REVERB ACOUSTICS
Noise and Vibration Consultants

Noise Impact Assessment
Mixed-Use Development
18 Honeysuckle Drive
Newcastle NSW

August 2014

Prepared for Doma Group Pty Ltd
Report No. 14-1812-R1

Building Acoustics - Council/OEH Submissions - Modelling - Compliance - Certification

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1 INTRODUCTION

Reverb Acoustics has been commissioned to conduct a noise impact assessment for a proposed mixed-use development at 18 Honeysuckle Drive, Newcastle. The purpose of this assessment is to determine the noise impact, within habitable spaces of the development, and to ensure that noise levels comply with the requirements of the Roads and Maritime Services (RMS), Department of Planning and Infrastructure (DoPI), Office of Environment and Heritage (OEH) and Newcastle City Council (NCC). Further assessment has also been undertaken to determine the noise impact from social activities (people leaving entertainment venues during the evening and night), and noise and vibration from passing rail traffic on the Great Northern Rail line.

The Assessment was requested by Doma Group Pty Ltd in support of and to accompany a Development Application to NCC and to ensure any noise control measures required for the development are incorporated during the design stages.

2 TECHNICAL REFERENCE / DOCUMENTS

NSW Environment Protection Authority (1999). *Environmental Criteria for Road Traffic Noise*

Department of Environment, Climate Change and Water (2010). *Draft Road Noise Policy.*

NSW Environment Protection Authority (2000). *Industrial Noise Policy*

Department of Environment and Climate Change NSW (2007). *Noise Guide for Local Government.*

Department of Planning (2008). *"Development near Rail Corridors and Busy Roads - Interim Guidelines".*

AS 2107-2000 *"Acoustics-Recommended Design Sound Levels and Reverberation Times for Building Interiors".*

AS 1276.1-1999 *"Acoustics – Rating of sound insulation in buildings and of building elements. Part 1: Airborne sound insulation".*

Plans supplied by dwp suters Pty Ltd. Note that variations from design supplied to us may affect the acoustic recommendations.

A Glossary of commonly used acoustical terms is presented in Appendix A to aid the reader in understanding the Report.

3 EXISTING ACOUSTIC ENVIRONMENT

Consideration must be given to the extent of the existing acoustic environment and whether such levels are appropriate for the land use of the receiver area. As such, a background and ambient noise level survey was conducted using a Type 1, Svan 949 environmental noise logging monitor, installed at the north east corner of the site, approximately 8 metres from the near lane of traffic on Honeysuckle Drive and Worth Place (Monitoring Location 1-see Figure 1). The selected location is representative of the acoustic environment in the receiver area and is considered an acceptable location for determination of the background noise levels in accordance with Appendix B of the OEH's Industrial Noise Policy (INP).

Sound levels were continuously monitored from Wednesday 11 June to Tuesday 17 June 2014, to determine the existing background and ambient noise levels for the area. The instrument was programmed to accumulate environmental noise data continuously and store results in internal memory. The data were then analysed to determine 15 minute Leq and statistical noise levels using dedicated software supplied with the instrument.

The instrument was calibrated with a Brüel and Kjaer 4230 sound level calibrator producing 94dB at 1kHz before and after the monitoring period, as part of the instrument's programming and downloading procedure, and showed an error less than 0.5dB.

Table 1 shows a summary of our noise survey, including the Assessment Background Levels (ABL's), for the day, evening and night periods. From these ABL's the Rating Background Level (RBL) has been calculated, according to the procedures described in the DECC's INP and by following the procedures and guidelines detailed in Australian Standard AS1055-1997, "Acoustics - Description and Measurement of Environmental Noise, Part 1 General Procedures". A complete set of logger results is not shown, but available on request.

Table 1: Summary of Noise Logger Results, dB(A)

Time Period	Background L90			Ambient Leq		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
RBL*	**49.8**	**47.6**	**43.9**	**--**	**--**	**--**
LAeq	**--**	**--**	**--**	**64.8**	**62.1**	**57.3**
Current Leq, 1hr (day)=65.6dB(A)			**Current Leq, 1hr (night)=60.2**			

A summary of the measured noise environment at the site appears in Table 2, taken from our logger results. The measured noise levels are typical for residential areas near a busy road.

Table 2: Existing Source Noise levels

Time Period	Leq		Lmax		L10		L90	
	Range	Average	Range	Average	Range	Average	Range	Average
Day	55-76	64	71-96	79	56-80	67	47-57	51
Evening	54-74	60	70-95	76	56-68	63	43-54	48
Night	47-66	56	65-86	73	48-68	59	40-53	46

Site, weather and measuring conditions were all satisfactory during our noise surveys. We therefore see no serious reason to modify the results because of influencing factors related to the site, weather or our measuring techniques.

Previous attended monitoring was also conducted by Reverb Acoustics on the balcony of the penthouse apartment of Building A4 (Monitoring Location 2). Background noise levels at this location were higher than those measured at the site. Therefore, to provide a measure of conservatism, the lower levels at the site have been adopted for assessment purposes.

Figure 1: Site Plan

LEGEND:
R1: Multi-storey residential apartments
R2: Multi-storey residential apartments
R3: Vacant land (possible future residential)
R4: Shop-top residences
R5: TAFE campus
R6: Multi-storey commercial
R7: On-grade public carpark

4 CRITERIA

4.1 Road Traffic Noise

Criteria for the assessment of quasi-steady-state noise sources, such as continuous road traffic and mechanical services, are sourced from AS/NZS 2107-2000 *"Acoustics-Recommended Design Sound Levels and Reverberation Times for Building Interiors"* and are detailed below.

Room Type	dBA
RESIDENTIAL BUILDINGS	
Houses and apartments near major roads	
Living areas	35 – 45
Sleeping areas	30 – 40
Common areas (foyer, lobby)	45 – 55
SHOP BUILDINGS	
Small retail stores	45 – 50
Enclosed carparks	55 – 65
OFFICE BUILDINGS	
Reception areas	40 – 45
General office areas	40 – 45
Private offices	35 – 40

DoPI's *"Development near Rail Corridors and Busy Roads - Interim Guidelines*" (released in December 2008) is a more recent document for assessment of road traffic noise impacts on residential developments. Limits specified within the Policy, which are virtually identical to those in AS/NZS2107-2000 are shown below:

Type of Occupancy	*Noise Level in dB(A)*	*Applicable Time Period*
Sleeping areas (bedroom)	35	Night 10pm to 7am
Other habitable rooms (excluding garages, kitchens bathrooms & hallways)	40	At any time

Table 3 summarises satisfactory internal noise levels for residences, used for the basis of this assessment.

Table 3: Internal Noise Level Criteria (Residential)

Location	**Criterion – dB(A),Leq**		**Remarks**
	Day	**Night**	
Sleeping areas	-	35	Windows closed
	-	40	Windows open
Other habitable rooms	40	-	Windows closed
	45	-	Windows open

Note: Provision for air conditioning will be available, therefore windows open criteria do not apply in this case.

Note that limits specified in the OEH documents are in agreement with those contained in AS/NZS 2107-2000 and DoPI's Guideline. Therefore, for residential areas the aim of the assessment is to ensure that the allowable noise levels shown above and in Table 3 are not (theoretically) exceeded within any habitable room due to road traffic noise. Assessment for commercial areas are based on those detailed in AS/NZS 2107-2000.

4.2 Rail Traffic Noise

Previously rail noise assessments for residential situations were conducted in accordance with the requirements of Rail Infrastructure Corporation's (RIC's) *"Interim Guidelines for Councils – Consideration of rail noise and vibration in the planning process".* However, DoPI's *"Development near Rail Corridors and Busy Roads - Interim Guidelines*" is the most recent document and will be used for assessment purposes. Limits specified within the Policy, which will be used for the purpose of this assessment, are shown below:

Type of Occupancy	*Noise Level in dB(A)*	*Applicable Time Period*
Sleeping areas (bedroom)	35	Night 10pm to 7am
Other habitable rooms (excluding garages, kitchens bathrooms & hallways)	40	At any time

If criteria are exceeded by more than 10dB(A) with windows open, mechanical ventilation should be incorporated into the design of affected rooms.

DOPI's Guideline specifies limits for assessment of rail traffic noise upon residential developments only. The Policy requires consideration of rail traffic noise under Clauses of SEPP (Infrastructure) 2007. Limits specified in AS/NZS2107-2000 are the most appropriate criteria to assess rail traffic noise impacts on commercial receivers and have therefore been adopted for assessment purposes.

4.3 Rail Traffic Vibration

4.3.1 Personal comfort

Various authorities have set maximum limits on allowable ground and building vibration in different circumstances and situations, all directed at personal comfort rather than building damage. This usually leads in virtually every situation to people who interpret the effects of a vibration to ultimately determine its acceptability. The most recent criteria for assessment of rail traffic vibration impacts upon occupants of a building are those contained in DoPI's *"Development near Rail Corridors and Busy Roads - Interim Guidelines*". The Guideline recommends that the OEH's *Assessing Vibration: A Technical Guideline (2006)* should be used for the assessment of vibration. Limits set out in the OEH Guideline are for vibration in buildings, and are directed at personal comfort for continuous, impulsive and intermittent vibrations. Table 4 shows the Vibration Dose Values for intermittent vibration activities such as train passbys, pile driving and use of vibrating rollers, taken from Table 2.4 of the Guideline, above which various degrees of adverse comment may be expected.

Table 4: Acceptable Vibration Dose Values ($m/s^{1.75}$)
Above which Degrees of Adverse Comment are Possible

Location	Day (7am-10pm)		Night (10pm-7am)	
	Preferred	**Maximum**	**Preferred**	**Maximum**
Critical areas #	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Hospital operating theatres, precision laboratories, etc.

Figure 3.2 of DoP's Guideline only requires assessment of rail traffic vibration when a development is within 60 metres of the rail line. Since the proposed development is outside this minimum setback distance, a rail traffic vibration assessment is not required.

4.3.2 Building Safety Criteria

Australian Standard AS2187.2-1993, dealing specifically with blasting vibration, specifies a maximum peak particle velocity of 10mm/sec for houses and a preferred limit of 5mm/sec where site specific studies have not been undertaken. German Standard DIN 4150 - 1986, Part 3 Page 2, specifies a maximum vibration velocity of 5 to 15 mm/sec in the foundations for dwellings and 3 to 8 mm/sec for historical and sensitive buildings, for the range 10 to 50Hz. British Standard BS 7385 Part 2, specifies a maximum vibration velocity of 15mm/sec at 4Hz increasing to 20mm/sec at 15Hz increasing to 50mm/sec at 40Hz and above, measured at the base of the building.

The above listed criteria vary from 3mm/sec up to 15mm/sec, therefore, the more conservative limit of **3mm/sec** will be adopted for the purposes of this assessment. It should be acknowledged, however, that intermittent ground vibration velocities at 5mm/sec are generally considered the threshold at which architectural (cosmetic) damage to normal dwellings may occur and velocities at 10mm/sec should not cause any significant structural damage, with the exception of the most fragile and brittle of buildings.

4.4 Mechanical Plant (Proposed Development)

Noise from industrial noise sources scheduled under the Protection of Environment Operations Act is assessed using OEH's Industrial Noise Policy (INP). Local Councils may also apply the criteria for land use planning, compliance and complaints management. The INP specifies two separate criteria designed to ensure existing and future developments meet environmental noise objectives. The first limits intrusive noise to 5dB(A) above the background noise level and the other applies to protection of amenity of particular land uses based on the existing (Leq) noise level from industrial and commercial noise sources. Project Specific Noise Levels are established for new developments by applying both criteria to the situation and adopting the more stringent of the two. In high traffic areas where the existing traffic noise levels are at least 10dB above the Acceptable Noise Level, the high traffic amenity criterion applies.

The existing L(A)eq for the receiver area is dominated by traffic on nearby roads, with negligible contribution from industrial noise sources during the day and evening. Reference to Table 2.1 of the INP shows that the area is classified as urban, and industrial noise contributions are more than 6dB(A) below the recommended Leq during these time periods, so the recommended Acceptable Noise Level (ANL) applies in this case, i.e. no ANL reduction required for industrial noise contributions. Table 5 below specifies the applicable base objectives for industrial noise. In high traffic areas where the existing traffic noise levels are at least 10dB above the Acceptable Noise Level, the high traffic amenity criterion applies.

Table 5: - Base Noise Level Objectives

Period	Intrusiveness Criterion	Amenity Criterion
Day	55 (50+5)	55 (65-10)
Evening	53 (48+5)	52 (62-10)
Night	49 (44+5)	47 (57-10)
Receiver Type: Urban (See OEH's INP - Table 2.1)		

Project specific noise levels, determined as the more stringent of the intrusiveness criterion and the amenity / high traffic criterion, are as follows:

Day **55dB LAeq,15 Minute** 7am to 6pm Mon to Sat or 8am to 6pm Sun and Pub Hol.
Evening **52dB LAeq,15 Minute** 6pm to 10pm
Night **47dB LAeq,15 Minute** 10pm to 7am Mon to Sat or 10pm to 8am Sun and Pub Hol.

Commercial Premises
65-70dB LAeq,15 Minute when in use

4.5 Sleep Arousal

Chapter 19-3 of OEH's ENCM and Section 2.4.5 of their Noise Guide for Local Government state *"the L1 level of any specific noise source should not exceed the background noise level (L90) by more than 15dB(A) when measured outside the bedroom window"*. This criterion is applied to residential situations between the hours of 10.00pm and 7.00am where a receptor's sleep may be interrupted by noise. It is applied in this case to occupants of apartments likely to receive noise from people on city streets and vehicles in nearby public carparks.

Based on the measured background noise level of 44dB(A),L90 for night at the site (10pm to 7am), the sleep arousal criterion is set at **59dB(A),L1(1 min)** at the bedroom window of any affected apartment.

5 METHODOLOGY AND ANALYSIS

5.1 Traffic Noise Levels

Applicable noise level metrics, namely, for the day and night are those calculated from our measurements at the site. A +2.5dB(A) facade adjustment must be applied to our results, as measurements were conducted in the free-field. Received traffic noise for 2014 was calculated as follows:

received noise (free field) + *facade correction* = *received noise*

Applying the above formula gives:

Day	65.6dB(A) + 2.5dB(A) =	**68dB(A) Leq15hr**	7am – 10pm
Night	60.2dB(A) + 2.5dB(A) =	**63dB(A) Leq9hr**	10pm – 7am

For assessment purposes, DoPI's document suggests using data gathered over the entire day (7am to 10pm) and night (10pm to 7am) periods. However, we consider DoPI's criteria to be a minimum design goal for inner city apartments subjected to high levels of traffic noise, therefore, for the purposes of this assessment, we have assumed that the noise level during peak traffic periods to be constant over the full assessment period. The implications are that calculated noise levels will be higher, resulting in more stringent noise control recommendations, which will in turn benefit future occupants.

Reference to nearby RMS traffic stations indicate that approximately 15,000-20,000 vehicles pass the site along Honeysuckle Drive, projected to the year 2014. A figure of 5% heavy vehicles has been adopted. The AADT for the year 2014 was applied to our computer programme, based on the OEH and RMS approved CORTN Method of Traffic Noise Prediction, and noise levels were calculated to the theoretical facades of each future residential unit. The CoRTN values are merely arbitrary, as calculated noise levels are adjusted to correlate with our measured peak external noise levels, with the intention is to provide a (theoretical) means of determining the degree of noise control required for a particular building component.

Equivalent continuous noise levels were calculated for each traffic lane separately on the basis that the noise source (i.e. the traffic) was located in approximately the centre of the respective lane. In particular, this gives an accurate estimation of the location of bus and truck exhausts which are generally located on the right hand side, being approximately at the same point for both traffic directions. Our calculations have been modified to compensate for the differing acoustic centres of cars and heavy vehicles, by modelling each separately and logarithmically adding received noise levels.

Once the traffic noise level at the outer face of each building element was determined, the required Rw was calculated in accordance with the mathematical procedure given in AS3671-1989 *"Acoustics - Road traffic noise intrusion - Building siting and construction"*. This procedure is based on the required internal noise level shown in Section 5.3.

5.1.1 CoRTN Model Conversion

The OEH released their ECRTN in June 1999 and RNP in 2011, which specify modified assessment periods for day and night, namely, Leq,15hr (7am to 10pm) and Leq,9hr (10pm to 7am). These assessment periods have rendered the original Australian version of the CoRTN model invalid, which was designed to assess the impact over a single 24 or 18 hour period. Consequently, modification of the Model is required to adequately describe the new metrics.

The CoRTN algorithm pertaining to traffic flow percentages has been modified by inserting all AADT figures for arterial roads, contained in RTA publications - Traffic Volume Data for Hunter and Northern Regions, 1998, and establishing AADT figures for the applicable day and night periods. Our CoRTN model was then calibrated against long term measurements made at locations with reliable AADT figures.

5.1.2 Calculation Procedure

Once the traffic noise level at the outer face of each building element was determined, the required Rw was calculated in accordance with the mathematical procedure given in AS3671-1989 *"Acoustics - Road traffic noise intrusion - Building siting and construction"*. This procedure is based on the required internal noise level shown in Section 4.1.

<u>*Sample Calculation*</u>

Shown below is a sample calculation detailing the procedure followed in order to calculate required glazing for the bedroom in a Type A residential apartment on Level 2 fronting Honeysuckle Drive.

The traffic noise level at the outer face of the glazing is calculated as follows,

Table 6: Sample Calculation - Traffic Impact at Glazing
Bedroom Level 2 Apartment – North Facade on Honeysuckle Drive

		Octave band Sound Pressure Levels, dB(A)							
Propagation calculation	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Facade traffic noise, Leq[1]	63	43	51	52	56	58	55	49	41
Architectural shielding[2]		2	2	2	2	2	2	2	2
Directivity/distance Correction[3]		1	1	1	1	1	1	1	1
Traffic noise at window	60	40	48	49	53	55	52	46	38

1. Projected to the year 2014. 2. Enclosed balustrade. 2. Includes angle of incidence correction.

As the criterion for the Bedroom is 35dB(A), see Table 3, the required traffic noise reduction is *TNR* = 60-35 = 25dB(A). The traffic noise attenuation, *TNA*, required of the glazing is calculated according to the equation given in Clause 3.4.2.6 of AS 3671,

$$TNA = TNR + 10\log_{10}[(S/S_f) \times 3/h \times 2T_{60} \times C] \qquad \textit{equation 1}$$

where
S = Surface area of glazing = 3m^2
S_f = Surface area of floor = 12m^2
h = Ceiling height, assumed to be 2.7m
T_{60} = Reverberation time, s
C = No. of components = 2 (glazing, wall)

Assuming that the room is acoustically average (neither too 'live' nor too 'dead') equation 9.26 in *Noise and Vibration Control*, L.L. Beranek, 1971, gives a reverberation time of 0.46s. Consequently, the value of 0.5s was used in equation 1.

Using the values listed above gives

TNA = 23dB(A) for the glazing

Substituting this value into the equation given in Clause 3.4.3.1 of AS3671 gives

Rw = *TNA* + 6 ≈ 29.

As can be seen by the above results, the glazing must have a tested Rw29 rating. Published sound insulation performance in terms of Rw or STC ratings relate to partitions tested in ideal laboratory conditions or opinions based on such measurements. Field conditions (eg. flanking paths, penetrations, air leaks etc) caused by lack of supervision of workmanship or inadequate attention to detail at design/specification stage can reduce the Rw rating. For this reason we recommend selecting partition systems with a laboratory Rw rating 2-3dB higher than required on site. Therefore, the glazing in the Living Room must have a tested Rw32 rating. Based on typical laboratory performance data the glazing would consist of single-glaze laminated glass fitted with acoustic seals.

Similar calculations to those in the previous Section were performed for windows and doors on affected facades. From these calculations, a schedule of required glazing has been compiled. See Section 6.

5.2 Rail Traffic Noise and Vibration

Reverb Acoustics has completed a baseline rail noise and vibration survey along the full length of the Great Northern Rail Line. The survey area extended from the western end of Hunter Street, approximately 300 metres west of Wickham Railway Station to the termination of the line at Newcastle Railway Station. Survey locations were selected at each station and at regular intervals along the track. Several noise and vibration measurements were conducted at each chainage along the rail line and at varying distances, ranging from 10 metres to 80 metres perpendicular to the line. As part of our baseline survey, noise and vibration measurements were also conducted in the study area along Worth Place.

A peak vibration velocity less than 0.1mm/sec was measured at 20 metres from the line, which is only marginally above background vibration levels and approximately the same distance the proposed development is from the rail line.

Reference to CityRail timetables and consultation with Rail Infrastucture Corporation (RIC) indicates that the Great Northern Railway is used by diesel and electric passenger trains, with an average frequency of 94 diesel trains per day and 85 electric.

The predicted L(A)eq,1hr noise level for trains passing the site was calculated using the US EPA's Intermittent Traffic Noise calculation method. This method was adopted because train movements are not continuous, and have the same passby characteristic pattern as other vehicles.

The mathematical formula used to calculate the Leq,T noise level for intermittent rail traffic noise is given in Equation 2 below:

$$L_{eq},T = L_b + 10\log\left[1 + \frac{ND}{T}\left(\frac{10^{(L\max - Lb)/10} - 1}{2.3} - \frac{(L_{\max} - L_b)}{10}\right)\right] \text{ ...... } \textit{Equation 2}$$

Where L_b is background noise level, dB(A) L_{MAX} is train noise, dB(A)
T is the time (min) *N* is number of trains
D is duration of noise of each train (min)

Average maximum train noise levels were measured at the above mentioned locations, while background noise levels are those shown in Table 1. The Lmax train noise levels used in Equation 2 are the maximum predicted noise levels produced at the facade of the development by trains passing the site.

Vibration levels for train passbys were measured using a Vibroch V801 Seismograph. The instrument was coupled to a triaxial geophone, which was installed on hard compacted earth or existing pavement. A sandbag was placed over the geophone during each series of measurements to ensure elevated readings were not recorded due to bouncing and movement, which may occur at higher vibration amplitudes. The unit is capable of measuring and storing peak Z-axis vibration velocities, as well as vibration in three directions simultaneously and gives peak velocity and acceleration on the x, y and z axes.

5.2.1 Analysis – Rail Noise and Vibration

Table 5 shows rail traffic noise and vibration measurements at the previously nominated locations, approximately 20m from the track. All measurements were taken during the busiest time period on a weekday morning between 8am and 9am.

Table 7: Measured Train Noise Levels

Train Type	Leq dB(A)	Lmax dB(A)
1. Diesel Passenger	75	82
2. Diesel Passenger	68	77
3. Electric Passenger	71	76
4. Diesel Passenger	74	81
5. Electric Passenger	64	72
6. Electric Passenger	67	74
7. Diesel Passenger	76	81
8. Electric Passenger	71	75
9. Diesel Passenger	69	78
10.Diesel Passenger	75	81
11.Diesel Passenger	67	75
12.Electric Passenger	61	70
13.Electric Passenger	72	75
14.Diesel Passenger	68	76
15.Electric Passenger	68	78
16.Electric Passenger	63	71

The following Table shows a sample calculation of the predicted rail traffic noise (LAeq,1hr) calculated to the theoretical facade of a proposed residence in an exposed location, with no allowance for topographical features or acoustic barriers.

Table 8: Received Train Noise Levels

	L(A)eq,1hr DAY	L(A)eq,1hr NIGHT
Rec Noise Level, Lmax.	75/81	75/81
Train frequency	15	9
Average Bgd Noise, dB(A)	44	
Calculated train noise, Leq	**59**	**54**
Criteria (day/night)	**40 (internal)**	**35 (internal)**
Exceedance	**19**	**19**

Theoretical results in the above table indicate that rail traffic noise impacting on the proposed extension may exceed DoPI's limits. Therefore, in order to satisfy the requirements of DOPI's Interim Guidelines for Councils, acoustic modifications will need to be incorporated in the design. To put results into context, an L(A)eq,1hr impact of 19 implies that the facade must be capable of attenuating 19dB (i.e. 54dB(A),Leq(1hr) – 35 = 19). Windows are typically the acoustic weak spot and standard 3-4mm glass will only achieve 10dB attenuation, if the window frames are fully sealed into the parent wall. Facades with an Leq(1hr) impact greater than 10dB(A), must have acoustical modifications incorporated in the design.

Similar calculations to those above were performed for windows and doors on affected facades. From these calculations, a schedule of required glazing has been compiled. See Section 6.

Attended vibration monitoring conducted at nearby sites revealed that no perceptible vibration above background levels was recorded from train passbys at a distance greater than 20 metres from the rail line. Under certain circumstances, say if a large vibrating track maintenance machine was to pass the site and the resonant frequency of the ground happened to be an exact multiple of the driving frequency of the source, then higher vibration levels could be expected. However, it is doubtful that levels would reach a magnitude capable of causing any adverse comment or structural damage.

Vibration can be felt at levels well below those considered to cause structural damage. Complaints from occupiers are usually due to the belief that if vibration can be felt then it is likely to cause damage. Slamming of doors or footfall within a building can produce vibration levels above those produced by passing rail traffic. Passing trains will only produce loads, and therefore vibration, when their mass is accelerated, for example when hitting joins or deformities in rails. This emphasises the importance of properly maintained rail lines.

Vibration levels caused by trains passing the site are unlikely to cause direct failure, and it is considered the main action is triggering cracks in materials already subjected to stress or natural forces, however, as previously mentioned, this may also arise from internal forces such as slamming of doors. In our experience, vibration will only begin to trigger "natural cracking" at levels above 1mm/sec.

5.3 Received Noise – People on City Streets

Noise levels produced by people on the streets and in the public carpark opposite the site leaving nearby entertainment venues in the early hours of the morning have the potential to interrupt the sleep of occupants within apartments. Typical noise produced by patrons congregating on the footpath and leaving entertainment venues has been sourced from our library of technical data. This library has been accumulated from measurements taken in many similar situations in the Newcastle CBD in the vicinity of Nite Clubs, and allows theoretical predictions of future noise impacts at each receiver and recommendations concerning noise control measures to be incorporated in the design of the site.

Our measurements were taken over a representative time period to include all aspects of the noise, including the cumulative impact of several people talking with a loud voice simultaneously. Sound measurements enable the acoustic sound power (dB re 1pW) to be calculated. The sound power level is then theoretically propagated to exposed facades and propagated through each building element to determine the internal noise level. Comparison of the predicted noise levels and the allowable level are then compared to give the noise impact.

An estimated worst-case situation has been modelled with several groups of people gathered on the street near the development. The sources were placed at varying locations on the pavement ranging from 20-30 metres from nearest residential units. Based on the above scenario a peak noise level of 60-65dB(A) has been predicted at the external facade of more exposed apartments, which at times may be up to 6dB(A) above the sleep arousal criterion of 59dB(A),L1.

Windows are typically the acoustic weak spot and standard 3-4mm glass will only achieve 10-15dB attenuation if the window frames are fully sealed into the parent wall, therefore, where appropriate, thicker glazing has been specified (See Section 8). Laminated glass typically attenuates 25dB or more at speech frequency (500Hz-1kHz), depending on the thickness and orientation of the glazing. So, based on an exterior noise level of 65dB, noise events within units are not expected to exceed 40dB(A),L1 and considered acceptable.

It should be acknowledged that assessment of sleep arousal need only be applied to dedicated bedrooms and compliance within recreational and transitory areas such as living rooms or entries is not required. In saying this, apartments in commercial districts are generally subjected to high noise levels for longer periods in the early evening and assessment within these rooms seems appropriate, given the situation. Furthermore, noise transfer between contiguous areas is more significant in open plan design, typical of modern apartments.

5.4 Mechanical Plant

Council prefers the background noise level of the area to be maintained, although, in certain circumstances may permit the noise level in question to exceed the prevailing background noise level by 5dB(A), provided the sound is bland and free from impulsive and/or tonal components. This is in agreement with conditions contained within OEH's INP. In respect to the above, a planning limit of **47dB(A),Leq** for night (10pm-7am) applies at the boundary of the nearest residential neighbour, while a planning limit of **65dB(A),Leq** applies for commercial tenancies, assuming office/retail areas.

Our client has indicated that the majority of mechanical plant will be located in a plant room on the roof of the commercial building, condenser platforms on the west side of the residential building, and in the Level 2 carpark. We have further assumed that two (2) carpark exhaust outlets may also be located on the roof. Listed below is the anticipated type and number of plant items:

Location	*Plant Item*
Plant Room *(Commercial Blg Roof)*	Cooling Towers (x2) Chillers (x2) Chilled Water Pumps (x2) Condenser Water Pumps (x2) AHU (x6)
Level 2 carpark	Split System Air Con (x11)
Roof *(Residential Blg)*	Carpark Exhaust outlet (x2)
West Side Blg each Res Level *(Residential Blg)*	Split System Air Con (9+)

As the exact type of plant is not known at this stage, we have sourced information from our library of technical data. The sound power of the proposed plant is propagated to residential locations taking into account sound intensity losses due to spherical spreading and barrier insertion loss provided by intervening structures, with additional minor losses such as molecular absorption, directivity and ground absorption ignored in the calculations. As a result, predicted received noise levels are expected to slightly overstate actual received levels and thus provide a measure of conservatism. Comparison of the predicted noise levels produced by the plant and the allowable level are then compared to give the noise impact at the receiver. The following Table shows sample calculations to predict noise from anticipated mechanical plant on Level 2 carpark, propagated north east to nearest residential apartments across Honeysuckle Drive (R1).

Table 9: Calculated SPL, Level 2 Carpark Plant – Propagated NE to Nearest A'ments (R1)

		Octave Band Centre Frequency, Hz							
Item	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Combined Lw plant (x11)	86	56	73	75	77	79	82	77	68
Barrier loss		0	0	0	0	0	0	0	0
SPL at Receiver	**42**	13	29	31	33	35	38	33	24
Criteria (night)	**47**								
Impact	**-**								

As can be seen by the results in Table 9, noise emissions from mechanical plant on the Level 2 carpark of the residential building will be compliant with the night criterion of 47dB(A),Leq at nearest residences. See Section 8 for required acoustic modifications for all plant areas.

6 DISCUSSION AND RECOMMENDATIONS

6.1 Building Construction

6.1.1 Glazing Windows/Sliding Doors

Glass installed in window assemblies must comply with AS1288-1994. Materials, construction and installation of all windows are to comply with the requirements of AS2047-1999. Similar calculations to those in Section 7 were performed for all building elements of the proposed development. From these calculations, a schedule of required glazing has been compiled, shown below. The glazing systems, sighted in the following Tables, are presented as a guide for the supplier:

Glazing Systems:

Type A: Standard glazing. No acoustic requirement.
Type B: Single-glaze 5-8mm clear float glass.
Type C: Single glaze laminated glass
Type D: Insulating Glass Unit (IGU) or double-glaze.

Note: The typical glazing shown in the following Tables should be used as a guide only. The supplier of the window/door must be able to provide evidence from a registered laboratory that the complete system will achieve the specified Rw performance, i.e. do not simply install our recommended glass in a standard window frame.

Table 10: Glazing Schedule – Residential Building

Facade	Location	Room Use	Required Rw Must Achieve for Compliance	Typical Glazing System (Not for Specification)
GROUND				
North	Commercial/Retail	All	**30**	Type C
East	Commercial/Retail	All	**30**	Type C
PARKING LEVEL 2				
North	Type C	All Living	**32**	Type C
East	Type C	All Living	**31**	Type C
		All Bed	**33**	Type C
South	Type C	All Bed	**32**	Type C
		All Bath	**29**	Type B or C
LEVEL 1				
North/West	Type A, F	All Living	**32**	Type C
		All Bed	**32**	Type C
	Type B,C	All Living	**32**	Type C
		All Bed	**34**	Type C or D
East	Type C	All Living	**32**	Type C
		All Bed	**33**	Type C
	Type E	All Living	**30**	Type C
		All Bed	**32**	Type C
South	Type E,D,A	All Living	**31**	Type C
		All Bed	**32**	Type C
LEVELS 2, 3				
North/West	Type A, F	All Living	**32**	Type C
		All Bed	**33**	Type C
	Type B,C	All Living	**33**	Type C
		All Bed	**34**	Type C or D
East	Type C	All Living	**32**	Type C
		All Bed	**33**	Type C
	Type E	All Living	**30**	Type C
		All Bed	**32**	Type C
South	Type E,D,A	All Living	**31**	Type C
		All Bed	**32**	Type C
LEVELS 4, 5, 6, 7				
North/West	Type A, F	All Living	**31**	Type C
		All Bed	**33**	Type C
	Type B,C	All Living	**32**	Type C
		All Bed	**34**	Type C or D
East	Type C	All Living	**31**	Type C
		All Bed	**33**	Type C
	Type E	All Living	**29**	Type B or C
		All Bed	**32**	Type C
South	Type E,D,A	All Living	**30**	Type C
		All Bed	**32**	Type C

Table 11: Glazing Schedule – Commercial Building

Facade	Location	Room Use	Required Rw Must Achieve for Compliance	Typical Glazing System (Not for Specification)
GROUND				
North	Retail	Cafe	**28**	Type B or C
LEVEL 1				
North	Commercial	All	**33**	Type C
East/West	Commercial	All	**32**	Type C
South			**30**	Type C
LEVELS 2, 3				
North	Commercial	All	**32**	Type C
East/West	Commercial	All	**31**	Type C
South	Commercial	All	**30**	Type C
LEVELS 4, 5, 6				
North	Commercial	All	**31**	Type C
East/West	Commercial	All	**30**	Type C
South	Commercial	All	**30**	Type C

6.1.2 Roof/Ceiling Construction

a) Roof construction may consist of *either* reinforced concrete *or* sisalation or wire mesh laid down on roof trusses/purlins. This is to be completely covered with a 30-40mm foil faced building blanket hard under the roof sheeting (in situations where joists are at centres close enough to avoid excessive sagging of the blanket, the sisalation/wire mesh may be omitted). Close off gaps between purlins and roof sheeting with Unisil Eaves Filler Strips, bituminous compound, or similar. Install an impervious ceiling of 1 sheet of taped and set 10mm plasterboard. To further assist in low frequency attenuation, all ceiling voids should contain a layer of fibreglass or rockwool insulation. The insulation is to be installed in addition to, not in lieu of the building blanket. Specialised acoustic insulation is preferred, however, dense thermal insulation (eg, R3 batts) will suffice and is much less expensive (\$15/m^2 for Rockwool 350 and \$5/m^2 for R3 batts).

6.1.3 Wall Construction

b) Brick veneer/cavity brick//masonry construction is acceptable. Where external brickwork stops below the height of the stud frame, plasterboard, Villaboard, or similar, is to be fixed to the outside of the stud frame to fill the void. The infill material is to extend from the top of the top plate to a point in line with the bottom of the top course of brickwork. Alternatively, an overside noggin is to be fixed to the underside of the top plate to project within 10-20mm of the inside surface of the external wall.

c) Lightweight cladding (i.e. Shadowclad, Colorbond, or similar) should include internal lining 1 sheet taped and set 13mm fire rated plasterboard, and a cavity infill of R1.5/S1.5 fibreglass or polyester insulation. All lightweight cladding should also be backed with either 6mm fibre cement sheeting (Villaboard, Hardiflex) or 10mm construction plywood.

6.1.4 Balconies

d) To reduce the field of view of the noise source (i.e. traffic), enclosed balustrade is recommended for all residential apartments, consisting of stud wall, masonry or fixed glass panels to a height of 800-900mm. Vertical gaps between each panel that do not exceed 125mm are permitted. A gap of say 50-100mm is permitted at floor level to allow cleaning, hosing, etc

6.2 Mechanical Plant

e) All plant room doors are to be minimum 30-40mm solid core with proprietary acoustic seals fitted at door surrounds

f) Ventilation louvres in plant room walls must be acoustic louvres in preference to standard aluminium louvres. The louvres must have the following insertion loss values (typically Fantech SBL1, Nap Silentflo 300S Line or Robertson Type 7010):

Required Insertion Loss Values for Acoustic Barriers – dB

	Octave Band Centre Frequency, Hz							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
NR	10	12	15	19	20	18	18	14
STL	4	6	9	13	14	12	12	8

g) Any exhaust plant that produces a sound pressure level in excess of 72dB(A) at a distance of 1 metre from the discharge must have acoustic silencers fitted at the fan. Silencers must have the following insertion loss values:

Required Silencer Insertion Loss - dB

Octave Band Centre Frequency, Hz							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
4	6	9	14	23	26	24	22

h) Acoustic barriers are not required adjacent to residential plant on the west side of the building or on the Level 2 carpark unless noise emissions are above an SPL in excess of 78dB(A) at a distance of 1 metre in which case acoustic barriers equal in height to the highest plant item must be erected along the full length of the side facing towards the receiver. Barrier construction is to consist of an outer layer of 12mm fibre cement sheeting, 25mm construction plywood, Hebel Powerpanel, or similar material, with an absorbent inner surface of Woodtex (available through Enviro Acoustics Ph. 9605 1333) fixed to furring channels, with a cavity infill of S1.5 polyester insulation. The acoustic barrier must continue at least 300mm below the top of the plant deck.

i) Where plant intended to be installed on the site produces noise in excess of specified levels, noise control will be required to ensure satisfactory noise emissions. The Contractor responsible for supplying and installing the plant should be asked to supply evidence that installed plant meets this noise emission limit, or that noise control included with the plant is effective in reducing the sound level to the specified limit.

j) It should be noted that no penalties have been applied for tonality in our calculations, therefore the tenderer's attention is drawn to the fact that mechanical plant may be near sensitive receivers and it is vitally important that units are free from specifically annoying characteristics (eg. tones, squeaks, pulsations etc). Careful selection of plant, equipment, piping and ducting systems is recommended to ensure quiet and vibration free operation in compliance with the specified noise criteria. Replacement and/or modification will be necessary to all systems causing undue noise or vibration exceeding the specified criteria.

These are probably the easiest and most economical methods of construction currently to hand, although many other combinations can be made to achieve the same result. Discussions with either your building consultant or architect may give rise to other more economical noise control options for carrying out the work, subject to review by us.

7 CONCLUSION

A noise impact assessment for the proposed mixed-use development at 18 Honeysuckle Drive, Newcastle, has been completed. The report has shown that the site is suitable for the intended purpose, providing our recommendations are implemented. An assessment of external noise impacts upon the development has resulted in the compilation of a schedule of minimum construction details to satisfy the requirements of the OEH, DOPI and NCC. <u>The recommended construction shown in Tables 10 and 11 should be used as a guide only.</u> <u>The supplier of the window/door must be able to provide evidence from a registered laboratory that the complete system will achieve the specified Rw performance</u>. <u>Do not simply install the recommended glazing in a standard frame</u>.

The guidelines herein are preliminary in that the selection of building materials depends on user/client requirements, space limitations, budgetary constraints and practicalities that relate to the acoustic design of suites. Adequate building facade design may be achieved through many different combinations of materials, all of which may achieve the same result, subject to review by us.

We have designed exposed facades of the building to ensure maximum noise level passbys from heavy vehicles are below 55-60dB(A). This upper limit is generally considered the threshold at which awakenings may occur. (Ref: OEH's ECRTN and RNP). Special attention has also been given to designing the building facade of each apartment to ensure maximum noise levels from passing rail traffic, patrons, and vehicles in the carparks are at acceptable levels.

The adopted train passby noise levels represent the average maximum noise level from train passbys. Therefore, individual train passbys may at times produce higher noise levels than those adopted. No significant increase in maximum received noise levels are expected in the future, as locomotive and rolling stock manufacturers are continuously developing noise reduction strategies addressing engine, exhaust and wheel noise.

We conclude, with a high degree of confidence that vibration levels at the expected magnitudes will not cause direct structural damage or cause undue annoyance to the occupants. We suspect that one or more natural forces, as discussed in Section 5.2, will be the cause of any future damage. It should be noted, however, that vibration may be noticed on occasion while a person is standing or seated quietly. Other noticeable indicators may be rattling of window frames and ornaments, and possible visible movement of hanging pictures, etc.

In conclusion, providing the recommendations given in this report are implemented, road traffic noise levels and rail traffic noise and vibration levels, will comply with the requirements of the OEH, RMS, DoPI and NCC within habitable spaces of the proposed development. We therefore see no acoustic reason why the proposal should be denied.

REVERB ACOUSTICS

S. Brady.

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APPENDIX A
Definition of Acoustic Terms

Definition of Acoustic Terms

Term	Definition
dB(A)	A unit of measurement in decibels (A), of sound pressure level which has its frequency characteristics modified by a filter ("A-weighted") so as to more closely approximate the frequency response of the human ear.
Rw/STC	Weighted Noise Reduction Index/Sound Transmission Class. The ability of a partition to attenuate sound, in dB. Given as a single number representation.
Lw	Sound Power Level radiated by a noise source per unit time re 1pW.
Leq	Equivalent Continuous Noise Level - which, lasting for as long as a given noise event has the same amount of acoustic energy as the given event. Used in NSW as a descriptor for intrusive noise from industrial premises.
L90	The noise level which is equalled or exceeded for 90% of the measurement period. An indicator of the mean minimum noise level, and is used in Australia as the descriptor for background or ambient noise (usually in dBA).
L10	The noise level which is equalled or exceeded for 10% of the measurement period. L_{10} is an indicator of the mean maximum noise level, and is generally used in Australia as the descriptor for intrusive noise (usually in dBA).
ABL	*Assessment Background Level* – A single figure representing each individual assessment period (day, evening, night). Determined as the L90 of the L90's for each separate period.
RBL	*Rating Background Level* – The overall single figure background level for each assessment period (day, evening, night) over the entire monitoring period.