ARUP

Schools Infrastructure New South Wales

Bungendore North Campus High School

Noise and Vibration Assessment Report

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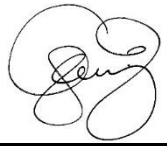
Signature			

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1. Introduction

This Noise and Vibration Assessment Report has been prepared to support a Review of Environmental Factors (REF) for the NSW Department of Education (DoE) for the construction and operation of the new Bungendore North Campus High School (the activity).

The purpose of the REF is to assess the potential environmental impacts of the activity prescribed by State Environmental Planning Policy (Transport and Infrastructure) 2021 (T&I SEPP) as "development permitted without consent" on land carried out by or on behalf of a public authority under Part 5 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The activity is to be undertaken pursuant to Chapter 3, Part 3.4, Section 3.37A of the T&I SEPP.

This document has been prepared in accordance with the Guidelines for Division 5.1 assessments (the Guidelines) by the Department of Planning, Housing and Infrastructure (DPHI) as well as the Addendum Division 5.1 guidelines for schools and Addendum October 2024 (Consideration of environmental factors for health services facilities and schools). The purpose of this report is to:

- Identify noise-sensitive receivers affected by operation and construction of the school
- Set noise and vibration criteria based on relevant standards
- Establish current ambient and background noise levels at and around the site
- Quantify the main sources of construction noise and vibration
- Assess the main operational noise sources, including building services and traffic.
- Determine if criteria are met and recommend mitigation measures if needed.

The assessment evaluates noise and vibration impacts on the surrounding community and land uses, as well as noise intrusion on the proposed development.

1.1 Site description

The project site, and land to which the REF applies (the site) includes Nos. 4-6, and 10 Majara Street, part Lot 1 DP 1276279 (Majara Street road reserve) and part Lot 1 DP 1276282 as identified in Figure 1.

As shown at Figure 4, the Bungendore North Campus High School will utilise the former Council administration building and car park located at 10 Majara Street. Demountable buildings are proposed to be placed north of the existing building. Public domain upgrades will feature in part Lot 1 DP 1276279 and part Lot 1 DP 1276282.

The site is located between Mick Sherd Oval (to the west) and the rail corridor (to the east). The site is located approx. 170m north of the Bungendore Train Station and Bungendore Primary School. The Bungendore Primary School, located on the corner of Gibraltar Street and Majara Street currently accommodates Bungendore High School on a temporary basis.

Figure 1: Aerial image of the site (Source: Urbis 2024)

Figure 2: Aerial image of the site including sensitive receiver location

Figure 3 summarises NSW Planning Portal zone classifications for surrounding land uses.

Figure 3: NSW Planning Portal zone classifications

1.2 Proposed activity description

The proposed activity is for the construction and operation of the new Bungendore North Campus High School. The high school will accommodate the operational needs of the high school on a temporary basis (together with the existing high school located within the grounds of Bungendore Public School) as students as enrolments continue to grow. These facilities will be utilised until such time the permanent high school at Birchfield Drive is established.

Specifically, the project involves the following:

- Use of the former Council administration building as part of the new Bungendore North Campus High School,
- New demountable classrooms,
- Landscaping, outdoor play areas, shade structure and basketball court,
- On site staff parking which utilises the existing car park and access from Majara Street, and
- Public domain upgrades to part Lot 1 DP 1276279 (Majara Street Road reserve) and part lot 1 DP 1276282 to enable kiss and drop from Majara Street and pedestrian connectivity to surrounding areas.

The North Campus facilities proposed will supplement the existing high school facilities located within the Bungendore Primary School site.

Refer to the Review of Environmental Factors (REF) for the detailed scope of works and operational details. Figure 4 provides an extract of the proposed site plan.

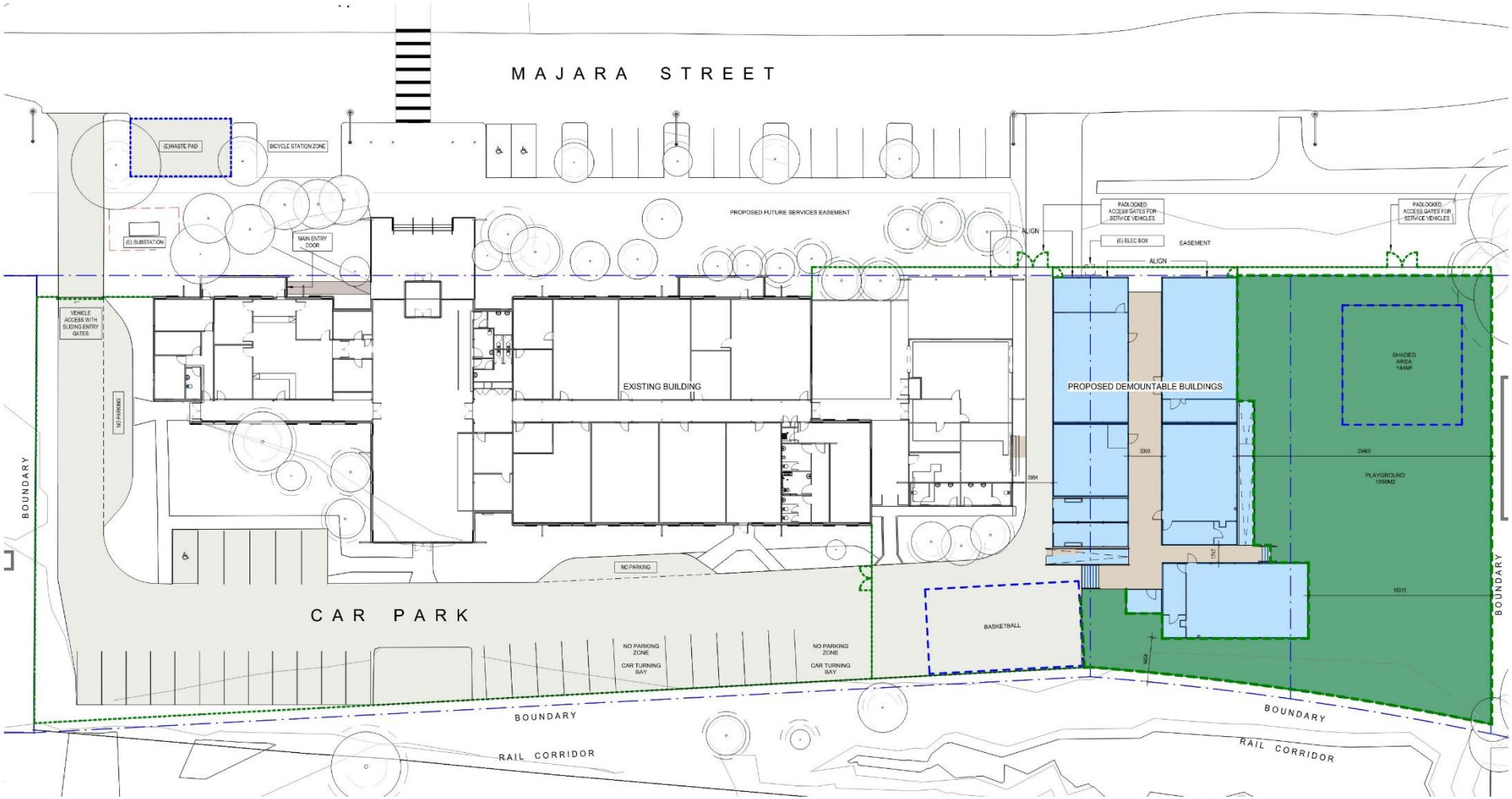


Figure 4: Site Plan

1.3 Existing acoustic environment

An acoustic assessment was undertaken in the Environmental Noise and Vibration Assessment in support of a State Significant Development Application (now not proceeding). Unattended noise measurements were undertaken as part of this previous assessment in February 2022 at locations depicted in Figure 2. Measured data is reproduced in Table 1 for reference.

The previous SSDA ENVA included assessment of a larger project area and school student cohort, for a permanent operational basis. As outlined in section 1.2, the current proposed project will operate on a temporary basis to support continued growth of students and will entail minor changes to existing buildings on site.

Table 1: Unattended noise monitoring data – Environmental Noise and Vibration Assessment of SSDA (14394209)

Measurement Location	Rating Background Level, (dB(A) L_{90})		
	Day (7am to 6pm)	Evening (6pm to 10pm)	Night (10pm to 7am)
M1 – 10 Majara St (Project site)	40	35	32
M2 – 24 Butmaroo St (Tennis courts)	43	39	30[1]
M3 – 63 Turallo Terrace (Scout Hall)	39	30[1]	30[1]
M4 – 16 Majara St (Southern Residence)	41	31	30[1]
M5 – 49 Gibraltar St (Police Station)	40	32	30[1]

Notes:

1 – As per the EPA Noise Policy for Industry "Where the rating background noise level is found to be less than 30 dB(A) for the night period, then it is set to 30 dB(A)"

2. Acoustic assessment criteria

2.1 Relevant standards, guidelines and regulations

The following have been used to develop the noise and vibration criteria for the project:

Local Council Guidelines and Policies

- Palerang Development Control Plan (2015)

NSW Government Guidelines and Policies

- NSW Department of Education – Educational Facilities Standards and Guidelines v2.0, 0001c Design Checklist – Acoustics
- NSW Department of Planning, Development Near Rail Corridors and Busy Roads – Interim Guideline (2008)
- NSW Department of Environment and Conservation, Assessing Vibration: A technical guideline (February 2006)
- NSW Environmental Protection Authority – Noise Policy for Industry (October 2017)
- NSW Environmental Planning Policy (Transport and Infrastructure) 2021
- NSW Road Noise Policy (March 2011)
- NSW EPA, Environmental Criteria for Road Traffic Noise (1999) Australian and International Standards
- NSW Department of Environment and Climate Change (DECC) "Interim Construction Noise Guideline" (ICNG) 2009.
- NSW Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline" (AVTG) 2006.
- NSW Protection of the Environmental Operations (POEO) Act 1997.

National Standards

- AS 2107:2016 Acoustics—Recommended design sound levels and reverberation times for building interiors
- AS 2021:2021 – Acoustics – Aircraft noise intrusion – building siting and construction.
- AS 2436:2010 – Guide to Noise and Vibration Control on Construction, Demolition & Maintenance Sites.
- AS 1055:1997 – Acoustics – Description and Measurement of Environment Noise.

Industry guidelines

- Association of Australasian Acoustical Consultants (AAAC) — Guideline for Educational Facilities, Version 2.0
- Association of Australian Acoustical Consultants (AAAC) Guidelines for Child Care Centre Acoustic Assessment, V 3.0

Sustainability Standards

- Green Building Council of Australia – Buildings v1

2.2 Queanbeyan-Palerang Local Government Area

There are four DCPs that apply in the Queanbeyan-Palerang Local Government Area. The Pelarang Development Control Plan (2015) does not have any specific acoustic requirements for the development.

2.3 Operational noise emissions

Consideration is given to the following:

- Noise emission from building services
- Noise emission from school activities and operations; and
- Noise emission from additional traffic generated by the development.

The following sections summarise corresponding assessment criteria.

2.3.1 Building services

2.3.1.1 Normal operations

Building services noise emissions is assessed in accordance with the NSW Noise Policy for Industry (NPfI) which is primarily concerned with controlling intrusive noise impacts in the short-term for residences and maintaining long-term noise level amenity for residences and other land uses.

The NPfI sets out the procedure to determine the project noise trigger levels relevant to industrial noise sources (e.g. building services equipment). The project noise trigger level is a level that, if exceeded would indicate a potential noise impact on the community and so 'trigger' a management response.

Intrusive noise trigger level

The intrusiveness noise trigger level is applicable to residential premises only and is summarised as follows:

- LAeq,15minute $\leqslant$ Rating Background Level (RBL) plus 5 dB

  (where LAeq,15minute represent the equivalent continuous noise level of the source)

Note that as the Intrusive Noise Trigger Level is established from the prevailing background noise levels at the residential receiver location, the existing background noise level is to be measured.

Recommended and project amenity noise level

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPfI where feasible and reasonable. An extract from the policy is given below in Table 2.

Table 2: NPI Recommended Amenity Noise Levels (RANLs)

Receiver	Noise amenity area	Time of Day	Recommended amenity noise levels (RANLs) $L_{Aeq,}$ dB(A)
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45

Receiver	Noise amenity area	Time of Day	Recommended amenity noise levels (RANLs) L_{Aeq}, dB(A)
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom - internal	All	Noisiest 1-hour period when in use	35 (see notes for table)
Hospital ward – Internal External	 All All	 Noisiest 1-hour Noisiest 1-hour	 35 50
Place of worship – Internal	 All	 When in use	 40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, gold course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dB(A) to recommended noise amenity area

Notes:

The recommended amenity noise levels (RANLs) refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

1. The NPI defines day, evening and nighttime periods as:

• Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.

• Evening: the period from 6 pm to 10 pm.

• Night: the remaining period.

(These periods may be varied where appropriate. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable LAeq noise level may be increased to 40 dB $L_{Aeq(1hr)}$)

The NSW Planning Portal classifies existing development around the site as predominantly low density residential and public recreation (refer Figure 3).

The recommended amenity noise levels (RANLs) represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level (PANL) represents the objective for noise from a single industrial development at a receiver location.

To ensure that any new industrial source of noise is within the RANLs for an area, the PANL applies for each new source of industrial noise as follows:

- Project Amenity Noise Level (PANL) = Recommended Amenity Noise Level (RANL) minus 5 dB(A)

To standardise the time periods for the intrusiveness and amenity noise levels, the policy assumes that the $L_{Aeq,15min}$ will be taken to be equal to the $L_{Aeq,\ period}$ + 3 decibels (dB).

2.3.1.2 Project specific noise trigger levels

The criteria derived in the Environmental Noise and Vibration Assessment of SSDA (14394209) is adopted as it is still relevant for the proposed development on the project site. Table 3 summarises the derived project specific noise levels based on background and ambient noise monitoring and the NPfI.

Table 3: NPI Project specific noise levels

Receiver	Time Period	Project Specific Noise Levels – dB $L_{Aeq, 15min}$	
		Intrusive Noise Trigger Levels	Project Amenity Noise Level (PANL)
R1 (based in M4)	Day	**46**	53
	Evening	**36**	43
R2 (based in M3)	Day	**48**	53
	Evening	44	**43**
R3 (based in M1)	Day	**45**	53
	Evening	**40**	43
School and Childcare Centre outdoor areas	When in use	-	55
School and Childcare Centre internal	When in use	-	35

The school is not expected to operate during the night-time period, therefore daytime criterion is taken as the most onerous target on which assessment of noise emission is based.

2.3.1.3 Modifying factors

Table C1 of the NPI sets modifying factor corrections for annoying noise characteristics such as tonality, dominant low frequency, intermittency or irregularity.

When assessing low frequency impacts, an initial screening test is first undertaken by evaluating whether the difference in noise levels in C-weighted and in A-weighted are 15 dB or more at the receivers, which identifies the potential for an unbalanced spectrum in which case further assessment is required.

2.3.1.4 Emergency equipment

There are no provisions in NSW legislation for noise impacts associated emergency plant.

In lieu of relevant criteria, the VIC EPA State Environment Protection Policy (SEPP) No. N-1 states:

> *Where the noise source under consideration is a standby generator, standby boiler or fire pump, the noise limit shall be increased by 10 dB for a day period and by 5 dB for all other periods.*

This is considered an appropriate provision for short and intermittent operation of equipment during testing such as stair pressurisation fans.

2.3.2 School activity

There are no specific regulatory policies or guidelines for noise associated with general school activity. Furthermore, the following is noted from NSW Land and Environment Court (LEC) proceeding (Meriden School v Pedavoli, 22 Oct 2009, case NSW LEC 183)

> *"All noise that emanates from the normal activities at a school is not offensive".*

Notwithstanding, assessment of noise impacts from this type of activity is typically made with reference to the Association of Australasian Acoustical Consultants (AAAC) Guideline for Child Care Centre Acoustic Assessment. The Guideline states the following with respect to outdoor activity:

> *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 Leq,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.*

The guidance relating to up to 4 hours outdoor play is deemed appropriate in the context of typical high school programme and activity.

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.

The Guideline states the following with respect to indoor play:

> *The cumulative Leq,15 minute noise emission level resulting from the use and operation of the childcare centre, with the exception of noise emission from outdoor play discussed above, shall not exceed the background noise level by more than 5 dB at the assessment location as defined above. This includes the noise emission resulting from:*
>
> - *Indoor play;*
> - *Mechanical plant;*
> - *Drop off and pick up;*
> - *Other activities/operations (not including outdoor play).*

Assessment of school activities will be guided by these noise management levels to assist in operational management of the school, noting they are aspirational criteria and not mandatory requirements.

2.3.3 Road traffic noise

The NSW Road Noise Policy (RNP) includes assessment criteria for existing noise sensitive receivers affected by additional traffic on existing roads generated by land use developments. These criteria are reproduced in Table 4 for reference.

Table 4: Road traffic noise assessment criteria for residential land uses.

Road category	Type of project / land use	Assessment criteria	
		Day (7am–10pm)	Night (10pm–7am)
Freeway / arterial / sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	60 dB $L_{Aeq, (15\ hour)}$ (external)	55 $L_{Aeq, (9\ hour)}$ (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	55 $L_{Aeq, (1\ hour)}$ (external)	50 $L_{Aeq, (1\ hour)}$ (external)

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.

In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

2.4 Noise intrusion

2.4.1 Internal background noise levels

Section 0.03 of the EFSG Acoustic Checklist states the following:

> *An internal noise level assessment must be carried out for all new buildings to ensure comfortable acoustic conditions for the spaces occupied.*
>
> *The internal noise levels within the space must meet the limits stipulated in Table 11.06.1 of Section 11.6 Acoustic Performance Guidelines or be within the range stipulated in Table 1 of the AS/NZS 2107:2016 standard. The more stringent of the two should be met.*

For normal operations, internal noise levels are to be met cumulatively taking into account the sources discussed in the following sections.

2.4.1.1 Building services noise

Building services are typically the predominant source of background noise within a space. Internal building services noise targets are set at 3 dB below overall internal noise criteria to allow for cumulative compliance once noise intrusion through façade elements is added.

2.4.1.2 Road traffic noise intrusion

EFSGs stipulate that road noise shall be assessed in accordance with the requirements of the State Environmental Planning Policy (Transport and Infrastructure) 2021 (TISEEP).

The TISEPP is supported by the Development Near Rail Corridors and Busy Roads – Interim Guideline (DNRCBR), which sets the following internal noise criteria for educational facilities:

Table 5: TISEPP internal airborne noise criteria.

Receiver type	Time	Airborne noise, L_{Aeq}
Educational Institutions including childcare centres	When in use	40 $L_{Aeq,15hr}$

Based on the use of the different spaces, lower internal noise levels may be required in line with the EFSG, therefore, the TISEPP criteria should be considered as a minimum legislative requirement.

2.4.1.3 Rail noise intrusion

EFSGs stipulate that rail noise shall be assessed in accordance with the requirements of the State Environmental Planning Policy (Transport and Infrastructure) 2021 (TISEEP). The TISEPP is supported by the Development Near Rail Corridors and Busy Roads – Interim Guideline, which requires an acoustic assessment of rail noise impact for buildings other than residential.

Table 6 presents the rail noise criteria. Table 7 presents the rail vibration criteria based on Assessing Vibration: a technical guideline as recommended in the Development Near Rail Corridors and Busy Roads Interim Guideline.

Table 6: TISEPP internal noise criteria.

Receiver type	Time	Airborne noise, dBL_{Aeq}	Groundborne noise, $dBL_{Amax,slow}$
Educational Institutions including child care centres	When in use	40 $L_{Aeq,15hr}$	45[2]

Receiver type	Time	Airborne noise, dBL_{Aeq}	Groundborne noise, $dBL_{Amax,slow}$

Note:

1. Development Near Rail Corridors and Busy Roads-Interim Guideline notes that the maximum airborne noise level recommended in Table 3.1 of the Interim Guideline for development other than residential is based on Environmental Criteria for Road Traffic Noise (EPA 1999). Based on the intention and context of Table 3.1 of the Interim Guideline, the recommended maximum noise level is considered to be appliable for rail noise.

2. There are no specific rail ground-borne noise criteria for schools in the Development Near Rail Corridors and Busy Roads – Interim Guideline. Instead, the Interim Guideline refers to Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects for guidance which recommends ground-borne internal noise trigger level of 45 dBLAsmax for schools. Noting the above trigger level is recommended for rail projects, and thus is only provided as guidance for this project.

Table 7: TISEPP intermittent vibration criteria

Receiver type	Time	Acceptable vibration dose values for intermittent vibration
Offices, schools, educational institutions and places of worship	Daytime (7.00 am to 10.00 pm)	0.4-0.8 $m/s^{1.75}$

2.4.1.4 Natural ventilation implications

Internal noise criteria are typically achieved through a sealed building. Ideally, where natural ventilation is to be provided, the same criteria would also be achieved, particularly for critical spaces where higher ambient noise levels may otherwise impact on speech intelligibility or unduly impact concentration.

For less critical uses, research has indicated that occupants are willing to accept trade-offs in the ambient noise levels where natural ventilation is provided. It is noted that for teaching and learning spaces this recommendation is based on the ability to close the windows to achieve internal noise targets.

2.4.2 Outdoor areas

The criteria from the TISEEP considers the impact of road traffic noise on internal comfort, but does not address external amenity.

The NSW Environmental Criteria for Road Traffic Noise (ECRTN), the NSW Road Noise Policy (RNP) and RING provide criteria for school playgrounds and childcare outdoor play areas respectively.

Criteria for outdoor learning areas are not provided by any of the relevant policies and guidelines referenced.

The proposed aspirational noise criteria for outdoor areas are presented in Table 8.

Table 8: Aspirational noise criteria for outdoor areas.

Type of space	Assessment Criteria, $L_{Aeq, 1hr}$
Outdoor school playgrounds	55 (Road) 65 (Rail noise guidance for active recreation by RING)
Outdoor learning areas	50

The above criteria should be aimed for where possible and practical, however, may not be feasible nor necessary to achieve based on the site constraints and the specific uses proposed for the different areas.

2.5 Construction noise and vibration

The project involves the repurposing of an existing building into the school. Major construction activities are not expected. The recommended construction noise and vibration trigger levels are presented for reference and guidance.

2.5.1 Hours of work

Construction works will be undertaken within the hours outlined in Table 9, in accordance with ICNG standard hours of construction

Table 9: Proposed Hours of Construction

Day	Standard construction hours
Monday to Friday	7.00 am to 6:00 pm
Saturdays	8.00 am to 1:00 pm
Sundays or Public Holidays	No construction

In some additional cases, after-hours permits may be sought from the relevant authorities where special requirements exist, for example oversized deliveries.

2.5.2 Construction noise criteria

The Interim Construction Noise Guideline (ICNG) provides recommended noise levels for airborne construction noise at sensitive land uses. The ICNG provides construction management noise levels above which all 'feasible and reasonable' work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These noise management levels (NMLs) for residential receivers and other sensitive receivers are reproduced in Table 10 and in Table 11 respectively.

Table 10: Construction noise management levels (NMLs) at residential receivers

Time of day	Management level[1] $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • 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 • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Time of day	Management level[1] $L_{Aeq\ (15\ min)}$	How to apply
Outside recommended standard hours	Noise affected RBL + 5dB	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 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Note:

1. 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.

Table 11: Construction noise management levels (NMLs) at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

1 - Noise management levels apply when receiver areas are in use only.

For work within standard construction hours, if after implementing all 'feasible and reasonable' noise levels the site still exceeds the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB below the noise-affected level as a threshold where the proponent should negotiate with the community.

Measured noise data obtained at the logger location most representative of each noise catchment area has been used to derive appropriate noise management levels for the project. These are summarised in Table 4.

Table 12: Construction Noise Management Criteria for Residential Premises

Time Period	Description	NML Criteria $L_{Aeq\ (15\ min)}$[1]
During recommended standard hours	Noise affected	55
	Highly noise affected	75
Outside recommended standard hours	Noise affected	50

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.

2.5.3 Construction vibration criteria

2.5.3.1 Disturbance to buildings occupants

Potential vibration disturbance to human occupants of buildings is made in accordance with the NSW Assessing Vibration; a technical guideline. The criteria outlined in the guideline is based on the British Standard BS 6472-1992. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent', as described in Table 13.

Table 13: Types of vibration – Definition

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

For continuous and intermittent vibration, the preferred and maximum values (in are weighted acceleration values (Wg for z axis and Wd for x and y axes). For intermittent vibration, the preferred and maximum values are Vibration Dose Values (VDVs), based on the weighted acceleration values.

Table 14 reproduces the 'Preferred' and 'Maximum' acceleration values for continuous and impulsive vibration (Wg for z axis and Wd for x and y axes). Table 15 reproduces the 'Preferred' and 'Maximum' Vibration Dose Values (VDVs) for intermittent vibration, based on the weighted acceleration values (Table 2.2 and 2.4 of the Guideline respectively).

Table 14: Preferred and maximum vibration acceleration levels for human comfort, m/s^2

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis[3]	x- and y-axes[3]	z-axis[3]	x- and y-axes[3]
Continuous vibration (weighted root-mean-square (RMS) acceleration, m/s^2, 1-80Hz)					
Critical areas[4]	Day- or night-time	0.0050	0.0036	0.010	0.0072
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
Workshop	Day- or night-time	0.040	0.029	0.080	0.058
Impulsive vibration (weighted2 RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[4]	Day- or night-time	0.0050	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis[3]	x- and y-axes[3]	z-axis[3]	x- and y-axes[3]
	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
Workshop	Day- or night-time	0.64	0.46	1.28	0.92

Notes:

1_Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am

2_None (to avoid confusion with the acceleration unit)

3_Two frequency weightings (Wg and Wd) are required for the general measurement of whole body vibration with respect to its effect on activities. The weightings should be applied to measurements made in the three vibration axes: Wg for z axis and Wd for x and y axes.

4_Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring.

Table 15: Acceptable vibration dose values (VDV) for intermittent vibration (m/s$^{1.75}$)

Location	Daytime[1]		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[3]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1_Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am

2_Note that the VDV is dependent upon the level and duration of the vibration event and the number of vibration events occurring during the assessment period; a higher vibration level is permitted if the total duration of the vibration event(s) is small.

3_Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above such as assessing intermittent values against the continuous or impulsive criteria for critical areas and/or referring to criteria in Section 1.2)

2.5.3.2 Impact on structures and services

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 and/or German Standard DIN4150-3.

Standard structures

British Standard 7385 Part 1:1990, defines different levels of structural damage as:

> *Cosmetic – The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
>
> *Minor – The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
>
> *Major – Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

BS7385-2 (Table 1 and Section 7.4.2) sets limits for the protection against the different levels of structural damage and those levels (for frequencies within the range 4-250 Hz) are reproduced in Table 16. The criteria relate predominantly to transient vibration that does not give rise to resonant responses in structures, and to low rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, the BS7385-2 values

may need to be reduced by up to 50%. Activities considered to have the potential to cause dynamic loading in some structures (e.g. residences) include rock breaking/hammering and sheet piling activities. On the basis that the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range) a conservative vibration damage screening level per receiver type is given below:

Reinforced or framed structures: 25.0 mm/s PCPV

Unreinforced or light framed structures: 7.5 mm/s PCPV

At locations where the predicted and/or measured vibration levels are greater than above, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

Table 16: BS 7385-2 Structural damage criteria – low rise building

Line	Type of structure	Damage level	Peak component particle velocity [1] (PCPV), mm/s					
			Where vibration that does not give rise to resonant responses in structures [3]			Where vibration might give rise to resonant responses in structures [4]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above	4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50			25		
		Minor[2]	100			50		
		Major[2]	200			100		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50	7.5 to 10	10 to 25	25
		Minor[2]	30 to 40	40 to 100	100	15 to 20	20 to 50	50
		Major[2]	60 to 80	80 to 200	200	30 to 40	40 to 100	100

Notes:

1_Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

2_Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

3_Levels relates to transient vibrations in low-rise buildings.

4_A 50% reduction might apply to the guide levels for "vibration that does not give rise to resonant responses in structures" if there is potential for continuous vibration to give rise to dynamic magnifications. Activities considered to have the potential to cause dynamic loading in some structures (e.g. residences) include rock breaking/hammering and sheet piling activities.

Sensitive structures

German Standard DIN 4150 – Part 3 'Structural vibration in buildings – Effects on Structure' is generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings.

Heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound and should otherwise be assessed in accordance with BS7385-2. If a heritage building or structure is found to be structurally unsound (following inspection) DIN 4150-3, line 3 as outlined in Table 17, provides a conservative cosmetic damage objective that should be adopted unless alternative limits are justified by a dilapidation or structural survey. The sensitivity of heritage buildings and other potentially at-risk structures are subject to confirmation by the contractor prior to start of any works.

Table 17: DIN 4150-3 structural damage guideline values

Line	Type of structure	Peak component particle velocity (PCPV), mm/s				
		Vibration at the foundation at a frequency of			At horizontal plane of highest floor	In the vertical direction, at floor slabs
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under a preservation order)	3	3 to 8	8 to 10	8	20[2]

Notes

1_At frequencies above 100 Hz, the values given in this column may be used as minimum values.

2_Guideline value might have to be lowered to prevent minor damage

Buried services

DIN 4150-2:2016 part 3 sets out guideline values for vibration effects on buried pipework (see Table 18).

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50 mm/s and 100 mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

Table 18: Guideline values for vibration impacts on buried pipework

Line	Pipe material	Peak component particle velocity (PCPV) measured on pipe, mm/s	
		Where vibration that does not give rise to resonant responses in structures[3]	Where vibration might give rise to resonant responses in structures[4]
1	Steel, welded	100	50
2	Vitrified clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80	40
3	Masonry, plastic	50	25
-	High pressure gas pipelines2	75 Monitoring required if predicted above 50. No piling within 15 m of pipeline without detailed assessment.	
-	Electrical cables/Telecommunication services (such as fibre optic cables)	50 to 100 Detailed assessment should be carried out.	

Notes:

1_For gas and water supply pipes within 2 m of buildings, the levels given in DIN4150-3 should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

2_Based on UK National Grid's specification

3_Levels relates to transient vibrations.

4 A 50% reduction to the guide levels for "vibration that does not give rise to resonant responses in structures" might be appropriate if there is potential for continuous vibration to give rise to dynamic magnifications. Activities considered to have the potential to cause dynamic loading in some structures include rock breaking/hammering and sheet piling activities.

3. Operational noise and vibration assessment

3.1 Operating Hours

Typical hours of school operations used as the basis of assessment are summarised in Table 19.

Table 19: School hours of operation

Operation	Times
School hours	8am to 4pm, Monday to Friday
Recess and lunch	8am to 4pm, Monday to Friday Various times throughout the day Expected total less than 4 hours
Administration / Office	8am to 4pm, Monday to Friday
Waste collection	Outside of school hours Monday to Friday

3.2 Building services noise emission

Limited information is available at this early stage of design on proposed building services upgrades to the existing development. The following qualitative assessment is provided:

- It is understood that the building services systems in the existing Queanbeyan-Palerang Regional Council building will be mostly sufficient for the school to be used on a temporary basis and will be reused and mostly unchanged. The noise emission from the existing systems is therefore not expected to increase and therefore has not been further assessed.
- To account for insufficiencies in the existing building services system, an additional wall-mounted air conditioning unit has been proposed for both one converted General Learning Space and the Performance Space, see mechanical markup ‘Design SK-M-01 Existing HVAC Zones Rev2’. Equipment selections and associated noise data will need to be reviewed when information becomes available. It is anticipated that environmental noise criteria will be readily achievable for these units given the proposed locations in the context of surrounding receivers.
- The temporary demountable buildings will have a mechanical ventilation system which is predetermined and integrated within the demountable building product. The temporary demountable buildings will need to be assessed and designed by the manufacturer to meet the acoustic criteria as this information becomes available.
- The performance space will include natural ventilation openings to the north and south equalling open area of 5% of the floor area. This is discussed further in Section 3.4.3.

During ongoing design of the development, equipment will be selected and provided with noise and vibration attenuation measures as required to meet the Project goals.

Noise mitigation treatment may be required, including:

- Specification of maximum sound power levels for all items of plant as part of the project documentation.
- Use of attenuators to control fan noise.
- Acoustic louvres to control noise from plantroom ventilation openings.
- Vibration isolators to reduce vibration input to the building structure.
- Acoustic screens around external plant, where required.
- Incorporation of sound absorptive treatments in plantroom spaces.

Equipment selection and placement will be fundamental to achieving compliance with environmental noise emission criteria. This will be worked through with the Mechanical Engineers during detailed design stages.

3.2.1 Electrical equipment

The new 300kVA substation proposed to the south west of the site is expected to be readily controlled via standard enclosure. Adverse impacts to either the school or nearby noise sensitive receivers is not anticipated provided sufficient attenuation is specified for these items of electrical equipment, the details of which are to be worked through in subsequent phases of design.

3.3 Operational activities noise emission

3.3.1 Outdoor play areas

Assessment of noise emission from outdoor play areas is based on the following assumptions:

- Active (i.e. playground and basketball) outdoor play areas defined in the architectural site plan (refer Figure 4).
- Noise source levels of students playing outdoors are assumed in accordance with the method outlined in the AAAC Guidelines as reproduced in Table 20.
- Number of students occupying an outdoor play area derived based on expected class sizes and scaled to incorporate a combination of active and passive play.
- The following worst case scenario is assessed and presented in Table 21.
  - Basketball is assessed to have 30 students engaged in active play, and the playground is assessed to have 40 students engaged in active play, and 40 students engaged in passive play

Table 20: Sound power spectra for outdoor play areas - AAAC

Source	Overall dB(A)	Octave band centre frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
Active Play (per 10 children)	87	64	70	75	81	83	80	76	72	87
Passive Play (per 10 children)	81	58	64	69	75	77	74	70	66	81

Table 21: Predicted noise levels from outdoor play areas

Receiver	Distance to site (m)	Target criterion – day ($dBL_{Aeq,15min}$)	Predicted noise level ($dBL_{Aeq,15min}$)	Compliance?
R1	120-160	51	46	Yes
R2	60-90	53	52	Yes
R3	90-110	50	49	Yes

Noise levels during times when the entire student body is using the playground (i.e. recess and lunch) are expected to comply with the operational noise criteria for residential and existing school buildings.

3.3.2 Hall noise breakout

Assessment of noise breakout from the Hall has been undertaken based on the following assumptions:

- Noise source: internal reverberant level of up to 75 dB(A) which considers a typical worst case noisy learning activity / setting from sports and music.
- Windows / doors open – this includes glazed doors to east and west and louvres for natural ventilation. A minimum noise reduction of 10 dB from façade being partially open and 20 dB from closed doors is assumed.
- It is assumed that there will be no activities during night time (10pm to 7am).

Table 22 summarises predicted noise levels at the nearest noise sensitive receiver location due to noise breakout from the Hall.

Table 22: Predicted Gymnasium noise breakout

Nearest Receiver	Distance to site (m)	Target criterion ($dBL_{Aeq,15min}$)		Predicted noise level ($dBL_{Aeq,15min}$)		Compliance?
		Day	Evening	Doors closed	Doors open	
R1	65	51	36	15	25	Yes

Predicted noise breakout from typical hall (sports gymnasium) use are expected to comply with target criteria during the daytime and evening with doors open.

3.3.3 Carpark

On a temporary basis, the school will utilise an existing 28 car maximum carpark located on the eastern side of the site, and 17 car maximum car park to the western side of the site.

Assessment of carpark noise impacts to nearby noise sensitive receivers has been made with reference to the AAAC Guidelines. Typical sound power levels for vehicles within the car park area used as the basis of assessment are summarised in Table 23.

Table 23: Typical sound power levels for vehicles within the car park

Vehicle	Level (dBL_{Aeq})
Car	81
Delivery van	86

As a conservative worst-case scenario the car park noise assessment has considered the following:

- Noise source locations closest to the affected residences within the car park area.
- Up to 6 vehicle movements over a 15-minute period, 3 in each carpark.

The predicted operational noise levels associated with the car park are summarised in Table 24.

Table 24: Predicted car park operational noise levels

Receiver	Distance to site (m)	Target criterion ($dBL_{Aeq,15min}$)	Predicted cumulative noise level ($dBL_{Aeq,15min}$)	Compliance?
R1	30-70	53	51	Yes
R2	110-170	51	42	Yes
R3	80-130	50	44	Yes

The operational noise levels of the car parks are expected to meet the relevant criteria. The car parks will primarily be used during daytime hours and will feature controls, such as gate access, to restrict public and after-hours usage. Speed limits will help reduce noise emissions from vehicles accessing and navigating the car park.

3.3.4 School traffic

The previous Environmental Noise and Vibration Assessment of SSDA (14394209) demonstrated that the school generated traffic noise will be acceptable. The student number for the Bungendore North campus High School is significantly less than the previous SSDA, thus is expected to be less noisy and the same advice stands that school generated traffic noise will be acceptable.

3.3.5 Public Address

Noise from public address systems has the potential to affect nearby noise sensitive receivers. To reduce the likelihood of noise disturbance to surrounding properties, the following measures are recommended for all public address systems:

- Restrict usage to daytime hours only (7am to 6pm).

- Use best practice design, including directional speakers that focus inward toward the school and cover only the necessary areas.
- Set volume levels to the minimum required to ensure clarity and audibility within the designated coverage zones, as specified in EFSG.
- It has been assumed that there is no amplified sound from the outdoor performance spaces

3.3.6 Waste Removal, Deliveries and Cleaning

There will be a limited number of deliveries or waste removals on any given day. Waste collection and loading dock activities are preferred to occur either between the hours of 7:00-8:00 AM or 4:00-10:00 PM to minimise disruption to school operations and to align with noise restrictions.

To prevent disturbing the sleep of nearby residents, it is recommended that all noisy cleaning activities be conducted between 7:00 AM and 10:00 PM. If activities must occur between 10:00 PM and 7:00 AM, the following measures should be taken:

- Ensure windows and doors are closed to minimize noise emissions.
- Do not operate air conditioning.
- Refrain from performing outdoor cleaning activities (e.g., leaf-blowing).

3.4 Noise intrusion

3.4.1 Building envelope

The building envelope of the existing QPRC building will be re-used and mostly unchanged. The existing building envelope is made of masonry façade with windows and glazed doors, and metal roof, which is expected to provide reasonable acoustic performance for noise intrusion and potential noise emission control.

In lieu of detailed as-built information being available, the acoustic assessment carried out in this REF report conservatively assumes a minimum 20 dB attenuation when the windows/doors are closed, and minimum 10 dB attenuation from façade when windows/louvres/doors are open.

Minor modifications will be made to a few façade elements to accommodate minor mechanical system changes. These are not expected to significantly alter the acoustic performance of the existing building envelope.

3.4.2 Rail and road traffic noise

There is no road traffic data available for the project to facilitate road traffic noise intrusion analysis. Existing rail noise level measurements were conducted in the previous Environmental Noise and Vibration Assessment of SSDA (14394209) at attended measurement location A1 and the unattended logging locations shown in Figure 2. Overall noise measurements at these locations are taken to represent both road and rail noise profiles across the site. The resultant noise levels at the façade of the existing building are summarised in Table 25 and adopted as the basis of assessment in sections3.4.2.1, 3.4.2.2, and 3.4.3.

Table 25: Measured existing environmental noise levels

Location	Rail Noise Levels, daytime (7 am – 10 pm)	
	TISEPP ($dBL_{Aeq,15\ hour}$)[1]	Single pass by ($dBL_{Aeq,1\ min}$)
Eastern Façade (facing rail corridor)	53	60

[1] A review of logging graphs appended to the previous Environmental Noise and Vibration Assessment of SSDA (14394209) shows little variation in Leq level across the daytime period. $LAeq_{(15hr)}$ and $_{(1hr)}$ have therefore been used interchangeably in assessment of impacts.

3.4.2.1 Internal spaces

Assuming a worst case minimum façade attenuation of 20 dB with windows closed, rail and road traffic noise levels are not expected to exceed the 40 $dB_{Laeq\ 15\ hr}$ which is compliant with the maximum daytime internal airborne noise level for educational institutions outlined in the Development Near Rail Corridors and Busy Roads– Interim Guideline.

3.4.2.2 Outdoor areas

Road traffic noise levels across the site are summarised for outdoor areas in Table 26 against target criteria for outdoor areas presented in Section 2.4.2.

Table 26: Predicted road traffic noise levels – Outdoor Areas

Area	Predicted road traffic noise level $dBL_{Aeq,1hr}$	Complies?
Basketball court and outdoor sport areas / Playground	53	Yes
Outdoor learning and outdoor/covered performance	53	Partial

Compliance with aspirational criteria for outdoor play areas is expected to be achieved. A marginal exceedance of up to 3 dB is expected within some outdoor learning / covered performance areas.

3.4.3 Natural ventilation

The design currently allows for openable windows within General Learning Spaces. It is unlikely that internal noise criteria will be met with the windows open. Further it is noted that operable windows typically do not perform as well acoustically as fixed glazing. The option for mechanical ventilation should allow for windows to remain closed.

It is understood that the Hall could be naturally ventilated via existing manually operated louvred windows and roof ventilators. Based on the expected rail and road traffic noise levels at facades of the Hall, internal noise levels are anticipated to exceed the noise criteria for a sports gymnasium by 3 dB with natural ventilation openings. If the building envelope is closed, noise levels are expected to comply with the criteria for a sports gymnasium and for classes and/or exam although there may be occasional noise increase from train pass-bys.

3.4.4 Vibration and Ground-borne noise from rail

Vibration and ground-borne noise assessments for schools were conducted in the previous Environmental Noise and Vibration Assessment of SSDA (14394209). These assessments concluded that the rail vibration and ground-borne noise are acceptable for the education uses. This school, proposed to be used on a temporary basis, is located at the same site, and context of site and rail operations are still relevant. As such, rail vibration and ground-borne noise impact is considered acceptable for the Bungendore North Campus High School.

4. Construction noise and vibration

The project involves the repurposing of an existing building into the school. Major construction activities are not expected.

Where there are major construction activities which may generate significant noise and vibration, the Contractor will need to carry out an acoustic assessment and prepare a detailed CNVMP to meet the requirements in Section 2.5 based on the detailed construction plan and activities.

General construction noise and vibration management guidance is provided in Table 27 for reference.

Table 27: General construction noise and vibration management guidance

Item	Detail
Community consultation	Community consultation should occur prior to, and during works as follows: • Discuss with affected neighbours any atypical sensitivities (such as vibration sensitive equipment/processes in research or medical establishments, or exam periods for education establishments) to inform determination of criteria and where scheduling of activities may aid to minimise impacts • Seek to establish long-term contact personnel or processes to aid notification of planned activities and expected disruption/effects and their duration. Notifications should be as specific as practicable with regarding to nature, timing of works and any scheduled respite periods. • Advise neighbours of mitigation and management processes and complaints handling procedures. Where respite periods may be warranted, discuss community preferences in terms of respite vs shorter overall works duration. Where respite is to be provided, seek to align with receiver preferences. • Keep a register of any complaints, including details such as date, time, contact number, complainant location, description of complaint and action taken. • Provide quick response to complaints, both to aid understanding the cause of the complaint and reduce extended impacts.
Staff / training	Appoint a named member of the site staff who will act as the Responsible Person with respect to noise and vibration. Site managers to periodically check the site and subjectively assess emissions to nearby receivers to proactively manage works. All employees, contractors, and subcontractors to receive an environmental induction which should include: 1. Standard noise and vibration mitigation measures 2. Permissible hours of work outlined 3. Limitations on high noise and vibration generating activities 4. Location of nearest sensitive receivers Regularly train workers and contractors (such as at toolbox talks) to reinforce good work practices and communicate any received complaints, responses and changes to work practices where relevant. Document and communicate methods for use and maintenance of equipment to minimise noise and vibration. Avoid dropping of items, particularly from height. Avoid the use of radios or stereos outdoors. Avoid the overuse of public address systems. No swearing or unnecessary shouting. No slamming of doors.
Site/works planning	Where practicable, strategically locate primary site entries, site access, loading areas etc, away from the most noise sensitive receptors. Where practicable, fixed equipment (such as cranes, external hoists, waste chutes, generators etc.) should be located away from the most sensitive receptors. Where relevant to the equipment type, enclosures should be provided or acoustically shielded by structures or site sheds etc.

Item	Detail
	Hoarding and associated gates/doors, where required, should be solid, and sealed as far as practicable to reduce noise emission from internal works. Gates and doors should be kept closed where practicable. Carry out building/structures/utility condition surveys as noted below in this table.
Condition surveys	To be conducted prior to commencement of works Required where it has been established that the property, structure or utility is at risk of damage during the construction work. The findings of the survey may require amendment to proposed vibration criteria or management measures and therefore should be undertaken in suitable advance of the start date.
Works scheduling	Works to be scheduled taking into account approved works hours, any restrictions relevant to specific equipment/activities and respite periods etc. Highest noise generating activities should be scheduled for the least sensitive times, where practicable. The acceptability for any out-of-hours works should be confirmed with authorities (e.g. delivery of oversized items, where road closures are required or for emergency works).
Plant and equipment	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example: • Use of pulverisers in lieu of excavator mounter breakers/hammers during demolition. • Use of electric / hydraulic equipment • Use rock/concrete sawing to minimise vibration transfer to adjacent structures • Use of non-tonal reversing beepers (or an equivalent mechanism) for all construction vehicles and mobile plant regularly used onsite. Note, the use of non-tonal reversing alarms is recommended to minimise noise impacts however WHS requirements must be fully satisfied. Use only the necessary size and power of equipment. Select attenuated equipment/activities, such as: 1. Dampened jackhammers and hydraulic hammers (such as 'City' Model Rammer Hammers) 2. Sound damping of chutes and bins used for waste disposal 3. Use of residential grade mufflers 4. Rubber wheeled plant 5. Provide appropriate vibration attenuation to fixed plant items on site. Limit use of activities with potentially 'annoying' or intrusive characteristics such as impulsive, tonal or excessive low frequency sources. Ensure plant is regularly maintained, and repair or replace equipment as necessary (e.g. ensure air lines on pneumatic equipment do not leak). Turn off all vehicles, plant and equipment when not in use.
Vibration monitoring	Where required, vibration monitoring should be conducted where works are proposed within the 'minimum working distance' to a sensitive receiver/structure/utility with respect to cosmetic damage. Preliminary attended monitoring should be carried out to evaluate risk of works exceeding relevant limits. Screening measurements should be carried out with plant operating outside the minimum working distance, and progressively move closer. Where works are at risk of exceeding criteria, establish long-term monitoring. The monitors should provide 'real-time' alerts (SMS messages and/or flashing lights) when vibration criteria are exceeded. A warning level (below the relevant criteria) should be set in addition to the criteria limit. In the event that the vibration criterion is exceeded, works should cease. Where relevant, the project monitoring specialist and structural engineering advisor will be notified and requested to attend site. A visual inspect of the buildings or structures will be undertaken to determine whether any damage has been sustained. An exceedance of the vibration criterion may necessitate a change in work method. This could include:

Item	Detail
	1. Re-evaluation of the vibration criterion based on results of the initial condition investigation and inspections of the structure following the commencement of works. 2. Maintain vibration monitoring throughout works within 'minimum working distances'. 3. Reduce the size of demolition and construction equipment and develop alternative methodologies to minimise vibration. 4. Use less vibration emitting demolition methods if necessary closer to the sensitive building or structure 5. Balance variable speed vibrating plant and operate at speeds that do not produce resonance.
In the case of an exceedance	Approval to vary the authorised noise and vibration levels must be received in writing by the proponent from Council prior to activities being undertaken that exceed sanctioned emission levels. (Use where respite periods not specified under the approved DEC NMP) Such periods must be set and agreed to by Council's Health and Building Unit.
Review and improvement	The CNVMP forms the framework for the contractor to minimise noise and vibration impacts at the nearby receivers. Evaluation of the management performance against the applicable policies, objectives and targets should occur for the purpose of identifying opportunities for improvement. This should include: 1. Determine the cause or causes of non-conformances and deficiencies 2. Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies 3. Verify the effectiveness of the corrective and preventative actions 4. Document any changes in procedures resulting from process improvement

5. Summary of mitigation measures

Table 28 provides a summary of mitigation measures proposed.

Table 28: Mitigation measures

Mitigation Name	Section	Mitigation Measure	Reason for Mitigation Measure
Building services	Section 3.2	Mechanical equipment has not been selected at this stage of design. Appropriate equipment selection and noise mitigation design for any additional equipment must be conducted during design development to confirm compliance with environmental noise criteria in Section 2.3.1. .	Achieve internal and external building services noise and vibration criteria.
Operational activities	Section 3.3	Restrict usage of Public Address to daytime hours only (7am to 6pm). Use directional speakers and set volume levels to the minimum required to ensure clarity and audibility. Where practicable, all loading dock activities, waste removal and noisy cleaning activities should take place between 7:00-8:00 AM or 4:00-10:00 PM.	To minimise disruption to nearby residential receivers.
Construction noise and vibration	Section 4	Contractor to develop a detailed construction noise and vibration management plan once specific details of proposed construction activities and staging are known.	To effectively manage construction noise and vibration impacts to the surrounding community.

6. Evaluation of Environmental Impacts

An acoustic assessment has been undertaken of construction and operation of the proposed Bungendore North Campus High School. Where applicable, reference is made to the Environmental Noise and Vibration Assessment of SSDA (14394209) for the discontinued design scheme. This assessment has been based on information available at this stage of design and has been developed to a level of detail suitable for submission as appendix to the Review of Environmental Factors.

The operational assessment has considered noise emissions from school operations including building services, outdoor play areas, gymnasium use, and car parks. Road traffic noise increase associated with operation of the school has also been assessed along with noise intrusion into the development site. Various recommendations have been made to mitigate noise sources and enhance the building envelope where feasible and reasonable to demonstrate compliance with target criteria.

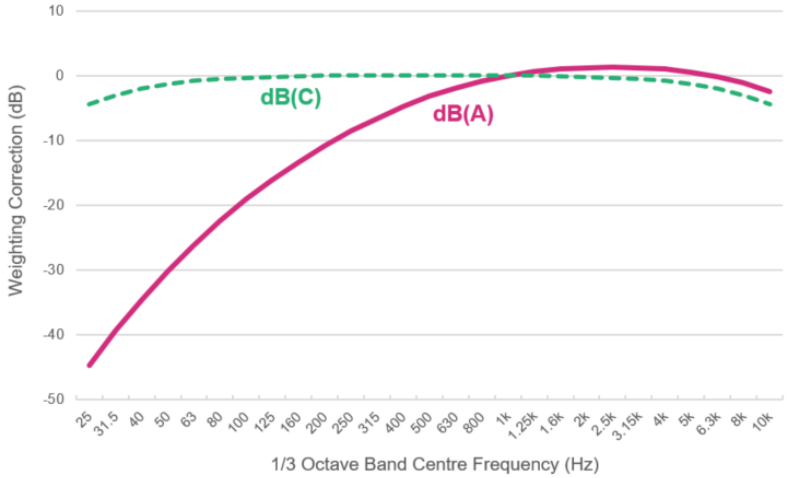
In lieu of detailed information being available at this stage of design, the construction noise and vibration assessment has made various assumptions based on typical approaches to building school developments. Various exceedances of target noise management levels have been identified and indicative mitigation and management measures put forward. A detailed Construction Noise and Vibration Management Plan will be required to be developed by the Contractor once more specific details are known.

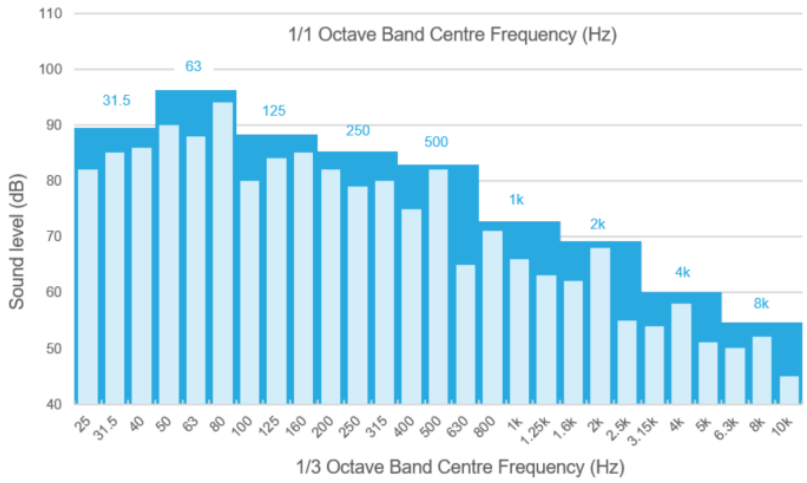
The extent and nature of potential impacts are considered low and not expected to have significant impact on the locality, community and/or the environment. Potential impacts can be appropriately mitigated or managed to ensure that there is minimal impact on the locality, community and/or the environment through implementation of the Mitigation Measures outlined at Section 5.

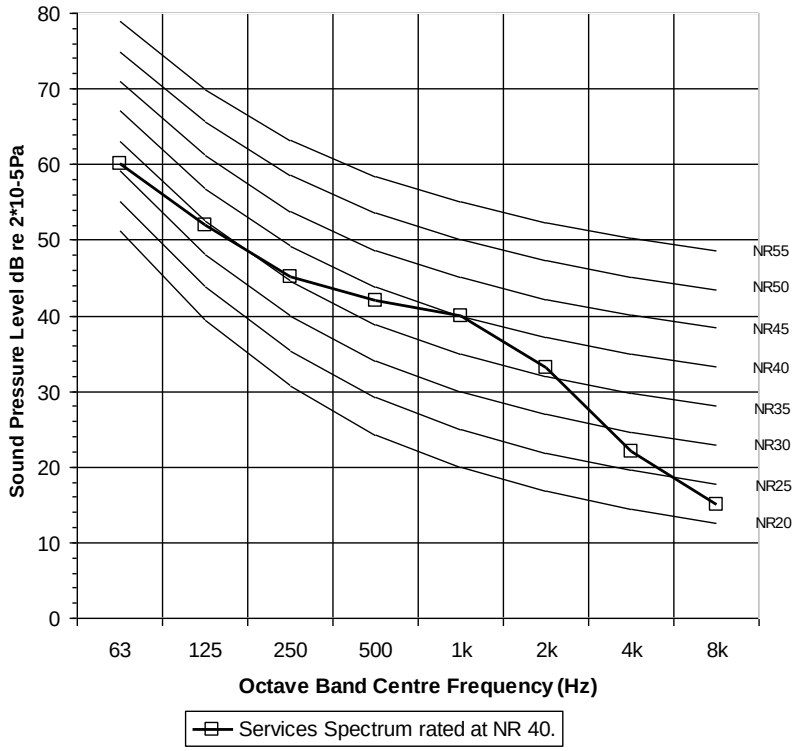
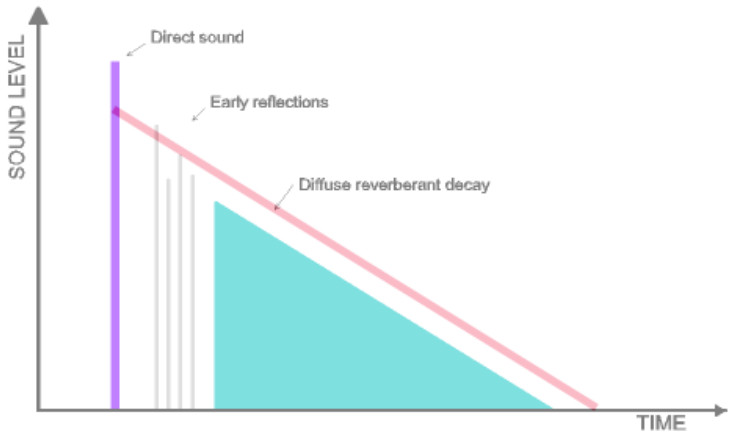
Appendix A

Glossary

Term	Definition
Absorption Coefficient, α	The amount of sound absorbed by a material, defined as the ratio of the amount of acoustic absorption of the material (in units of sabins) to the material's surface area. Absorption coefficient is broadly equivalent to the proportion of sound energy absorbed by the material. Noise-reduction Coefficient (NRC): The arithmetic average of the sound-absorption coefficients of a material at 250 Hz, 500 Hz, 1 kHz and 2 kHz. It is a simplified single-number index that provides an indication of the sound absorbing efficiency of a material, typically ranging from 0 to 1. The rating is affected by type, thickness, density and mounting of the material. Weighted absorption coefficient (α_w): The weighted absorption coefficient, defined in ISO 11654 is a frequency-weighted single number absorption coefficient used to categorise the overall absorption effectiveness of a material. Descriptors are used to indicate if the material absorbs strongly at high (H), mid (M) and/or low (L) frequencies – e.g. a material may be rated as α_w 0.85(LH), which indicates that it strongly absorbs at both low and high frequencies. Materials can also be assigned into five absorption classes, with Class A having the highest absorption and Class E having the lowest absorption.
Ambient noise level	The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a building is being investigated, the ambient noise level is the noise level from all other sources without the fan operating, such as traffic, birds, people talking and other noise from other buildings.
Background noise level	The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects. Assessment Background Level (ABL): A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time. Rating Background Level (RBL / min$L_{A90,1hour}$): A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.
Decibel (dB)	The logarithmic scale used to measure sound and vibration. Human hearing is not linear and involves hearing over a large range of sound pressures, which would be challenging to present on a linear scale. A logarithmic scale allows all sound levels to be expressed based on how loud they are relative to a reference sound (typically 20 µPa, which is the approximate human threshold of hearing). For sound in other media (e.g. underwater noise) a different reference level (1 µPa) is used instead. An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

Term	Definition
dB weighting curves	The frequency of a sound affects its perceived loudness and human hearing is less sensitive at low and very high frequencies. When seeking to represent the summation of sound pressure levels across the frequency range of human hearing into a single number, weighting is typically applied. Most commonly, A-weighting, denoted as dB(A), is used for environmental noise assessment. This is often supplemented by the linear or C-weighting curves, where there is the potential for excess low-frequency sound at higher sound pressure levels. 
dB(A)	dB(A) denotes a single-number sound pressure level that includes a frequency weighting (‘A-weighting’) to reflect the subjective loudness of the sound level. The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).
Flutter Echo	Flutter echo refers to an acoustic defect where sound reflects backwards-and-forwards between a set of parallel surfaces with very little energy loss. The resulting flutter echo decays very slowly and can ‘linger’ in the room long after sound travelling in other directions has been attenuated. Flutter echo can cause distortion to the sound quality, making it sound ‘metallic’, or if the flutter is strong enough or delayed enough, it can cause a sound to be ‘blurred’ and even be heard as a separate sound (a true ‘echo’). Flutter is treated by angling surfaces so they are not parallel (typically a minimum of 7º off-parallel), adding absorption to one or both surfaces, or by adding diffusion to one or both surfaces.

Term	Definition
Frequency	Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as 'pitch'. Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or 'low-pitched' and sounds with a higher frequency are perceived as 'treble' or 'high pitched'. The unit of frequency is the hertz (Hz), which is identical to cycles per second. A thousand Hz is generally denoted as kHz. Human hearing ranges approximately from 20 Hz to 20 kHz. While single weighted sound pressure levels simplify the assessment and evaluation of sound levels, frequency analysis is often undertaken. 'Octave bands', either 1/1 or 1/3 octave bands are most commonly utilised and are referred to by the nominal centre frequency of the band (e.g. 31.5 Hz), while being the summation of all frequencies between a defined lower and upper frequency. 
Impact Sound Pressure Level	The technical parameter used to determine impact sound isolation of floors is the impact sound pressure level, L_i. In the laboratory, the weighted normalised impact sound pressure level, $L_{n,w}$, is used to represent the impact sound isolation as a single figure. On site, the weighted normalised apparent impact sound pressure level, $L'_{n,w,}$ and the weighted standardised apparent impact sound pressure level, $L'_{n,Tw}$, are used to represent the impact sound isolation of a floor as a single figure. These single weighted values are determined by comparing the spectral impact sound pressure levels (as defined in ISO 140-6 and ISO 140-7) with reference values outlined in AS/NZS ISO 717.2.
$L_{10(period)}$	The sound level exceeded for 10% of the measurement period, or alternatively, the sound levels would be lower for 90% of the time. The L_{10} is often defined as the 'average maximum' sound levels, as in AS1055-2018 with the advent of statistical sound level meters.
$L_{90(period)}$	The sound level exceeded for 90% of the measurement period. The L_{90} is often defined as the 'average minimum' or 'background' noise level for a period of measurement. For example, 45 $dBL_{A90,15min}$ indicates that the sound level is higher than 45 dB(A) for 90% of the 15-minute measurement period.
$L_{eq(period)}$	The equivalent ('eq') continuous sound level, used to describe the level of a time-varying sound or vibration measurement. The L_{eq} is often defined as the 'average' level, and mathematically, is the energy-average level over a measurement period – i.e. the level of a constant sound that contains the same sound energy as the measured sound.
L_{peak} / L_{max}	The L_{peak} is the 'absolute maximum' level of a sound or vibration recorded within the measurement period. As the L_{peak} is often caused by an instantaneous event, it can vary significantly between measurements. L_{max} is the maximum rms sound pressure level within a measuring period. L_{max} gives a better picture of what the general maximum level was in a measurement, making it easier to calculate and measure for a noise source waveform that is changing constantly in its magnitude.

Term	Definition
Noise Rating (NR) Curves	A set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The 'NR' value is obtained by plotting the octave band spectrum on the set of standard curves. The highest value curve which is reached by the spectrum is the NR value. Shown below is a mechanical plant noise spectrum at NR 40. 
Reverberation Time (T_{60})	The time, in seconds, taken for a sound within a space to decay by 60 dB after the sound source has stopped is denoted at the reverberation time (RT). The RT is an important indicator of the subjective acoustic within a space. A long RT subjectively corresponds to an acoustically 'live' space, while a short RT subjectively corresponds to an acoustically 'dead' space. 

Term	Definition
Sound Level Difference (D)	Used to quantify the sound insulation between two spaces and is equal to the difference in sound level between the rooms within a particular frequency band. For example, if the sound level in the source room is 100 dB and the sound level in the adjacent room is 75 dB, the sound level difference is 25 dB for that frequency band. The weighted sound level difference, D_w, as defined in AS/NZS ISO 717.1, is used to provide a single-number descriptor to describe the overall performance of a partition across multiple frequency bands. Note however that D_w is only calculated over a frequency range from 100 Hz to 3.15 kHz and hence sound outside of this range is excluded from calculation of D_w – particularly low frequency (bass) sound below 100 Hz. Also used are the weighted normalised level difference ($D_{n,w}$), which corrects the measured sound level difference to a reference sound absorption area in the receiving room, or the weighted standardised level difference ($D_{nT,w}$), which corrects the measurements to a reference reverberation time in the receiving room. These single numbers are determined by comparing the spectral sound insulation test results (as defined in ISO 140-4) with reference values, as outlined in AS/NZS ISO 717.1.
Sound Power and Sound Pressure	The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of the environment and distance from a source. The sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.
Sound Reduction Index (R)	A measure of the sound level loss through a material for a particular frequency band. Sound reduction index is sometimes also referred to as transmission loss. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency band. The weighted sound reduction index, R_w, is a single figure description of sound reduction index across multiple frequency bands and is defined in BS EN ISO 717-1: 2000. R_w values are calculated from measurements in an acoustic laboratory. Note however that R_w is only calculated over a frequency range from 100 Hz to 3.15 kHz and hence sound outside of this range is excluded from calculation of R_w – particularly low frequency (bass) sound below 100 Hz. Sound insulation ratings derived from site measurements are referred to as apparent sound reduction index (R'_w) ratings.
Spectrum Adaptation Terms (C and C_{tr})	C and C_{tr} denote a spectrum adaptation (in dB) that are added to the R_w or D_w value of a partition to adjust for different sound characteristics. C is used to measure the performance of a partition for medium to high-frequency sound sources, such as speech. C_{tr} is used to measure the performance of a partition for low-frequency sound sources such as road traffic. The values of C and C_{tr} are dependent on the construction of the partition and are usually negative quantities, they typically increase the R_w requirement of a partition. For example, for a partition with an R_w of 56 dB and C_{tr} -6 dB, the R_w+C_{tr} is only 50 dB. The overall performance of the partition is quoted as the sum of the R_w value and the spectrum adaptation terms, e.g. D_w+C 55 dB; R_w+C_{tr} 60 dB.

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Speech Transmission Index (STI)</td><td>STI is a technical index, predictable and measurable using specialised equipment, for assessing speech and vocal intelligibility. STI takes into account the signal/noise ratio of the speech signal and the reverberation of the receiving environment. The higher the value of STI, the higher the expected speech intelligibility.

STI ratings are assigned subjective categories, as follows:

<table>
<tr><th>STI range</th><th>Subjective category</th></tr>
<tr><td>< 0.3</td><td>Bad</td></tr>
<tr><td>0.3 – 0.45</td><td>Poor</td></tr>
<tr><td>0.45 – 0.6</td><td>Fair</td></tr>
<tr><td>0.6 – 0.75</td><td>Good</td></tr>
<tr><td>0.8 – 1.0</td><td>Excellent</td></tr>
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</td></tr>
<tr><td>Structureborne noise</td><td>The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.</td></tr>
<tr><td>Vibration</td><td>Waves in a solid material are called ‘vibration’, as opposed to similar waves in air, which are called ‘sound’ or ‘noise’. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (e.g. a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.</td></tr>
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