RAPT CONSULTING

Acoustic Assessment – All Saints College Multi-Purpose Centre Maitland, NSW

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1. Introduction

1.1 Background

RAPT Consulting has been engaged to undertake acoustic services for SHAC as part of the Catholic Diocese Maitland Newcastle All Saints College Multi-Purpose Centre (MPC) located at Corner Hunter Street & Odd Street, Horseshoe Bend Maitland NSW 2320.

The project involves the construction of a new Multi-Purpose Centre, refurbishment of the existing St Paul’s Parish Hall and extension of an existing carpark within a masterplan scheme. The proposal will become a shared facility for use by All Saint’s College Students at the St Peter’s Campus and St Mary’s Campus in Maitland. The Multi-Purpose Centre will be approximately 1700sqm, incorporating a full-sized indoor basketball court, learning spaces and amenities.

1.2 Purpose

The purpose of this acoustic assessment is to consider both onsite noise generation during construction and operation and to provide input regarding acoustic issues to consider during the concept design stage of the project.

The outcomes of this assessment include recommendations for potential noise and vibration mitigation and management measures designed to achieve an acceptable noise amenity for residential (dwelling) occupants and other sensitive receivers surrounding the proposal site. Additionally, this assessment provides recommendations for:

- Acoustic ratings for partitions, glazing and doors
- Internal noise levels and reverberations times

The project site and surrounding area is shown in Figure 1-1.

Figure 1-1 Site and Surrounding Area (Source: Google Maps)

This assessment has been undertaken with consideration to:

- *Road Noise Policy* (RNP, DECCW, 2011)
- *Noise Policy for Industry* (NPfI) (NSW EPA, 2017)
- *Interim Construction Noise Guideline* (ICNG) (NSW DECC, 2009)
- German Standard DIN 4150, Part 3: *Structural Vibration in Buildings: Effects on Structures*
- British Standard BS *7385 Part 2-1993 Evaluation and measurement for vibration in buildings*
- *Assessing Vibration: A Technical Guideline* (DECC, 2006)
- Australian Standard AS2107:2016 - *Recommended design sound levels and reverberation times for building interiors*
- Association of Australian Acoustical Consultants Guideline for Educational Facilities Acoustics

1.3 Limitations

The purpose of the report is to provide an independent acoustic assessment for the proposal.

It is not the intention of the assessment to cover every element of the acoustic environment, but rather to conduct the assessment with consideration to the prescribed work scope.

The findings of the noise assessment represent the findings apparent at the date and time of the assessment undertaken. It is the nature of environmental assessments that all variations in environmental conditions cannot be assessed and all uncertainty concerning the conditions of the ambient environment cannot be eliminated. Professional judgement must be exercised in the investigation and interpretation of observations.

In conducting this assessment and preparing the report, current guidelines for acoustics, noise and vibration were referred to. This work has been conducted in good faith with RAPT Consulting's understanding of the client's brief and the generally accepted consulting practice.

No other warranty, expressed or implied, is made as to the information and professional advice included in this report. It is not intended for other parties or other uses.

2. Existing Environment

To establish background and ambient noise levels, noise monitoring was undertaken by RAPT Consulting at the eastern end of The All Saints College in the vicinity of the nearest potentially affected residential receptor located at 2 Carrington Street from 29 March to 01 April, 2021. Site observations noted the location is considered indicative of the local ambient noise environment and this site also presented as secure location whereby minimising the risk of theft or vandalism to the monitoring equipment. Additionally, they are considered as acceptable locations for determination of the background noise with consideration to the NSW Environment Protection Authority's (EPA's) – Noise Policy for Industry (NPfI).   During site visits it was noted that existing road traffic, distant road traffic, natural wildlife, and an underlying urbuan 'hum' primarily described the ambient noise environment and is indicative of an urban noise environment.

The monitoring location is shown in Figure 2-1.

Figure 2-1 Monitoring Location with Nearest Residence in the Background

Monitoring was undertaken using a RION NL-42 noise logger with Type 2 Precision. Calibration was checked prior to and at the conclusion of the measurements with no significant drift. These loggers are capable of measuring continuous sound pressure levels and are able to record LAmin, LA90, LA10, LAmax and LAeq noise descriptors. The instrument was programmed to accumulate environmental noise data continuously over sampling periods of 15 minutes for the entire monitoring period.

The LA90 descriptor is used to measure the background noise level. This descriptor represents the noise level that is exceeded for 90 per cent of the time over a relevant period of measurement. The LA90 descriptor is used to establish the Rating Background Noise Level (RBL), which is the overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. The RBL has been calculated, according to the procedures described in the EPA's NPfI and by following the procedures and guidelines detailed in Australian Standard AS1055-1997, "Acoustics - Description and Measurement of Environmental Noise, Part 1 General Procedures."

The LAeq is the equivalent continuous noise level which would have the same total acoustic energy over the measurement period as the varying noise actually measured, so it is in effect an energy average.

Logged data was reviewed and filtered to exclude any extraneous data during the monitoring period. Weather information for the unattended noise logging was obtained from the Bureau of Meteorology Maitland all weather station for the monitoring period and any data adversely affected by rain, wind (more than 5 m/s as per NPfI) were discarded.

The RBL and ambient LAeq levels are provided in Table 2-1 below.

Table 2-1 Background and Ambient Noise Monitoring Results

Address	Rating background level, L_{A90}, dB(A)			Ambient noise levels, L_{Aeq} dB(A)		
	Day	Evening	Night	Day	Evening	Night
All Saints College	45	45	40	62	57	55

3. Noise and Vibration Objectives

3.1 Construction Noise

Construction noise is assessed with consideration to DECCW *Interim Construction Noise Guidelines* (ICNG) (2009) The ICNG are non-mandatory guidelines that are usually referred to by local councils and other NSW government entities when construction / demolition works require development approval. The ICNG recommend standard hours for construction activity as detailed in Table 3-1.

Table 3-1 ICNG Recommended Construction Hours

Work type	Recommended standard hours of work
Normal construction	Monday to Friday: 7 am to 6 pm. Saturday: 8 am to 1 pm. No work on Sundays or Public Holidays.

The ICNG provides noise management levels for construction noise at residential and other potentially sensitive receivers. These management levels are to be calculated based on the adopted rating background level (RBL) at nearby locations, as shown in Table 3-2.

Table 3-2 Recommended Construction Noise Management Levels

Period	Management Level $L_{Aeq(15\ min)}$
Residential Recommended standard hours	Noise affected level: RBL + 10 Highly noise affected level: 75 dB(A)
Residential Outside recommended standard hours	Noise affected level: RBL + 5 Highly noise affected level: 75 dB(A)
Classrooms at schools and other educational institutions	Internal Noise Level 45 dB(A) (applies when properties are being used)
Hospital wards and operating theatres	Internal Noise Level 45 dB(A) (applies when properties are being used)
Places of worship	Internal Noise Level 45 dB(A) (applies when properties are being used)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)

Period	Management Level $L_{Aeq(15\ min)}$
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Offices, retail outlets	70 dB(A)

The above levels apply at the boundary of the most affected residences / offices or within 30 m from the residence where the property boundary is more than 30 m from the residence.

The *noise affected level* represents the point above which there may be some community reaction to noise. Where the *noise affected level* is exceeded all feasible and reasonable work practices to minimise noise should be applied and all potentially impacted residents should be informed of the nature of the works, expected noise levels, duration of works and a method of contact. The *noise affected level* is the background noise level plus 10 dB(A) during recommended standard hours and the background noise level plus 5 dB(A) outside of recommended standard hours.

The *highly noise affected level* represents the point above which there may be strong community reaction to noise and is set at 75 dB(A). Where noise is above this level, the relevant authority may require respite periods by restricting the hours when the subject noisy activities can occur, considering:

- Times identified by the community when they are less sensitive to noise (such as 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.

It is understood most works required for the proposal would be undertaken during standard construction hours. Based on the above and the RBL's established from site monitoring construction noise management levels (NML's) for residential receivers have been derived, as shown in Table 3-3.

Table 3-3 Construction NML's dB(A) Leq(15min)

Period	RBL L_{A90}, dB(A)	Standard hours NML's,$L_{Aeq,15min}$, dB(A)
Day	45	55

3.2 Vibration Guidelines

Vibration during construction and operational activity is expected to primarily originate from trucks and machinery during stages of construction and associated activities. RAPT Consulting also understand that blasting and heavy ground impact activities is not expected to occur during the construction works.

3.2.1 Human Exposure

Vibration goals during the were sourced from the DECCW's *Assessing Vibration: a technical guideline*, which is based on guidelines contained in British Standard (BS) 6472–1992, *Evaluation of human exposure to vibration in buildings (1–80 Hz).*

Intermittent vibration is assessed using the vibration dose value (VDV), fully described in BS 6472 – 1992. Acceptable values of vibration dose are presented in Table 3-4.

Table 3-4 Acceptable Vibration Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime [1]		Night-time [1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas [2]	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

3.3 Building Damage

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to the following International Standards and Guidelines:

- British Standard BS7385.2 - 1993 *Evaluation and Measurement for Vibration in Buildings*, Part 2 - Guide to damage levels from ground borne vibration. and
- German Standard DIN 4150-3: 1999-02 *Structural Vibration – Part 3*: *Effects of vibration on structures*.

DIN 4150-3: 1999-02 is utilised in this case in the assessment of potential building damage resulting from ground borne vibration produced by the proposed activity.

The recommended Peak Particle Velocity (PPV) guidelines for the possibility of vibration induced building damage are derived from the minimum vibration levels above which any damage has previously been encountered and are presented in Table 3-5.

Table 3-5 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on structures

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz*	
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20-40	40-50	40
Dwellings and buildings of similar design and/or occupancy	5	5-15	15-20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 of table 5-7 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Ground Vibration – Minimum Working Distances from Sensitive Receivers

The Transport for NSW *Construction Noise and Vibration Strategy* (CNVS) provides guidance for minimum working distances. As a guide, minimum working distances from sensitive receivers for typical items of vibration intensive plant are listed in Table 3-6. The minimum distances are quoted for both “cosmetic” damage (refer BS 7385) and human comfort (refer OH&E’s *Assessing Vibration - a technical guideline*). DIN 4150 has criteria of particular reference for heritage structures.

Table 3-6 Recommended Minimum Safe Working Distances for Vibration Intensive Plant from Sensitive Receiver

Plant Item	Rating / Description	Minimum Distance Cosmetic Damage		Minimum Distance Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1-2 tonne)	5m	11m	15m to 20m
	<100 kN (2-4 tonne)	6m	13m	20m
	<200 kN (4-6 tonne)	12m	15m	40m
	<300kN (7-13 tonne)	15m	31m	100m
	>300kN (13-18 tonne)	20m	40m	100m
	>300kN (>18 tonne)	25m	50m	100m
Small Hydraulic Hammer	300kg (5 to 12 t excavator)	2m	5m	7m
Medium Hydraulic Hammer	900kg (12 to 18 t excavator)	7m	15m	23m
Large Hydraulic Hammer	1600kg (18 to 34 t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet Piles	2m to 20m	5m to 40m	20m
Pile Boring	≤ 800mm	2m (nominal)	5m	4m
Jack Hammer	Hand Held	1m (nominal)	3m	2m

Unlike noise which travels through air, the transmission of vibration is highly dependent on substratum conditions between the source/s and receiver. Also dissimilar to noise travelling through air, vibration levels diminish quickly over distance, thus an adverse impact from vibration on the broader community is not typically expected. Vibration during works is considered an intermittent source associated with two main types of impact, disturbance at receivers and potential architectural/structural damage to buildings. Generally, if disturbance issues are controlled, there is limited potential for structural damage to buildings.

3.4 Operational Noise

The New South Wales *Noise Policy for Industry* (NPfI) provides guidance on the assessment of operational noise impacts. The guidelines include both intrusive and amenity criteria that are designed to protect receivers from noise significantly louder than the background level and to limit the total noise level from all sources near a receiver.

Intrusive noise levels set by the NPfI control the relative audibility of operational noise compared to the background level. Amenity criteria limit the total level of extraneous noise. Both sets of criteria are calculated and the lower of the two in each time period normally apply. Intrusive criteria are simply 5 decibels above the measured (or adopted) background level with a minimum of 40 dB(A) for daytime and 35 dB(A) for evening and night time.

Amenity noise levels are determined based on the overall acoustic characteristics of the receiver area and the existing level of noise excluding other noises such as traffic and insects. Residential receiver areas are characterised into 'urban', 'suburban', 'rural' or other categories based on land uses, the existing level of noise from industry, commerce, and road traffic. Project amenity noise levels are the recommended amenity noise level (Table 2.1 of the NPfI) minus 5 dB(A) and plus 3 dB(A) to convert from a period level to a 15-minute level. The project noise trigger level is the lower value between the intrusive and the amenity noise levels.

The NPfI noise criteria are planning levels and are not mandatory limits required by legislation however the noise criteria assist the regulatory authorities to establish licensing conditions. Where noise criteria are predicted to be exceeded, feasible and reasonable noise mitigation strategies should be considered. In circumstances where noise criteria cannot be achieved negotiation is required to evaluate the economic, social and environmental costs and benefits of the development against the noise impacts.

The NPfI is generally intended for large and complex industrial sources and are not strictly applicable to school developments. However, it is the most useful guideline policy for the assessment of plant and equipment noise impact to surrounding receivers. Therefore, the NPfI will be referred to for determining operational noise goals for this proposal.

Nearest residential receptors are considered urban. It is understood the facility intends to operate up to 10:00pm during weekdays and up to 12:00am on weekends. Target noise levels are provided for residences, commercial premises, and classrooms in Table 3-7.

Table 3-7 Project Noise Trigger Levels dB(A)

	Day 7 am to 6 pm	Evening 6pm to 10pm	Night 10pm to 7am
Rating Background Level $L_{A90(Period)}$	45	45	40
Project Intrusive Noise Level, $L_{Aeq(15min)}$	50	50	45
Project Amenity Noise Level (Urban), $L_{Aeq(Period)}$	55	45	40
Project Amenity Noise Level $L_{Aeq(15min)}$	58	48	43
Project Trigger Level Residential $L_{Aeq(15min)}$	**50**	**48**	**43**
Commercial Premises (When in use) $L_{Aeq(15min)}$	**63**	**63**	**63**
Active Recreation (When in use) $L_{Aeq(15min)}$	**53**	**53**	**63**
School Classroom Internal	**35**	**35**	**35**

3.5 Road Noise Criteria

The NSW *Road Noise Policy* (RNP) recommends various criteria for different road and residential developments and uses. Although it is not mandatory to achieve the noise assessment criteria in the RNP, proponents will need to provide justification if it is not considered feasible or reasonable to achieve them. Based on the definitions in the RNP, the roads surrounding the proposal are local roads. The following noise goals provided in Table 3-8 Below.

Table 3-8 Road Noise Policy Goals

Road Category	Day	Night
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)

For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding ‘no build option’.

3.6 Australian Standard 2107:2016

Australian Standard (AS) AS2107 – Acoustics – Recommended design sound levels and reverberation times for building interiors provides recommended design sound levels for different areas of occupancy in educational buildings which are presented in Table 3-8.

Table 3-9 Recommended Design Sound Levels and Reverberation Times

Type of Occupancy	Recommended design sound levels, L_{Aeq}, dB(A)		Recommended Reverberation Time (T) s
	Satisfactory	Maximum	
Art/Craft Studios	40	45	0.6 to 0.8
Assembly Halls Up to 250 Seats	30	40	Curve 1*
Assembly Hall over 250 seats	30	35	0.6 to 0.8
Audio-Visual Areas	35	45	0.6 to 0.8
Computer Rooms Teaching	40	45	0.4 to 0.6
Computer Room Laboratories	45	50	0.4 to 0.6
Conference Rooms	35	40	0.6 to 0.7
Corridors and Lobbies	45	50	0.6 to 0.8
Drama Studios	35	40	See Note 2
Duplicating Rooms / Stores	45	50	0.6 to 0.8
Engineering Workshops	50	60	See Note 3
Gymnasiums	45	55	See Note 2
Interview / Counselling Rooms	40	45	0.3 to 0.6
Laboratories Teaching	35	45	0.5 to 0.7
Laboratories Working	40	50	0.6 to 0.8

Type of Occupancy	Recommended design sound levels, L_{Aeq}, dB(A)		Recommended Reverberation Time (T) s
	Satisfactory	Maximum	
Lecture Rooms up to 50 Seats	30	35	Curve 1*
Lecture Theatres without speech Reinforcement	30	35	Curve 1*
Lecture Theatres with speech Reinforcement	35	45	Curve 1*
Library General Areas	40	50	0.4 to 0.6
Library Reading Areas	40	45	0.4 to 0.6
Library Stack Areas	45	50	See Note 3
Manual Arts Worships	40	45	Seen Note 3
Medical Rooms (First Aid)	40	45	0.6 to 0.8
Music Practice Rooms	40	45	0.7 to 0.9
Music Studios	30	35	Curve 2*
Office Areas	40	45	0.4 to 0.6
Professional and administrative offices	35	40	0.6 to 0.8
Teaching Spaces Primary Schools	35	45	0.4 to 0.5 See Note 4
Teaching Spaces Secondary Schools	35	45	0.5 to 0.6 See Note 4
Staff Common Rooms	40	45	0.4 to 0.6
Toilet / Change / Showers	45	55	-

Note 2: Recommended reverberation time is 10 percent to 20 percent higher than Curve 1 of Appendix A.

Note 3: Reverberation time should be minimised as far a practicable for noise control

Note 4: Certain teaching spaces including those intended for students with learning difficulties and students with English as a second language, should have reverberation times at the lower end of the specified range.

Figure 3-1 shows the recommended reverberation times taken form AS 2107.

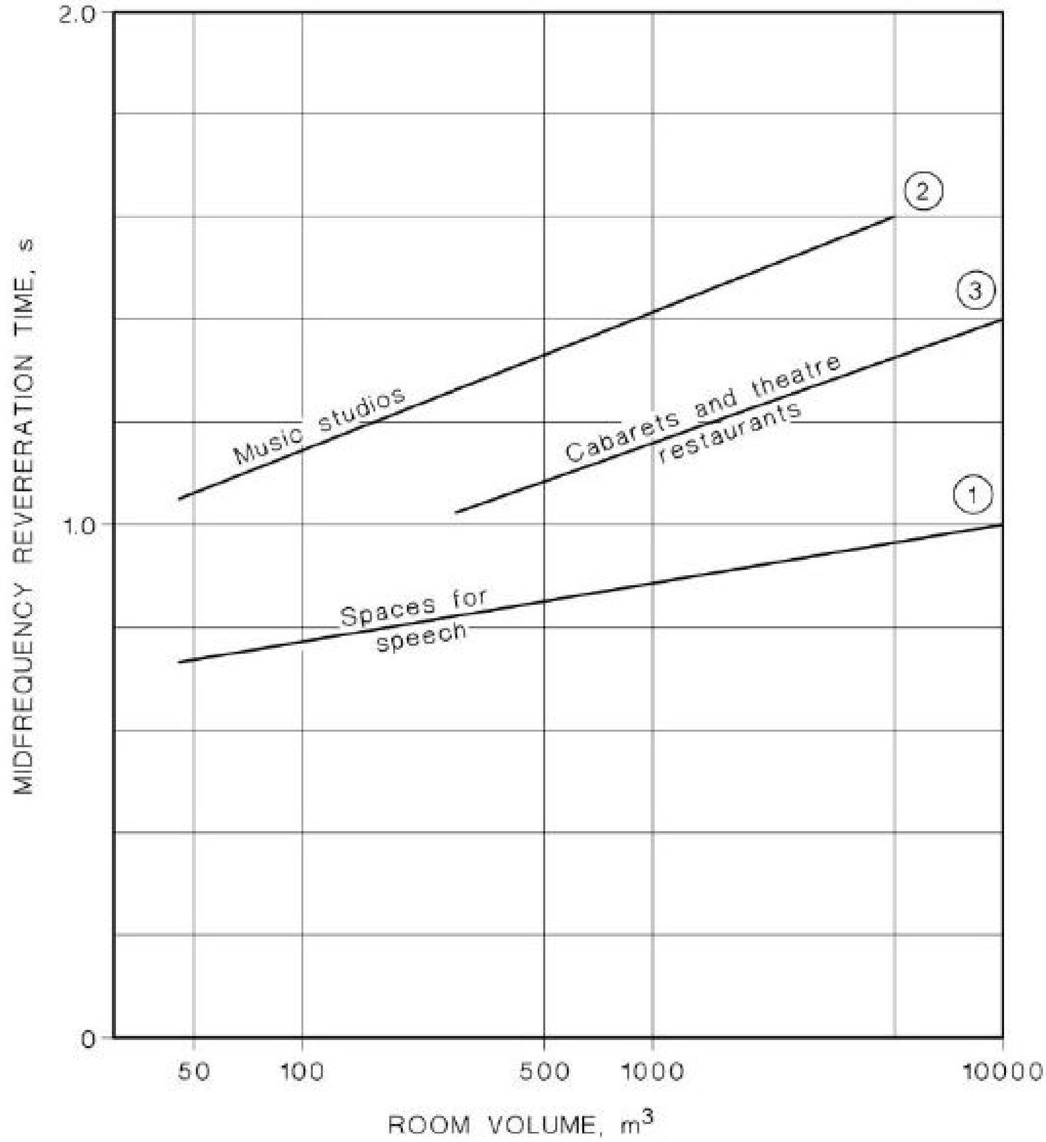


Figure 3-1 Recommended Reverberation Times

3.7 Airborne and Impact Sound Insulation Requirements

The Association of Australian Acoustical Consultants (AAAC) Guideline for Educational Facilities Acoustics also provides guidance for airborne and impact sound insulation requirements internal noise levels and is provided in Table 3-10.

Table 3-10 Airborne and Impact Sound Insulation Requirements

Room	Source Room Activity Noise	Receiving Room Noise Tolerance	Impact sound insulation rating (L'nTw)
Art/Craft Studios	Average	Medium	60
Assembly Hall up to 250 Seats	High	Low	60
Assembly Hall over 250 seats	High	Low	60
Audio-Visual Areas	High	Low	60
Computer Rooms - Teaching	Average	Low	60
Computer Rooms - Laboratories	Average	Medium	60
Conference Room	Average	Low	55
Corridors and Lobbies	Average	High	65
Dance Studio	High	Very Low	55
Dining Rooms	High	Medium	65
Drama Studios	High	Very Low	55
Duplicating Rooms/Stores	High	High	65
Engineering Workshops	High	High	65
Gymnasiums	High	Medium	65
Interview/Counselling Rooms	Average	Low	55
Kitchens	High	High	-
Laboratories-Teaching	Average	Low	60
Laboratories-Working	Average	Medium	65
Lecture Rooms-Up To 50 Seats	Average	Low	55
Lecture Theatres-without speech	Average	Very Low	50

Room	Source Room Activity Noise	Receiving Room Noise Tolerance	Impact sound insulation rating (L'nTw)
reinforcement and >50 Seats			
Lecture Theatres-With Speech Reinforcement	Average	Low	50
Libraries-General Areas	Low	Low	55
Libraries-Reading Areas	Low	Low	55
Libraries-Stack Areas	Average	Medium	55
Manual Arts Workshops	Average	Medium	65
Medical Rooms (first aid)	Average	Low	60
Music Practice Rooms	Very High	Low	55
Music Studios	Very High	Very Low	50
Office Areas	Low	Low	55
Open Plan Teaching Areas	Average Medium	Medium	55
Plant Room	High	High	-
Professional and Administrative Offices	Low	Low	60
Staff Common Rooms	Average	Medium	60
Study Rooms	Low	Low	55
Teaching Spaces-Hearing Impaired	Average	Very Low	50
Teaching Spaces-Primary Schools	Average	Low	55
Teaching Spaces-Secondary Schools	Average	Low	55
Toilet/Change/Showers	Average	High	-

The AAAC additionally provides a matrix for minimum design Rw performance for adjacent rooms which is based on guideline performance requirements outlined in Table 3-10. Table 3-11 outlines the minimum design performance matrix.

Table 3-11 Minimum Design Rw Performance Matrix

Receiving Room Noise Tolerance	Activity in Source Room			
	Low	Average	High	Very High
High	30	35	45	55
Medium	35	40	50	55
Low	40	45	55	55
Very Low	45	50	55	60

3.8 HVAC Noise

For environmental considerations in critical listening spaces, the sound generated by mechanical equipment must be considered in the design of the Heating, Ventilating and Air Conditioning (HVAC) system to ensure that the relevant internal noise requirements are met. Thus, the selection of the mechanical equipment and the design of spaces should be undertaken with an emphasis on the goal of providing acceptable sound levels in occupied spaces of the buildings in which the HVAC equipment is in service.

AHRI Standard 885 provides criteria for various spaces expressed in terms of Room Criteria (RC) Levels. Each RC Level is associated with an RC Curve, which details spectral criteria. Relevant RC Levels are presented in Figure 3-2 below.

Table 15. Design Guidelines for HVAC System Noise in Unoccupied Spaces	
Space	RC (N)
Residences, Apartments, Condominiums	25 to 35
Hotels/motels	
Individual rooms or suites	25 to 35
Meeting/banquet rooms	25 to 35
Corridors, lobbies	35 to 45
Service/support areas	35 to 45
Office Buildings	
Executive and private offices	25 to 35
Conference rooms	25 to 35
Teleconference rooms	≤ 25
Open plan offices	≤ 40
With sound masking	≤ 35
Corridors and lobbies	40 to 45
Hospitals and clinics	
Private rooms	25 to 35
Wards	30 to 40
Operating rooms	25 to 35
Corridors and public areas	30 to 40
Performing Arts Spaces	
Drama theaters	25
Concert and recital halls	25
Music teaching studios	25
Music practice rooms	30 to 35
Laboratories (with fume hoods)	
Testing/research, minimal speech communication	45 to 55
Research, extensive telephone use, speech communication	40 to 50
Group teaching	35 to 45
Churches, mosques, synagogues	
With critical music programs	25 to 35
Schools[1]	
Classrooms	25 to 30
Large Lecture rooms	25 to 30
Without speech amplification	≤ 25
Libraries	30 to 40
Courtrooms	
Unamplified speech	25 to 35
Amplified speech	30 to 40
Indoor stadiums and gymnasiums	
School and college gymnasiums and natatoriums	40 to 50
Large seating capacity spaces (with amplified speech)	45 to 55

[1] Some educators and others believe that HVAC-related sound criteria for schools, as listed in previous editions of this table, are too high and impede learning for affected groups of all ages. See ANSI Standard S12.60-2002 (Reaffirmed 2007) for classroom acoustics and a justification for lower sound criteria in schools. The HVAC component of total noise meets the background noise requirement of that standard if HVAC-related background sound ≤ RC 25(N).

Reprinted with permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2007 ASHRAE Handbook, HVAC Applications, Chapter 47, Table 42.

Figure 3-2 AHRI Standard 885 Design Guidelines for HVAC Noise in Unoccupied Spaces

4. Acoustic Assessment

4.1 Construction Noise

Construction can occur in the vicinity of residences or other sensitive land uses and be variable in times of occurrence. These aspects of construction can exacerbate noise levels and their effects. Construction noise by its nature is temporary, may not be amenable to purpose-built noise control measures applied to industrial processes, and may move as construction progresses. With these constraints in mind, the ICNG was developed to focus on applying a range of work practices most suited to minimise construction noise impacts, rather than focusing only on achieving numeric noise levels. While some noise from construction sites is inevitable, the aim of the Guideline is to protect much of residences and other sensitive land uses from noise pollution most of the time.

While it is unknown at this stage what specific plant and equipment are planned to be used, generally the typical construction activity on the proposal will be in the form of construction of the building. Other equipment may be used however it is anticipated that they would produce similar noise emissions. Therefore, an assumed construction sequence would be:

- Excavation/Site preparation.
- Construction of building.

Table 4-1 provides general plant and machinery data that has been used to predict noise levels at the neighbouring properties. The noisiest data has been chosen for each piece of plant/machinery to present a worst-case scenario.

Table 4-1 Plant and Equipment Noise Levels

Plant Item	Activity Noise Level L_{Aeq} @ 10m	DEFRA Construction Noise Database	Anticipated Usage %
Excavation			
Dozer	80	Table 2 Ref 10	50
Tracked Excavator	79	Table 2 Ref 14	50
Articulated Dump Truck	74	Table 2 Ref 32	50
Roller	73	Table 2 Ref 38	50
CFA Piling	79	Table 3 REF 21	50
Building			
Concrete Pump & Cement Mixer	67	Table 4 Ref 24	50
Poker Vibrator	69	Table 4 Ref 34	50

Plant Item	Activity Noise Level L_{Aeq} @ 10m	DEFRA Construction Noise Database	Anticipated Usage %
Mobile Telescopic Crane	67	Table 4 Ref 36	50
Diesel Generator	61	Table 4 Ref 75	90

Note 1The sound power levels for the individual plant items are worst-case levels representative of the equipment operating at maximum capacity. In practice, not all plant items would operate at maximum capacity at the same time and therefore the estimated usage has been adjusted to reflect this. This adjustment is consistent with RAPT Consulting experience on similar projects.

Construction Operations

Acoustic modelling was undertaken using Bruel and Kjaer's "Predictor" to predict the effects of construction noise. Predictor is a computer program for the calculation, assessment and prognosis of noise propagation. Predictor calculates environmental noise propagation according to ISO 9613-2, "Acoustics – Attenuation of sound during propagation outdoors". Terrain topography, ground absorption, atmospheric absorption and relevant shielding objects are taken into account in the calculations.

Construction noise levels have been predicted based on the potential construction noise levels provided in Table 4-1. These noise levels represent different equipment noise levels and give an idea how noise levels may change across the proposal area with different activities being undertaken.

The magnitude of off-site noise impact associated with construction would be dependent upon several factors:

- The intensity of construction activities
- The location of construction activities;
- The type of equipment used;
- Intervening terrain; and
- The prevailing weather conditions.

In addition, construction machinery would likely move about the study area, variously altering the directivity of the noise source with respect to individual receivers and their distances. Noise levels at sensitive receivers can be significantly lower than the worst-case scenario when the construction works move to a more distant location in the work area. An example of this is shown in Figure 4-1.

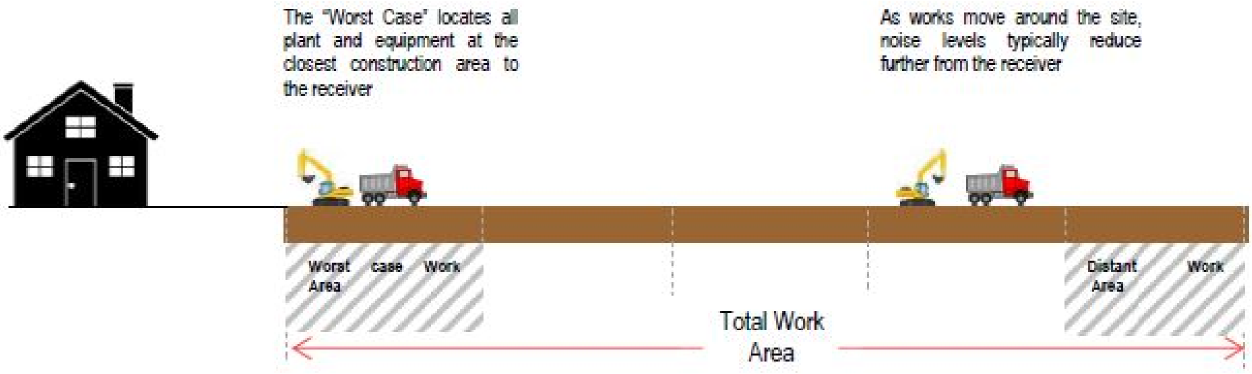


Figure 4-1 Example of Differing Work Areas

During any given period, the machinery items to be used in the study area would operate at maximum sound power levels for only brief stages. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Finally, certain types of construction machinery would be present in the study area for only brief periods during construction. Therefore, the modelled construction noise results are considered to represent a worst-case scenario. Two scenarios were assessed, one for the excavation and one for building.

Figure 4-2 Excavation dB(A) Leq(15min)

Figure 4-3 Building Construction dB(A) Leq(15min)

The results of the construction assessment indicate exceedances of NML's has the potential to be exceeded particularly during excavation. However, the highly affected noise level is expected to be complied with in all cases. Assuming standard façade and glazing treatments would attenuate at least 20 dB(A), internal noise levels have the potential to be exceeded at St Nicholas Early Education during excavation activities. Internal noise levels are expected to be met during building activities. NML's for offices and retail outlets and other commercial receivers is expected to be complied with. While it is expected NML's can be achieved in most cases, there is a risk for NML's to be exceeded depending on work activities and locations. With this in mind it is recommended a construction noise management plan be implemented as part of the proposal to minimise the risk of adverse noise emanating upon the community.

4.2 Construction Noise Management Plan

A Construction Noise Management Plan (CNMP) could be prepared prior to the commencement of works and implemented through all phases of the proposed construction works. The CNMP would provide the framework for the management of all potential noise impacts resulting from the construction works and would detail the environmental mitigation measures to be implemented throughout the construction works.

4.2.1 Planning and design of construction works

During the detailed planning, scheduling and design of the construction works the following noise management and mitigation measures should be investigated and, as required, implemented prior to the commencement of noise generating works.

Notification before and during construction

- Affected neighbours to the construction works would be advised in advance of the proposed construction period at least 1 week prior to the commencement of works.
- Consultation and communication between the site and neighbours to the site would assist in minimising uncertainty, misconceptions and adverse reactions to noise.
- All site workers (including subcontractors and temporary workforce) should be familiar with the potential for noise impacts upon residents and encouraged to take all practical and reasonable measures to minimise noise during their activities.
- The constructor or site supervisor (as appropriate) should provide a community liaison phone number and permanent site contact so that the noise related complaints, if any, can be received and addressed in a timely manner.
- The constructor (as appropriate) should establish contact with the residents and communicate, particularly when noisy activities are planned.

Best practice measures when operating on construction site

- Construction works should adopt Best Management Practice (BMP) and Best Available Technology Economically Achievable (BATEA) practices as addressed in the ICNG. BMP includes factors discussed within this report and encouragement of a project objective to reduce noise emissions. BATEA practices involve incorporating the most advanced and affordable technology to minimise noise emissions.
- Ensure that all construction works scheduled for standard construction hours comply with the start and finish time.
- Where practical, simultaneous operation of dominant noise generating plant should be managed to reduce noise impacts, such as operating at different times or increase the distance between plant and the nearest identified receiver.
- High noise generating activities such as jack hammering should only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block.
- Where possible, reversing beepers on mobile equipment would be replaced with low-pitch tonal beepers (quackers). Alternatives to reversing beepers include the use of spotters and designing the site to reduce the need for reversing may assist in minimising the use of reversing beepers.
- Equipment which is used intermittently should be shut down when not in use.
- All engine covers should be kept close while equipment is operating.
- The construction site would be arranged to minimise noise impacts by locating potentially noisy activities away from the nearest receivers wherever possible.

- To minimise heavy equipment handling noise, material stockpiles should be located as far as possible from the nearest receptors

- Loading and unloading areas should be located as far as possible from the nearest receptors.

- Where possible, trucks associated with the work area should not be left standing with their engine operating in a street adjacent to a residential area.

- All vehicular movements to and from the site should comply with the appropriate regulatory authority requirement for such activities.

Complaints handling

Noise and vibration monitoring should be undertaken upon receipt of a complaint to identify and quantify the issue and determine options to minimise impacts.

- If valid noise and/or vibration data for an activity is available for the complainant property, from works of a similar severity and location, it is not expected that monitoring will be repeated upon receipt of repeated complaints for these activities, except where vibration levels are believed to be potentially damaging to the building.

- Any noise and/or vibration monitoring should be undertaken by a qualified professional and with consideration to the relevant standards and guidelines. Attended noise and/or vibration monitoring should be undertaken upon receipt of a noise and/or vibration complaint. Monitoring should be undertaken and reported within a timely manner (say 3 to 5 working days). If exceedance is detected, the situation should be reviewed to identify means to reduce the impact to acceptable levels.

4.3 Construction Vibration

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

Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- The efficiency of the energy transfer mechanism of the equipment (i.e. impulsive, reciprocating, rolling or rotating equipment).

- The Frequency content.

- The impact medium stiffness.

- The type of wave (surface or body).

- The ground type and topography.

Due to the above factors, there is inherent variability in ground vibration predictions without site-specific measurement data.

Ground Vibration – Minimum Working Distances from Sensitive Receivers

The Transport for NSW CNVS provides guidance for minimum working distances. As a guide, minimum working distances from sensitive receivers for typical items of vibration intensive plant are listed in Table 4-2. The minimum distances are quoted for both "cosmetic" damage (refer BS 7385) and human comfort (refer DECC's Assessing Vibration - a technical guideline). DIN 4150 has criteria of particular reference for heritage structures. The minimum working distances are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

Table 4-2 Recommended Minimum Safe Working Distances for Vibration Intensive Plant from Sensitive Receiver

Plant Item	Rating / Description	Minimum Distance Cosmetic Damage		Minimum Distance Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1-2 tonne)	5m	11m	15m to 20m
	<100 kN (2-4 tonne)	6m	13m	20m
	<200 kN (4-6 tonne)	12m	15m	40m
	<300kN (7-13 tonne)	15m	31m	100m
	>300kN (13-18 tonne)	20m	40m	100m
	>300kN (>18 tonne)	25m	50m	100m
Small Hydraulic Hammer	300kg (5 to 12 t excavator)	2m	5m	7m
Medium Hydraulic Hammer	900kg (12 to 18 t excavator)	7m	15m	23m
Large Hydraulic Hammer	1600kg (18 to 34 t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet Piles	2m to 20m	5m to 40m	20m
Pile Boring	≤ 800mm	2m (nominal)	5m	4m

Plant Item	Rating / Description	Minimum Distance Cosmetic Damage		Minimum Distance Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Jack Hammer	Hand Held	1m (nominal)	3m	2m

Where vibratory rollers are proposed it is recommended <50 kN (1-2 tonne) be utilised. Additionally, if hydraulic hammering were to occur, it is recommended no larger than small 300kg (5 to 12t excavator) be utilised.

4.4 Operational Noise

Noise modelling was also undertaken for operational noise.

Mechanical Plant

At this stage, the mechanical plant has not been selected for the development. However, it is not uncommon for the mechanical plant not to be selected prior to submitting a development application. Mechanical plant may consist of an air conditioning system and exhaust fans. A typical range of sound power levels for mechanical plant is given in Table 4-3 below.

Table 4-3 Sound Power Levels of Mechanical Plant

Plant Type	SWL dB(A)
Small (single fan) condenser	65
Medium (double fan) condenser	70
Large (double fan) condenser	80

For conservatism, is has been assumed that large double fan condenser units will be operating as an outdoor source.

Multi-Purpose Centre Noise

It is understood the idea of stage 2 of the project (when the project is an open cola) is that it will only be used during school hours, because it isn't enclosed there won't be any out of hours school performances or the like until stage 3 is complete. The multi-purpose centre (MPC) may be used for sports, presentations and performances. The MPC will have doors opening to the outside. Often these doors will be closed, however for conservative purposes calculations have assumed doors are open or as an open air source. Noise emissions to the surrounding properties was calculated based on an MPC sound power level of 90 dB(A)

Leq,15min representing the sound level during a music performance or gymnasium ball sports activity.

The results of the assessment are shown in Figure 4-4.

Figure 4-4 MPC Operational Noise dB(A) Leq(15min)

The results of the operational assessment indicate operational noise from the MPC will comply with project noise trigger levels at all receptors during day, evening, and night time. While compliance is expected for the operations of the proposal, it is recommended that MPC doors remain closed wherever possible and an operational noise management plan be implemented to deal with the unlikely event where excessive noise may be generated.

Road Traffic Noise

For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'. This would equate to a 60% increase in overall traffic volumes which is not expected. The overall increase in traffic volumes is expected to be negligible and comply with noise objectives.

4.5 Internal Acoustics – Design Review

4.5.1 External Noise Intrusion

Noise from external sources such as road traffic, mechanical plant and other natural sources may potentially impact on the MPC. Based on the noise monitoring undertaken, it is recommended the following minimum configurations are considered in Table 4-4.

Table 4-4 External Configuration Recommendations

– Component	– Minimum Configuration
Wall Rw40	**Timber Frame or cladding:** 6mm fibre cement sheeting or weatherboards or plank cladding externally, 90mm deep timber stud or 92mm metal stud, 13mm standard plasterboard internally **Brick Veneer:** 110mm brick, 90mm timber stud or 92mm metal stud, minimum 50mm clearance between masonry and stud frame, 10mm standard plasterboard internally
Glazing Rw30	Minimum 6.38mm laminated glass with acoustic seals
Entry Doors Rw30	Minimum 40mm solid core timber door fitted with acoustic seals

Other options exist provided the Rw ratings are satisfied.

4.5.2 Partition Acoustic Ratings and Constructions

Example wall and door constructions capable of achieving the nominated ratings are provided in Table 4-5. Other options exist provided the Rw ratings are satisfied.

Table 4-5 Example acoustic Partition System Options

Category	Wall	Glazing	Doors
Rw30	10mm standard plasterboard 64mm steel stud or 90mm timber stud to ceiling level (cavity insulation not required) 10mm standard plasterboard	6.38mm laminated glass with acoustic seals	40mm solid core timber door fitted with acoustic seals (minimum mass 10 kg/m2) *Overall acoustic performance of partition is reduced by inclusion of any door.
Rw35	13mm standard plasterboard 64mm steel stud 50mm glasswool insulation (min. 14kg/m3) 13mm standard plasterboard	Minimum 10.38mm laminated glass with acoustic seals	40mm solid core timber door fitted with acoustic seals (minimum mass 10 kg/m2)
Rw40	13mm standard plasterboard 64mm steel stud 50mm glasswool insulation (min. 14kg/m3) 13mm standard plasterboard	10.38mm laminated glass with acoustic seals not more than 30% of partition or, Fixed single-glazed unit 12.5mm acoustic laminate	45mm solid core fitted with acoustic seals (minimum mass 22kg/m2)
Rw45	13mm fire-rated plasterboard 92mm steel stud 75mm glasswool insulation (min. 14kg/m3) 13mm fire-rated plasterboard	Fixed double-glazed unit 10mm 16mm air gap12.5mm acoustic laminate with acoustic seals	Proprietary acoustic door with integrated frame and acoustic seals with an acoustic rating of Rw35
Rw50	2 x 13mm standard plasterboard 64mm steel stud (NOT timber) 50mm thick, 14kg/m3 insulation in partition cavity 2 x 13mm standard plasterboard	Glass up to 30% of partition area: 8mm glass 65mm air gap 12.38mm laminated glass with acoustic seals	Proprietary acoustic door with integrated frame and acoustic seals, with an acoustic rating of Rw 40

Rw55	2 x 13mm standard plasterboard 64mm steel OR 70mm timber studs, full height slabto-slab construction 50mm thick, 14kg/m3 insulation in partition cavity 20mm clear space 64mm steel OR 70mm timber studs, full height slabto-slab construction	Generally, not recommended	Proprietary acoustic door with integrated frame and acoustic seals, 80mm thick, with an acoustic rating of Rw 45

** For Situations where Recommended Rw >45, Extent of wall - Wall to continue to underside of slab above,or continue to underside of roof truss. For Situations where recommended Rw 40 wall continues min. 100mm above ceiling height inclusive of acoustic insulation in the ceiling.*

4.5.3 Sound Transfer Over Ceilings

Where partitions are not full height slab-to-slab or slab-to-roof walls, where they do not extend above ceiling level to block the ceiling void, then noise transfer over ceilings is a critical transfer path. The level of acoustic treatment to ceilings and the practicality of achieving high sound insulation figures should be considered on a case-by-case basis and often requires site testing of sound insulation performance.

The following general advice is provided for sound insulation ratings that can typically be achieved by over ceiling noise transfer, for a range of ceiling types.

Table 4-6 Indicative Ceiling Sound Transfer Ratings

Ceiling Type	Indicative Rating Dw
Solid plasterboard ceiling with no openings	35-40
Plasterboard ceiling with penetrations	30-35
Acoustic ceiling tiles	30-35
Perforated ceiling	15-25

4.5.4 Partition Review

A review of the existing concept design and suggested partitions has been undertaken and the following figures present partition recommendation mark ups.

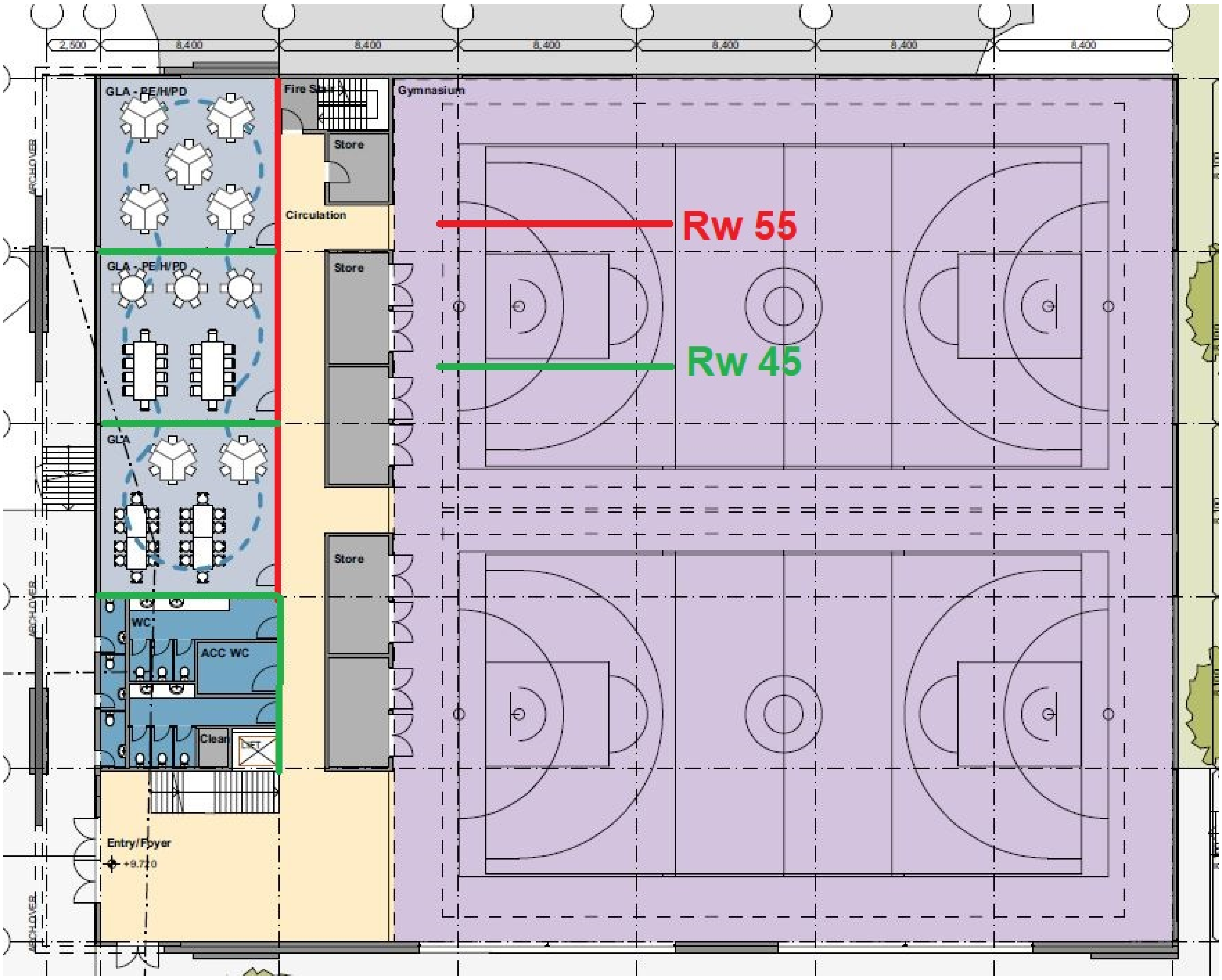


Figure 4-5 Ground Floor Partition Markup

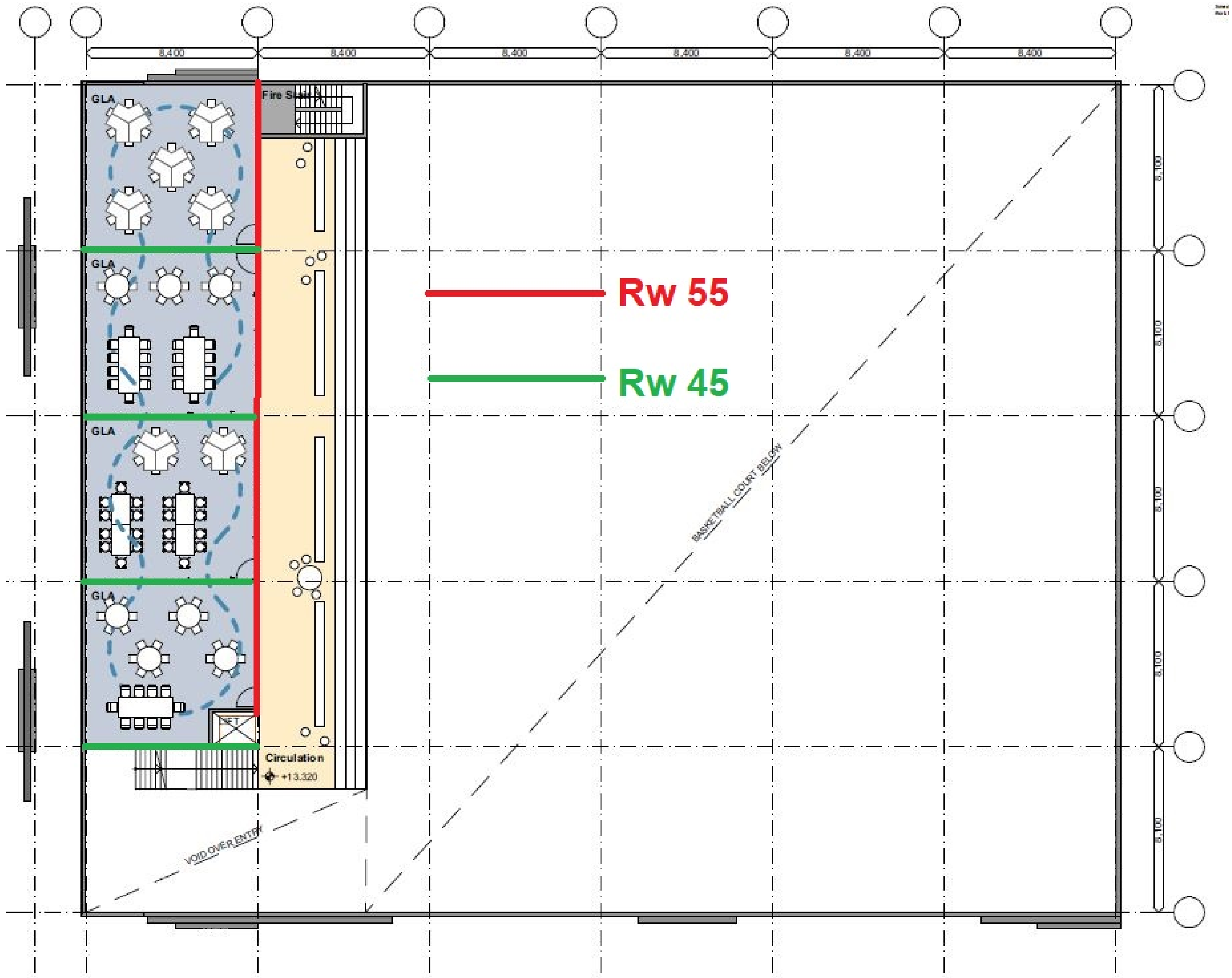


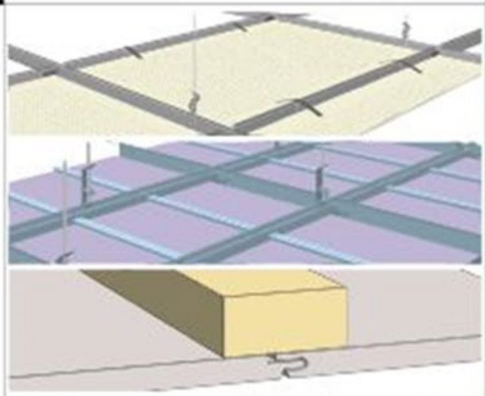
Figure 4-6 First Floor Partition Markup

4.5.5 Airborne Sound Transfer Between Floors

At the time of this review, it is not known what floor / ceiling systems are proposed particularly between the general learning areas. However as a minimum it is recommended they have a specification of Rw of 50 and an $L'_{nT,w}$ of 55.

Acoustic ceiling tiles can also be selected as per CSR System 890.

Acoustic Tile Ceiling Systems

SYSTEM SPECIFICATION	TYPICAL LAYOUT	ACOUSTIC OPINION OR TEST
• Rondo Duo suspended ceiling system with appropriate acoustic ceiling tiles. OR • Fricker Easy Access System™ with appropriate acoustic ceiling tiles OR • Plasterboard ceiling or timber battens with Ecophon Focus F acoustic ceiling tiles.		Refer to CSR Fricker

System **CSR 890** with acoustic ceiling tile options as per below	Material & Thickness	Edge Details	Colour	NRC	CAC (db)	LR	Ceiling System				
							TWE	TWA	OWE	FC	WP
USG Mars ClimaPlus™	Mineral Fibre 19mm	SQ SLT FLB	White White White	.70-.80 .75-.85 .70-.80	35 35 35	89% 89% 89%	• • •				
USG Radar ClimaPlus™	Mineral Fibre 15mm	SQ SLT	White White	.50-.60 .50-.60	33-35 33-35	84% 84%	• •				
USG Impressions ClimaPlus™	Mineral Fibre 15mm	SQ SLT	White White	.55 .55	33-35 33-35	84% 84%	• •				
USG Olympia Micro ClimaPlus™	Mineral Fibre 15mm	SQ SLT	White White	.50 .50	30-35 30-35	87% 87%	• •				
USG Millennia ClimaPlus™	Mineral Fibre 19mm	SQ	White	.70	35	87%	•				
Daiken Exceltone New NDF	Mineral Fibre 15mm	SQ TB AK	White White White	.55-.60 .55-.60 .55-.60	36-40 36-40 36-40	87% 87% 87%	• •		(AK) •		
Daiken Exceltone Travertine Delica	Mineral Fibre 15mm	SQ TB AK	White White White	.55-.60 .55-.60 .55-.60	36-40 36-40 36-40	87% 87% 87%	• •		(AK) •		
Fricker 610-A	Mineral Fibre 15mm	SQ SBK	White White	.70 .70	33-39 33-39	88% 88%	•	(SBK) •			
Fricker 611-A	Mineral Fibre 15mm	SQ SBK	White White	.55 .55	33-39 33-39	88% 88%	•	(SBK) •			
Fricker 616-A	Mineral Fibre 15mm	SQ SBK	White White	.70 .70	33-39 33-39	88% 88%	•	(SBK) •			

Notes:

Edge Details

SQ = Square,
SLT = Shadowline Tapered
FLB = Fineline Bevel
TB = Tegular
SBK = Kerfed, Bevelled and Cut Back
AK = Shiplap
AK (F) = Tongue & Groove direct fix

Ceiling System

TWE = Two Way Exposed
TWA = Two Way Access
OWE = One Way Exposed
FC = Fully Concealed
WP = Wall Panel
NRC = Noise Reductionj Coefficient
CAC = Ceiling Attenuation Class
LR = Light Reflectance

Figure 4-7 Acoustic Tile Options (Source CSR Gyprock Fibre Cement, The Red Book - Fire & Acoustic Design Guide)

4.5.6 Roof / Ceiling Systems

Roof / Ceiling systems from an acoustic perspective are primarily designed to attenuate external noise including rain. It is recommended the roof / ceiling system have a specification of Rw 45.

4.5.7 Room Acoustics and Reverberation Control

As internal finishes have yet to be decided upon, internal design should be based on achieving values listed in Table 3-10. As detailed design progresses calculations will be undertaken to ascertain achievement of reverberation times.

4.5.8 Plant and Service Area Noise

At this stage, the design and selection of the mechanical equipment systems, such as air-conditioners, chillers and exhaust fans etc, required to service the proposed building has not been finalised. A detailed analysis of noise emission from the plant equipment can be conducted at a later stage once this has been finalised to check compliance with the adopted noise criteria.

4.5.9 Flow Noise

The ASHRAE Handbook provides criteria for various spaces in buildings expressed in terms of Room Criteria (RC) Levels. Each RC Level is associated with an RC Curve, which details spectral criteria. Relevant RC Levels and corresponding approximate sound pressure levels are presented in Table 4-7 below.

Chapter 48 of the ASHRAE HVAC Applications provides maximum recommended airflows in rectangular and circular ducts for a variety of configurations detailed in Table 4-7 below.

Table 4-7Maximum Recommended Airflows in Rectangular and Circular Ducts

Category	Main Duct Location	Design RC	Maximum Airflow Velocity (m/s) Rectangular	Maximum Airflow Velocity (m/s) Circular
1	In shaft or above drywall ceiling	45	17.8	25.4
		35	12.7	17.8
		25	8.6	12.7
2	Above suspended acoustic ceiling	45	12.7	22.9
		35	8.9	15.2
		25	6.1	10.2
3	Duct located within occupied space	45	10.2	19.8
		35	7.4	13.2
		25	4.8	8.6

Notes to the above table:

- Branch ducts should have airflow velocities of about 80% of the values listed;
- Velocities in final runouts to outlets should be 50% of the values or less; and
- Elbows and other fittings can increase airflow noise substantially, depending on the type. Thus, duct airflow velocities should be reduced accordingly.

Table 4-8 provides maximum recommended air velocities at neck of supply diffusers or return registers to achieve specified acoustical design criteria.

Table 4-8 Maximum Recommended Air Velocities at Neck of Supply Diffusers or Return Registers to Achieve Specified Acoustical Design Criteria

Type of Opening	Design RC	"Free" Opening Airflow Velocity (m/s)
Supply Air Outlet	45	3.2
	40	2.8
	35	2.5
	30	2.2
	25	1.8
Return Air Opening	45	3.8
	40	3.4
	35	3.0
	30	2.5
	25	2.2

Notes to the above table:

- Table intended for use when no sound data are available for diffuser or grille is used. The number of diffusers or grilles increases sound levels, depending on proximity to receiver. Allowable outlet or opening airflow velocities should be reduced accordingly in these cases.
- Allow to provided supply and return air attenuators and internal acoustic insulation to all ductwork.

5. Conclusion

This concept design acoustic assessment has been undertaken for SHAC as part of the All Saints College Multi-Purpose Centre.

Based on the monitoring results and the information provided regarding the development, it is expected compliance with all operational environmental noise goals can be achieved.

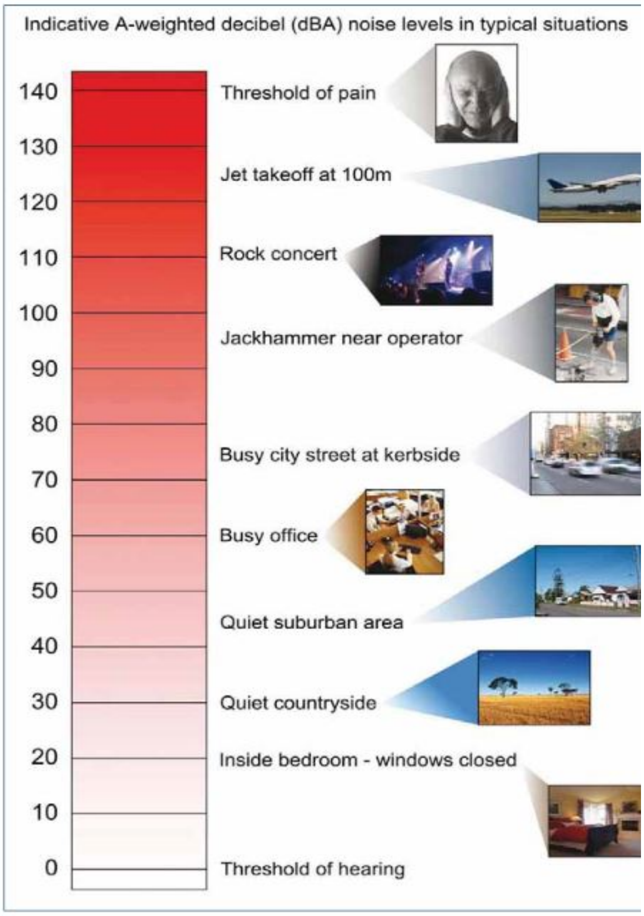
While construction noise is expected to comply in most cases, a series of mitigation strategies have been provided in Section 4.2.

Internal noise goals are expected to comply provided design measures similar to what has been outlined in Section 4.5 of this report are investigated and implemented. However further analysis and design reviews will be required over the course of the design period. This includes:

- Detailed review and specification of doors and glazing systems;
- Detailed review and specification of partitions, floors and ceilings;
- Detailed review and specification of surface finishes;
- Detailed review of the mechanical services design;
- Noise breakout from external HVAC plant.

Glossary of Acoustic Terms

Term	Definition
dB	Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics. The picture below indicates typical noise levels from common noise sources.



Term	Definition
dB(A)	Frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies.
$L_{Aeq(period)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{A10(period)}$	The sound pressure level that is exceeded for 10% of the measurement period.
$L_{A90(period)}$	The sound pressure level that is exceeded for 90% of the measurement period.
L_{Amax}	The maximum sound level recorded during the measurement period.
Noise sensitive receiver	An area or place potentially affected by noise which includes:

	A residential dwelling. An educational institution, library, childcare centre or kindergarten. A hospital, surgery or other medical institution. An active (e.g. sports field, golf course) or passive (e.g. national park) recreational area. Commercial or industrial premises. A place of worship.
Rating Background Level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
Feasible and Reasonable (Noise Policy for Industry Definition)	**Feasible** mitigation measure is a noise mitigation measure that can be engineered and is practical to build and/or implement, given project constraints such as safety, maintenance and reliability requirements. Selecting **Reasonable** measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure. To make a judgement, consider the following: Noise impacts Noise mitigation benefits Cost effectiveness of noise mitigation Community views.
Sound power level (SWL)	The sound power level of a noise source is the sound energy emitted by the source. Notated as SWL, sound power levels are typically presented in dB(A).
DnT,w	Weighted Standardised Level Difference A single number rating of the sound level difference between two rooms. DnT,w is typically used to measure the on-site sound insulation performance of a building element such as a wall, floor or ceiling
Dw	Weighted Sound Level Difference A single number rating of the sound level difference between two rooms. Dw is typically used to measure the on-site sound insulation performance of a building element such as a wall, floor or ceiling
Impact sound	Sound produced by an object impacting directly on a building structure, such as footfall noise or chairs scrapping on a floor
L'nT,w	Weighted, Standardised Impact Sound Pressure Level A single number rating of the impact sound insulation of a floor/ceiling when impacted on by a standard 'tapper' machine. L'nT,w is measured on site. The lower the L'nT,w, the better the acoustic performance.
Lw (or SWL)	Sound Power Level. The level of total sound power radiated by a sound source.
Masking Noise	Intentional background noise that is not disturbing, but due to its presence causes other unwanted noises to be less intelligible, noticeable and distracting.

NRC	Noise Reduction Coefficient A single number rating between 0 and 1 of the ability of a material to absorb sound. It is the average of the absorption coefficients in the 250-2000Hz octave bands rounded to the nearest 0.05. The larger the number, the more absorptive the material.
Octave Band	Octave Band A range of frequencies where the highest frequency included is twice the lowest frequency. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.
Room Criterion (RC)	The Room Criteria (RC) Method is a HVAC related background noise acceptability rating method. The RC method is a family of criterion curves (specifying sound levels by octave bands) intended to establish HVAC system design goals and a rating procedure.
RT or T60	Reverberation Time The time (in seconds) taken for the sound pressure level generated by a particular noise incident to decay by 60 decibels following the conclusion of the noise event (hence T60 abbreviation). Reverberation Time is used for assessing the acoustic qualities of a space, describing how quickly sound decays within a space. The reverberation time is related to the room volume and total absorption.
Rw	Weighted Sound Reduction Index A single number rating of the sound insulation performance of a specific building element. Rw is measured in a laboratory. Rw is commonly used by manufacturers to describe the sound insulation performance of building elements such as plasterboard and concrete.
Speech transmission	(STI) is a measure for the transmission quality of speech with respect to intelligibility. A value of 0 indicates completely unintelligible speech while a value of 1 indicates perfectly intelligible speech.