which includes a Core 21 school with 18 Home bases and 2 support classes, with the selected core facilities at Core 35, for the Hall, Library, Staff facilities and Admin. These facilities are distributed as follows (refer to Figure 2):

- Building A: Administrative offices, open office areas, interview rooms, library spaces, amenities.
- Buildings B2 and B3: Homebases, shared practical activity areas, amenities.
- Building C: Communal Hall, offices, storage spaces, canteen, amenities.
- Outdoor areas: Assembly space, games court, play space, covered outdoor learning areas (COLAs).
- Carpark comprising 17 car spaces for proposed stage.
- Waste collection area situated near the north-eastern corner of the project site.

It is proposed that the school will operate as follows:

- School hours: 8:00 am to 4:00 pm.
- Out of hours: 7:00 am to 8:00 am; 4:00 pm to 6:00 pm.
- Vacation care hours: 7:00 am to 6:00 pm, Monday to Friday, during school holidays

Additionally, it is intended that the Communal Hall in Building C, and library in Building A; operate between 6:30 pm and 10:00 pm as part of the out of hours operation. On rare occasions, these out of hours activities could extend till 12:00 am.

In the event of additional demand, the school can be expanded to a Core 35 primary school, facilitating future expansion of up to 26 additional home bases and 2 additional support classes. However, this will be the subject of a separate and future planning approval.

Based on the report titled "Transport and Traffic Assessment" (issued by PTC, dated 9 August 2021, referred herein as the *TTA Report*), it is understood the NPSMR has a maximum capacity of 414 students. Additionally, it is advised that waste collection will be conducted weekly; with the waste collection area being accessible from Deerubbin Drive.

1.2 Site Layout

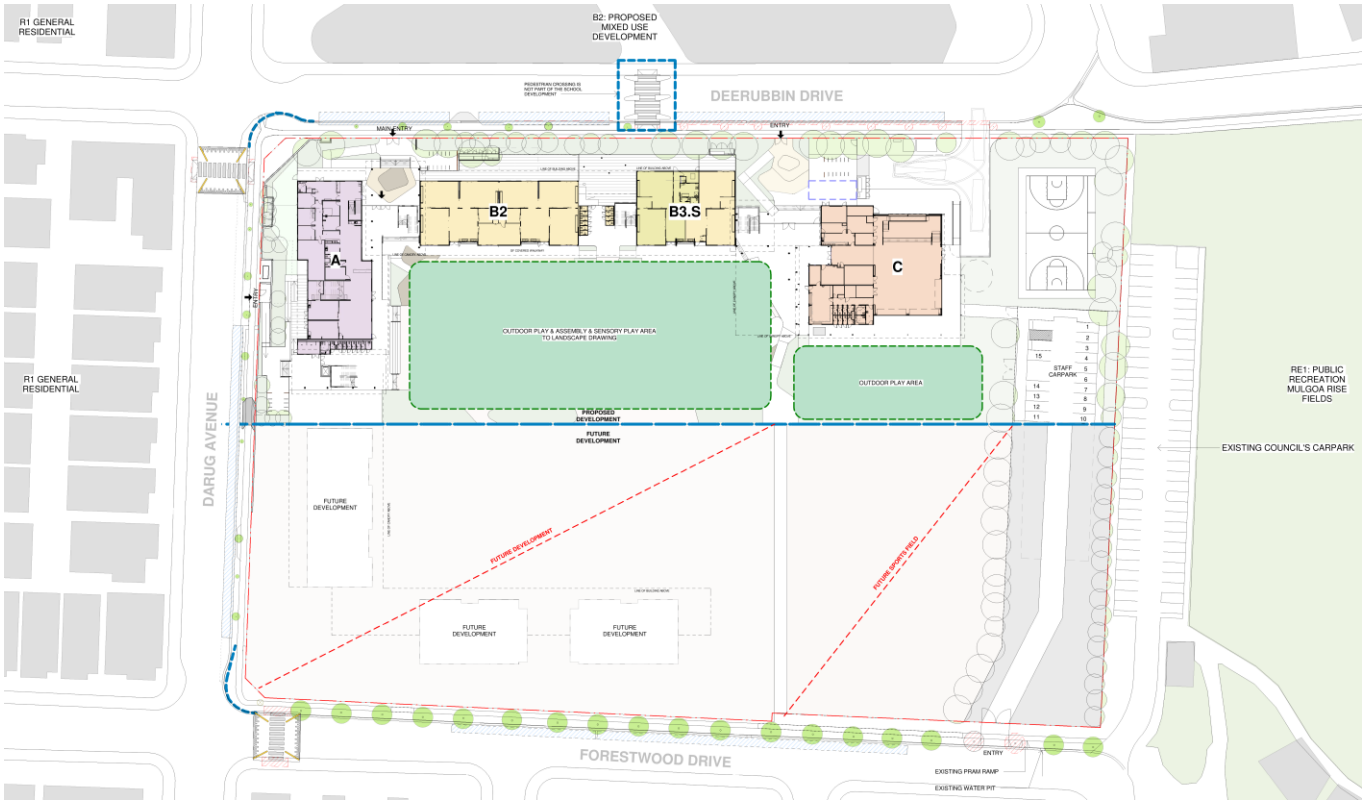
The NPSMR is surrounded by the following premises which are also considered the nearest noise affected receivers (refer to Figure 1):

- Residences which are located along the western and southern property boundaries. Residences along the western property boundary are situated across Darug Avenue; and those along the southern property boundary are located across Forestwood Drive.
- A future mixed-use development which will be located across Deerubbin Drive (i.e. 90-98 Glenmore Ridge Drive), along the northern property boundary.
- Residences which are also situated along Deerubbin Drive, to the north-east and north-west from the site.
- Along the eastern property boundary: Active recreation areas (i.e. Mulgoa Rise Fields), and areas dedicated to environmental conservation.

Since the receivers listed above are the nearest affected receivers, the acoustic assessment discussed in this report is undertaken at these receivers.

Figure 1 Site layout and location

Figure 2 Site layout



1.3 Planning Secretary's Environmental Assessment Requirements (SEARs)

The sections of the SEARs which are relevant to the acoustic assessment are the following:

10. *Noise and Vibration*

- *Provide a noise and vibration impact assessment that:*
    - *Includes a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation and construction.*
    - *Details the proposed construction hours and provide details of, and justification for, instances where it is expected that works would be carried out outside standard construction hours.*
    - *Includes a quantitative assessment of the main sources of operational noise, including consideration of any public-address system, school bell, mechanical services (e.g. air conditioning plant), use of any school hall for concerts etc. (both during and outside school hours) and any out of hours community use of school facilities.*
    - *Outlines measures to minimise and mitigate the potential noise impacts on nearby sensitive receivers.*
    - *Considers sources of external noise intrusion in proximity to the site (including, road rail and aviation operations) and identifies building performance requirements for the proposed development to achieve appropriate internal amenity standards.*

- *Demonstrates that the assessment has been prepared in accordance with polices and guidelines relevant to the context of the site and the nature of the proposed development.*

Relevant policies and guidelines:

- *NSW Noise Policy for Industry 2017 (NSW Environment Protection Authority (EPA)*
- *Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)*
- *Assessing Vibration: A Technical Guideline 2006 (Department of Environment and Conservation, 2006)*

These requirements are addressed as follows in this report:

- The criteria used for the assessment of construction activities are discussed in Section 4. These criteria are derived in accordance with the *Interim Construction Noise Guideline.* The assessment of these construction activities and relevant outcomes are discussed in Section 6.
- For typical operational activities, the assessment criteria are summarised in Section 3. These criteria are obtained according to the *NSW Noise Policy for Industry 2017* and other relevant statutory requirements. The assessment of typical operational activities and relevant outcomes are discussed in Section 5.
- The requirements discussed in document titled *Assessing Vibration: A Technical Guideline 2006* are considered for the operational acoustic assessment, as well as the assessment of construction vibration.

2 EXISTING ACOUSTIC ENVIRONMENT

To determine the existing noise environment at the nearest affected receivers, the following has been considered:

- For residences along southern property boundary (i.e. across Forestwood Drive), unattended noise measurements were conducted in the vicinity of these residences (i.e. *Logger Location 1*). Survey methodology and measurement results are discussed in Sections 2.1 and 2.3 respectively.

- For residences along northern and western property boundary (i.e. across Deerubbin Drive and Darug Avenue respectively), unattended noise measurements discussed in report titled *"Noise Impact Assessment Proposed Mixed-Use Development 90-98 Glenmore Ridge Drive Glenmore Park NSW"* (dated June 2020, issued by Reverb Acoustics Pty. Ltd.); are used. Location where these measurements were conducted is shown as *Logger Location 2* in Figure 2. Measurement results are discussed in Section 2.4.

  This latter report is referred herein as the *90-98 Glenmore Ridge Drive DA Acoustic Report*.

2.1 Unattended Noise Monitoring

For residences located along southern property boundary (i.e. along Forestwood Drive), noise levels were monitored at these residences in order to determine the existing noise levels. This unattended noise monitoring was conducted between Wednesday 17 March and Tuesday 30 March 2021.

The logger location is shown in Figure 1. The logger was installed in the front yard of residence at No 30 Forestwood Drive, Glenmore Park. The logger faced the southern property boundary of the project site.

The instrumentation for the survey comprised one Rion NL-42 noise logger (serial number 409024). Calibration of the logger was checked prior to and following measurements using a Bruel & Kjaer Type 4230 sound calibrator (serial number 1275644). The calibrator emitted a calibration tone of 94 dB at 1 KHz. The drift in calibration did not exceed ±0.5 dB. All equipment carries appropriate and current NATA (or manufacturer) calibration certificates.

Charts presenting summaries of the measured daily noise data are attached in Appendix B. The charts present each 24 hour period and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels for the corresponding 15 minute periods. This data has been filtered to remove periods affected by adverse weather conditions, based on weather information obtained from Badgerys Creek AWS weather station (ID 067108).

2.2 Noise Descriptors & Terminology

Environmental noise constantly varies in level with time. Therefore, it is necessary to measure environmental noise in terms of quantifiable time periods and statistical descriptors. Typically environmental noise is measured over 15 minute periods and relevant statistical descriptors of the fluctuating noise are determined to quantify the measured level.

Noise (or sound) consists of minute fluctuations in atmospheric pressure capable of detection by human hearing. Noise levels are expressed in terms of decibels, abbreviated as dB or dBA, the "A" indicating that the noise levels have been frequency weighted to approximate the characteristics of normal human hearing. Because noise is measured using a logarithmic scale, 'normal' arithmetic does not apply, e.g. adding two sound sources of equal values result in an increase of 3dB (i.e. 60 dBA plus 60 dBA results in 63 dBA). A change of 1 dB or 2 dB in the sound level is difficult for most people to detect, whilst a 3 dB – 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change roughly corresponds to a doubling or halving in loudness.

The most relevant environmental noise descriptors are the L_{Aeq}, L_{A1}, L_{A10} and L_{A90} noise levels. The L_{Aeq} noise level represents the "equivalent energy average noise level". This parameter is derived by integrating the noise level measured over the measurement period. It represents the level that the fluctuating noise with the same acoustic energy would be if it were constant over the measured time period.

The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample period. These levels can be considered as the maximum noise level, the average repeatable maximum and average repeatable minimum noise levels, respectively.

Specific acoustic terminology is used in this assessment report. An explanation of common acoustic terms is included as Appendix A.

2.3 Noise Monitoring Results – Logger Location 1

The noise levels measured at the logger location have been used to assess the noise impact of the development to the nearest noise affected receivers identified in Section 1.2. The time periods used are in accordance with those recommended in the NSW Environment Protection Authority's (EPA) Noise Policy for Industry (NSW NPI). The measurement results are presented in Table 1 below.

Table 1 Measured ambient noise levels in accordance with the NSW NPI

Measurement Location	Daytime 7:00 am to 6:00 pm		Evening 6:00 pm to 10:00 pm		Night Time 10:00 pm to 7:00 am	
	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}
Logger Location 1: No. 30 Forestwood Drive Glenmore Park	34 dBA	52 dBA	34 dBA	50 dBA	32 dBA	49 dBA

Notes:

1. *For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am*
2. *The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level*
3. *The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.*

2.4 Noise Monitoring Results – Logger Location 2

To determine existing ambient noise levels for residences near the northern and western property boundaries, the noise measurement results discussed in Section 2.1 of the 90-98 Glenmore Ridge Drive DA Acoustic Report; are used in our assessment. Table 2 below summarises these measurement results.

These measurements were conducted to establish the operational acoustic criteria for the future mixed-use development to be located at 90-98 Glenmore Ridge Drive. As discussed in Section 1.2, this development is situated along the northern property boundary of our project site.

Table 2 Measured ambient noise levels at 90-98 Glenmore Ridge Drive

Measurement Location	Daytime 7:00 am to 6:00 pm		Evening 6:00 pm to 10:00 pm		Night Time 10:00 pm to 7:00 am	
	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}
Logger Location 2 At southern property boundary of future mixed-use development at 90-98 Glenmore Ridge Drive	43 dBA	51 dBA	38 dBA	47 dBA	33 dBA	46 dBA

Notes:

4. *For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am*
5. *The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level*
6. *The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.*

3 OPERATIONAL ACOUSTIC CRITERIA

3.1 NSW Noise Policy for Industry

In NSW, the control of noise emissions is the responsibility of Local Governments and the NSW Environment Protection Authority (NSW EPA).

Consequently, the NSW EPA has prepared a document titled Noise Policy for Industry (NSW NPI) which provides a framework and process for determining external noise criteria and subsequent assessments. The NSW NPI criteria for industrial noise sources have two components:

- Controlling the intrusive noise impacts for residents and other noise sensitive receivers in the short term; and
- Maintaining noise level amenity of particular land uses for residents and sensitive receivers in other land uses.

3.1.1 Intrusive Noise Impacts (Residential Receivers)

The NSW NPI states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15 minutes period, does not exceed the background noise level measured in the absence of the source by more than 5 dBA. This is often termed the Intrusiveness Criterion.

The 'Rating Background Level' (RBL) is the background noise level to be used for assessment purposes and is determined by the methods given in the NSW NPI. Using the rating background noise level approach results in the intrusiveness criterion being met for 90% of the time. Adjustments are to be applied to the level of noise produced by the source that is received at the assessment point where the noise source contains annoying characteristics such as tonality or impulsiveness.

3.1.2 Protecting Noise Amenity (All Receivers)

To limit continuing increase in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.2 of the NSW NPI. That is, the ambient L_{Aeq} noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the 'Background Creep' or Amenity Criterion.

The amenity assessment is based on noise criteria specified for a particular land use and corresponding sensitivity to noise. The cumulative effect of noise from industrial sources needs to be considered in assessing the impact. These criteria relate only to other continuous industrial-type noise and do not include road, rail or community noise. If the existing (measured) industrial-type noise level approaches the criterion value, then the NSW NPI sets maximum noise emission levels from new sources with the objective of ensuring that the cumulative levels do not significantly exceed the criterion.

3.1.2.1 Area Classification

The NSW NPI characterises the "Urban" noise environment as an area with an acoustical environment that:

- Is dominated by "urban hum" or industrial noise source.
- Has through traffic with characteristically heavy and continuous traffic flows during peak periods.
- Is near commercial or industrial districts.
- Has any combination of the above.

…where "urban hum" means the aggregate unidentifiable sound of man and mostly due to traffic-related sound sources.

The area surrounding the proposed development falls under the "Urban" area classification in accordance with the zoning maps obtained from NSW Government's ePlanning Spatial Viewer (refer to Figure 3 below). Residential areas that are located within B2 and R1 zones, are classified as "Urban" in accordance with Table 2.3 of the NSW NPI. For residential and non-residential receivers in an urban area, the recommended amenity criteria are shown in Table 3 below.

It is noted that the "urban" classification is found to be consistent with the assessment classification considered in the 90-98 Glenmore Ridge Drive DA Acoustic Report.

Figure 3 Zoning at and around project site

Table 3 NSW NPI – Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day[1]	Recommended Amenity Noise Level ($L_{Aeq, period}$)[2]
Residence	Urban	Day	60
		Evening	50
		Night	45
Commercial premises	All	When in use	65
Active recreation areas	All	When in use	55

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

When the existing noise level from industrial noise sources is close to the recommended "Amenity Noise Level" (ANL) given above, noise from the new source must be controlled to preserve the amenity of the area in line with the requirements of the NSW NPI.

Where existing road traffic noise is high enough to render stationary noise sources effectively inaudible, the ANL can be modified so that the amenity criteria is not unduly stringent in an environment where road traffic noise is the dominant source of environmental noise. If all the conditions below are satisfied, the ANL becomes $L_{Aeq,\ traffic}$ minus 15 dBA. The conditions are:

- The road traffic noise is the dominant noise source.
- The existing noise is 10dBA or more above the recommended ANL for the area.
- It is highly unlikely the road traffic noise levels would reduce in the near future.

3.1.3 Project Trigger Noise Levels

The intrusive and amenity criteria for industrial noise emissions derived from the measured data are presented in Table 4. These criteria are nominated for the purpose of determining the operational noise limits for mechanical plant associated with the commercial components of the development to potentially affected noise sensitive receivers.

For each assessment period, the lower (i.e. the more stringent) of the amenity or intrusive criteria are adopted. These are shown in bold text in Table 4.

Table 4 External noise level criteria in accordance with the NSW NPI

Location	Time of Day	Project Amenity Noise Level, $L_{Aeq,\ period}$ [1] (dBA)	Measured $L_{A90,\ 15\ min}$ (RBL) [2] (dBA)	Measured $L_{Aeq,\ period}$ Noise Level (dBA)	Intrusive $L_{Aeq,\ 15\ min}$ Criterion for New Sources (dBA)	Amenity $L_{Aeq,\ 15\ min}$ Criterion for New Sources (dBA) [4]
Residences along: Forestwood Drive	Day	55	34	52	**40** [5]	58
	Evening	45	34	50	**39**	48
	Night	40	32	49	**37**	43
	Shoulder period: 6:30 am- 7:00 am	-	39	-	**44**	
Residences along: Darug Avenue Deerubbin Drive	Day	55	43	51	**48**	58
	Evening	45	38	47	**43**	48
	Night	40	33	46	**38**	43
	Shoulder period: 6:30 am- 7:00 am	-	37		**42**	
Commercial premises at future mixed use development along Deerubbin Drive	When in use	60	-	52	-	**63**
Active Recreation Areas: Mulgoa Rise Fields	When in use	50	-	52	-	**53**

Note 1: Project Amenity Noise Levels corresponding to "Urban" areas, equivalent to the Recommended Amenity Noise Levels (Table 3) minus 5 dBA
Note 2: L_{A90} Background Noise or Rating Background Level
Note 3: Project Noise Trigger Levels are shown in bold
Note 4: This is based on the assumption that the existing noise levels are unlikely to decrease in the future
Note 5: Minimum project intrusiveness noise level as per Table 2.1 of the NSW NPI

It is noted that noise measurements for the "shoulder period" are obtained as follows:

- For residences along Forestwood Drive: This is calculated from the lowest 10th percentile of $L_{AF90,15min}$ noise measurements for the equivalent of one week's worth of valid data during that shoulder period.
- For residences along Darug Avenue and Deerubbin Drive: This is obtained from Table 5 of the 90-98 Glenmore Ridge Drive DA Acoustic Report.

3.1.4 Sleep Disturbance

In accordance with the NSW NPI, sleep disturbance is to be assesses in two stages addressing the likelihood of sleep disturbance and sleep awakening.

For the criterion addressing the likelihood of sleep disturbance, the NSW NPI recommends that the maximum noise level event should not exceed the following:

- 40 dB $L_{Aeq,\ 15\ minutes}$ or the prevailing RBL plus 5 dB, whichever is the greater; and / or
- 52 dB L_{AFmax} or the prevailing RBL plus 15 dB, whichever is the greater

As a result, the criterion of 52 dB L_{AFmax} is adopted as the criterion for the likelihood of sleep disturbance at all residences.

Regarding sleep awakening, ongoing research is still being undertaken to quantify an appropriate criterion. The NSW Road Noise Policy (NSW RNP) provides guidelines and a summary of current research being undertaken on this topic. According to the NSW RNP, an accurate representation of sleep disturbance impacts on a community from a noise source is particularly difficult to quantify mainly due to differing responses of individuals to sleep disturbance – this is found even within a single subject monitored at different stages of a single night's sleep or during different periods of sleep.

In addition, the differing grades of sleep state make a definitive definition difficult, and even where sleep disturbance is not noted by the subject, factors such as heart rate, mood and performance can still be negatively affected.

An assessment of sleep disturbance should consider the maximum noise level or $L_{A1(1\ minute)}$, and the extent to which the maximum noise level exceeds the background level and the number of times this may happen during the night-time period. 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 10.00pm and 7.00am); and
- Whether there are times of day when there is a clear change in the existing noise environment (such as during early morning shoulder periods).

Currently the information relating to sleep disturbance impacts indicates that:

- Maximum internal noise levels below 50–55 dBA are unlikely to cause an awakening from a sleep state.
- One or two noise events per night with maximum internal noise levels of 65–70 dBA are not likely to affect health and wellbeing significantly.

As a result, the adopted sleep awakening criterion for the project is an internal noise level of 50 - 55 dB L_{AFmax}. This criterion is applicable for noise emissions generated by short term events occurring during the night time period. Therefore, allowing for a 10 dB noise reduction for open windows, it is proposed that the noise screening criterion for sleep awakening should be 60 - 65 dB L_{AFmax} external noise level at residential properties.

3.1.5 Emergency Plant / Infrequent Operational Activities

For emergency plant (such as stand-by generators) or activities which are conducted infrequently, such as waste collection (to be undertaken weekly as discussed in Section 1.1); the NSW NPI allows for modifying factors that can be subtracted from the predicted noise levels. These modifying factors should be applied prior to assessing against the external noise level criteria. These duration modifying factors are summarised in Table 5 below.

Under the assumption that each waste collection event has a duration of between 15 minutes to 1 hour, and there is only one such event in a 24 hour period, then a modifying factor of 5 dB can be applied to the predicted noise levels. Alternatively, the modifying factor can be added to the relevant criterion (as a leniency factor) prior to the assessment.

Table 5 Modifying factors for duration

Allowable Duration of Noise (one event in any 24 hour period)	Allowable Exceedance at Receiver for the Period of Noise Event	
	Daytime and Evening (7am – 10pm)	Night time (10pm – 7am)
1 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

Note: Where the duration of the noise event is smaller than the duration of the project trigger noise level (PNTL), that is, less than 15 minutes, the allowable adjusted project noise trigger level (APNTL) is derived as follows:

$$APNTL = 10\log((10^{\frac{PNTL}{10}}\ x\ (\frac{900 - duration}{900})) + (10^{\frac{PNTL+allowable\ exceedance\ in\ table\ above}{10}}\ x\ duration))$$

3.2 Outdoor Noise Emissions (Play Areas & Communal Hall)

No mandatory legislation is available which addresses external noise emission from communal halls, or outdoor gatherings (generally caused by student activities such as talking, playing, etc). However, the *"Guideline for Child Care Centre Acoustic Assessment"* (version 3.0, dated September 2020), issued by the Association of Australasian Acoustical Consultants (AAAC) provides guidance on how to assess similar activities to a primary school.

For outdoor play areas that have the potential to impact on residential receivers the guideline states:

> *The noise impact from children at play in a childcare centre differs from the domestic situation in that it is a business carried out for commercial gain, the number of children can be far greater than in a domestic situation and the age range of the children at the centre does not significantly vary over time as it would in a domestic situation. However, the noise from children is vastly different, in both character and duration, from industrial, commercial or even domestic machine noise. The sound from children at play, in some circumstances, can be pleasant, with noise emission generally only audible during the times the children play outside. Night-time, weekend or public holiday activity is not typical and childcare centres have considerable social and community benefit.*
>
> ***Base Criteria** – With the development of childcare centres in residential areas, the background noise level within these areas can at certain times, be low. Thus, a base criterion of a contributed $L_{eq,15min}$ 45 dB(A) for the assessment of outdoor play is recommended in locations where the background noise level is less than 40 dB(A).*

Background Greater Than 40 dB(A) *– The contributed $L_{eq,15min}$ noise level emitted from an outdoor play and internal activity areas shall not exceed the background noise level by more than 5 or 10 dB at the assessment location, depending on the usage of the outdoor play area. AAAC members regard that a total time limit of approximately 2 hours outdoor play per morning and afternoon period should allow an emergence above the background of 10 dB (i.e. background +10 dB if outdoor play is limited to 2 hours in the morning and 2 hours in the afternoon).*

Up to 4 hours (total) per day *– If outdoor play is limited to no more than 2 hours in the morning and 2 hours in the afternoon, the contributed $L_{eq,15\ minute}$ noise level emitted from the outdoor play shall not exceed the background noise level by more than 10 dB at the assessment location.*

More than 4 hours (total) per day *– If outdoor play is not limited to no more than 2 hours in the morning and 2 hours in the afternoon, the contributed $L_{eq,15\ minute}$ noise level emitted from the outdoor play area shall not exceed the background noise level by more than 5 dB at the assessment location.*

- *The assessment location is defined as the most affected point on or within any residential receiver property boundary. Examples of this location may be: 1.5 m above ground level;*
- *On a balcony at 1.5 m above floor level;*
- *Outside a window on the ground or higher floors*

Although the guideline is intended for childcare centres, we are of the opinion that assessing noise from children at play based on the NSW NPI criteria is overly restrictive. This type of noise emissions is different in both character and duration to that of industrial, commercial or even machine noise emissions. For example, noise generated by students playing is intermittent in character, as noise from mechanical services is typically constant.

Based on noise measurement results discussed in Section 2; the noise targets summarised in Table 6 are adopted for the assessment of noise emissions by children at play in outdoor areas and inside the communal hall.

Table 6 Noise targets for assessment of noise emissions by children at play

Type of Receiver	Daytime Period 7:00 am – 6:00 pm (dB $L_{Aeq,\ 15\ minutes}$)	Evening Period 6:00 pm – 10:00 pm (dB $L_{Aeq,\ 15\ minutes}$)	Night time Period 10:00 pm – 12:00 am (dB $L_{Aeq,\ 15\ minutes}$)
Residences along: Forestwood Drive	45	45	45
Residences along: Darug Avenue & Deerubbin Drive	48	45	45

It is noted that a noise target of 45 dB $L_{Aeq,\ 15\ minutes}$ is also adopted for the night time period. This is consistent with the typically recommended external noise level of 45 dB L_{Aeq} outside a bedroom window. This is obtained by allowing a noise reduction of 10 dB for open windows and a design noise level of 35 dB L_{Aeq} inside the bedroom (as per Table 1 of standard AS/NZS 2107:2016).

3.3 Noise Emissions from Carpark

It is likely that all traffic activity related to the school development (i.e. transportation for students and parking within the school premises) will be produced by light vehicles and it is considered feasible to assess car park noise impacts with reference to the NSW NPI as it is forecast that traffic movements in and out of the car park will occur during distinct time periods, i.e. in the morning before school commences and again in the afternoon following the end of school hours. Therefore, the criteria used for the assessment of carpark noise emissions should be as discussed in Section 3.1 (refer to Table 4).

Since the operational times for the NPSMR starts at 6:30 am, the criteria for sleep disturbance, as well as the shoulder period criteria, are considered in our carpark noise assessment.

3.4 Penrith Development Control Plan 2014

Section E7.4 of the Penrith Development Control Plan 2014 (Penrith DCP 2014), which corresponds to Glenmore Park Stage 2, sub-section 7.4.4.6 includes objective and performance measures for visual and acoustic privacy. However, these conditions do not state specific numeric criteria for educational facilities. Therefore, we refer to other operational acoustic criteria discussed in this report to address acoustic amenity and privacy for the NPSMR.

3.5 Internal Noise Level Criteria

3.5.1 The State Environmental Planning Policy (Infrastructure) 2007

The State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP) was introduced to assist the delivery of necessary infrastructure by improving regulatory certainty and efficiency. The Infrastructure SEPP has specific planning provisions and development controls for various types of infrastructure and for development located adjacent to infrastructure. To provide guidelines for this type of assessment (noise intrusion from road and rail traffic noise), the Department of Planning of the NSW Government has prepared a document titled *"Developments Near Rail Corridors and Busy Roads – Interim Guideline"* (DNRC & BR-IG).

The DNRC & BR-IG applies to development adjacent to rail corridors and busy roads. It can also provide a useful guide for all development that may be impacted by, or may impact on, rail corridors or busy roads. According to the DNRC & BR-IG, busy roads are defined as follows:

- Roads specified in Clause 102 of the Infrastructure SEPP: Freeway, tollway or a transitway or any other road with an average annual daily traffic (AADT) volume of more than 40,000 vehicles.
- Any other road is defined as roads with an average annual daily traffic (AADT) volume of more than 20,000 vehicles
- Any other road with a high level of truck movements or bus traffic.

According to Clauses 87 (rail) and 102 (road), if the development is an educational establishment, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded (with windows and doors closed):

- In any bedroom in the building – 35 dBA $L_{Aeq(9hour)}$ between 10:00 pm and 7:00 am
- Anywhere else in the building (other than a garage, kitchen, bathroom or hallway) – 40 dBA L_{Aeq} at any time (i.e. $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$).

If internal noise levels with windows or doors open exceed the criteria by more than 10 dB, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and meet the ventilation requirements of the National Construction Code 2019 (NCC 2019).

Where windows must be kept closed, the adopted ventilation systems must meet the requirements of the NCC 2019 and the current Australian set of standards AS/NZS 1668 and AS 1668 titled *"The use of ventilation and air conditioning in buildings".*

It is noted that the nearest major road or rail corridor to the project site is the M4 Western Motorway. This is located at approximately 2.2 km from the project site. Therefore, based on this distance, the NPSMR is not subject to a road traffic noise intrusion assessment in accordance with the DNRC & BR-IG.

3.5.2 Project Quality Requirements

Noise from air-conditioning plant and traffic noise intrusion are generally the principal contributors to the overall internal noise levels. It is important that an appropriate ambient noise level is established in an educational development.

A reduced level of ambient noise is required in certain spaces to achieve good communication throughout the space. A higher level of ambient noise is generally preferable in open plan spaces to ensure a moderate level of acoustic privacy between workstations. Too loud a background noise level may, however, lead to communication difficulties and fatigue.

As part of the project specific requirements for the NPSMR development, the internal noise level criteria have been defined from two guidelines:

- Design Guide 11 Acoustics (DG 11-Acoustics), which is part of the Educational Facilities Standards & Guidelines (EFSG) issued by the NSW Department of Education.
- Condition 10 - Acoustic Comfort, which is part of the Green Star – Design & As Built v1.3 rating scheme.

Table 7 below summarises the internal noise level criteria derived from these two guidelines. **Please note that the internal noise level criteria are not enforced or requested by local statutory conditions. Therefore, it is concluded that compliance with recommended internal design noise levels will be addressed as part of the assessment process to confirm fulfillment with the project specific requirements.**

Table 7 Recommended design internal noise levels as per EFSG and Green Star guidelines

Room	Internal Noise Level (dB L_{Aeq})
Assembly halls up to 250 seats: Communal Hall	35
Corridors & lobbies	45
Duplicating rooms / stores	50
Interview / counselling rooms: Interview room Interview / counselling	35
Kitchens	50
Libraries – General areas	40 - 45
Libraries – Reading areas	40 - 45
Libraries – Stack areas	45
Medical rooms (First aid)	40
Office areas: Deputies hub Library shared office / workroom Staff meeting Staff room & annexe	40
Open plan teaching areas: Special programs rooms	40
Professional & administrative offices: Principal / meeting room	35
Teaching spaces – Primary schools: Homebases	40
Toilet / change / showers	50

Generally, where the final noise levels are within +/- 2 dB of the specified level given above, the design criteria will be considered as achieved. Both the upper and lower limits will need to be satisfied especially where privacy is important or where noise intrusion to be avoided.

Standard AS/NZS 2107:2016 requires that the measurement to assess compliance with this Standard should be taken with the space unoccupied but ready for occupancy and for a sufficiently long period to characterize the effects of the sound source(s). The sound level meter shall comply with AS IEC 61672.1. The time period of the measurement shall be selected to ensure that the sample is representative of the noise in the area (in many cases where there is not a great variation in noise levels, a measurement time of 30 seconds may be appropriate).

3.5.3 Emergency Operations: Standard AS/NZS 1668.1:2015

According to standard AS/NZS 1668.1:2015, internal noise levels generated by smoke control systems should comply with the following:

> *The noise level in occupied spaces during operation of the smoke control systems (including smoke exhaust fans and air pressurization fans) shall not exceed 65 dBA. Where the internal occupied ambient noise levels exceed 60 dBA, the smoke control systems shall not exceed 5 dBA above the internal occupied ambient noise levels, to a maximum level of 80 dBA.*
>
> *Noise levels in fire-isolated exits and car parks, as well as and smoke control zones served by hot layer smoke control systems shall not exceed 80 dBA.*

3.6 Aircraft Noise Intrusion

In accordance with DG11-Acoustics, general learning areas, music, drama, movement studios and halls are to be assessed where the school site lies within Australian Noise Exposure Forecast (ANEF) 25 (or higher) as shown on airport planning instruments. The procedures discussed in standard AS 2021:2015 *"Acoustics - Aircraft noise intrusion - Building siting and construction"* are to be used in the assessment.

Currently, no ANEF (Australian Noise Exposure Forecast) contours are available for the future Western Sydney Airport, since this is a future development. Instead, ANEC (Australian Noise Exposure Concept) contours are provided. These ANEC contours are provided in the Western Sydney Airport website (https://www.westernsydneyairport.gov.au/about/flight-paths/noise-tool).

Based on these ANEC contours, it is observed that the project site will be exposed to a less than 20 ANEC contour (refer to Figure 4). Therefore, the site is no subject to the aircraft noise intrusion assessment.

Figure 4 ANEC contours for Western Sydney Airport in relation to the NPSMR

3.7 Noise Impact on Local Roads

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW Road Noise Policy (NSW RNP) states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night-time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

Also, the NSW RNP recommends the criteria summarised in Table 8 which is applicable to residential land uses.

Table 8 Road traffic noise assessment criteria for residential land uses according to the NSW RNP

Road Category	Type of project/land use	Assessment Criteria	
		Day (7:00 am – 10:00 pm)	Night (10:00 pm – 7:00 am)
Local roads	Existing residences affected by noise from new local road corridors Existing residences affected by noise from redevelopment of existing local roads Existing residences affected by additional traffic on existing local roads generated by land use developments	55 dB $L_{Aeq,\ 1\ hour}$ (external)	50 dB $L_{Aeq,\ 1\ hour}$ (external)

3.8 Vibration Criteria – Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled *"Assessing Vibration – A Technical Guideline"*. (AVTG) This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration - from uninterrupted sources (refer to Table 9)
- Impulsive vibration - up to three instances of sudden impact e.g. dropping heavy items, per monitoring period (refer to Table 10)
- Intermittent vibration - such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 11)

Table 9 Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions, and places of worship	Day or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day or night-time	0.04	0.029	0.080	0.058

Table 10 Impulsive vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions, and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Table 11 Intermittent vibration impacts criteria (m/s$^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
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

4 CONSTRUCTION NOISE & VIBRATION CRITERIA

4.1 Construction Noise Criteria

4.1.1 Interim Construction Noise Guideline

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works
- Focus on applying all "feasible" and "reasonable" work practices to minimise construction noise impacts
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage
- Provide flexibility in selecting site-specific feasible and reasonable work practices to minimise noise impacts

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for residential receivers have been reproduced from the guideline and are listed in Table 12 below.

Specific non-residential receivers in the vicinity of the proposed construction site, and their recommended 'management levels', are presented in Table 13.

Based on the measured background noise levels summarised in Section 2, the NMLs to be used in this assessment are listed in Table 14.

In consultation with Richard Crookes Constructions (RCC), it is proposed that construction works will be conducted under typical standard construction hours.

Table 12 NMLs for quantitative assessment at residences (from ICNG)

Time of Day	Noise Management Level $L_{Aeq(15minute)}$[1,2]	How to Apply
Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15minute)}$ 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.
	Highly noise affected 75 dBA	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 + 5 dB	• 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 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1 *Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).*

Table 13 NMLs for quantitative assessment at non-residential receivers

Land Use	$L_{Aeq(15minute)}$ Construction NML
Offices, retail outlets	External noise level 70 dBA
Active recreation areas (Mulgoa Rise Fields)	External noise level 65 dBA

Note 1: External noise level criterion estimated from internal noise level criterion assuming a 10 dB noise level difference for open windows

Table 14 NMLs as basis for the acoustic assessment

Receiver Types	NML, dB $L_{Aeq(15minute)}$	
	Standard Hours **Monday to Friday:** **7 am to 6 pm** **Saturday:** **8 am to 1 pm**	**Outside Standard Hours**
Residences	44	Evening period: 39 Night-time period: 37
Offices, retail outlets	70 (external)	70 (external)
Active recreation areas (Mulgoa Rise Fields)	65 (external)	65 (external)

4.1.2 Sleep Disturbance

As discussed in Section 4.1.1, it is noted that construction works will be undertaken during standard construction hours. These standard hours are only part of the daytime period. Therefore, a sleep disturbance assessment is not required.

4.2 Construction Traffic Noise Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW Road Noise Policy (NSW RNP) states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night-time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

4.3 Vibration Criteria

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed. Refer to further discussion in Section 3.8
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects. Refer to further discussion in Section 4.3.1
- Effects on building structures – where vibration can compromise the integrity of the building or structure itself. Refer to further discussion in Section 4.3.1

4.3.1 Vibration Criteria – Building Contents & Structure

The vibration effects on the building itself are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration"* (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999).

4.3.1.1 Standard BS 7385 Part 2 – 1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 15 and illustrated in Figure 5.

Table 15 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in Figure 5	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385 Part 2 – 1993 states that the values in Table 15 relate to transient vibration which does not cause resonant responses in buildings.

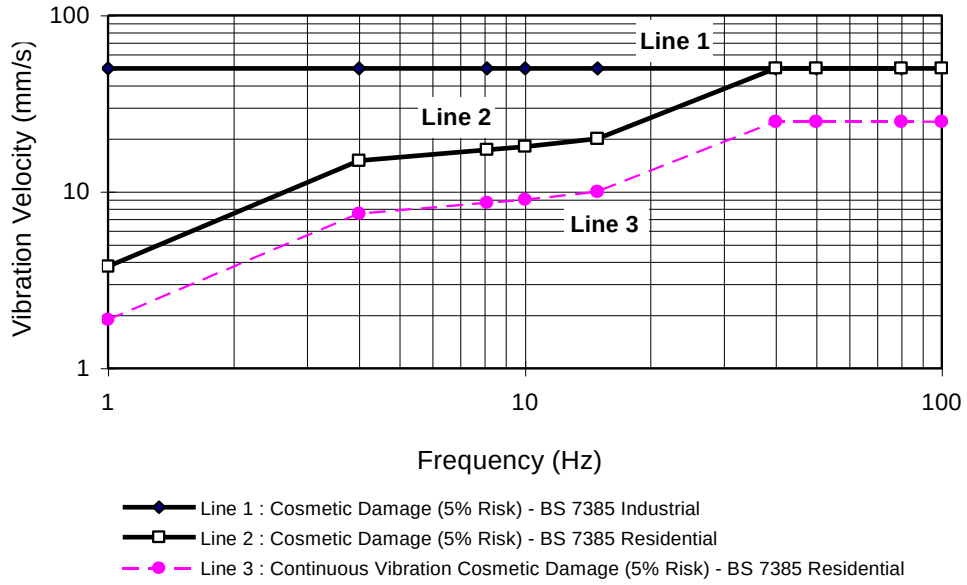
Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 15 may need to be reduced by up to 50% (refer to Line 3 in Figure 5).

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the recommended values corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 15, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 15 should not be reduced for fatigue considerations.

Figure 5 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage



4.3.1.2 Standard DIN 4150 Part 3 – 1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 16. The criteria are frequency dependent and specific to particular categories of structures.

Table 16 Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s Vibration at the foundation at a frequency of			
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	Vibration of horizontal plane of highest floor at all frequencies
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

4.4 Ground-Borne Noise Criteria

Ground-borne noise is noise generated by vibration transmitted through the ground into a structure. The following ground-borne limits for residences are only applicable when ground-borne noise levels are higher than airborne noise levels. The ground-borne noise levels are for evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home.

- Evening (6 pm to 10 pm) - Internal: $L_{Aeq\ (15\ min)}$ 40 dBA
- Night-time (10 pm to 7 am) - Internal: $L_{Aeq\ (15\ min)}$ 35 dBA

Mitigation options to deal with ground-borne noise may include extensive community consultation to determine the acceptable level of disruption and the provision of respite accommodation in some circumstances, not just restriction of work hours.

It is noted that no construction works are currently proposed for the evening and night-time periods, therefore, an assessment of ground-borne is not currently required for this development.

5 OPERATIONAL ACOUSTIC ASSESSMENT

5.1 External Noise Emissions – Building Services

The layout of outdoor plant items for the NPSMR, is shown in Figure 6 and Figure 7. To comply with the external noise level criteria discussed in Section 3.1, the following is advised (also refer to Figure 6 and Figure 7 below):

- Outdoor plant items should be installed as shown in Figure 6 and Figure 7. Number of plant items should not exceed those shown in these figures.
- Each outdoor unit should not exceed the maximum sound pressure levels listed in Table 17. These maximum sound pressure levels should be obtained at 1.5m from the unit, under free field conditions (excluding any wall reflections).

Table 17 Maximum sound pressure levels for each outdoor unit

Outdoor Unit Type (as shown in Figure 6 and Figure 7)	Max. Allowable Sound Pressure Levels (dB re $1x10^{-6}$ Pa) Measured at 1.5m under free field conditions								
	63 Hz	125 Hz	250 Hz	500 Hz	1 KHz	2 KHz	4 KHz	8 KHz	dBA
RXYQ8	66	61	61	56	51	44	36	33	58
RXYQ14	64	64	61	57	52	47	45	40	59
RXYQ24	65	66	62	61	58	54	47	41	63

- Solid screens should be installed around outdoor units as shown in Figure 6 and Figure 7. Solid screen should extend from ground level to top of tallest outdoor unit. Screen should be constructed of material which achieves a minimum sound insulation performance of Rw 30 – 35. Material example: FC sheet with 9mm minimum thickness (14 kg/m^2 minimum mass density). Solid screen should be fully closed and free of gaps.
- Operational times for outdoor units should be as follows:
    - RXYQ14 units in front of Building A: 6:30 am till 10:00 pm.
    - RXYQ24 units in front of Buildings B2 and B3: 7:00 am till 6:00 pm.
    - RXYQ8 units in front of Building C: 6:30 am till 10:00 pm.

Noise information for outdoor split units has not been provided. However, the following limiting sound power levels and operational times are advised in order to maintain compliance with external noise level criteria:

- Aggregate sound power level for 2 split units near Building A: 70 dBA Lw (dB re 1pW). Operational times to extend from 6:30 am till 10:00 pm.
- Sound power level for split unit near Building B2: 70 dBA Lw (dB re 1pW). Operational times to extend from 7:00 am till 6:00 pm.
- Sound power level for split unit near Building B3: 70 dBA Lw (dB re 1pW). Operational times to extend from 7:00 am till 6:00 pm.
- Aggregate sound power level for 2 split units near Building C: 70 dBA Lw (dB re 1pW). Operational times to extend from 6:30 am till 10:00 pm.

Please note that the aggregate sound power level is the summation of the emitting sound power levels for each individual unit.

Figure 6 Layout of outdoor units

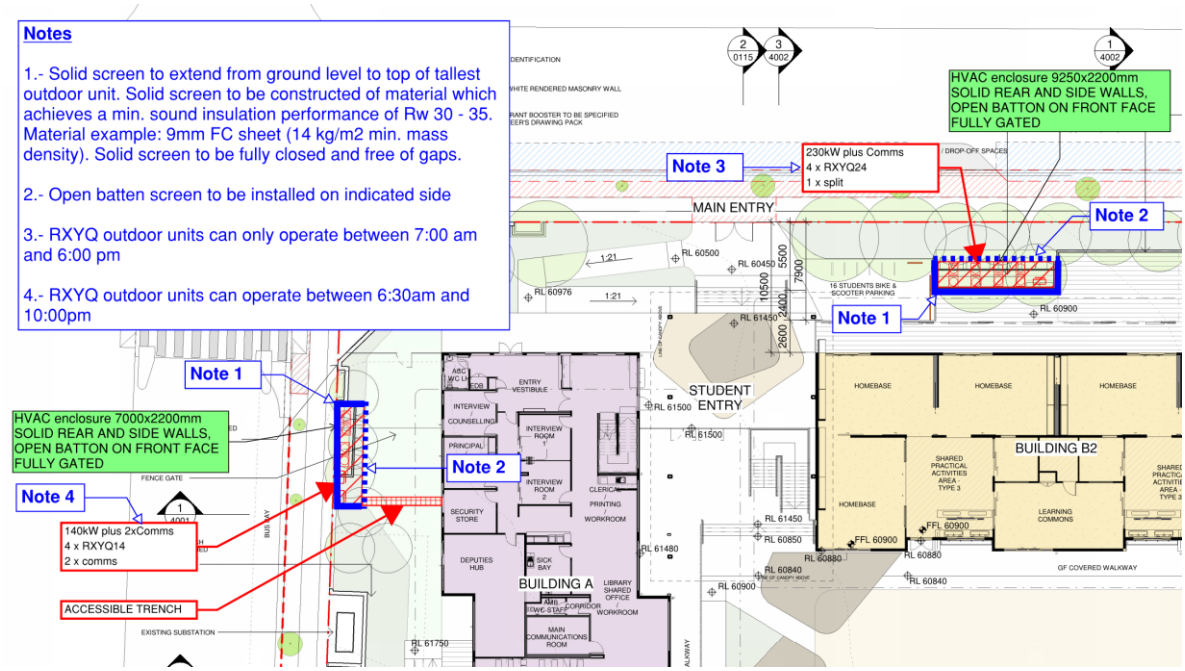
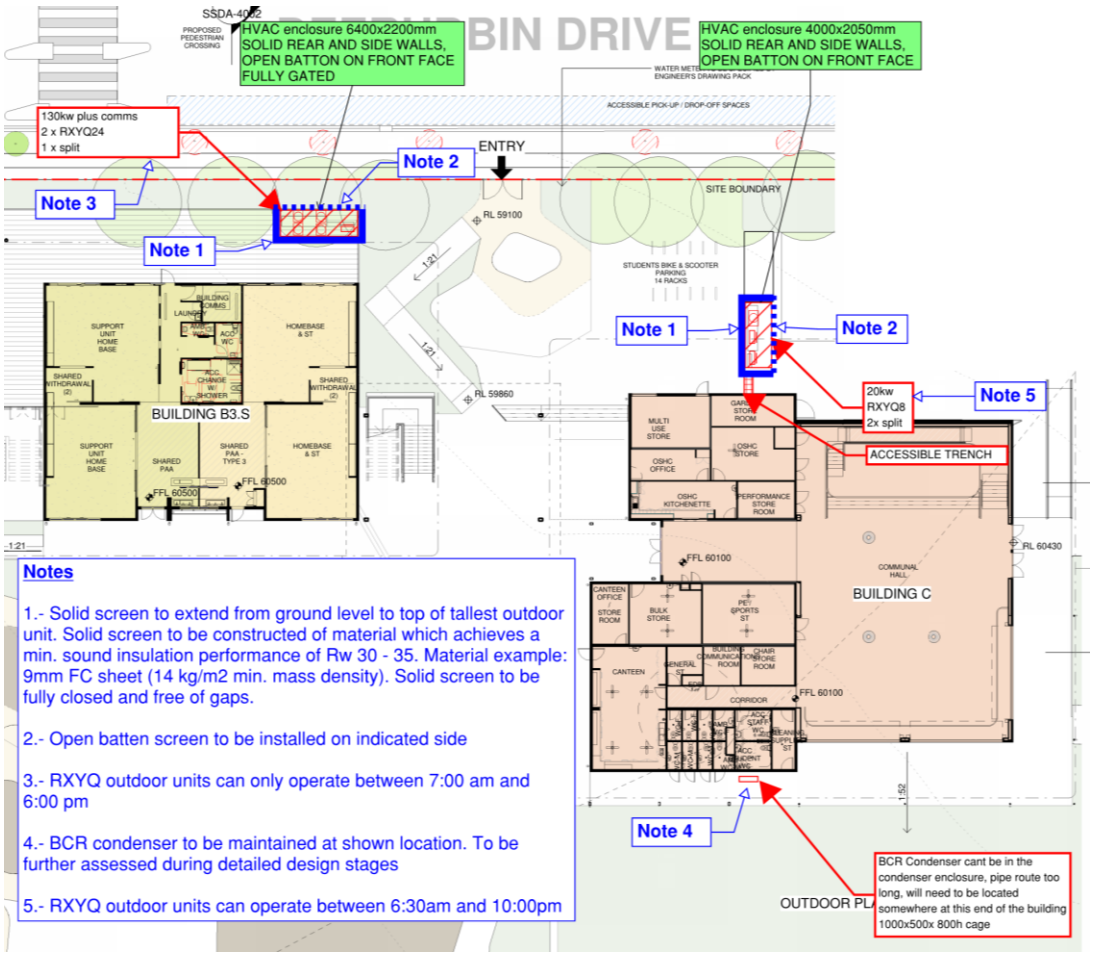


Figure 7 Layout of outdoor units



Noise information for outdoor BCR condenser has also not been provided. In-principle, unit location shown in Figure 7 is found to be acceptable. Nevertheless, it is advised this unit is to be assessed further during detailed design stages to confirm compliance with external noise level criteria in Section 3.1.

Additionally, it is recommended that any noise emission from plant items which are not addressed in this report (such as ducted units, fans, etc), should be controlled so that the operation of such plant does not adversely impact upon neighbouring residential and commercial receivers. Hence, the mechanical services, in general terms, should be designed to comply with the external noise level criteria discussed in Section 3.1.

This should be conducted as part of the detailed assessment of mechanical noise emissions which is required to be undertaken during the detailed design stage.

For these plant items which have not been assessed, the following design measures should be considered as part of the detailed design stage and mitigations may include the following:

- Mechanical plant installation locations and the positioning of external air duct paths (such as inlets and outlets) near the property boundary should be limited, as far as practicable.
- Plant room walls should achieve a minimum airborne sound insulation performance of Rw 45 -50. Whenever possible, the plant rooms should only be accessible from inside the building.
- If airflow paths are required to/from outside (such as outside air, exhaust air, relief air, etc) these paths should be fully ducted and include minimum 50 mm thick internal insulation; and / or include acoustic louvres. When the extent of ductwork is not sufficient for treatment, then rectangular silencers may be required (this especially applies to fans and AHUs).
- Ornamental louvres should generally only be considered if they are blanked off with FC sheeting or plant room external walls (subject to further Detailed Design acoustic assessment).
- All plant room walls and roof / ceiling to be internally lined with insulation, which in combination with insulation facing, should achieve a minimum noise reduction coefficient (NRC) rating of 0.8.
- AHUs and FCUs should include return air / outside air plenums which are in internally lined with minimum 50 mm thick insulation.
- Variable speed drives should be implemented whenever possible.
- Reduce the number of operational plant items between 6:00 pm and 7:00 am (and during the night-time period generally).
- Outdoor units and other plant items to be screened from direct line of sight to the affected residences (depending on their locations).

The above recommendations should be considered as in-principle, best practice acoustic treatment that will need to be confirmed during detailed design stages.

5.2 Internal Noise Emissions – Building Services

As discussed in Section 5.1, the mechanical ventilation design is still ongoing at the time of issuing this report. Nevertheless, it is advised that this should be designed to achieve the internal noise level criteria discussed in Section 3.5.

All emergency plant (such smoke exhaust fans, smoke spill air fans and stair pressurisation fans) should comply with the criteria discussed in standard AS/NZS 1668.1:2015 (refer to Section 3.5.3).

Mechanical plant should be resiliently mounted. Vibration isolation mounts and supports should be designed to achieve compliance with vibration criteria discussed in Section 3.8.

5.3 Outdoor Noise Emissions - Playgrounds

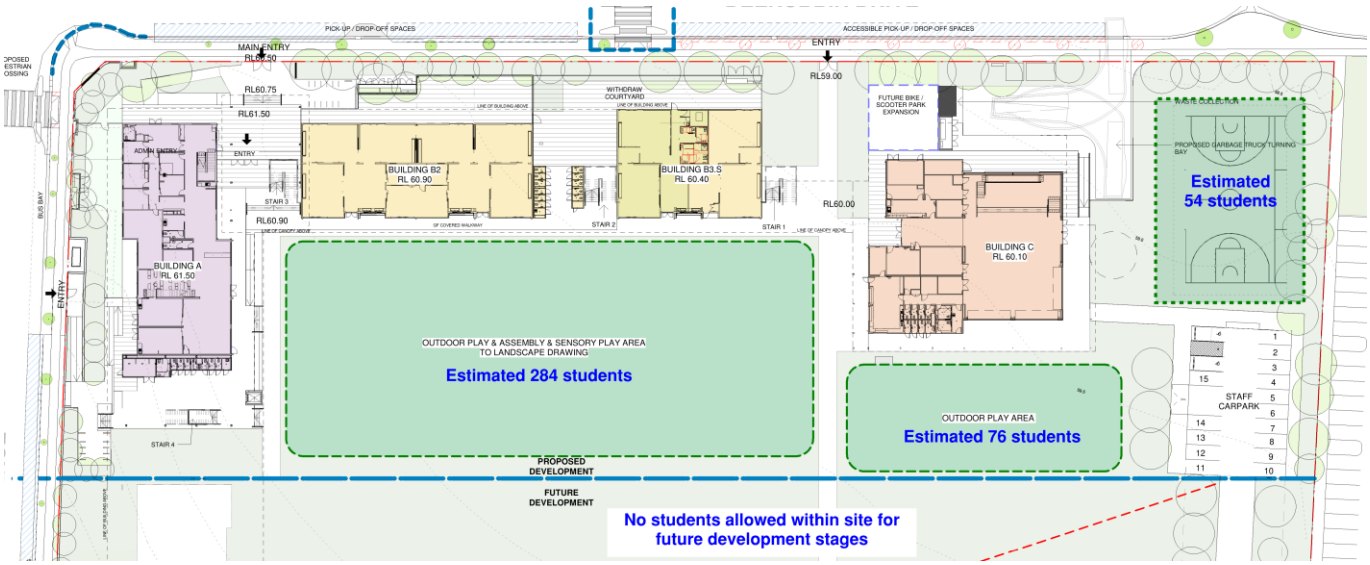
For the prediction of outdoor noise emissions due to students playing in outdoor areas, a typical lunch / recess period has been considered. In this scenario, it is assumed all students are in the designated playground areas as summarised in Table 18 and Figure 8. This distribution of students is consistent with providing each student the required minimum area of 10 m^2.

Under this prediction, it is assumed that no students are allowed into the future development area of the NPSMR.

Table 18 Summary of noise modelling assumptions

Outdoor Area	Number of Students	Noise Modelling Considerations (plane source across area of play)
Outdoor play area, south of Buildings B2 & B3	Estimated 284 students	Sound power level: 98 dB $L_{Aeq, 15\ minutes}$
Outdoor play area, south of Building C	Estimated 76 students	Sound power level: 92 dB $L_{Aeq, 15\ minutes}$
Games court, east of Building C	Estimated 54 students	Sound power level: 91 dB $L_{Aeq, 15\ minutes}$

Figure 8 Distribution of students during outdoor activities (for noise modelling purposes)



To predict the noise impact into nearest affected receivers, a 3D computational model of the site and surrounding area was developed and subsequently analysed using SoundPLAN version 8.0 acoustic modelling software. A summary of the predicted noise levels, as well as assessment outcomes, is presented in Table 19.

From Table 19, it is observed that compliances are achieved at all nearest affected residential receivers.

Table 19 Predicted noise emissions for a typical lunch / recess period

Receiver	Predicted Noise Levels (dB $L_{Aeq, 15\ minutes}$)	Daytime Noise Emission Target (dB $L_{Aeq, 15\ minutes}$)	Assessment Outcomes
34 Forestwood Drive	46	45	Compliance (marginal) [1]
31 Darug Avenue	45	48	Compliance
27 Darug Avenue	45	48	Compliance
90-98 Glenmore Ridge Drive (future mixed-use development)	40-46	48	Compliance
71 Deerubbin Drive	45	48	Compliance

Note 1: Exceedances of 1-2 dB are considered to be marginal since these are found to be subjectively imperceivable

5.4 Outdoor PA System

A detailed design of the outdoor PA system is not available at this stage. Therefore, as a performance requirement, it is recommended the outdoor PA system should be designed so noise emissions from the PA system do not exceed the intrusiveness criteria listed in Table 4. Noise emissions should be obtained under free-field conditions, excluding any noise reflections from walls or vertical structures.

Finally, the following it is recommended to be considered as part of the PA system design:

- Outdoor PA system should not operate outside school opening hours (i.e. between 6:30 pm and 6:30 am), and should not operate within the night time period (i.e. between 10:00 pm and 7:00 am).
- Low-powered horn-type speakers should be located and orientated to provide a good coverage of the school areas whilst being directly away from residences and sensitive receivers. System coverage shall be reviewed during the design phases.
- Speakers should be mounted with a downward angle and as close to the floor as possible. Speakers should be mounted below the height of school buildings and include directional speakers to mitigation noise spill to neighbouring receivers.
- Once appropriate noise levels from the speakers are obtained within school premises and at nearest affected receivers, the system gain should be limited so that staff cannot increase the noise levels.

5.5 Architectural Treatment - Building Envelope

To achieve compliance with the operational criteria discussed in Section 3, the conceptual treatments and performance requirements summarised in the following sub-sections, are recommended.

5.5.1 Buildings A, B2 & B3

All external windows and external doors (including sliding doors, openable and non-openable windows); should achieve a minimum sound reduction performance of Rw 35. Window performance is not only subject to the glazing selection but also to the construction of the window frame and the frame seal selection. Therefore, it is advised window manufacturer should confirm that the required sound insulation can be achieved. It is anticipated that the window system should comprise Q-Lon (or equivalent) or fin seals with deep C channels as part of the window track. Windows should also include laminated glass panels.

As per the windows, the performance of sliding doors is not only subject to the glass selection, but also to the door frame construction and frame seals. Therefore, it is recommended that the door manufacturer confirms that the door system achieves the required performance. Typically, these doors should include fin rubber seals and Q-Lon seals, with deep C channels as part of the door track and laminated glass panels.

Non-glazed components should achieve a minimum sound insulation performance of Rw 45. For conceptual recommendations regarding building envelope constructions, refer to Figure 9, Figure 10 and Figure 11. These include two roof treatment options, of which one option is to be selected and finalised. It is advised that recommended conceptual treatments are to be considered and further developed during detailed design stages.

5.5.2 Building C: Communal Hall

Figure 12 shows the conceptual recommendations for the building envelope at the Communal Hall. It is advised that these recommendations are to be further developed during detailed design stages.

In addition to these in-principle treatments, the following is also advised:

- All external windows and external doors should achieve a minimum sound reduction performance of Rw 30. Window performance is not only subject to the glazing selection but also to the construction of the window frame and the frame seal selection. Therefore, it is advised window manufacturer should confirm that the required sound insulation can be achieved. It is anticipated that the window system should comprise Q-Lon (or equivalent) or fin seals with deep C channels as part of the window track. Windows should also include laminated glass panels.

- As per the windows, the performance of sliding doors is not only subject to the glass selection, but also to the door frame construction and frame seals. Therefore, it is recommended that the door manufacturer confirms that the door system achieves the required performance. Typically, these doors should include fin rubber seals and Q-Lon seals, with deep C channels as part of the door track and laminated glass panels.

- Ceiling supporting grid should comprise resilient rubber mounts / clips (not shown in Figure 12). Otherwise, refer to treatment option shown in Figure 10.

5.5.3 Building C: Offices

Refer to conceptual treatment discussed in Section 5.5.1.

Figure 9 Building envelope recommendations, with roof treatment option 1

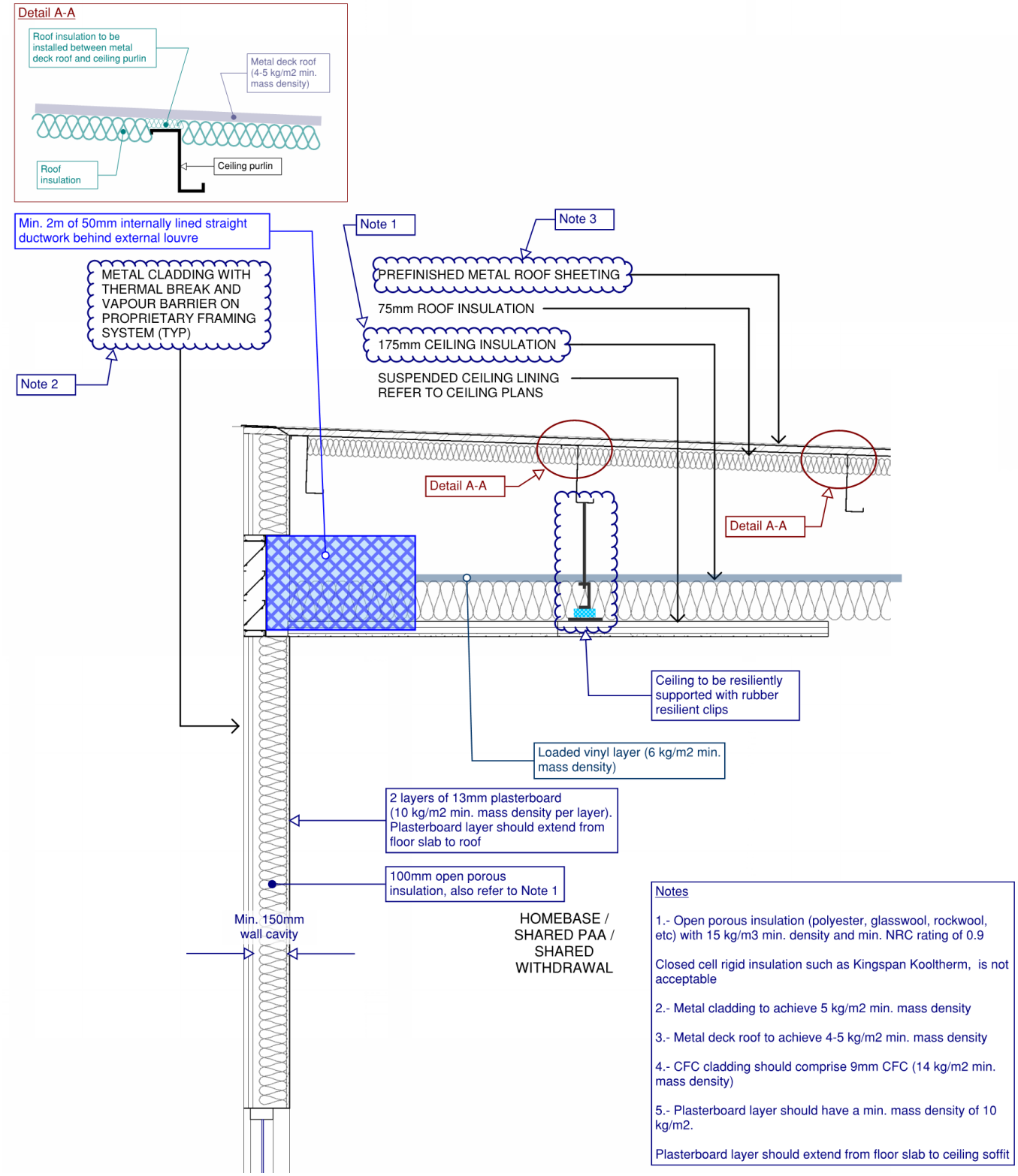


Figure 10 Building envelope recommendations, with roof treatment option 2

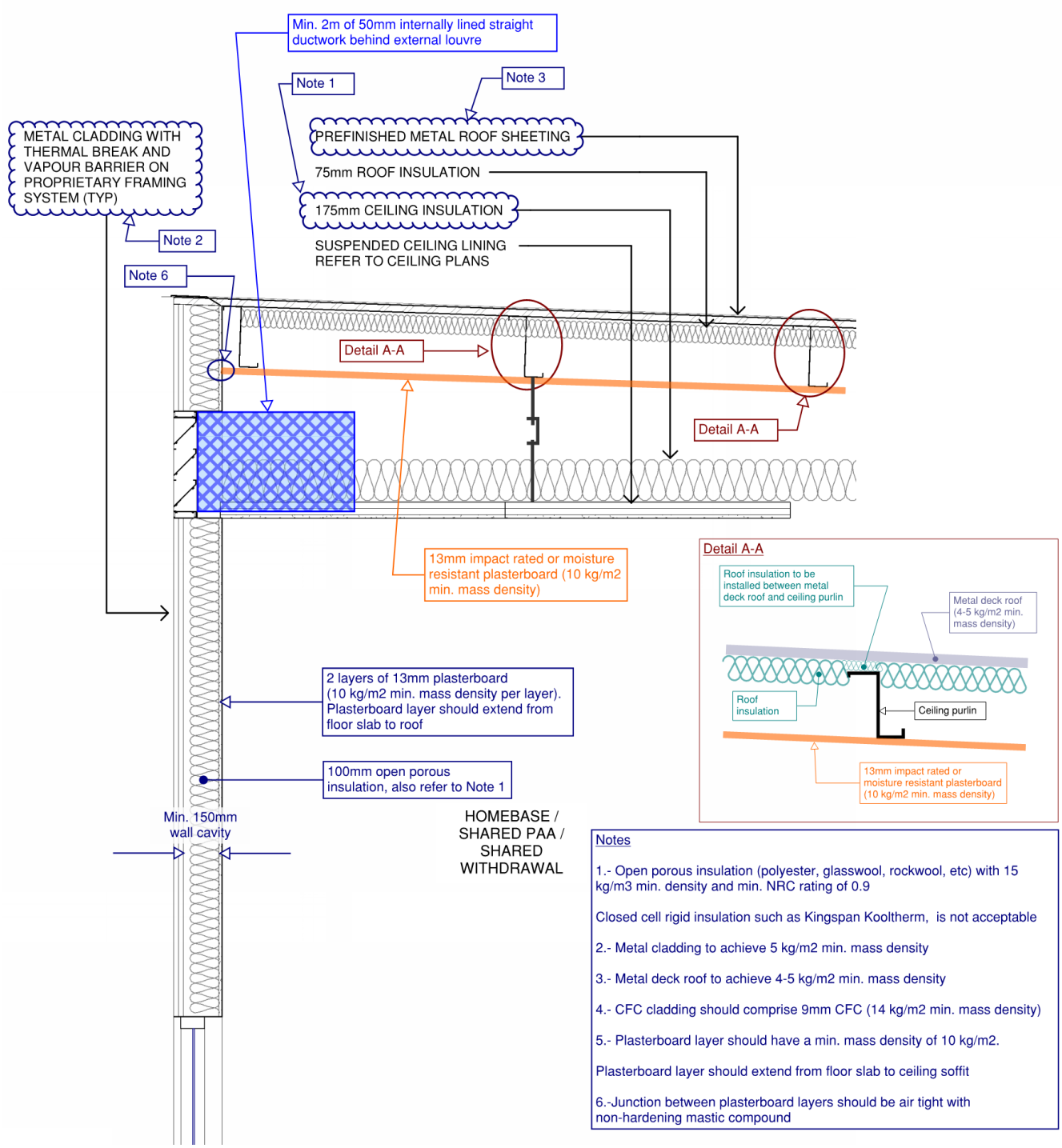


Figure 11 Building envelope recommendations – Buildings B2 & B3

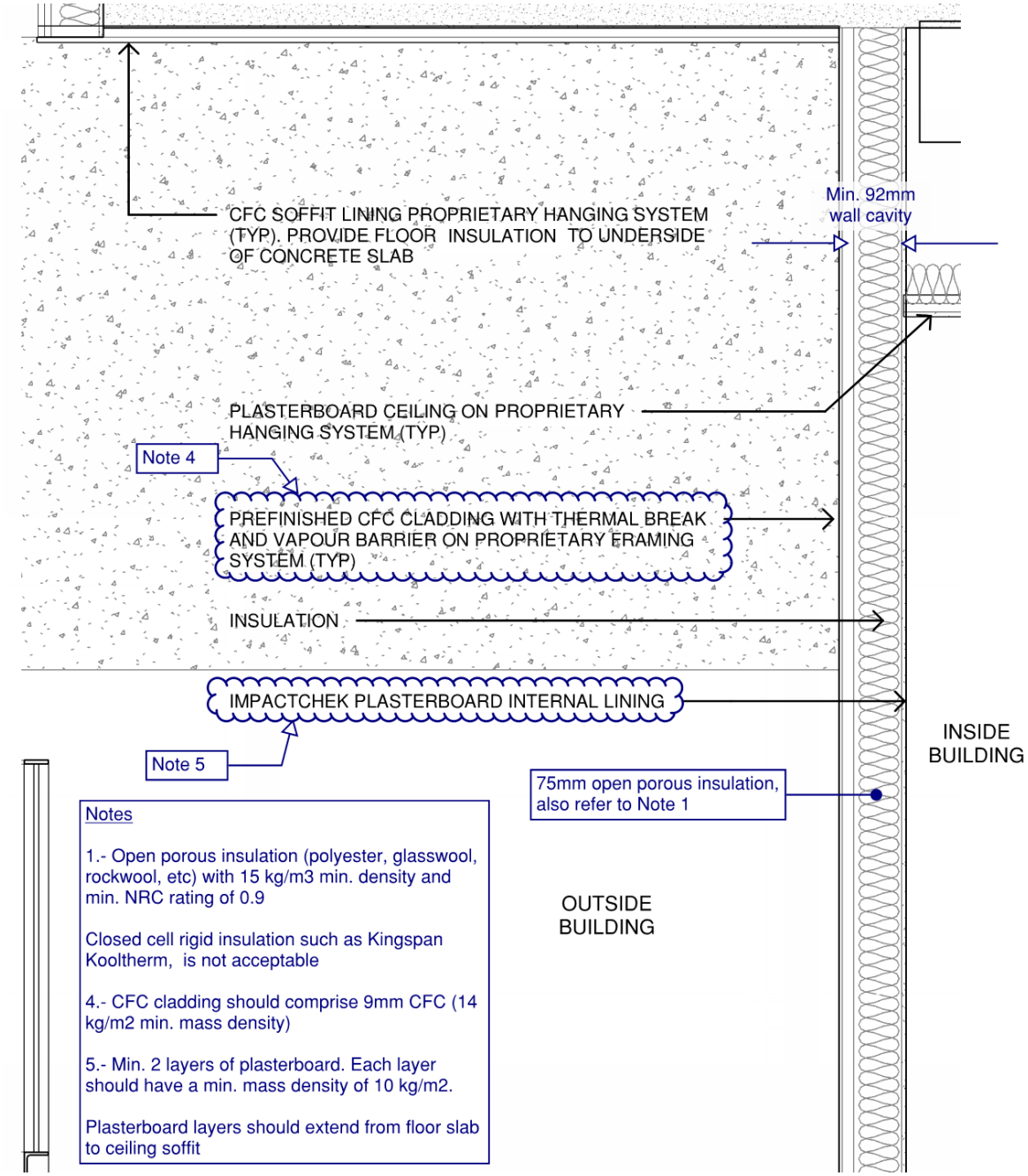
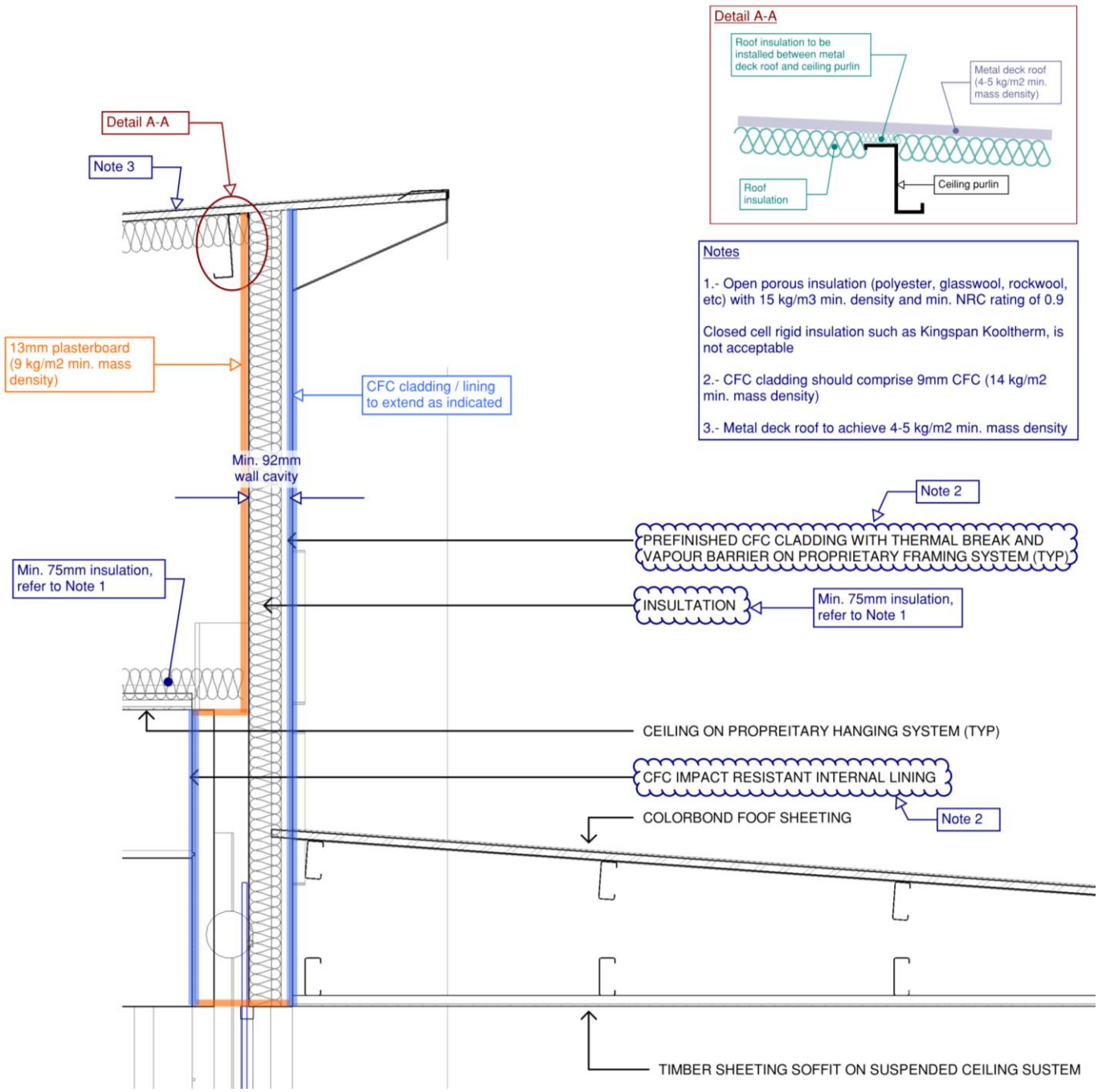


Figure 12 Building envelope recommendations – Building C, Communal Hall



5.6 Operational Procedures

According to Section 1.1, it is proposed to use the school premises during the extended hours of between 6:30 pm and 10:00 pm.

On rare occasions, out of hours activities are to be undertaken between 10:00 pm and 12:00 am. If these activities were to take place, then it is advised that these events should be conducted indoors in the library spaces of Building A, and in the Communal Hall on Building C.

Also, the following operational procedures are recommended in relation to these events:

- Only speeches and similar events should be conducted in the library spaces. No musical events are recommended in this space.

- After 10:00 pm, all external windows and doors should be kept closed in the library spaces in Building A, and in the Communal Hall, Building C. These include the vertical bifold doors in the Communal Hall.

5.7 Carpark Noise Emissions

5.7.1 Methodology

The staff carpark has a capacity for 17 vehicles. For our assessment, the sound power levels summarised in Table 20 are considered. It is also assumed the carpark will be only used by light vehicles, and the maximum vehicle velocity within the car park is 35 km/hour.

Table 20 Sound power levels for vehicle movements and activities

Vehicular Activity	Sound Power Level (dB re 1pW) [1]
Light vehicle pass-by	91 dB L_{Amax}
Car door closing	98 dB L_{Amax}
Engine start	93 dB L_{Amax}

Note 1: Noise information used for the prediction of $L_{Aeq,15\ minutes}$ noise levels

Vehicle movements were modelled as line sources with sound power levels corrected for length, assessment time (i.e. 15 minutes), and number of movements. Hence, the following equation has been used:

$$SWL_{line\ source} = SWL_{base\ sound\ power\ level} + 10 \log (t_{event} / t_{assessment\ period}) + 10 \log (N)$$

Where:

$SWL_{line\ source}$:	Sound power level of line source
$SWL_{base\ sound\ power\ level}$:	Base sound power levels as listed in Table 20
t_{event}:	Duration of individual event in seconds
$t_{assessment\ period}$:	Assessment period in seconds (900 seconds which corresponds to 15 minutes)
N:	Number of events

Also, it is noted that for light vehicle movements, engine noise was modelled at an elevation of 1m above ground level. For our predictions, it is assumed that a maximum of 17 vehicles arrive or depart from the carpark within a 15 minute period.

5.7.2 Noise Emissions During Typical Operational Hours

Therefore, based on this assumption, noise emissions from typical carpark activities have been predicted at the nearest affected residences, these are summarised in Table 21 below. Table 21 also summarises the findings from the assessment conducted for the daytime period (i.e. from 7:00 am to 6:00 pm), and the shoulder period extending between 6:30 am and 7:00 am.

From Table 21 it is noted that carpark noise emissions achieve compliance with the nominated criteria at the nearest impacted residences.

Table 21 Predicted $L_{Aeq,\ 15\ minutes}$ noise emissions from carpark activities

Residential Receiver	Predicted Noise Levels (dB $L_{Aeq,\ 15\ minutes}$)	Noise Emission Criteria (dB $L_{Aeq,\ 15\ minutes}$)	Assessment Outcomes
19 Parkway Avenue	40	Day: 40 Shoulder period: 44	Compliance
34 Forestwood Drive	35	Day: 40 Shoulder period: 44	Compliance
31 Darug Avenue	Less than 30	Day: 40 Shoulder period: 44	Compliance
27 Darug Avenue	Less than 30	Day: 40 Shoulder period: 44	Compliance
90-98 Glenmore Ridge Drive (future mixed-use development)	35	Day: 40 Shoulder period: 44	Compliance
71 Deerubbin Drive	35-40	Day: 40 Shoulder period: 44	Compliance

Note 1: Exceedances of 1-2 dB are considered to be marginal since these are found to be subjectively imperceivable
Note 2: Day-time period is between 7:00 am and 6:00 pm; shoulder period is between 6:30 am and 7:00 am

5.7.3 Sleep Disturbance Assessment

As discussed in Section 1.1, the typical operational hours for the school starts at 6:30 am. For the purpose of the acoustic assessment, the period between 6:30 am and 7:00 am is considered to be part of the night-time period. Consequently, noise emissions during this period are subject to a sleep disturbance assessment in accordance with the criteria discussed in Section 3.1.4.

Table 22 below summarises the L_{Amax} noise levels predicted at the nearest affected residences, due to typical carpark short term events. From this table it is noted that all predicted noise levels are below the sleep disturbance and sleep awakening criteria. Therefore, it is unlikely that sleep disturbance or sleep awakening events will occur at these residences due to typical vehicle events in the school carpark.

Table 22 Summary of predicted L_{AFmax} noise levels from vehicle events in the school carpark

Receiver	Predicted Noise Levels (dB L_{AFmax})	Noise Emission Criteria	Assessment Outcomes
19 Parkway Avenue	45	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Unlikely for sleep disturbance and awakening events to occur

Receiver	Predicted Noise Levels (dB L_{AFmax})	Noise Emission Criteria	Assessment Outcomes
34 Forestwood Drive	40	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Unlikely for sleep disturbance and awakening events to occur
31 Darug Avenue	40	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Unlikely for sleep disturbance and awakening events to occur
27 Darug Avenue	40	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Unlikely for sleep disturbance and awakening events to occur
90-98 Glenmore Ridge Drive (future mixed-use development)	50	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Unlikely for sleep disturbance and awakening events to occur
71 Deerubbin Drive	50	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Unlikely for sleep disturbance and awakening events to occur

Note 1: Exceedances of 1-2 dB are considered to be marginal since these are found to be subjectively imperceivable

5.8 Waste Collection

5.8.1 Methodology

As discussed in Section 1.1, waste collection will occur on a weekly basis. As shown in Figure 2, the waste collection area is accessible from Deerubbin Drive. Collection will be conducted by a front loaded or rear loaded, heavy rigid, waste collection truck.

The methodology used in the related assessment is as per discussed in Section 5.7.1, except the base sound power levels used in the predictions are those summarised in Table 23 below.

Table 23 Sound power levels for garbage truck movements and activities

Vehicular Activity	Sound Power Level (dB re 1pW) [1]
Garbage truck pass-by	104 dB L_{Amax}
Truck door closing [2]	99 dB L_{Amax}
Engine start	94 dB L_{Amax}
Beeping alarm	100 dB L_{Amax}

Note 1: Noise information used for the prediction of $L_{Aeq,15\ minutes}$ noise levels

5.8.2 Predicted Noise Emissions

Noise emissions for typical waste collection activities have been predicted using the information discussed in Section 5.8.1, and assuming the garbage truck operates at a maximum speed of 35 km/hour when arriving or departing from site.

Predicted noise levels at the nearest affected residences are summarised in Table 24. From this table, it is noted that compliance is achieved at all assessed locations, provided that waste collection is conducted on a weekly basis, between 7:00 am and 6:00 pm.

If collections were to be conducted before 7:00 am, noise emissions would be subject to a sleep disturbance assessment (as discussed in Section 3.1.4). Hence, it is observed that the future mixed-use development at 90-98 Glenmore Ridge Drive will be the most affected receiver. Noise levels of 65 dB L_{Amax} are predicted at this location. As a result, sleep disturbance and sleep awakening are likely to occur at this residential premises. Therefore, it is recommended that no waste collection activities should be conducted between 10:00 pm and 7:00 am.

Table 24 Predicted $L_{Aeq,\ 15\ minutes}$ noise emissions from waste collection activities

Residential Receiver	Predicted Noise Levels (dB $L_{Aeq,\ 15\ minutes}$)	Noise Emission Criteria [3] (dB $L_{Aeq,\ 15\ minutes}$)	Assessment Outcomes
19 Parkway Avenue	Less than 30	Day: 45	Compliance
34 Forestwood Drive	Less than 30	Day: 45	Compliance
31 Darug Avenue	Less than 30	Day: 45	Compliance
27 Darug Avenue	Less than 30	Day: 45	Compliance
90-98 Glenmore Ridge Drive (future mixed-use development)	45	Day: 45	Compliance
71 Deerubbin Drive	40	Day: 45	Compliance

Note 1: Exceedances of 1-2 dB are considered to be marginal since these are found to be subjectively imperceivable
Note 2: Day-time period is between 7:00 am and 6:00 pm; shoulder period is between 6:30 am and 7:00 am
Note 3: Criteria includes 5 dB modifying factor as discussed in Section 3.1.5

5.9 Noise Impact on Local Roads

5.9.1 Methodology

Refer to Section 5.7.1.

5.9.2 Noise Emissions During Typical Operational Hours

In Section 5 of the TTA Report, three school transport scenarios are discussed. From these scenarios, the base case scenario considers the highest vehicle utilisation for the school commute. Hence, this base case scenario has been considered in our acoustic assessment. This scenario allows for 293 vehicles arriving to school (i.e. drop-off), or departing from school (i.e. pick-up); within a 30 minutes interval.

Also, the TTA Report mentions that the following parameters have been adopted for the base case scenario:

- 30 seconds dwell time for drop-off
- 210 seconds dwell time for pick-up
- Pick-up and drop-off times take place within a 30 minutes interval. It is assumed that these times occur within the AM and PM school peak hours. According to the TTA Report, the school peak hours are:
    - AM peak hour: 7:45 am – 8:45 am
    - PM peak hour: 3:15 pm – 4:15 pm

It is noted that these school peak hours are within the daytime period according to the NSW RNP (i.e. between 7:00 am and 10:00 pm). Therefore, the noise impact on local roads is assessed based on the daytime criteria listed in Table 8

- Drop-off and pick-up locations as shown in Figure 13 below (obtained from Figure 41 of TTA Report). For our acoustic assessment, the following is assumed regarding number of vehicles arriving to or departing from these locations:
    - At Deerubbin Drive: 98 vehicles within a 30 minutes period
    - At Darug Avenue: 98 vehicles within a 30 minutes period
    - At Forestwood Drive: 98 vehicles within a 30 minutes period

Figure 13 Drop-off and pick-up locations (from Figure 41 of TTA Report)

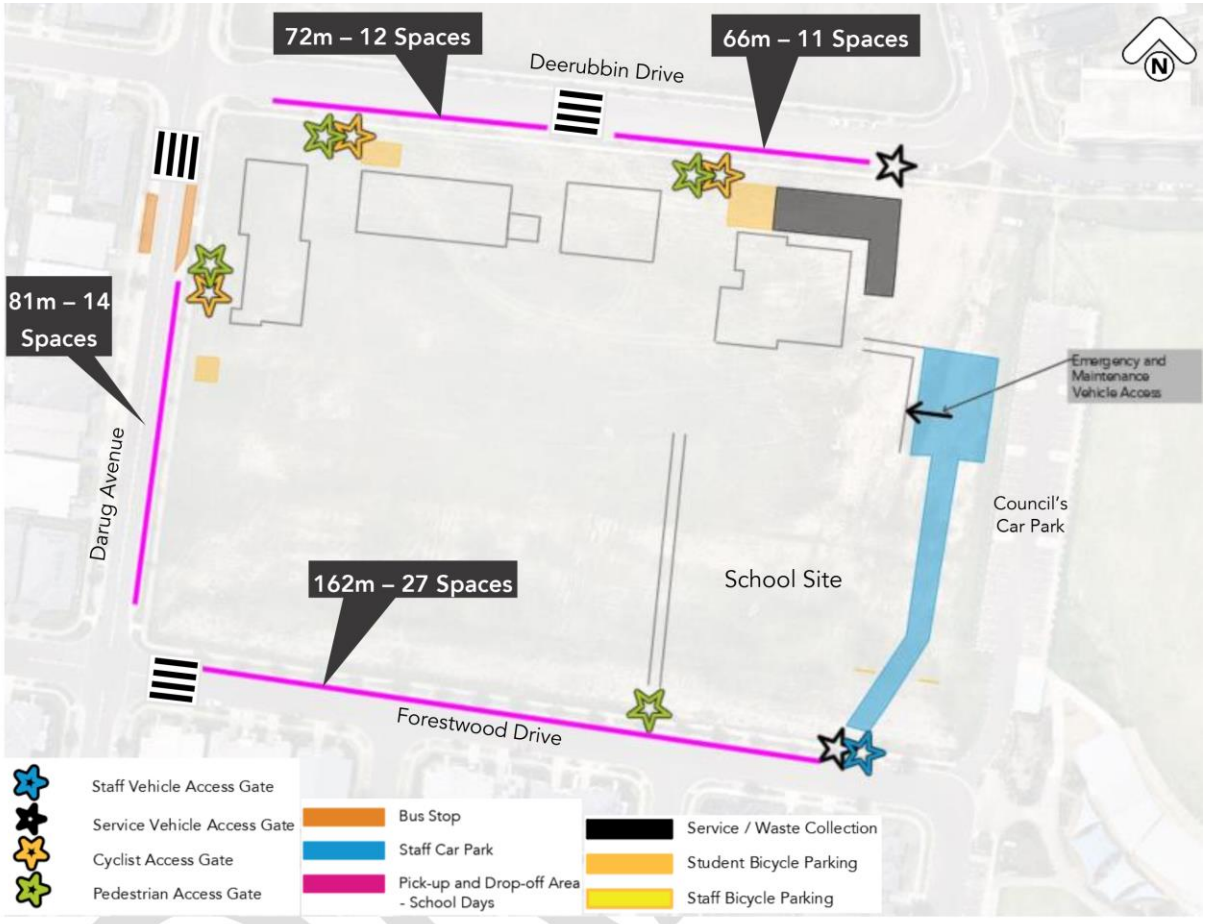


Figure 41 - Pick-up and Drop-off Requirement for Base Case Scenario

Additionally, the noise modelling information discussed in Section 5.7 has also been considered in our calculations of noise emissions on local roads (i.e. 35 km/hour vehicle speed, base sound power levels listed in Table 20, conversion to line source sound power levels).

Based on this information, noise emissions from vehicular activities on local roads have been predicted at nearest affected receivers. These are summarised in Table 25 below.

Table 25 Noise emissions from vehicular activities on local roads

Receiver	Predicted Noise Levels (dB $L_{Aeq, 1\ hour}$)	Noise Emission Criteria (dB $L_{Aeq, 1\ hour}$)	Assessment Outcomes
34 Forestwood Drive	54	Day: 55	Compliance
27 Darug Avenue	54	Day: 55	Compliance
90-98 Glenmore Ridge Drive (future mixed-use development)	51	Day: 55	Compliance
71 Deerubbin Drive	50	Day: 55	Compliance

Note 1: Exceedances of 1-2 dB are considered to be marginal since these are found to be subjectively imperceivable
Note 2: Day-time period is between 7:00 am and 10:00 pm

From Table 25 it is noted that the predicted noise levels achieve compliance with the criteria discussed in Section 3.7.

5.9.3 Sleep Disturbance Assessment

As discussed in Section 5.7.3, the shoulder period between 6:30 am and 7:00 am is considered to be part of the night-time period, and as a result, subject to the sleep disturbance assessment.

Table 26 summarises the L_{Amax} noise levels predicted at the nearest affected residences, due to vehicular short-term events on local roads (such as engine start, door closing, etc). From this table it is noted that all predicted noise levels are below the sleep disturbance and sleep awakening criteria. Therefore, it is unlikely that sleep disturbance or sleep awakening events will occur at these residences.

Table 26 Summary of predicted L_{AFmax} noise levels

Receiver	Predicted Noise Levels (dB L_{AFmax})	Noise Emission Criteria	Assessment Outcomes
34 Forestwood Drive	35	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Compliance
27 Darug Avenue	35	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Compliance
90-98 Glenmore Ridge Drive (future mixed-use development)	35	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Compliance
71 Deerubbin Drive	30	Sleep disturbance: 52 dB L_{Amax} Sleep awakening: 60 – 65 dB L_{Amax}	Compliance

Note 1: Exceedances of 1-2 dB are considered to be marginal since these are found to be subjectively imperceivable

6 CONSTRUCTION NOISE & VIBRATION ASSESSMENT

6.1 Construction Noise Assessment

No information is currently available for the construction and demolition program. However, a preliminary tender program has been provided. From this program, and based on previous project experience, construction and demolition tasks have been assumed for our assessment. These are summarised in Table 27 below, along with the equipment likely to be used in each task and their sound power levels.

Table 27 Summary of predicted sound power levels

Tasks	Equipment	Sound Power Levels (dBA re 1pW)	Aggregate Sound Power Level per Task (dBA re 1pW)
Site possession and establishment	Elevating platform	102	113
	Mobile crane	110	
	Power hand tools	109	
	Franna crane	102	
	Semi - trailer (idle)	102	
Site clearance & bulk earthworks	Dump truck	109	114
	Skid steer	110	
	Compactor	107	
Footings	Concrete pump	103	115
	Concrete truck	107	
	Piling rig	113	
	Welder	101	
New structure and roof works (Communal Hall)	Dump truck	109	121
	Concrete saw	119	
	Skid steer	110	
	Power hand tools	109	
	Welder	101	
	Concrete pump truck	110	
	Concrete agitator truck	108	
Onsite installation	Mobile crane	110	114
	Franna crane	102	
	Semi - trailer (idle)	102	
	Welder	101	
	Power hand tools	109	
	Scissor lift	98	
External works	Welder	101	114
	Saw cutter	109	
	Dump truck	109	
	Power hand tools	109	

Tasks	Equipment	Sound Power Levels (dBA re 1pW)	Aggregate Sound Power Level per Task (dBA re 1pW)
Internal works	Power hand tools	109	112
	Welder	101	
	Saw cutter	109	
	Handheld nail gun	101	

For this assessment, the nearest affected receivers on which our assessment is conducted, are listed in Table 28 below. Please note that receivers at the future mixed-use development to be located along the northern property boundary, across Deerubbin Drive (i.e. 90-98 Glenmore Ridge Drive), is not considered since it is anticipated that this development will not be finalised before the school construction is finished.

Based on the equipment sound power levels given in Table 27, noise levels have been predicted at these nearest affected properties for each construction scenario (where each construction scenario comprises two or more construction tasks). These predicted noise levels are summarised in Table 29.

Table 28 Receiver IDs for assessment purposes

Receiver ID	Noise Sensitive Locations	Type
RE01	71 Deerubbin Drive, Glenmore Park	Residential
RE02	27 Darug Avenue, Glenmore Park	Residential
RE03	34 Forestwood Drive, Glenmore Park	Residential
CM01	71 Deerubbin Drive, Glenmore Park	Commercial
AR01	Mulgoa Rise Fields	Active Recreation Area

Table 29 Predicted $L_{Aeq\ (15\ minutes)}$ noise levels at residential receivers

Scenario	Tasks	Aggregate Sound Power Level per Scenario (dBA re 1pW)	Predicted Noise Levels, dBA				
			RE01	RE02	RE03	CM01	AR01
1	Site establishment	110	60-65	60-75	60-65	60-65	55-65
2	Site clearance	111	60-65	60-75	60-65	60-65	60-65
3	Footings	112	55-65	60-75	60-65	55-65	60-65
4	New structure and roof works (Communal Hall) Onsite installation	119	65-70	65-75	65-70	65-70	70-75
5	External works & internal works	115	60-70	60-75	60-65	60-70	60-70

These predicted noise levels have been assessed against the construction noise criteria discussed in Section 4.1. The outcomes of this assessment are summarised in Table 30.

Table 30 Summary of assessment outcomes and exceedances based on the ICNG criteria

Scenario	Parameter	Assessment Outcome				
		RE01	RE02	RE03	CM01	AR01
1	*Predicted Noise Levels, dBA*	*60-65*	*60-75*	*60-65*	*60-65*	*55-65*
	Within standard construction hours					
	Exceedance over NML, dB	16-21	16-31	16-21	0	0
2	*Predicted Noise Levels, dBA*	*60-65*	*60-75*	*60-65*	*60-65*	*60-65*
	Within standard construction hours					
	Exceedance over NML, dB	16-21	16-31	16-21	0	0
3	*Predicted Noise Levels, dBA*	*55-65*	*60-75*	*60-65*	*55-65*	*60-65*
	Within standard construction hours					
	Exceedance over NML, dB	11-21	16-31	16-21	0	0
4	*Predicted Noise Levels, dBA*	*65-70*	*65-75*	*65-70*	*65-70*	*70-75*
	Within standard construction hours					
	Exceedance over NML, dB	21-26	21-31	21-26	0	5-10
5	*Predicted Noise Levels, dBA*	*60-70*	*60-75*	*60-65*	*60-70*	*60-70*
	Within standard construction hours					
	Exceedance over NML, dB	16-26	16-31	16-21	0	5

*Note 1: Nil exceedances (i.e. 0 dB shown with **green** font) indicate compliance. Exceedances shown with **orange** font indicate noise affected receivers. Exceedances shown with **red** font indicate highly noise affected receivers*

Consequently, from the assessment summarised in Table 30, the following is noted:

- Residential premises closest to the project site (especially those located within line of sight from the project site), are likely to be noise affected by construction activities. This is observed for all considered construction scenarios.
- The building at 71 Deerubbin Drive is a mixed use development, with commercial premises located at Ground Level. From the assessment it is noted that these commercial premises are not likely to be affected by construction noise.
- Active recreation areas at Mulgoa Rise Fields, are likely to be noise affected during construction of the Communal Hall and other school premises.

Therefore, based on these findings, the conceptual management procedures discussed in Section 6.4 are recommended.

6.2 Construction Traffic Noise Assessment

No information regarding vehicular traffic movements related to construction activities; is available at this stage. Nevertheless, it is noted that vehicle numbers on surrounding roads would need to increase by around 60% from existing traffic flows, for a 2 dB increase in road traffic noise to occur.

Therefore, it is recommended that a traffic survey should be undertaken to confirm the expected traffic volumes generated by the construction activities do not exceed the recommended maximum growth of 60% relative to the existing traffic volumes.

6.3 Vibration Assessment

To retain compliance with the human comfort vibration criteria discussed in Section 4.3, it is recommended that the indicative safe distances listed in Table 31 should be maintained. These indicative safe distances should be validated prior to the start of construction works by undertaking measurements of vibration levels generated by construction and demolition equipment to be used on site.

Since the criteria for scientific or medical equipment (should any of these exist close to the site) can be more stringent than those required for human comfort, vibration validating measurements should be conducted at each site to determine the vibration level and potential impact onto this sensitive equipment.

Additionally, any vibration levels should be assessed in accordance with the criteria discussed in Section 4.3. This information should also be included as part of the CNVMP.

Table 31 Recommended indicative safe working distances for vibration intensive plant

Plant	Rating / Description	Safe Working Distances (m)	
		Cosmetic Damage (BS 7385: Part 2 DIN 4150: Part 3)	Human Comfort (AVTG)
Vibratory roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 – 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Jackhammer	Hand held	1	Avoid contact with structure and steel reinforcements

6.4 Noise & Vibration Management Procedures

The contractor should develop a construction noise and vibration management plan (CNVMP) in order to implement mitigation measures to manage the noise and vibration impact onto the potentially affected receivers.

The following sub-sections discuss the issues and measures that can be considered as part of this CNVMP.

6.4.1 Noise Mitigation Measures

A detailed construction program should be provided which should include the following:

- Schedule of construction activities (classified into scenarios if applicable)
- List of construction equipment per activity
- Location of construction equipment
- Duration of construction activities, as well as proposed construction hours

This construction program should be issued to assist on the prediction of the noise impact and to develop mitigation measures that can ameliorate this impact. A 3D computer noise model can be produced to conduct the noise level predictions and undertake the relevant assessment. The outcomes of this assessment should be discussed in the CNVMP.

The contractor should, where reasonable and feasible, apply best practice noise mitigation measures. These measures include the following:

- Maximising the offset distance between plant items and nearby noise sensitive receivers.
- Preventing noisy plant working simultaneously and adjacent to sensitive receivers.
- Minimising consecutive works in the same site area.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.

To minimise noise impacts during the works, the contractor should take all reasonable and feasible measures to attenuate the noise impact. Hence it is advised that on-site monitoring be conducted to attest this impact and propose mitigation measures as construction activities develop.

The contractor should also take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.

The contractor should apply all feasible and reasonable work practices to meet the NMLs and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and the contact details for the proposal.

A potential approach would be to schedule a respite period after continuous construction activity, or undertaking high noise generating works to less sensitive times.

Finally, undertake an assessment of road traffic noise generated by light and heavy vehicle movements which are associated with the development construction. For this purpose, request a traffic study report to determine the relevant traffic flows and assess the predicted road traffic noise levels in accordance with the criteria discussed in Section 4.2.

6.4.2 Vibration Mitigation Measures

The following vibration mitigation measures are recommended to be considered as part of a CNVMP:

- Any vibration generating plant and equipment is to be located in areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Identify of other vibration sensitive structures such as tunnels, gas pipelines, fibre optic cables, Sydney Water retention basins. Specific vibration goals should be determined on a case-by-case basis by an acoustic consultant which is to be engaged by the construction contractor.
- Identify heritage structures as well as vibration sensitive premises (such as those containing scientific and surgery equipment). Safe working distances from vibration generating equipment should be established in order to achieve compliance with the criteria discussed in Section 4.3.
- Hence, it is advised to conduct attended measurements of vibration generating plant at commencement of works to confirm compliance with vibration criteria discussed in Section 4.3. Measurements should be conducted at the nearest affected property boundary. If possible, measurements will also be used to validate the safe working distances advised in Table 31 and to establish safe working distances suitable to the project.

- Use lower vibration generating items of construction plant and equipment, that is, smaller capacity plant.
- Minimise conducting vibration generating works consecutively in the same area (if applicable).
- Schedule a minimum respite period prior to long continuous activities.
- Use only dampened rock breakers and/or "city" rock breakers to minimise the impacts associated with rock breaking works.

6.4.3 Miscellaneous Measures

Deliveries should be undertaken, where possible, during standard construction hours.

Maximise hammer penetration (and reduce blows) by using sharp hammer tips. Keep stocks of sharp profiles on site; and monitor the profiles in use.

It is advised that mobile plant and trucks operating on site for a significant portion of the project are to have reversing alarm noise emissions minimised. This is to be implemented subject to recognising the need to maintain occupational safety standards.

No public address system should be used on site.

A complaint response procedure should be implemented. Information to be gathered as part of this process should include location of complainant, time/s of occurrence of alleged noise or vibration impacts (including nature of impact particularly with respect to vibration), perceived source, prevailing weather conditions and similar details that could be utilised to assist in the investigation of the complaint. All resident complaints will be responded to in the required timeframe and action taken recorded.

7 CONCLUSIONS

Pulse White Noise Acoustics (PWNA) has been engaged to undertake an acoustic assessment for the New Primary School in Mulgoa Rise (NPSMR), which is to be located at 1-23 Forestwood Drive, Glenmore Park, NSW. This assessment is prepared to address the acoustic conditions included in the Secretary's Environmental Assessment Requirements (SEARs) related to this new development.

The following sub-sections summarise the outcomes of this assessment.

7.1 Operational Acoustic Assessment

7.1.1 External & Internal Noise Emissions – Building Services

Conceptual treatments have been provided for outdoor plant items. These treatments include solid screens and, recommended operational times and limiting sound power levels. These are discussed in Section 5.1.

Additionally, it is also advised that the mechanical / AC ventilation system should be design to achieve the internal noise level criteria discussed in Section 3.5.2.

Emergency plant should be designed to comply with the internal noise level criteria discussed in standard AS/NZS 1668.1:2015 (refer to Section 3.5.3).

Mechanical plant should be resiliently mounted. Vibration isolation mounts and supports should be designed to achieve compliance with vibration criteria discussed in Section 3.8.

7.1.2 Outdoor Noise Emissions – Playgrounds

Noise emissions from outdoor playgrounds at nearest affected residences, are found to be compliant with the noise emission target discussed in Section 3.2.

7.1.3 Outdoor PA System

A detailed design of the outdoor PA system is not available at this stage. Therefore, as a performance requirement, it is recommended the outdoor PA system should be designed so noise emissions from the PA system do not exceed the intrusiveness criteria listed in Table 4. Noise emissions should be obtained under free-field conditions, excluding any noise reflections from walls or vertical structures.

It is also advised that outdoor PA system should not operate during the night time period (i.e. between 10:00 pm and 7:00 am) and neither outside school opening hours (i.e. between 6:30 pm and 6:30 am). Further conceptual recommendations are provided in Section 5.4.

7.1.4 Building Envelope Constructions

To achieve compliance with the operational criteria discussed in Section 3, conceptual treatments and performance requirements for building envelope constructions have been provided in Section 5.5. These conceptual treatments are to be further developed during detailed design stages.

7.1.5 Operational Procedures

Operational procedures have been recommended for the extended hours of 6:30 pm and 10:00 pm.

If out of hours activities were to be conducted after 10:00 pm, and these are likely to be conducted in rare occasions, then these events should be conducted indoors in the library spaces of Building A, and in the Communal Hall on Building C.

Also, the following operational procedures are recommended in relation to these events:

- Only speeches and similar events should be conducted in the library spaces. No musical events are recommended in this space

- After 10:00 pm, all external windows and doors should be kept closed in the library spaces in Building A, and in the Communal Hall, Building C. These include the vertical bifold doors in the Communal Hall

7.1.6 Carpark Noise Emissions

Noise emissions from vehicular activities in the carpark are unlikely to exceed the relevant operational criteria during the proposed operational hours.

Also, these noise emissions are unlikely to cause sleep disturbance and sleep awakening events at the nearest residences.

Finally, it is advised that waste collection should be conducted between 7:00 am and 6:00 pm.

7.1.7 Noise Impact on Local Roads

The noise emissions from vehicular activities on local roads, which are related to the use of the school, are found to be with the relevant noise criteria for local roads.

Additionally, it has been found that noise emissions from short term vehicular events are unlikely to cause sleep disturbance and sleep awakening at the nearest residences.

7.1.8 Aircraft Noise Intrusion

Based on ANEC contours for the future Western Sydney Airport, it is observed that the project site will be exposed to a less than 20 ANEC contour (refer to Section 3.6). Therefore, the site is no subject to the aircraft noise intrusion assessment.

7.2 Construction Noise & Vibration Assessment

The preliminary construction noise and vibration assessment has determined that residential receivers will be noise affected by construction activities.

As a result, conceptual management procedures have been advised in Section 6.4 which should be considered and further developed into a detailed construction noise and vibration management plan (CNVMP).

Also, noise generated by road traffic related to construction activities, should be assessed against the criterion discussed in Section 6.2. This assessment can be conducted as part of the construction traffic management plan.

Finally, the CNVMP should also consider vibration impact onto the nearest affected locations. Hence vibration mitigation measures are discussed in Section 6.4.2, which includes the validation of safe working distances prior to starting vibration intensive tasks.

7.3 Final Remarks

Based on the findings from the acoustic assessment, it is our opinion that the proposed development can achieve the compulsory acoustic conditions as required by local authorities, provided the conceptual recommendations discussed herein are implemented and developed at later detailed design stages.

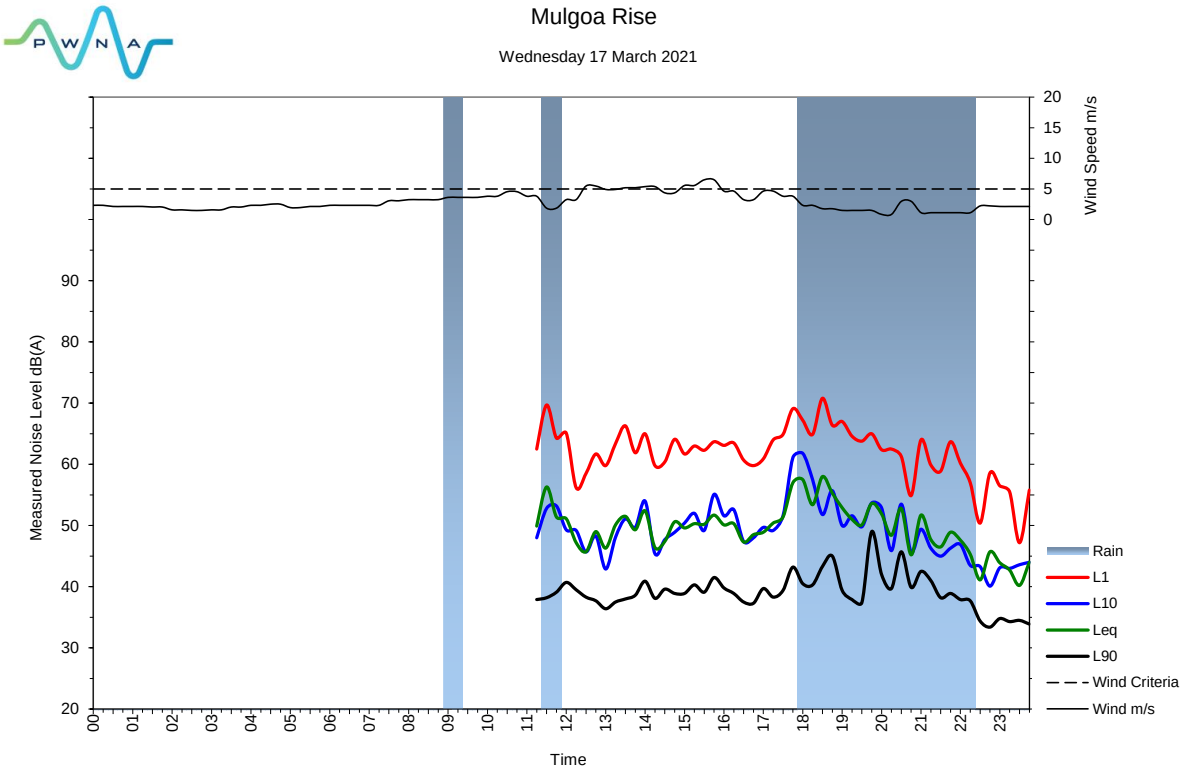
APPENDIX A: ACOUSTIC GLOSSARY

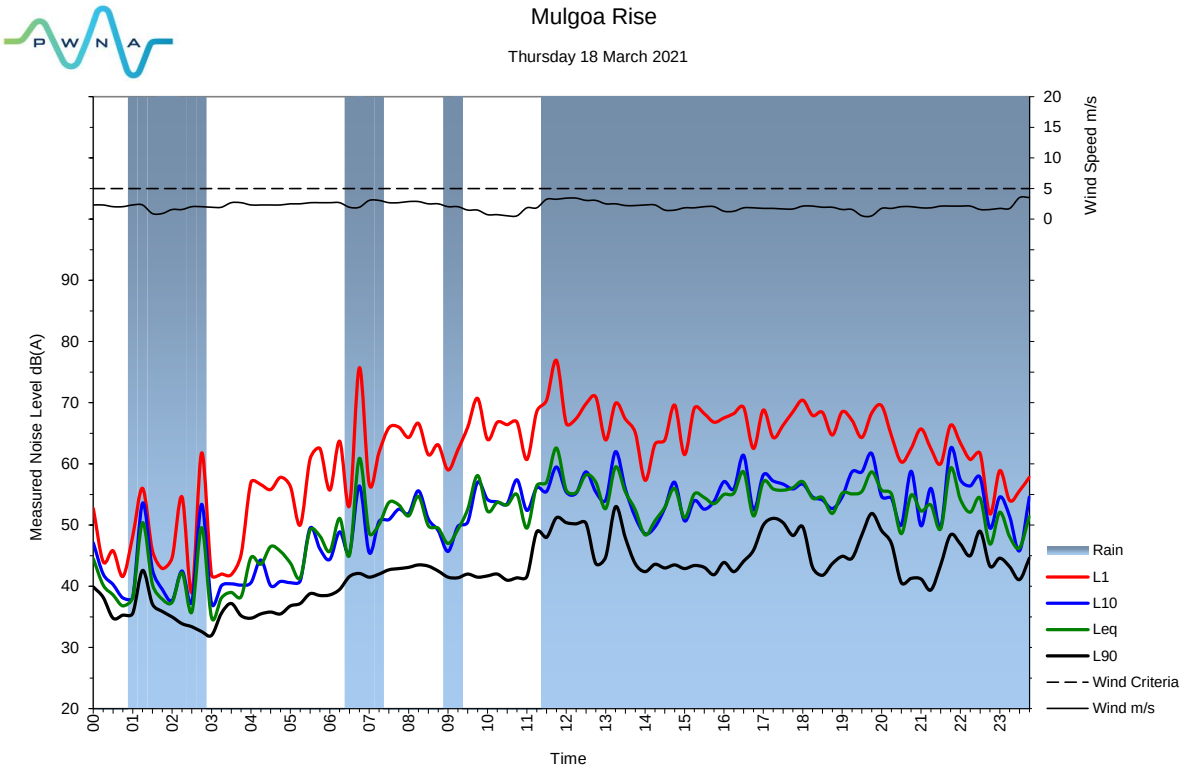
The following is a brief description of the acoustic terminology used in this report.

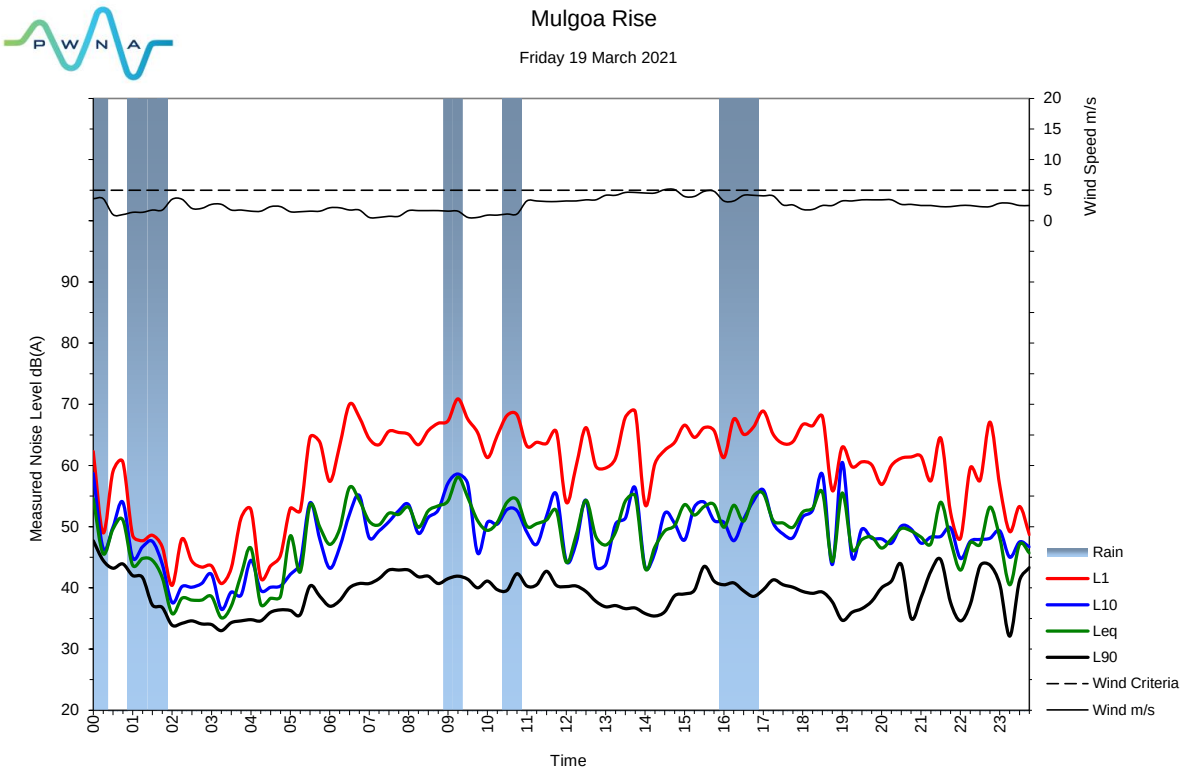
Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.

Background Sound Low	The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted, external ambient noise sources. Usually taken to mean the L_{A90} value
Ctr	A frequency adaptation term applied in accordance with the procedures described in ISO 717.
dB (A)	'A' Weighted overall sound pressure level
Noise Reduction	The difference in sound pressure level between any two areas. The term "noise reduction" does not specify any grade or performance quality unless accompanied by a specification of the units and conditions under which the units shall apply
NR Noise Rating	Single number evaluation of the background noise level. The NR level is normally around 5 to 6 dB below the "A" weighted noise level. The NR curve describes a spectrum of noise levels and is categorised by the level at 1000 Hz ie the NR 50 curve has a value of 50 dB at 1000 Hz. The NR rating is a tangential system where a noise spectrum is classified by the NR curve that just encompasses the entire noise spectrum consideration.
R_w	Weighted Sound Reduction Index - Laboratory test measurement procedure that provides a single number indication of the acoustic performance of a partition or single element. Calculation procedures for Rw are defined in ISO 140-2:1991 "Measurement of Sound Insulation in Buildings and of Building Elements Part 2: Determination, verification and application of precision data".
R'_w	Field obtained Weighted Sound Reduction Index - this figure is generally up to 3-5 lower than the laboratory test determined level data due to flanked sound transmission and imperfect site construction.
Sound Isolation	A reference to the degree of acoustical separation between any two areas. Sound isolation may refer to sound transmission loss of a partition or to noise reduction from any unwanted noise source. The term "sound isolation" does not specify any grade or performance quality and requires the units to be specified for any contractual condition
Sound Pressure Level, L_P dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, L_W dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt
Speech Privacy	A non-technical term but one of common usage. Speech privacy and speech intelligibility are opposites and a high level of speech privacy means a low level of speech intelligibility. It should be recognised that acceptable levels of speech privacy do not require that speech from an adjacent room is inaudible.
Transmission Loss	Equivalent to Sound Transmission Loss and to Sound Reduction Index in terminology used in countries other than Australia. A formal test rating of sound transmission properties of any construction, by usually a wall, floor, roof etc. The transmission loss of all materials varies with frequency and may be determined by either laboratory or field tests. Australian Standards apply to test methods for both situations.

APPENDIX B: UNATTENDED NOISE MEASUREMENTS



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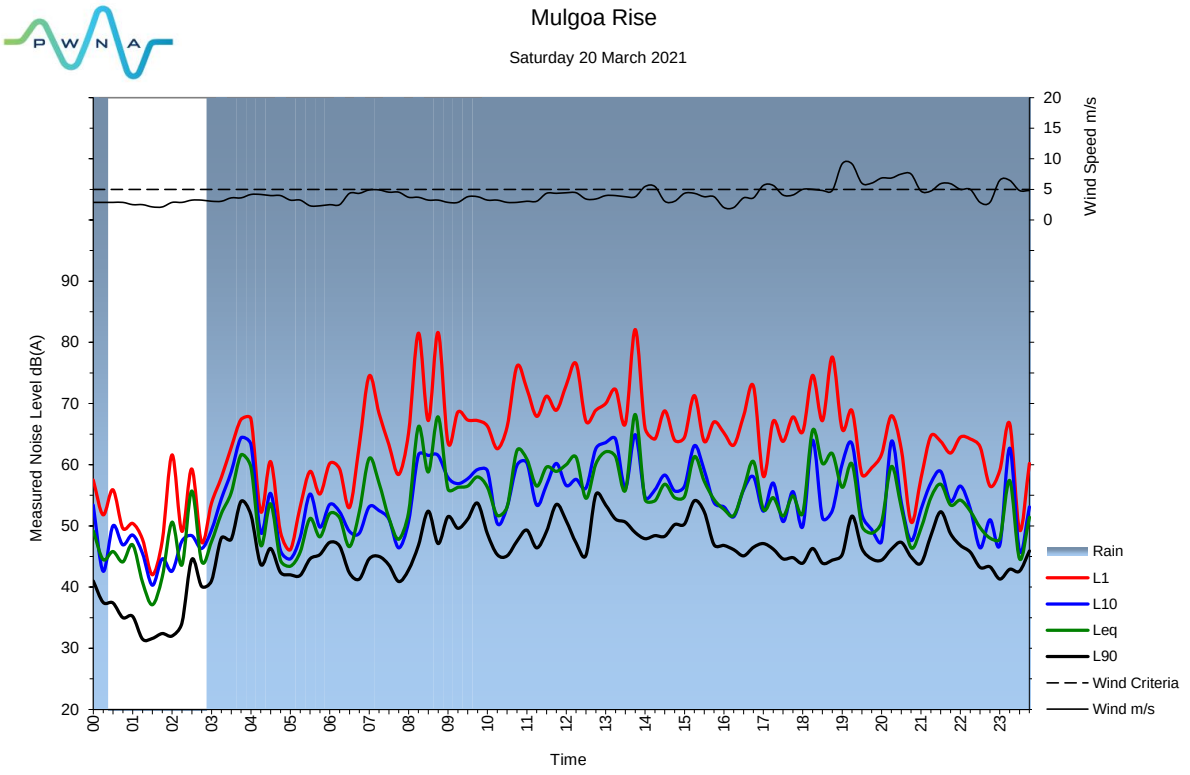
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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Time
Rain
L1
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Leq
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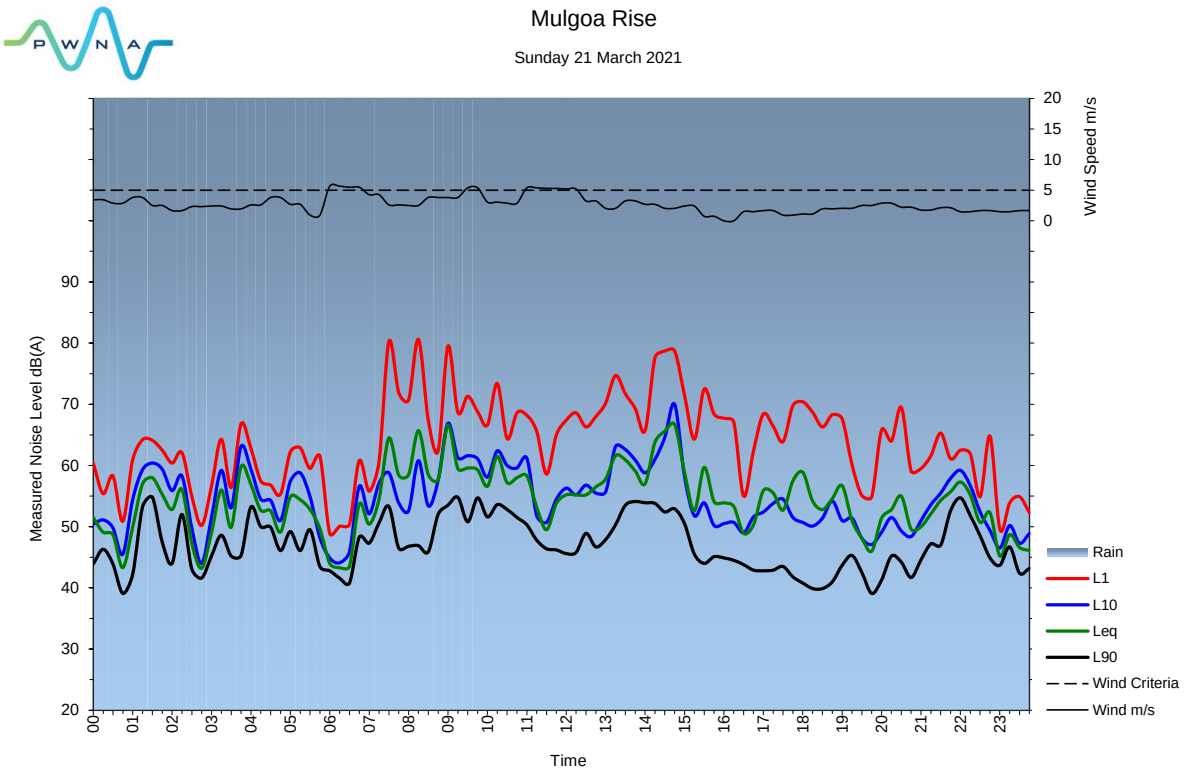
Wind Criteria
Wind m/s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Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
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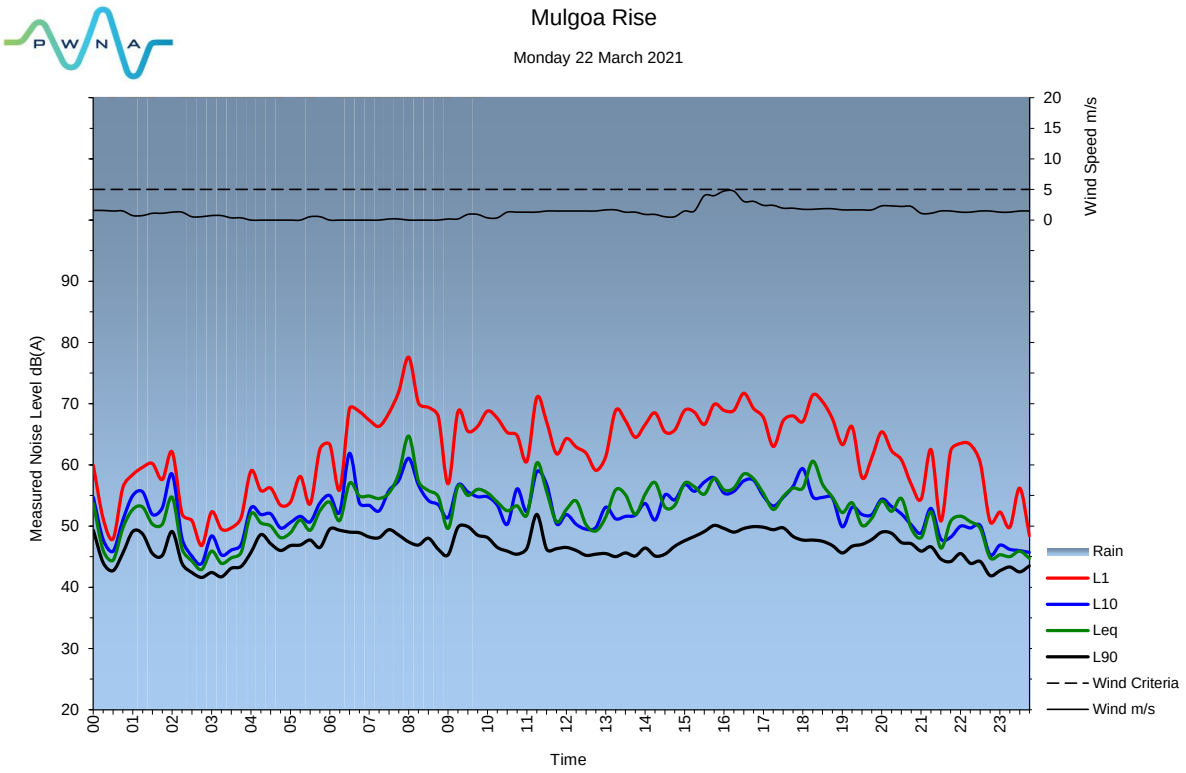
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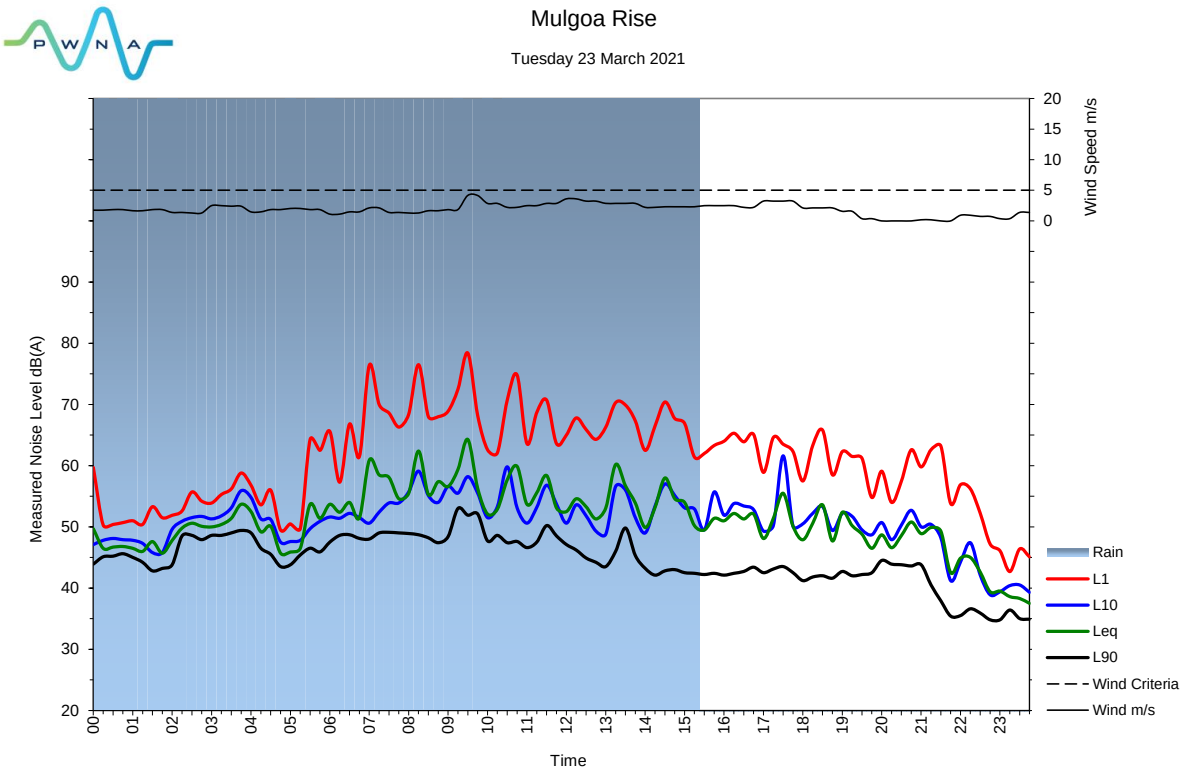
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
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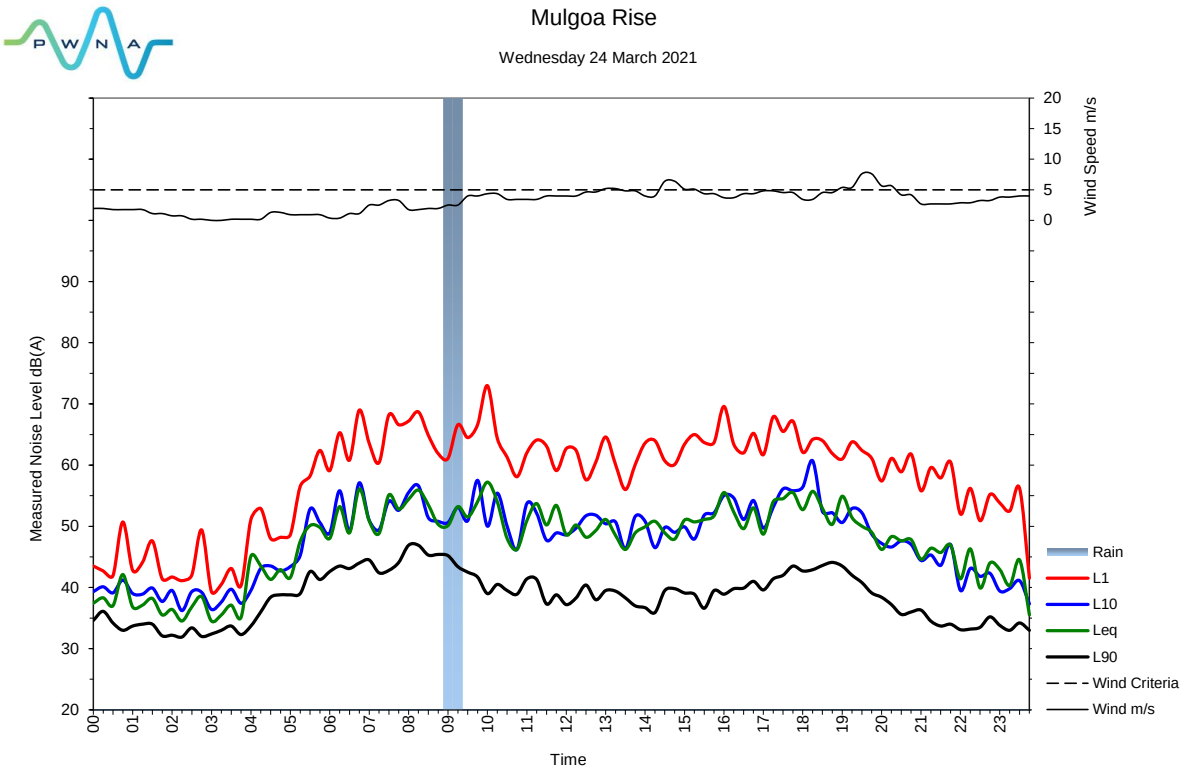
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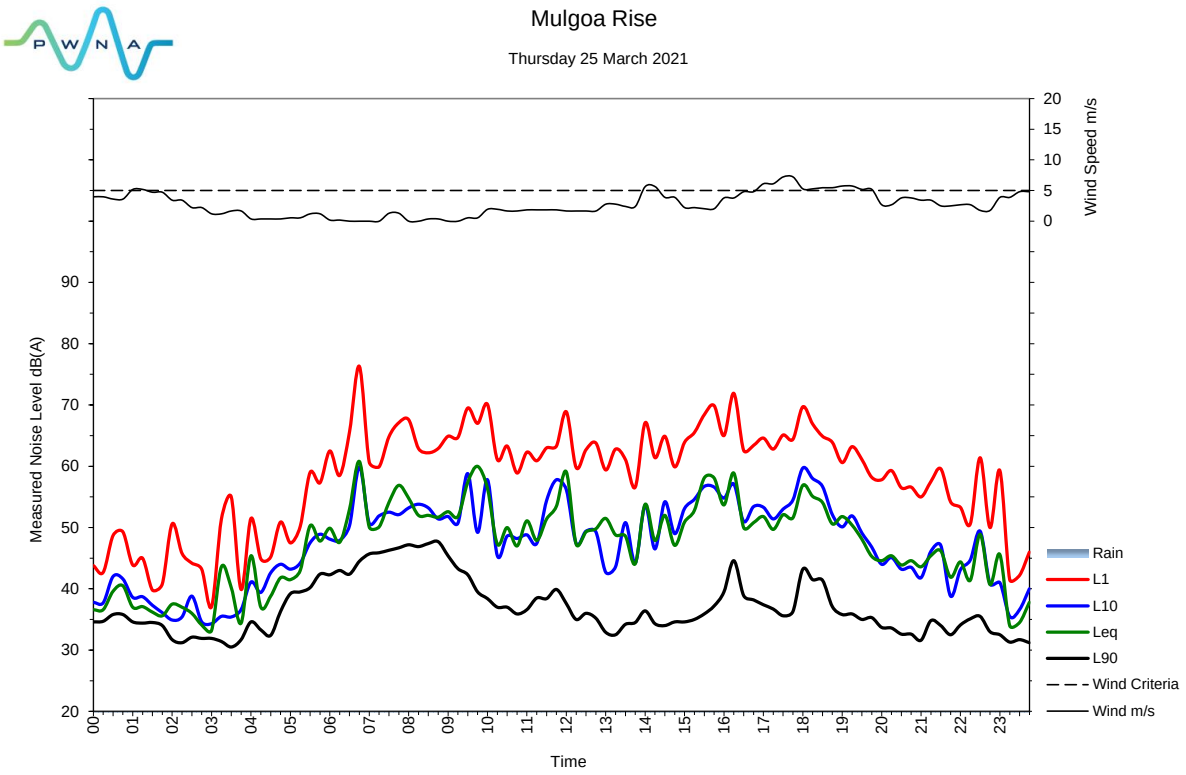
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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Time
Rain
L1
L10
Leq
L90
Wind Criteria
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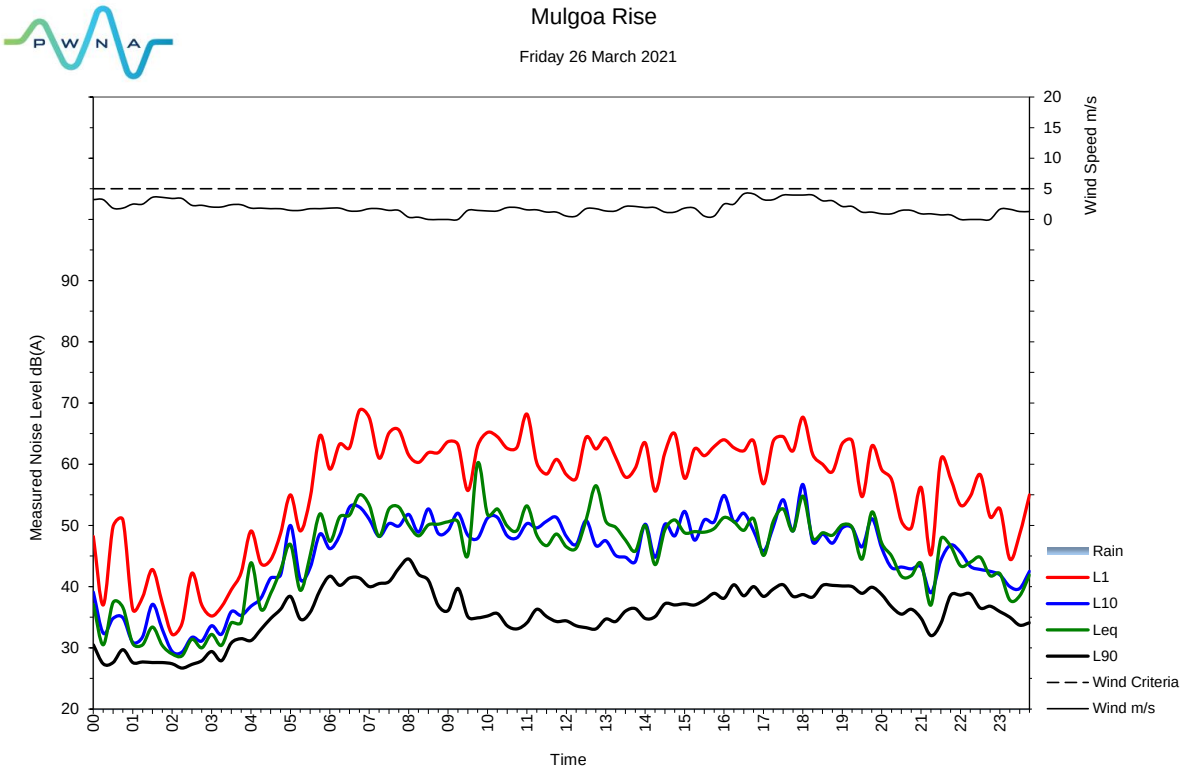
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Time
Rain
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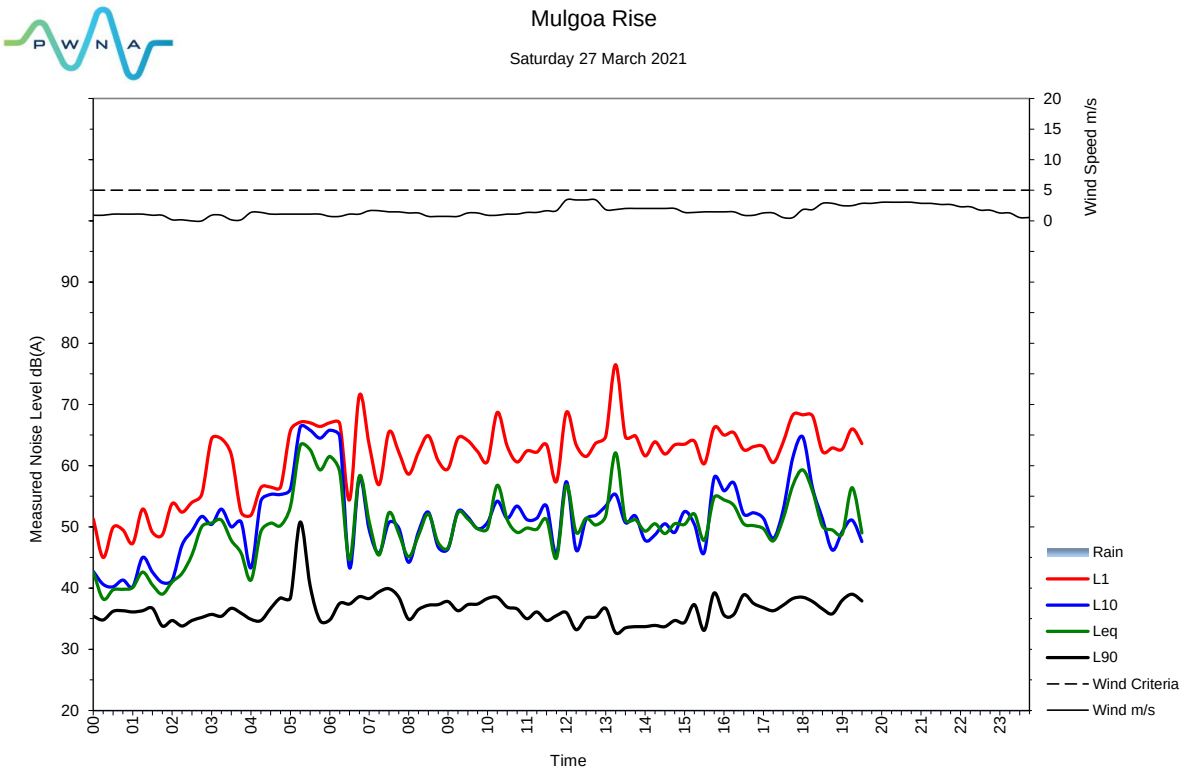
Leq
L90
Wind Criteria
Wind m/s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Rain
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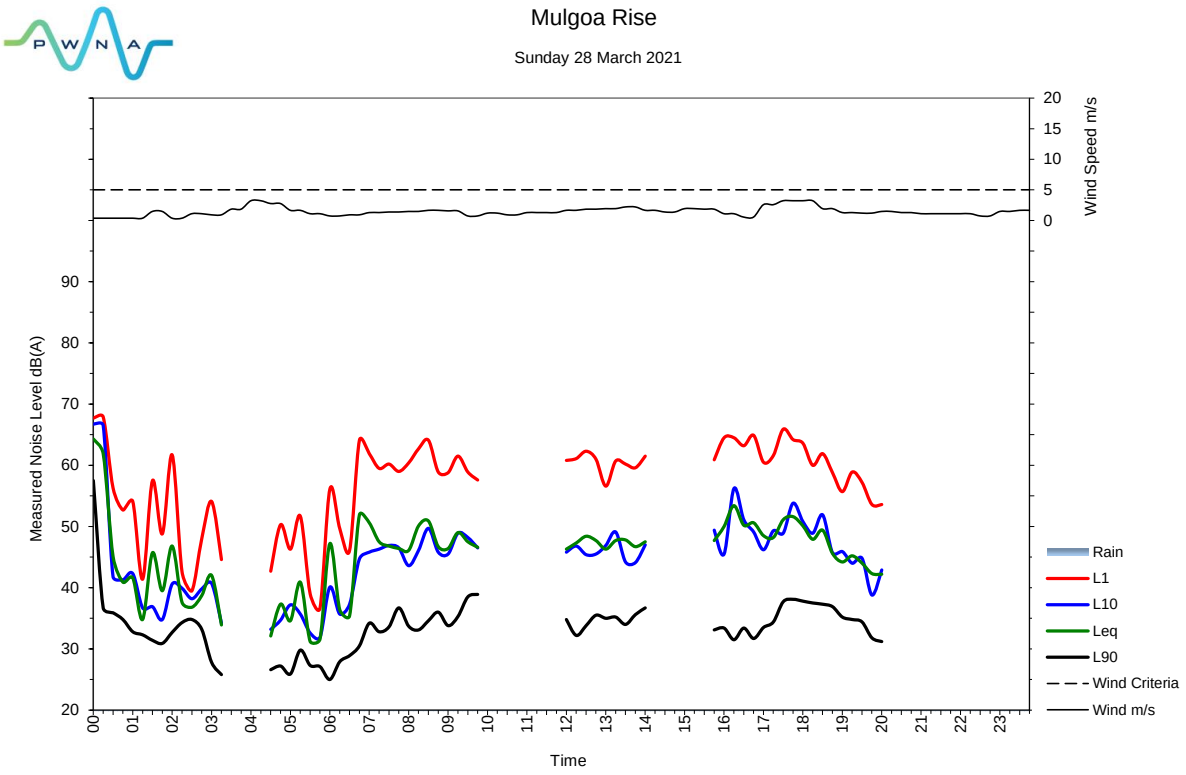
Leq
L90
Wind Criteria
Wind m/s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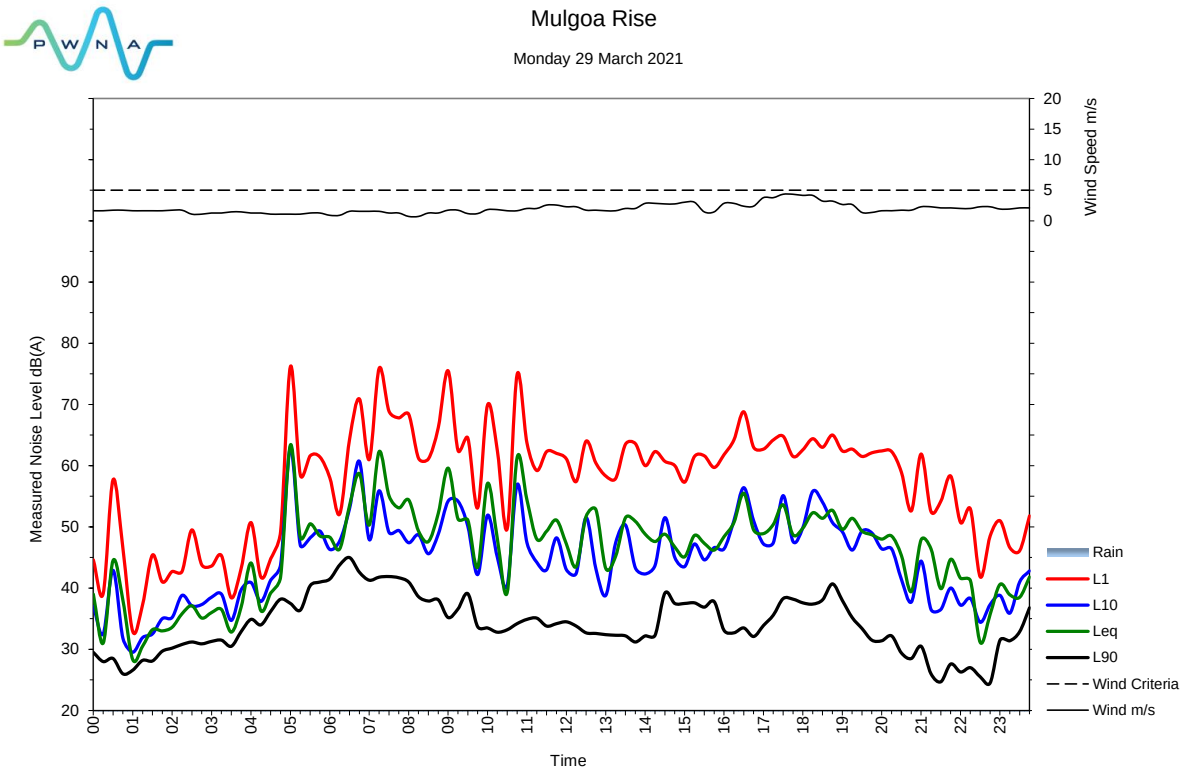
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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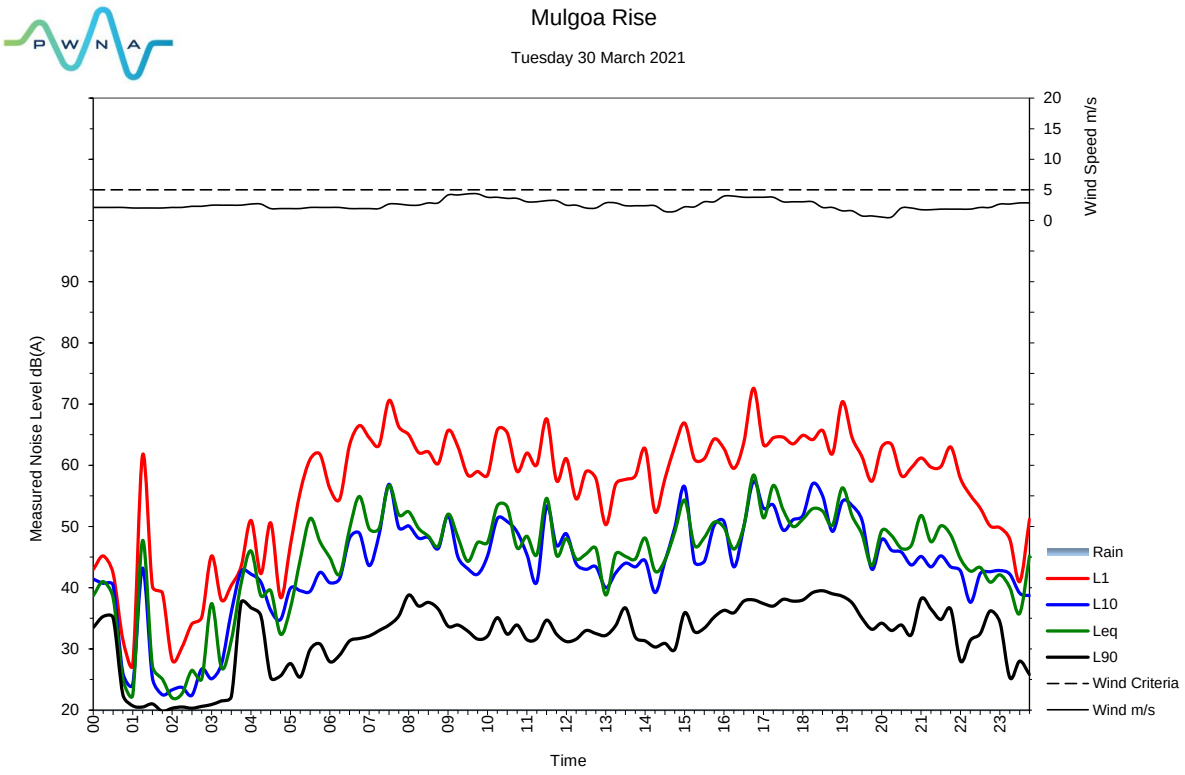
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s