Appendix G
Acoustics Report

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Acoustics
Vibration
Structural Dynamics

58 ANDERSON STREET, CHATSWOOD

Acoustic Assessment for Planning Proposal

28 September 2020

Reza Vakili

TK328-01F02 Acoustic Report for Planning Proposal (r4)

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1 Introduction

Renzo Tonin & Associates was engaged to assess noise impacts onto the proposed mixed-use development at 58 Anderson Street, Chatswood to support a planning proposal submission for the site. This report assesses noise intrusion and noise emission from the residential component of the proposed mixed-use development. Acoustic assessment for noise emissions from the use of the retail component shall be addressed in a separate report (typically undertaken by the tenant).

This study examines the effects of external noise intrusion onto the proposed development from road traffic noise and rail noise. A noise survey was carried out on site by Renzo Tonin & Associates from 9th May 2018 to 16th May 2018 to establish the existing levels of external noise affecting the development. These noise levels were used to predict noise levels inside the future residential spaces and then assessed against the recommended internal noise criteria for the project.

The following architectural drawings issued by Drew Dickson Architects were reviewed.

Table 1: Drawings Reviewed

Drawing No.	Revision	Date	Title
A-0000	K	18 Sept 2020	Cover Sheet
A-0001	K	18 Sept 2020	Locality Plan
A-0002	K	18 Sept 2020	Site Survey
A-1001	K	18 Sept 2020	Ground Floor Plan
A-1002	K	18 Sept 2020	Level 1 Floor Plan
A-1003	K	18 Sept 2020	Level 2 & Level 3 Plans
A-1004	K	18 Sept 2020	Level 4 & Level 5-10 Plans
A-1005	K	18 Sept 2020	Typical Levels 11-13 & Rooftop Terrace Plans
A-1200	K	18 Sept 2020	East Elevation
A-1201	K	18 Sept 2020	West Elevation
A-1202	K	18 Sept 2020	North & South Elevations

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Site and surrounds

The site is located at 58 Anderson Street, Chatswood and is currently occupied by a two-storey detached dwelling. The site is situated immediately to the east of the T1 North Shore, Northern & Western Line rail corridor and is bound by Wilson Street to the south and Anderson Street to the east. The site is bound by the rail corridor to the west by an existing retaining wall.

Figure 1: Photograph of existing rail corridor and retaining wall

The proposed development consists of a 15-storey mixed-use tower building with four levels allocated for commercial/retail tenancies and one basement multi-level for car stacker parking.

Long-term noise monitoring and operator attended vibration measurements of rail pass-bys have been undertaken on site as indicated in Figure 2 below to determine the existing acoustic environment.

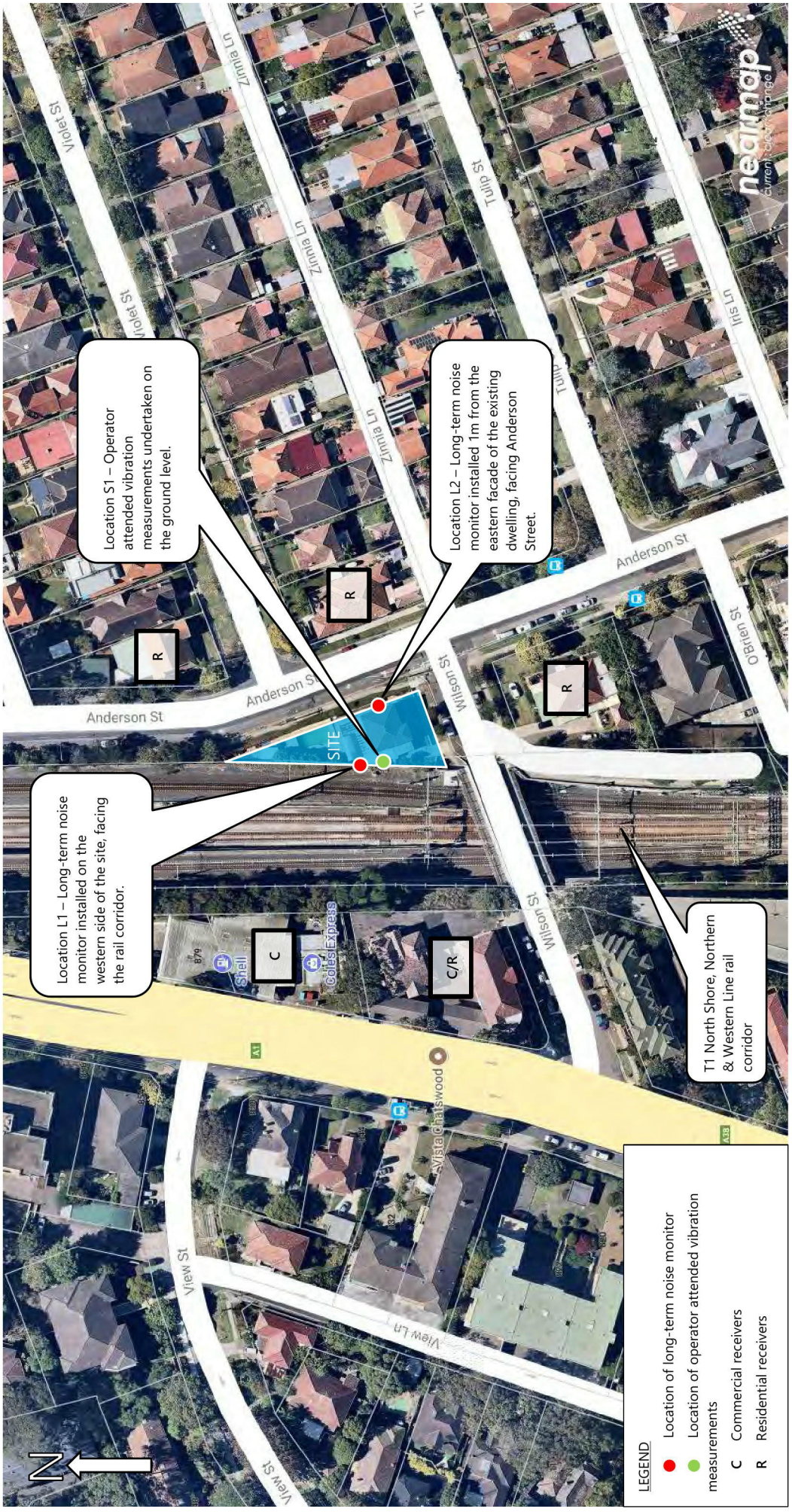

Figure 2: Aerial photograph (dated 6 May 2018) showing the site and surrounds

3 Ambient and background noise survey

Two unattended long-term noise monitors were installed on site from 9th May 2018 to 16th May 2018 to determine the existing level of ambient and background noise surrounding the site. As shown in Figure 2 above, one noise monitor was installed on the western side of the site to face the rail corridor and another noise monitor was installed on the eastern side of the site to face Anderson Street.

The noise monitors recorded noise levels on a continuous basis and stored data every fifteen minutes. The monitors were calibrated before and after measurements and no significant deviation in calibration was noted. The noise monitoring equipment used here complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as Type 2 instruments suitable for field use.

Detailed results of the background and ambient noise monitoring undertaken on site are presented in APPENDIX E.

3.1 Results of unattended noise monitoring

3.1.1 Rail and road traffic noise

The design rail and road traffic noise levels are taken from the representative L_{Aeq} for the week for both the day time (7am to 10pm) and night time (10pm-7am) periods. The design external traffic noise levels are presented Table 2 below.

Table 2: Representative Day and Night Road Traffic Noise Levels

Monitoring Location	Survey Period	Measured Noise Level $L_{eq,\,T}$ [1,2]
Location L1 – Western side of the site facing the rail corridor with direct line of sight.	Day time (7am to 10pm) 09/05/18 to 16/05/18	72
	Night time (10pm to 7am) 09/05/18 to 16/05/18	68
Location L2 – Eastern side of the site facing Anderson Street with direct line of sight.	Day time (7am to 10pm) 09/05/18 to 16/05/18	63
	Night time (10pm to 7am) 09/05/18 to 16/05/18	55

Notes:

1. Noise levels presented are facade corrected values.
2. Representative external noise levels in measured L_{Aeq} over 15 hour and 9 hour day and night period respectively.

3.1.2 Background noise

The results of the long-term noise monitoring have been summarised in accordance with the Noise Policy for Industry (NPfI) requirements published by the NSW Environment Protection Authority (EPA) and are presented in Table 3 below.

Table 3: Measured Site Background Noise Level

Noise Monitoring		Representative Background Noise Levels in dB(A)	Day[1]	Evening[2]	Night[3]
Location	**Duration**				
Location L1 – Western side of the site facing the rail corridor with direct line of sight.	09/05/18 to 16/05/18	$L_{A90(15min)}$	49	49	42
		$L_{Aeq(15min)}$	70	69	66
Location L2 – Eastern side of the site facing Anderson Street with direct line of sight.		$L_{A90(15min)}$	47	45	37
		$L_{Aeq(15min)}$	61	59	53

Notes:

Day, Evening & Night assessment periods are defined in accordance NSW EPA's NPfI as follows.

1. Day is defined as 7:00am to 6:00pm, Monday to Saturday; 8:00am to 6:00pm Sundays & Public Holidays. As results were affected by construction noise weekend day and Saturday morning, Sunday results have been presented for the Day time period
2. Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays
3. Night is defined as 10:00pm to 7:00am, Monday to Saturday; 10:00pm to 8:00am Sundays & Public Holidays

The representative background noise levels (L_{A90}) are used in defining external noise emission from the development such as mechanical ventilation and air-conditioning systems in accordance to the EPA Noise Policy for Industry.

4 Noise intrusion assessment

4.1 Criteria

The Standards, Government Policies, Guidelines and Council Development Control Plans (DCP) relevant to this development are as follows:

1. Willoughby City Council DCP 2016
2. State Environment Planning Policy (Infrastructure) 2007 (ISEPP)
3. Department of Planning (DoP) publication "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008 (DoP Guideline)

In accordance with the Willoughby Council DCP, design internal noise levels in accordance with the ISEPP, and DoP publication have been recommended for this development and is outlined in Table 4 below.

Table 4: Recommended Internal Noise Criteria for Rail and Road Traffic Noise

Type of Occupancy	Windows Condition	Design Noise Level	
		Day, $L_{Aeq\ (15hour)}$	Night, $L_{Aeq\ (9hour)}$
Bedrooms	Closed	-	35dB(A)
	Open	-	45dB(A)
Open-plan Living/Dining/Kitchen	Closed	40dB(A)	40dB(A)
	Open	50dB(A)	50dB(A)

4.2 Calculated internal noise levels from rail and road traffic

Results from the long-term noise survey were used to calculate internal road traffic noise levels within the proposed development. Noise calculations and predications were conducted using the Outside-In Glazing Spreadsheet developed in this office which takes into account external ambient noise levels, facade transmission loss and room sound absorption characteristics. Noise levels were calculated for each building facade to account for any variation in the external noise levels affecting different parts of the building.

It is noted that at this stage of the project the fine internal architectural details are yet to be finalised. For the purpose of the acoustic assessment the following dimensions were adopted for the calculation of internal noise levels and determination of indicative façade treatments.

- Bedroom: Nominal volume 34m^3; Nominal glazed area 21m^2
- Living room: Nominal volume 106m^3; Nominal glazed area: 30m^2

External facade & glazing constructions required to comply with the project noise criteria outlined in Table 4 above are presented in Section 4.3 below. These systems are indicative only and the particular glazing shall be assessed during the detailed design phase.

4.3 Glazing design requirements

Table 5 below presents recommended glazing treatment for the building facades to achieve compliance with the maximum noise levels nominated in Table 4 above.

Table 5: Recommended Glazing Treatment

Level	Facade	Occupancy Type	Recommended Minimum Sound Insulation Rating of Glazing Assembly	Indicative Glazing Configuration	Laboratory Test Reference
5 to 13	North	Living/Dining/Kitchen	R_w 37	Single laminated glass	ESTIMATE
	East	Living/Dining/Kitchen	R_w 32	Single laminated glass	ESTIMATE
		Bedroom	R_w 32	Single laminated glass	ESTIMATE
	South	Bedroom (with windows facing rail and Wilson St)	R_w 40	Double glazing or specialist glass	ESTIMATE
		Bedroom (with windows facing Wilson St and Anderson St)	R_w 35	Single laminated glass	ESTIMATE
	West	Living/Dining/Kitchen	R_w 40	Double glazing or specialist glass	ESTIMATE
		Bedroom	R_w 40	Double glazing or specialist glass	ESTIMATE

By way of explanation, the Sound Insulation Rating Rw is a measure of the noise reduction property of the partition, a higher rating implying a higher sound reduction performance.

Note that the Rw rating of systems measured as built on site (R'w Field Test) may be up to 5 points lower than the laboratory result.

LEGEND where no appropriate test certificate exists:

1. ESTIMATE: The client is advised not to commence detailing or otherwise commit to partition construction systems which have not been tested in an approved laboratory or for which an opinion only is available. Testing of partition construction systems is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested partition construction systems, estimates or opinions. The advice provided here is in respect of acoustics only.
2. ESTIMATE – APPROVED FOR CONSTRUCTION: Use of the form of construction is approved prior to laboratory certification. To complete the quality control of the design process and confirm the acoustical performance of the construction, we recommend testing in a laboratory to confirm the Rw rating as soon as practicable. In the case of impact rating for floor systems, no particular impact rating is guaranteed to comply with either the Building Code of Australia or Strata Scheme Management Act and hence carpet runners may still be required.
3. ESTIMATE – TEST NOT REQUIRED: Use of the form of construction is approved without laboratory certification. The STC/Rw of the form of construction exceeds the project requirements.
4. The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Level	Facade	Occupancy Type	Recommended Minimum Sound Insulation Rating of Glazing Assembly	Indicative Glazing Configuration	Laboratory Test Reference
NOTES FOR GLAZING CONSTRUCTIONS:					
5. The information in this table is provided for the purpose of Council approvals process and cost planning and shall not be used for construction unless otherwise approved in writing by the acoustic consultant.					
6. The design in this table is preliminary and a comprehensive assessment shall be conducted prior to Construction Certification.					
7. Before committing to any form of construction or committing to any builder, advice should be sought from an acoustic consultant to ensure that adequate provisions are made for any variations which may occur as a result of changes to the form of construction where only an "estimate" is available for the sound insulation properties of recommended materials.					
8. The glazing supplier shall ensure that installation techniques will not diminish the Rw performance of the glazing when installed on site.					
9. All openable glass windows and doors shall incorporate full perimeter acoustic seals equivalent to Q-Lon, which enable the Rw rating performance of the glazing to not be reduced.					
10. The above glazing thicknesses should be considered the minimum thicknesses to achieve acoustical ratings. Greater glazing thicknesses may be required for structural loading, wind loading etc.					
GENERAL					
11. The sealing of all gaps in partitions is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.					
12. Check design of all junction details with acoustic consultant prior to construction.					
13. Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.					
14. The information provided in this table is subject to modification and review without notice.					
15. The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.					

4.4 Facade and roof sound insulation

In principle advice is provided below for the acoustic requirements of the roof and external walls for this proposed development.

4.4.1 External Walls

The dominant path of external noise ingress into building interior is via window and doors. Assessment and recommendations regarding external noise intrusion has accordingly been made with respect to the windows and doors. It is therefore recommended that the external walls have a sound isolation rating (R_w) at least 15dB higher than that of the glazing specified in Table 5 above, to maintain the acoustic integrity of the overall facade system.

4.4.2 Roof and Ceiling

Similar to the external wall design, the roof/ceiling construction can generally provide acoustic performances well in excess of glazing or doors. The roof construction should have a sound isolation rating (R_w) at least 10dB higher than that of the glazing on its facade.

4.5 Ventilation

In accordance with the Department of Planning publication "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008:

If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia

However, the Department of Planning's Apartment Design Guide, July 2015 Objective 4B-1 requires that all habitable rooms are naturally ventilated, within an apartment complex.

Section 4J, *Noise and Pollution*, of the Apartment Design Guide nominates design solutions that may assist with delivering both the natural ventilation requirements and the internal noise levels (windows open) through careful design solutions. These may include wintergardens with operable facades, partially shielded and insulated balconies, building design and orientation, apartment setbacks and selection of acoustic materials for the building construction.

It has long been industry standard to assume a 10dB loss of noise from external to internal through an opened window in a building facade. It is based on the average results of a number of test cases, experimental data and published papers. This assumption has been well documented in The Roads and Traffic Authority (RTA) publications, including the RTA's Environmental Noise Management Manual (ENMM), Table 4.2.

Recent studies on noise reduction through facades with open windows[1] have shown that noise transmission through an open window can vary greatly based on the construction of the facades and noise flanking paths, including exposed floors and roof constructions.

The study indicates that noise loss through an open window of a development consisting of masonry construction with no exposed flooring and a concrete roof will be in the range of 11-15dB.

Further assessment of internal noise levels with windows opened is required at the detailed design phase of the project to consider facade design, opening sizes, balcony materials, room volumes, room finishes and shielding.

[1] Ryan, Lanchester and Pugh, 2011

5 Rail vibration assessment

5.1 Criteria

5.1.1 Regenerated noise

The Department of Planning's "Development near Rail Corridors & Busy Roads – Interim Guideline" 2008 (DoP Guideline) provides recommended criteria for ground-borne or regenerated rail noise. Table 6 summaries these noise limits for sleeping and living spaces.

Table 6: Recommended Internal Noise Criteria for Regenerated Rail Noise

Occupancy	Period	L_{Amax} Noise Limit [1]
Sleeping areas (Bedrooms)	10pm – 7am	35 dB(A)
Other habitable rooms (excluding garages, kitchens, bathrooms and hallways)	At any time	40 dB(A)

Notes:

1. L_{Amax} – is the-weighted maximum sound pressure level measures using a "slow" response time

5.1.2 Rail tactile vibration

Section 3.6.3 of the DoP Guideline provides recommended vibration criteria in accordance with the following documents:

1. Department of Environment and Conservation 2006 publication "Assessing Vibration: a technical guideline" (DEC Guideline)
2. German Standard DIN 4150 Part 3 1992
3. British Standard BS 7385 Part 2 1993
4. Australian Standard AS 2670.2 1990

The above documents have been reviewed and the criteria for assessment tactile vibration from train pass-bys affecting the proposed development is quantified in accordance with:

- Assessing Vibration: A technical guideline (Department of Environment and Conservation, 2006)
- British Standard BS6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)"

The criteria curves presented in BS6472:1992 are identical to those in Australian Standard AS2670.2 1990 and the International Standard 2631-2:1989.

Criteria for continuous vibration from the British Standard BS6472:1992 for residential spaces, offices and commercial workshop environments are shown in Figure 3 below.

Figure 3: Tactile Vibration Criteria for Residential Buildings

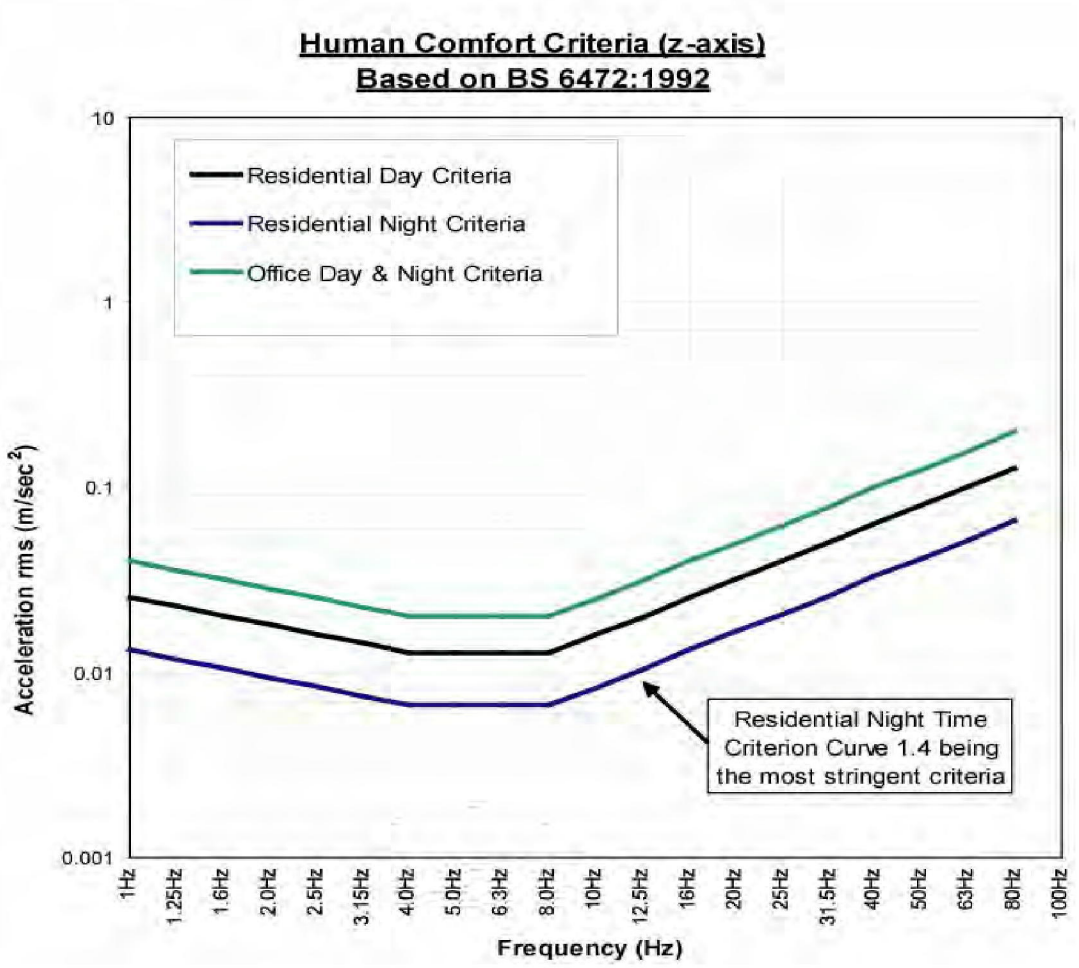

Table 2.4 of the DEC Guideline presents acceptable vibration dose values for intermittent vibration. Table 7 below outlines DEC's requirements.

Table 7: Acceptable VDVs for intermittent vibration in residential buildings m/s$^{1.75}$

Location	Period	Preferred VDV m/s$^{1.75}$
Residence	Day time (7am – 10pm)	0.20
	Night time (10pm – 7am)	0.13

5.2 Rail vibration monitoring locations

An operator attended rail vibration survey was undertaken on site in three different locations throughout the site from 4pm to 6pm on 9th May 2018 and 12pm to 1pm on 16th May 2017. Refer to APPENDIX E for more details of the monitoring location.

5.3 Instrumentation

Train vibration levels were measured using the Sinus SoundBook multi-channel analyser and PCB accelerometers at the location shown in above. Three accelerometers (x, y & z) were magnetically fixed to a steel bracket that has been glue fixed to the existing concrete slab on site.

Weather condition was fine during the operator-attended survey. All instruments were calibrated before and after measurement. No significant drift in calibration was observed.

The recorded ground vibration levels of train pass-bys are shown in Section 5.4 below together with the vibration criteria from British Standard BS6472-1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80 Hz)" and DECC intermittent vibration dosage criterion.

5.4 Measured tactile train vibration and assessment to BS6472 and DEC

Results of the train vibration survey were plotted against night and day criterion of British Standard BS6472-1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)" as show in Figure 4 to Figure 6 below. In addition, the measured train vibration levels were used to calculate the vibration dosage values (VDV) and then compared to the acceptable levels from the Table 2.4 of DEC guideline 2006.

Results from the measurements demonstrate that the floor induced vibration within the proposed building from each of the measured train pass-bys were compliant with the British Standard BS6472:1997 for human comfort in a residential environment during the day and night. Similarly, the calculated vibration dosage values (VDV) from our measurements complied with the preferred day and night VDV criterion as defined in the DEC guideline 2006.

Figure 4: Vibration Assessment for Human Annoyance BS6472 in Vertical Z-Axis Plane (Train 1 to 10)

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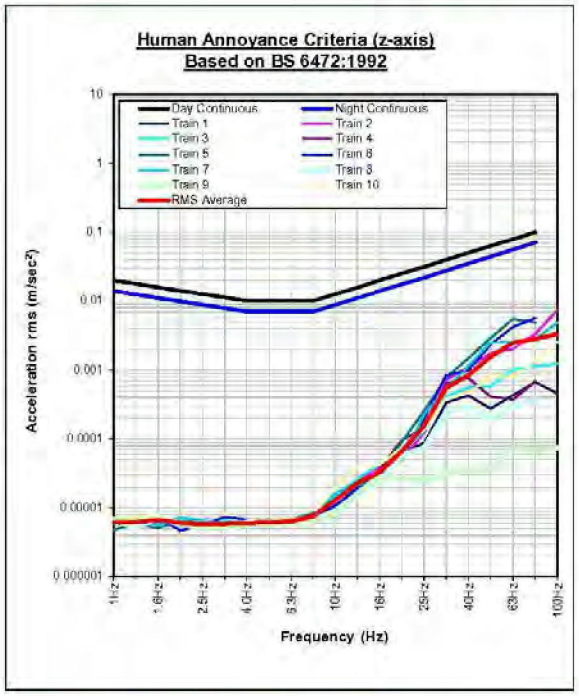
Vibration Survey Results

Vibration Assessment for Human Annoyance BS6472-1992 & DECCW

Project No.:	TK328-01
Location:	58 Anderson Street, Chatswood
Source:	Trains

Assessment Location:	Residential	Axis	Z	Total secs of Vib per Day (t):	14,550
Type of Vibration:	Intermittent			Total secs of Vib per Night (t):	3,600



Legend	Measurement	Train 1	Train 2	Train 3	Train 4	Train 5	Train 6	Train 7	Train 8	Train 9	Train 10	RMS Ave	Preferred DECCW Criterion	Maximum DECCW Criterion
Acceleration rms (m/sec²)	1Hz	0.0000064	0.0000061	0.0000070	0.0000067	0.0000048	0.0000060	0.0000058	0.0000068	0.0000066	0.0000061	0.0000063		
	1.25Hz	0.0000057	0.0000056	0.0000058	0.0000066	0.0000059	0.0000054	0.0000068	0.0000051	0.0000071	0.0000074	0.0000062		
	1.6Hz	0.0000071	0.0000061	0.0000062	0.0000063	0.0000051	0.0000073	0.0000057	0.0000073	0.0000071	0.0000079	0.0000067		
	2.0Hz	0.0000058	0.0000059	0.0000065	0.0000064	0.0000065	0.0000047	0.0000073	0.0000060	0.0000058	0.0000059	0.0000061		
	2.5Hz	0.0000054	0.0000052	0.0000064	0.0000053	0.0000062	0.0000056	0.0000066	0.0000058	0.0000052	0.0000057	0.0000058		
	3.15Hz	0.0000059	0.0000056	0.0000066	0.0000058	0.0000056	0.0000074	0.0000057	0.0000053	0.0000051	0.0000054	0.0000059		
	4.0Hz	0.0000058	0.0000062	0.0000063	0.0000057	0.0000059	0.0000068	0.0000058	0.0000061	0.0000057	0.0000065	0.0000061		
	5.0Hz	0.0000055	0.0000065	0.0000060	0.0000068	0.0000055	0.0000060	0.0000062	0.0000060	0.0000058	0.0000066	0.0000061		
	6.3Hz	0.0000064	0.0000062	0.0000064	0.0000057	0.0000069	0.0000063	0.0000064	0.0000062	0.0000060	0.0000063	0.0000063		
	8.0Hz	0.0000071	0.0000070	0.0000078	0.0000062	0.0000065	0.0000073	0.0000078	0.0000069	0.0000066	0.0000077	0.0000075		
	10Hz	0.0000106	0.0000130	0.0000141	0.0000107	0.0000130	0.0000109	0.0000161	0.0000090	0.0000082	0.0000191	0.0000129		
	12.5Hz	0.0000181	0.0000245	0.0000263	0.0000172	0.0000196	0.0000190	0.0000242	0.0000159	0.0000184	0.0000398	0.0000231		
	16Hz	0.0000236	0.0000386	0.0000431	0.0000354	0.0000312	0.0000256	0.0000302	0.0000236	0.0000286	0.0000417	0.0000330		
	20Hz	0.0000661	0.0000506	0.0000632	0.0000972	0.0000815	0.0000556	0.0000503	0.0000577	0.0000268	0.0000749	0.0000664		
	25Hz	0.0000869	0.0001242	0.0001324	0.0001420	0.0002548	0.0002013	0.0002275	0.0000742	0.0000245	0.0001388	0.0001560		
	31.5Hz	0.0003389	0.0007273	0.0004142	0.0008415	0.0007739	0.0008449	0.0005248	0.0002433	0.0000310	0.0003860	0.0005498		
	40Hz	0.0004232	0.0011119	0.0005629	0.0007662	0.0014747	0.0009907	0.0011432	0.0002952	0.0000342	0.0004611	0.0008416		
	50Hz	0.0002717	0.0017464	0.0005842	0.0004100	0.0028980	0.0023468	0.0024870	0.0001854	0.0000360	0.0008066	0.0015627		
	63Hz	0.0004322	0.0020140	0.0010205	0.0003724	0.0055102	0.0042153	0.0025591	0.0002907	0.0000759	0.0009022	0.0024665		
	80Hz	0.0006748	0.0032993	0.0011375	0.0006842	0.0049080	0.0056550	0.0027933	0.0003695	0.0000876	0.0013236	0.0029083		
	100Hz	0.0004571	0.0073498	0.0012207	0.0009009	0.0030582	0.0037621	0.0048984	0.0002617	0.0000742	0.0025516	0.0033256		
Weighted rms	Day	[illegible]												
	Night	[illegible]												
eVDV	Day	0.0025	0.0090	0.0039	0.0039	0.0160	0.0141	0.0099	0.0017	0.0005	0.0040	0.0083	0.20	0.40
	Night	0.0017	0.0063	0.0028	0.0028	0.0113	0.0099	0.0070	0.0012	0.0004	0.0028	0.0059	0.13	0.26

NOTE: Red indicates exceedence of Preferred DECCW Criterion
NOTE: Gray indicates continous vibration levels and criteria if intermittent criteria is selected

QTS-01 (rev 12) Human Annoyance Vibration Assessment BS6472-DEC - Z-axis

Figure 5: Vibration Assessment for Human Annoyance BS6472 in Vertical Z-Axis Plane (Train 11 to 20)

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Vibration Survey Results

Vibration Assessment for Human Annoyance BS6472-1992 & DECCW

Project No.:	TK328-01
Location:	58 Anderson Street, Chatswood
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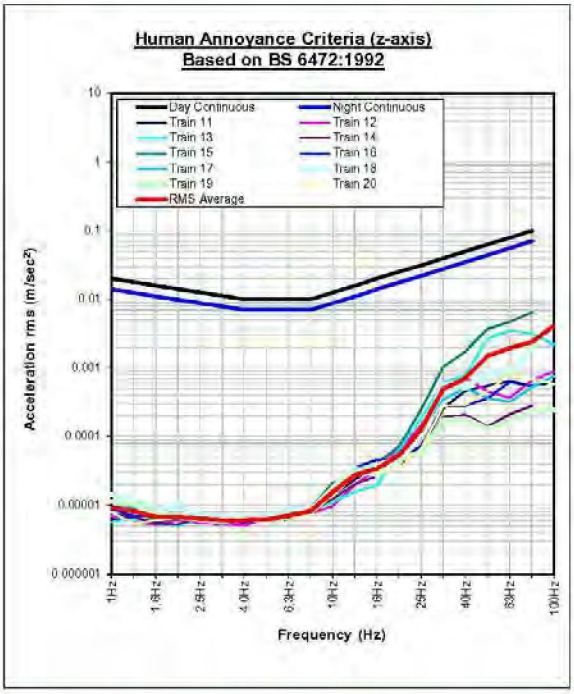

Legend	Measurement	Train 11	Train 12	Train 13	Train 14	Train 15	Train 16	Train 17	Train 18	Train 19	Train 20	RMS Ave	Preferred DECCW Criterion	Maximum DECCW Criterion
Acceleration rms (m/sec²)	1Hz	0.0000064	0.0000069	0.0000057	0.0000075	0.0000091	0.0000088	0.0000110	0.0000144	0.0000113	0.0000079	0.0000093		
	1.25Hz	0.0000065	0.0000057	0.0000063	0.0000068	0.0000088	0.0000070	0.0000091	0.0000127	0.0000104	0.0000054	0.0000082		
	1.6Hz	0.0000057	0.0000053	0.0000054	0.0000053	0.0000059	0.0000068	0.0000082	0.0000089	0.0000079	0.0000061	0.0000068		
	2.0Hz	0.0000061	0.0000061	0.0000050	0.0000053	0.0000064	0.0000067	0.0000071	0.0000097	0.0000069	0.0000066	0.0000067		
	2.5Hz	0.0000064	0.0000055	0.0000064	0.0000065	0.0000072	0.0000059	0.0000068	0.0000072	0.0000061	0.0000062	0.0000064		
	3.15Hz	0.0000060	0.0000054	0.0000054	0.0000056	0.0000061	0.0000063	0.0000063	0.0000067	0.0000059	0.0000065	0.0000060		
	4.0Hz	0.0000060	0.0000051	0.0000060	0.0000059	0.0000062	0.0000056	0.0000062	0.0000069	0.0000063	0.0000064	0.0000061		
	5.0Hz	0.0000058	0.0000064	0.0000058	0.0000065	0.0000063	0.0000064	0.0000058	0.0000064	0.0000060	0.0000064	0.0000062		
	6.3Hz	0.0000063	0.0000067	0.0000067	0.0000067	0.0000074	0.0000066	0.0000070	0.0000088	0.0000067	0.0000065	0.0000070		
	8.0Hz	0.0000078	0.0000076	0.0000082	0.0000082	0.0000090	0.0000082	0.0000084	0.0000085	0.0000081	0.0000075	0.0000082		
	10Hz	0.0000140	0.0000097	0.0000111	0.0000123	0.0000208	0.0000179	0.0000183	0.0000179	0.0000177	0.0000139	0.0000155		
	12.5Hz	0.0000235	0.0000198	0.0000157	0.0000202	0.0000292	0.0000352	0.0000280	0.0000351	0.0000311	0.0000264	0.0000272		
	16Hz	0.0000368	0.0000331	0.0000196	0.0000267	0.0000404	0.0000464	0.0000329	0.0000277	0.0000391	0.0000304	0.0000341		
	20Hz	0.0000394	0.0000663	0.0000667	0.0000458	0.0000723	0.0000459	0.0000605	0.0000425	0.0000471	0.0000347	0.0000536		
	25Hz	0.0000671	0.0001436	0.0001829	0.0000607	0.0002494	0.0000726	0.0001251	0.0001128	0.0000583	0.0000671	0.0001288		
	31.5Hz	0.0002581	0.0004868	0.0008084	0.0001916	0.0010389	0.0002820	0.0003504	0.0005811	0.0001732	0.0002830	0.0004939		
	40Hz	0.0004658	0.0007012	0.0007823	0.0002079	0.0017239	0.0002829	0.0005123	0.0005178	0.0001820	0.0002889	0.0007116		
	50Hz	0.0005552	0.0004560	0.0026647	0.0001393	0.0036978	0.0003625	0.0003615	0.0008725	0.0001292	0.0004646	0.0015022		
	63Hz	0.0006426	0.0003695	0.0035268	0.0002113	0.0047280	0.0006291	0.0003231	0.0009861	0.0001671	0.0007847	0.0019308		
	80Hz	0.0005549	0.0006521	0.0031839	0.0002801	0.0063889	0.0005409	0.0005184	0.0013675	0.0002422	0.0006851	0.0023737		
	100Hz	0.0006201	0.0008864	0.0021752	0.0002993	0.0123097	0.0004172	0.0007521	0.0034402	0.0002438	0.0005838	0.0041291		
Weighted rms	Day	0.0003	0.0003	0.0007	0.0003	0.0013	0.0002	0.0002	0.0003	0.0001	0.0003	0.0008		
	Night	0.0002	0.0002	0.0005	0.0002	0.0010	0.0002	0.0002	0.0003	0.0001	0.0003	0.0005		
eVDV	Day	0.0028	0.0034	0.0113	0.0013	0.0176	0.0024	0.0026	0.0049	0.0013	0.0027	0.0071	0.20	0.40
	Night	0.0019	0.0024	0.0079	0.0009	0.0124	0.0017	0.0019	0.0035	0.0009	0.0019	0.0050	0.13	0.26

NOTE: Red indicates exceedence of Preferred DECCW Criterion
NOTE: Gray indicates continous vibration levels and criteria if intermittent criteria is selected

QTS-01 (rev 12) | Human Annoyance Vibration Assessment BS6472-DEC - z axis

Figure 6: Vibration Assessment for Human Annoyance BS6472 in Vertical Z-Axis Plane (Train 21 to 25)

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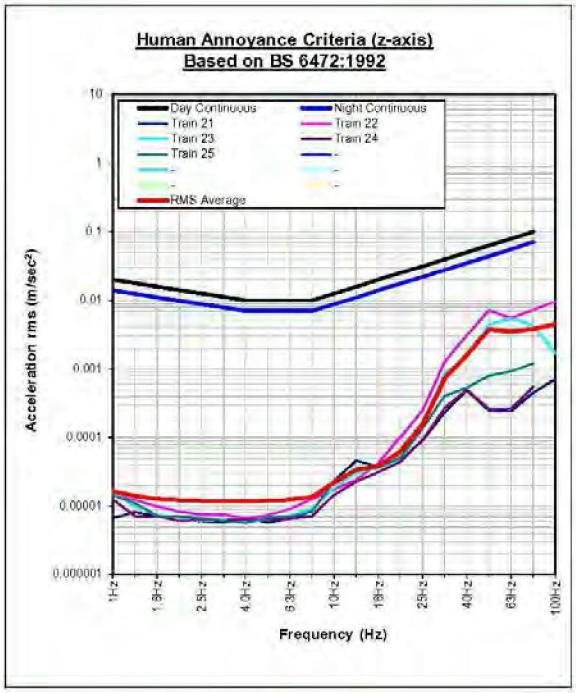
inspired to achieve

Vibration Survey Results

Vibration Assessment for Human Annoyance BS6472-1992 & DECCW

Project No.:	TK328-01
Location:	58 Anderson Street, Chatswood
Source:	Trains

Assessment Location:	Residential	Axis	Z	Total secs of Vib per Day (t):	14,550
Type of Vibration:	Intermittent			Total secs of Vib per Night (t):	3,600



Legend														
Measurement		Train 21	Train 22	Train 23	Train 24	Train 25	-	-	-	-	-	RMS Ave	Preferred DECCW Criterion	Maximum DECCW Criterion
Acceleration rms (m/sec²)	1Hz	0.0000087	0.0000142	0.0000154	0.0000126	0.0000146						0.0000185		
	1.25Hz	0.0000082	0.0000124	0.0000101	0.0000072	0.0000111						0.0000141		
	1.6Hz	0.0000074	0.0000099	0.0000074	0.0000072	0.0000072						0.0000127		
	2.0Hz	0.0000070	0.0000084	0.0000070	0.0000061	0.0000070						0.0000123		
	2.5Hz	0.0000060	0.0000076	0.0000061	0.0000064	0.0000067						0.0000120		
	3.15Hz	0.0000058	0.0000076	0.0000064	0.0000063	0.0000062						0.0000119		
	4.0Hz	0.0000066	0.0000066	0.0000058	0.0000063	0.0000057						0.0000118		
	5.0Hz	0.0000059	0.0000074	0.0000065	0.0000065	0.0000069						0.0000120		
	6.3Hz	0.0000066	0.0000091	0.0000073	0.0000066	0.0000071						0.0000124		
	8.0Hz	0.0000084	0.0000127	0.0000082	0.0000072	0.0000083						0.0000137		
	10Hz	0.0000228	0.0000178	0.0000185	0.0000145	0.0000229						0.0000220		
	12.5Hz	0.0000462	0.0000241	0.0000310	0.0000228	0.0000327						0.0000339		
	16Hz	0.0000381	0.0000425	0.0000362	0.0000312	0.0000368						0.0000385		
	20Hz	0.0000462	0.0001014	0.0000464	0.0000451	0.0000514						0.0000629		
	25Hz	0.0000918	0.0002492	0.0001852	0.0000926	0.0001372						0.0001585		
	31.5Hz	0.0002318	0.0012670	0.0008548	0.0002687	0.0004055						0.0007248		
	40Hz	0.0004949	0.0030588	0.0015793	0.0004999	0.0005305						0.0015884		
	50Hz	0.0002455	0.0071384	0.0044411	0.0002813	0.0007987						0.0037793		
	63Hz	0.0002423	0.0054959	0.0054701	0.0002625	0.0006279						0.0034962		
	80Hz	0.0004513	0.0072295	0.0043757	0.0005470	0.0012087						0.0038308		
	100Hz	0.0007098	0.0095417	0.0017143	0.0007467	0.0023383						0.0044830		
Weighted rms	Day	0.0001	0.0017	0.0015	0.0002	0.0008						0.0009		
	Night	0.0001	0.0017	0.0015	0.0002	0.0008						0.0009		
eVDV	Day	0.0022	0.0257	0.0177	0.0023	0.0041						0.0142	0.20	0.40
	Night	0.0016	0.0181	0.0125	0.0016	0.0029						0.0100	0.13	0.26

NOTE: Red indicates exceedence of Preferred DECCW Criterion
NOTE: Gray indicates continous vibration levels and criteria if intermittent criteria is selected

QTS-01 (rev 12) Human Annoyance Vibration Assessment BS6472-DEC - z axis

5.5 Calculated ground-borne rail noise inside proposed development

Regenerated or ground-borne rail noise is the low rumble heard inside buildings with vicinity of railway lines due to ground vibration generated by passing trains which propagate through soil and rock up into building elements such as foundation, wall and floors which re-radiates as audible sound.

Train vibration levels measured on site were used to predict the regenerated rail noise inside the proposed building nearest to the rail corridor. These calculated noise levels inside apartments are summarised in Table 8 below and compared to ground-borne noise criteria defined in Table 6.

Table 8: Calculated Regenerated Rail Noise Levels Inside Apartment

Floor Level	Proposed Occupancy/Space	Calculated[1] Ground-borne Rail Noise inside development	DoP Guideline 2008 Criteria[1] for Ground-borne Rail Noise inside Dwellings	Comply? (Yes/No)
Ground	Commercial	68 dB(A)	None	N/A
Level 1	Plant room	66 dB(A)	None	N/A
Level 2	Commercial	62 dB(A)	None	N/A
Level 3	Residential communal space	59 dB(A)	None	N/A
Level 4	Commercial	55 dB(A)	None	N/A
Level 5	Living, dining and kitchen	51 dB(A)	40 dB(A)	No, exceedance of 11 dB
	Sleeping Areas	51 dB(A)	35 dB(A)	No, exceedance of 16 dB

Notes:

1. Ground-borne noise calculations were based upon the measured L_{Max} (Slow) of 95% of train pass-events as per DOP Guideline 2008.

The above assessment predicts ground-borne rail noise levels inside proposed residential spaces of the development due to train pass-bys on the T1 North Shore, Northern & Western Line to exceed the $L_{Amax\ (slow)}$ criteria stipulated in the DoP Guideline 2008 by 11 to 16dB.

On the basis of the vibration measurements undertaken on site and the assessment and the assessment detailed above, vibration isolation is required to the proposed development to comply with the DoP Guideline 2008. It is recommended the proposed structure to be vibration isolated at the footings and at the perimeter of the building. We recommend a full and detailed assessment with respect to the design of the isolation treatment to be undertaken at the detailed design phase of the development. Construction/installation supervision of the isolation treatment should also be sought during the construction stage.

6 External noise emission from building services

6.1 EPA requirements

The NSW Environment Protection Authority (EPA) sets out noise criteria in its Noise Policy for Industry (NPfI) to control the noise emission from industrial sources.

The NPfI sets project noise trigger level to protect noise amenity for residential receivers. The project noise trigger level is set as the lower value of the following two assessment components:

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

Noise intrusiveness ensures that industrial noise does not exceed the background noise level by an excessive margin, preventing significant changes in the noise characteristic pertinent to the development site and surrounds. This is commonly referred to as the 'background plus 5' criterion. That is, the noise level from new industrial development, assessed in periods of 15 minutes, should not exceed the existing background noise level (measured in the absence of that development) by more than 5dB(A).

Noise amenity ensures that industrial noise levels do not increase without limit, for if a number of industrial noise sources are permitted to increase the background noise level by 5dB(A), in turn there would be a point where the ultimate noise level is unacceptable. A limit on the ultimate acceptable noise level is therefore included in the NPfI as a way of ensuring that cumulative noise impact from industrial growth is curtailed. This limit is referred to as the project amenity noise level. Amenity noise levels are not used directly as regulatory limits. They are used in combination with the project intrusiveness noise level to assess the potential impact of noise, assess reasonable and feasible mitigation options, and subsequently determine achievable noise requirements.

The table below presents the recommended amenity noise level relevant to the receivers surrounding the proposed development site. The project amenity noise level is defined as the recommended amenity noise level minus 5dB(A).

Table 9: NPfI Amenity Noise Levels - Recommended L_{Aeq} Amenity Noise Levels from Industrial Noise Sources [EPA NPfI Table 2.1]

Receiver	Noise amenity area	Time of day	L_{Aeq}, dB(A)
			Recommended Amenity noise level
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40

Receiver	Noise amenity area	Time of day	L_{Aeq}, dB(A) Recommended Amenity noise level
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See Column 4	5dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom - internal	All	Noisiest 1-hour period when in use	35
Hospital ward - internal	All	Noisiest 1-hour	35
Hospital ward - external	All	Noisiest 1-hour	50
Place of worship - internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5dB(A) to recommended noise amenity

Notes:

- Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am
- On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
- The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

In accordance with Section 2.4 of the NPfI, the following **exceptions** to the above method to derive the project amenity noise level apply:

1. In areas with high traffic noise levels (see Section 2.4.1 of the NPfI).
2. In proposed developments in major industrial clusters (see Section 2.4.2 of the NPfI).
3. Where the resultant project amenity noise level is 10dB, or more, lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

Where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant amenity noise level is assigned as the project amenity noise level for the development.

The applicable noise limits, according to the policy, are determined as follows:

Table 10: L_{Aeq} Design Criterion for Noise Production (EPA NPfI) ambient – receivers facing railway corridor

Time of Day	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
	Rating Background Level (RBL) L_{A90}	Intrusiveness Trigger Level (RBL+5)	Recommended Amenity Noise Level (RANL)	Project Amenity Noise Level (PANL)	Measured $L_{Aeq, period}$ existing noise levels	Traffic noise exceed the RANL by more than 10dB?	Existing noise level likely to decrease in future?	Exceptions to PANL?	Project Noise Trigger Level $L_{Aeq, period}$ dB(A)
Day (7am to 6pm)	49	54	55	50	70	Yes	No	Existing $L_{Aeq, period}$ minus 15 dB(A) = 55 dB(A)	54
Evening (6pm to 10pm)	49	54	45	40	69	Yes	No	Existing $L_{Aeq, period}$ minus 15 dB(A) = 54 dB(A)	54
Night (10pm to 7am)	42	47	40	35	66	Yes	No	Existing $L_{Aeq, period}$ minus 15 dB(A) = 51 dB(A)	47

Explanatory notes:

Column 1 – RBL measured in accordance with the NPfI and outlined in the results of the long-term noise monitoring has been summarised in accordance with NPfI requirements and are presented in Table 3 above.

Column 4 – Project Amenity Noise Level determined based on 'Residential - suburban' area in Table 2.2 (Amenity noise levels) of the EPA's NPfI minus 5dB

Column 5 – Measured in accordance with the NPfI

Column 8 - Determined in accordance with Section 2.4 of the NPfI.

Column 9 – Project Noise Trigger Level is the lower value of project intrusiveness noise level and project amenity noise level.

Table 11: L_{Aeq} Design Criterion for Noise Production (EPA NPfI) ambient – facing railway corridor - receivers facing Anderson Street

Time of Day	Column 1	Column 2	Column 3	Column 4	Column 5
	Rating Background Level (RBL) L_{A90}	Project Intrusiveness Trigger Level (RBL+5)	Recommended Amenity Noise Level (RANL)	Project Amenity Noise Level (PANL)	Project Noise Trigger Level $L_{Aeq, period}$ dB(A)
Day (7am to 6pm)	47	52	55	50	50
Evening (6pm to 10pm)	45	50	45	40	40
Night (10pm to 7am)	37	42	40	35	35

Explanatory notes:

Column 1 – RBL measured in accordance with the NPfI and outlined in the results of the long-term noise monitoring has been summarised in accordance with NPfI requirements and are presented in Table 3 above.

Column 4 – Project Amenity Noise Level determined based on 'Residential - suburban' area in Table 2.2 (Amenity noise levels) of the EPA's NPfI minus 5dB

Column 9 – Project Noise Trigger Level is the lower value of project intrusiveness noise level and project amenity noise level.

6.2 Maximum noise level event assessment

The potential for sleep disturbance from maximum noise level events, from the proposed development, needs to be considered. Section 2.5 of the NPfI provides sleep disturbance trigger levels, summarised as follows:

Table 12: Sleep disturbance noise trigger levels

Receiver	Sleep Disturbance Trigger Levels, 10:00pm to 7:00am	
	$L_{Aeq,\ 15\ minute}$	L_{AFmax}
All residential	Greater than 40dB(A) or RBL plus 5dB, whichever is the greater	52dB(A) or RBL plus 15dB, whichever is the greater

Where noise from the proposed development is predicted to exceed the sleep disturbance trigger levels above in Table 12, during the night time, a detailed noise level assessment is required. The detailed assessment is required to cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL, and the frequency of events occurring during the night time.

6.3 Recommended noise control measures for mechanical plant

Where necessary, noise amelioration treatment will be incorporated in the design to ensure that noise levels comply with the recommended EPA's NPfI noise emission criteria noted above.

At this stage details of mechanical plant have not been finalised, the following in-principal recommendations are provided:

- Acoustic assessment of mechanical services equipment will need to be undertaken during the detail design phase of the development to ensure that they shall not either singularly or in total emit noise levels which exceed the noise limits in EPA's NPfI or Council's requirements;
- As noise control treatment can affect the performance of the mechanical services system, it is recommended that consultation with an acoustic consultant be made during the initial phase of mechanical services system design in order to reduce the need for revision of mechanical plant and noise control treatment;
- Mechanical plant noise emission can be controllable by appropriate mechanical system design and implementation of common engineering methods that may include any of the following:
    - procurement of 'quiet' plant,
    - strategic positioning of plant away from sensitive neighbouring premises, maximising the intervening shielding between the plant and sensitive neighbouring premises,
    - commercially available silencers or acoustic attenuators for air discharge and air intakes of plant;

- acoustically lined and lagged ductwork;
- acoustic screens and barriers between plant and sensitive neighbouring premises; and/or
- Partially-enclosed or fully-enclosed acoustic enclosures over plant.

- Mechanical plant shall have their noise specifications and their proposed locations checked prior to their installation on site; and
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 "Rotating and Reciprocating Machinery – Mechanical Vibration".

We recommend a full and detailed assessment with fully documented acoustic treatments be undertaken at the detailed design phase of the development, followed by construction/installation supervision of mechanical plant and equipment acoustic treatment. Compliance testing following the installation of the plant should also be undertaken.

7 Internal sound insulation between tenancies

Internal walls and floors shall comply with the National Construction Code of Australia 2019 (formally Building Code of Australia). All services and doors shall comply with the requirements of the NCC 2019. APPENDIX C presents a summary of acoustic provisions outlined in Part F5 of the NCC 2019.

8 Conclusion

Renzo Tonin & Associates have completed an acoustic assessment of the proposed mixed use development at 58 Anderson Street, Chatswood including noise and vibration impacts on the site from road and rail and potential noise impacts from mechanical plant and equipment serving the site.

Our assessment has demonstrated ground-borne rail noise within the proposed residential building due to train pass-bys exceed the criteria stipulated in the Department of Planning publication "*Development Near Rail Corridors & Busy Roads – Interim Guideline 2008*". Vibration isolation is required to the proposed development to comply with the DoP Guideline 2008. A detailed analysis with respect to the specification of the building isolation is required at the detailed design stage for compliance with the DoP Guideline.

In addition, our analysis has also shown floor induced vibration within the proposed development due to train pass-bys will comply with the British Standard BS6472:1992 *"Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)"* and day and night VDV values set by the DEC guideline as required by the Department of Planning.

Noise impacts from road traffic (particularly on Anderson Street and Pacific Highway) have been considered and in-principle treatments for the control of traffic noise intrusion have been presented for compliance with the SEPP (Infrastructure) 2007 and DoP Guideline 2008.

Noise emission goals for the operation of mechanical plant and equipment have been set in accordance with the Noise Policy for Industry. It is feasible that noise emissions from the subject site can comply with these criteria, subject to detailed design for Construction Certificate.

APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Assessment and design methodology

B.1 Willoughby City Council Development Control Plan

Willoughby City Councils is the regulatory authority for the proposed development. Council's DCP 2006 refers to the State Environmental Planning Policy (Infrastructure) 2007 and Department of Planning publication "Development near rail corridors and busy roads – Interim Guidelines" as design guide for residential development near busy roads or rail corridor.

Relevant sections of Council's DCP are re-iterated below.

"C.14 Development near Railway Corridors or Busy Roads

Controls
Development located in the vicinity of a rail corridor or busy road needs to take into consideration the provisions of the State Environmental Planning Policy (Infrastructure) 2007 and the NSW Department of Planning "Development Near Rail Corridors and Busy Roads- Interim Guideline"

Performance Criteria
Development should be designed and constructed so as to:

- *Protect the safety and integrity of key transport infrastructure; and*
- *Ensure that the development achieves an appropriate acoustic amenity by meeting the internal noise criteria as specified in the State Environmental Planning Policy (Infrastructure) 2007."*

B.2 State Environmental Planning Policy (Infrastructure) 2007

The NSW State Environmental Planning Policy (Infrastructure) 2007 (known as 'ISEPP') came into force in NSW on 1 January 2008 to facilitate the effective delivery of infrastructure across the State. The aim of the policy includes identifying the environmental assessment category into which different types of infrastructure and services development fall and identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure.

Pertinent to noise assessment, the ISEPP includes the following clauses:

87 Impact of rail noise or vibration on non-rail development

1. This clause applies to development for any of the following purposes that is on land in or adjacent to a rail corridor and that the consent authority considers is likely to be adversely affected by rail noise or vibration:

a. a building for residential use,

b. a place of public worship,

c. a hospital,

d. an educational establishment or child care centre.

2. Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.

3. If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

a. in any bedroom in the building - 35 dB(A) at any time between 10 pm and 7am,

e. anywhere else in the building (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.

102 Impact of road noise or vibration on non-road development

2. This clause applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RTA) and that the consent authority considers is likely to be adversely affected by road noise or vibration:

f. a building for residential use,

g. a place of public worship,

h. a hospital,

i. an educational establishment or child care centre.

4. Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.

5. If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

b. in any bedroom in the building - 35 dB(A) at any time between 10 pm and 7am,

j. anywhere else in the building (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.

6. In this clause, "freeway", "tollway" and "transitway" have the same meanings as they have in the Roads Act 1993

B.2.1 Department of Planning publication 'Development near rail corridors and busy roads – Interim guideline'

To support the Infrastructure SEPP, the NSW Department of Planning released the *Development in Rail Corridors and Busy Roads – Interim Guideline* (December 2008). The Guideline assists in the planning, design and assessment of developments in, or adjacent to, major transport corridors in terms of noise, vibration and air quality. While the ISEPP applies only to roads with an AADT greater than 40,000 vehicles, the guideline is also recommended for other road traffic noise affected sites.

B.2.2 Clarification of ISEPP noise limits

The Guideline clarifies the time period of measurement and assessment. Section 3.4 '*What Noise and Vibration Concepts are Relevant*' and Table 3.1 of Section 3.6.1 confirms that noise assessment is based over the following time periods:

- Daytime 7:00am - 10:00pm $L_{Aeq(15hr)}$
- Night-time 10:00pm - 7:00am $L_{Aeq(9hr)}$

The noise criteria nominated in the ISEPP apply to internal noise levels with windows and doors closed. However, as the preliminary noise assessment is based on measurements/predictions at external locations, equivalent external noise criteria has been established. The equivalent external noise criterion is used to determine which areas of the development may require acoustic treatment in order to meet the internal noise requirements of the ISEPP. The equivalent external goals have been determined on the following basis:

- The ISEPP states: "*If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia*." The internal criteria with windows open is therefore 10dB(A) above the criteria explicitly outlined in the ISEPP.
- The generally accepted noise reduction through an open window from a free-field external position is 10dB(A). Windows/doors are assumed to be open no more than 5% of room floor area, in accordance with the Building Code of Australia (BCA) ventilation requirements.

Table 13 presents the ISEPP internal noise criteria along with the equivalent external noise criteria for residential premises.

Table 13: ISEPP noise criteria for new residential development

Room	Location	$L_{Aeq,\ 15hr}$ Day 7am – 10pm	$L_{Aeq\ 9hr}$ Night 10pm – 7am
Living rooms*	Internal, windows closed	40	40
	Internal, windows open	50	50
	External free-field (allowing windows to remain open)^	60	60
Bedrooms*	Internal, windows closed	40	35
	Internal, windows open	50	45
	External free-field (allowing windows to remain open)^	60	55

Room	Location	$L_{Aeq,\ 15hr}$ Day 7am – 10pm	$L_{Aeq\ 9hr}$ Night 10pm – 7am

Notes: * Requisite for 40,000AADT Roads only under ISEPP 2007.

^ ISEPP Guideline states that where internal noise criteria are exceeded by more than 10dB(A) with windows open mechanical ventilation is required. External goals have been calculated on the basis of nominal 10dB(A) reduction through an open window to a free-field position. Windows open to 5% of floor area in accordance with the BCA requirements.

APPENDIX C Internal sound insulation

C.1 National Construction Code of Australia 2019

The National Construction Code of Australia (NCC) outlines minimum requirements for inter-tenancy (party) walls and ceiling/ floors to maintain privacy. This includes the incorporation of penetration of a service through a floor or through more than one sole-occupancy unit.

NCC nominates required Weighted Sound Reduction Indexes (R_w) and spectrum adaptation factor (C_{tr}) for partition constructions, of different space/ activity types in adjoining units. The R_w and $R_w + C_{tr}$ are single number descriptors for quantifying the attenuating performance of partitions for typical intrusive noises produced inside residences. The higher the rating, the greater the isolation provided by the partition.

Spectrum adaptation factors are commonly used to compensate for the fact that certain kinds of sounds are more readily transmitted through insulating materials than others insulate.

The adaptation factor C_{tr} has now been introduced for most building elements which require an airborne sound insulation rating. The only exception is a wall which separates a dwelling from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification. Therefore, both the C_{tr} factor and the R_w of the building element will need to be considered in most cases.

The C_{tr} factor takes into account lower frequency level sounds, and has been chosen in large part, in recognition of the problem of the high bass frequency outputs of modern home theatre systems and music reproduction equipment.

The Deemed-to-Satisfy Provisions also have impact sound insulation requirements for floors. The terms to describe the impact sound insulation of the floor is the weighted normalised impact sound pressure level ($L_{n,w}$). The lower the $L_{n,w}$ of the floor, the better the performance of the floor in terms of impact sound insulation.

The following section represents a summary of acoustic provisions outlined in the Part F5 of the NCC.

C.2 Sound insultion provision of NCC of Australia

The acoustic provisions for inter-tenancy walls in Class 2 and 3 buildings are outlined in the National Construction Code of Australia and the following is an extract from the NCC:

F5.2 Determination of airborne sound insulation ratings

A form of construction required to have an airborne sound insulation rating must –

k. have the required value for weighted sound reduction index (Rw) or weighted sound reduction index with spectrum adaptation term (Rw + Ctr) determined in accordance with AS/NZS 1276.1 or ISO 717.1 using results from laboratory measurements; or

l. comply with Specification F5.2.

F5.3 Determination of impact sound insulation ratings

m. A floor in a building required to have an impact sound insulation rating must –

i. have the required value for weighted normalised impact sound pressure level (Ln,w) determined in accordance with AS/ISO 717.2 using results from laboratory measurements; or

ii. comply with Specification F5.2.

n. A wall in a building required to have an impact sound insulation rating must –

iii. for a Class 2 or 3 building be of discontinuous construction;

o. For the purposes of this part, discontinuous construction means a wall having a minimum 20 mm cavity between 2 separate leaves, and

iv. for masonry, where wall ties are required to connect leaves, the ties are of the resilient type; and

v. for other than masonry, there is no mechanical linkage between leaves except at the periphery.

F5.4 Sound insulation rating of floors

p. A floor in a Class 2 or 3 building must have an Rw + Ctr (airborne) not less than 50 and an Ln,w (impact) not more than 62 if it separates –

vi. sole-occupancy units; or

vii. a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.

F5.5 Sound insulation rating of floors

q. A wall in a Class 2 or 3 building must –

viii. have an Rw + Ctr (airborne) not less than 50, if it separates sole-occupancy units; and

ix. have an Rw (airborne) not less than 50, if it separates a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification; and

x. comply with F5.3(b) if it separates:

a bathroom, sanitary compartment, laundry or kitchen in one sole-occupancy unit from a habitable room (other than a kitchen) in an adjoining unit; or

xi. *a sole-occupancy unit from a plant room or lift shaft.*

r. A door may be incorporated in a wall in a Class 2 or 3 building that separates a sole-occupancy unit from a stairway, public corridor, public lobby or the like, provided the door assembly has an Rw not less than 30.

s. Where a wall required to have sound insulation has a floor above, the wall must continue to –

xii. *the underside of the floor above; or*

xiii. *a ceiling that provides the sound insulation required for the wall.*

F5.6 Sound insulation rating of services

t. If a duct, soil, waste or water supply pipe, including a duct or pipe that is located in a wall or floor cavity, serves or passes through more than one sole-occupancy unit, the duct or pipe must be separated from the rooms of any sole-occupancy unit by construction with an Rw + Ctr (airborne) not less than –

xiv. *40 if the adjacent room is a habitable room (other than a kitchen); or*

xv. *25 if the adjacent room is a kitchen or non-habitable room.*

u. If a storm water pipe passes through a sole-occupancy unit it must be separated in accordance with (a).

APPENDIX D Construction noise

The NSW *Interim Construction Noise Guideline* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.

  NSW noise policies, including the INP, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- Application of reasonable and feasible noise mitigation measures
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Table 14 below (reproduced from Table 2 of the ICNG) sets out the noise management levels and how they are to be applied for residential receivers. The guideline intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 14: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB(A)	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Sensitive Land Use

Table 15 below (reproduced from Table 3 of the ICNG) sets out the noise management levels for various sensitive land use developments.

Table 15: Noise management levels at other noise sensitive land uses

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

Notes: Noise management levels apply when receiver areas are in use only.

APPENDIX E Results of noise and vibration survey

E.1 Ambient and background noise survey

Location L01: West of site, facing the rail corridor

Survey Period: Wednesday 9th May 2018 to Wednesday 16th May 2018

Location L02: East of site, facing Anderson Street

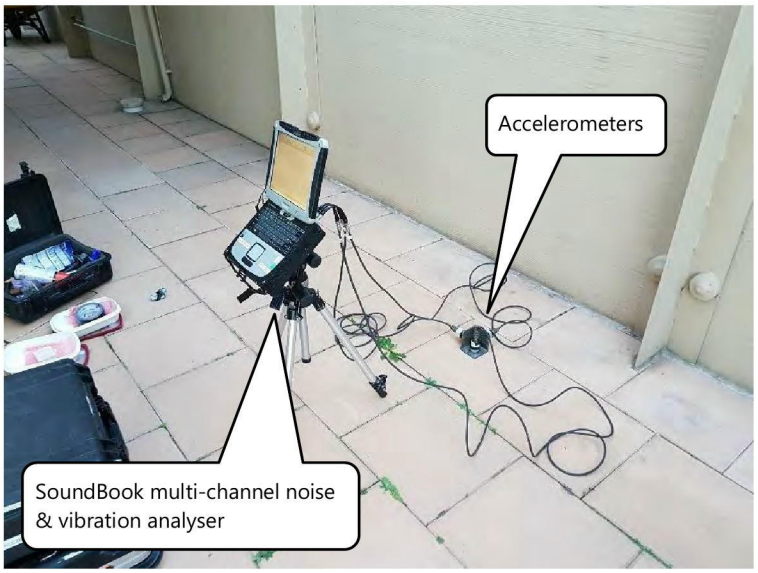
Survey Period: Wednesday 9th May 2018 to Wednesday 16th May 2018

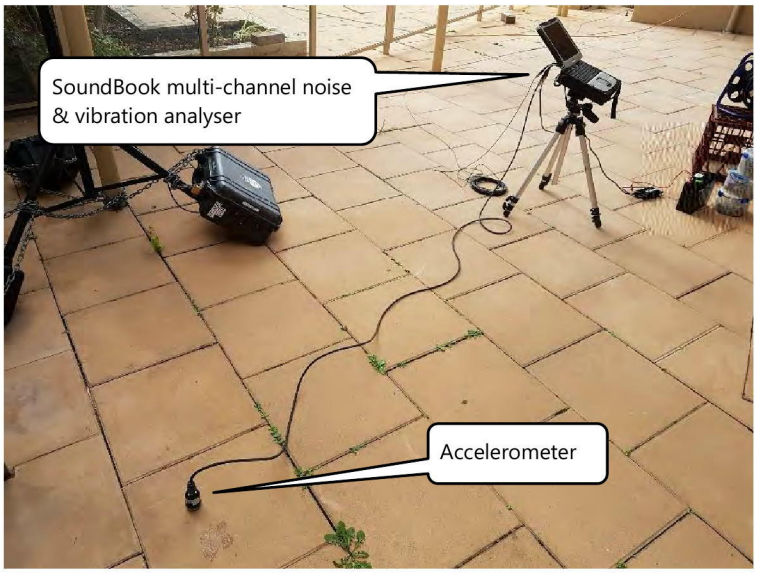
E.2 Operator attended vibration monitoring

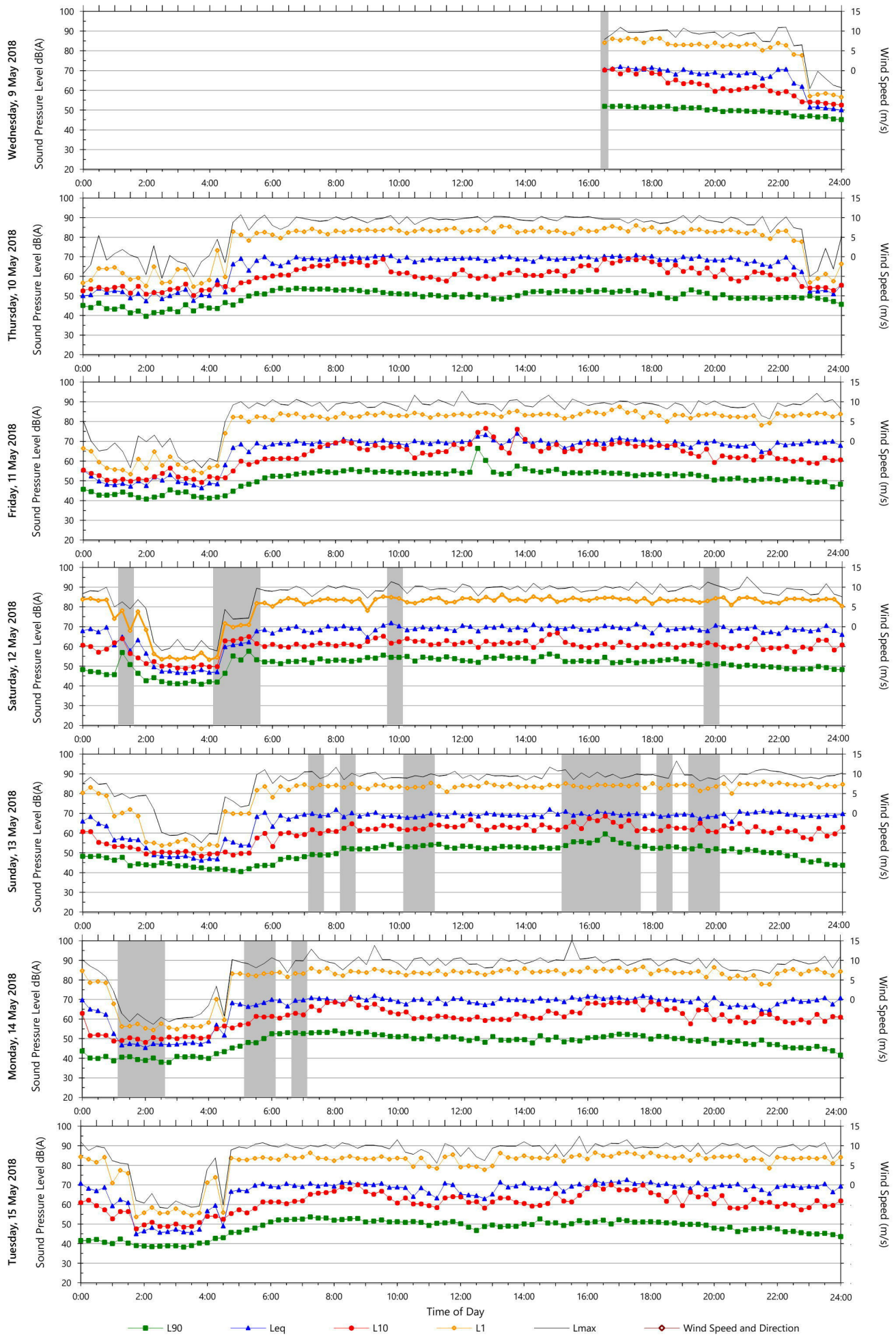
Location S1: On site

Survey Period: Wednesday 9th May 2018 and Wednesday 16th May 2018

Number of trains measured: 25







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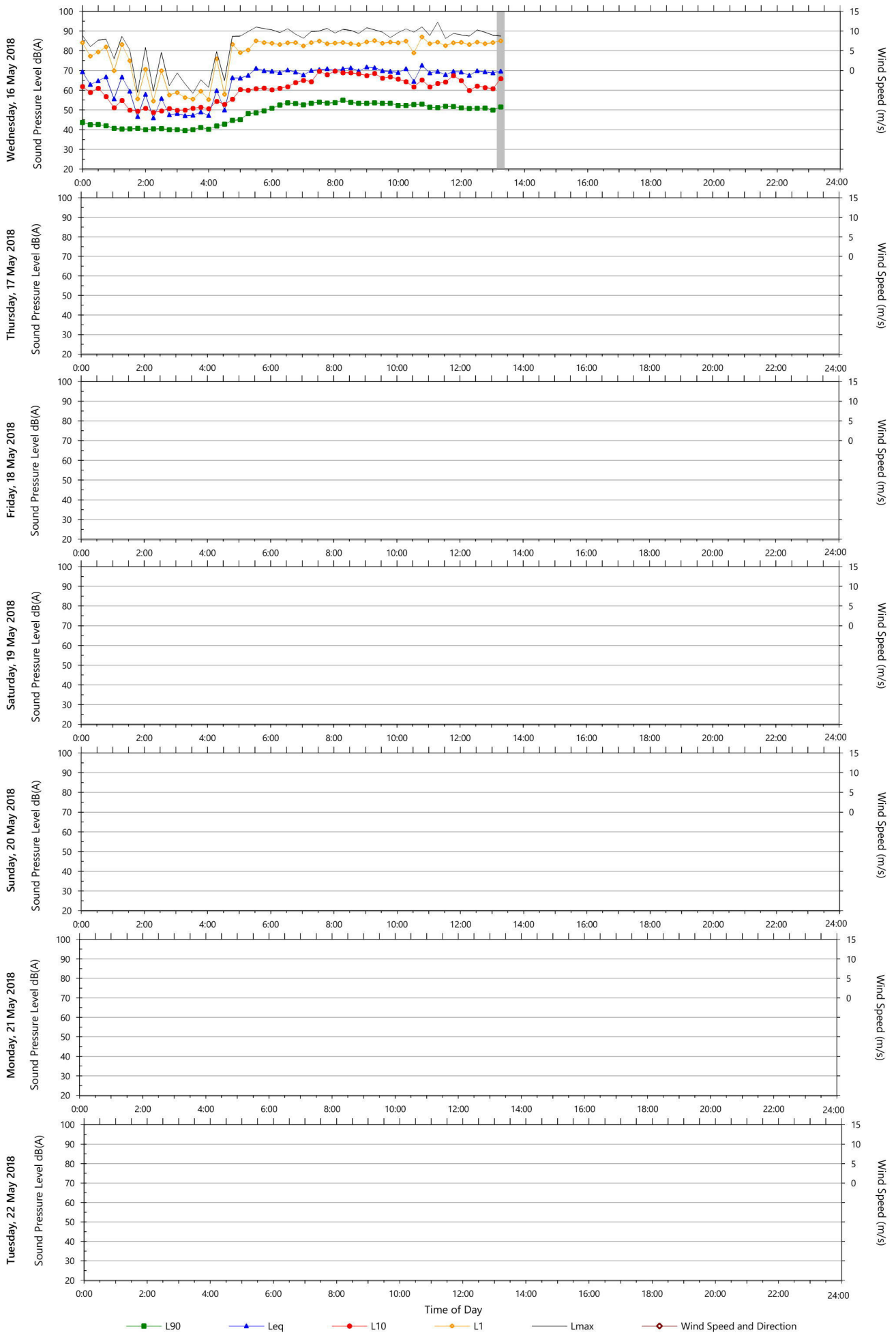
Template: QTE-26 (rev 17) Logger Graphs Program

Unattended Monitoring Results

Location: 58 Anderson Street, Chatswood - Location L01, Facing Rail Corridor



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Unattended Monitoring Results

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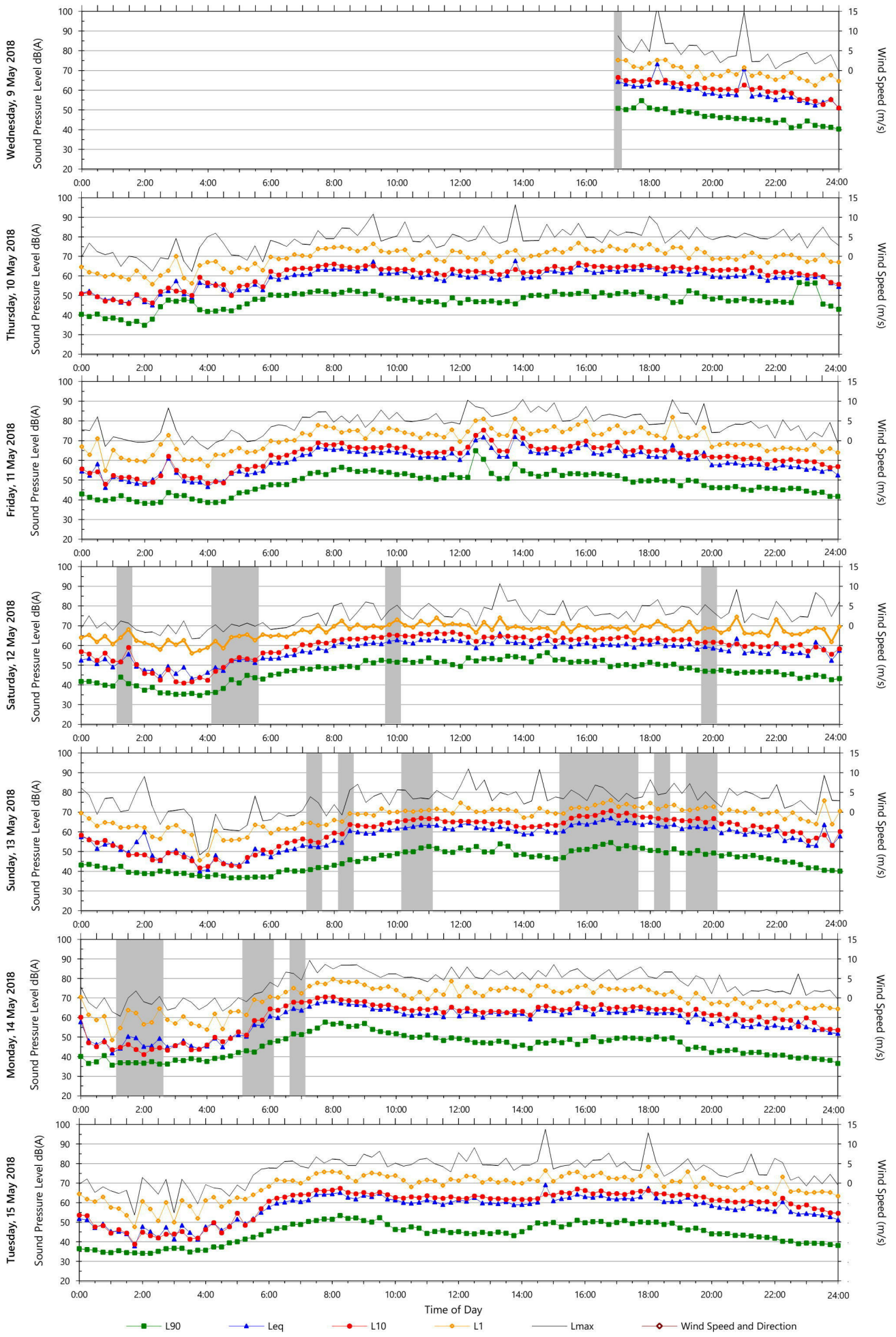

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Unattended Monitoring Results

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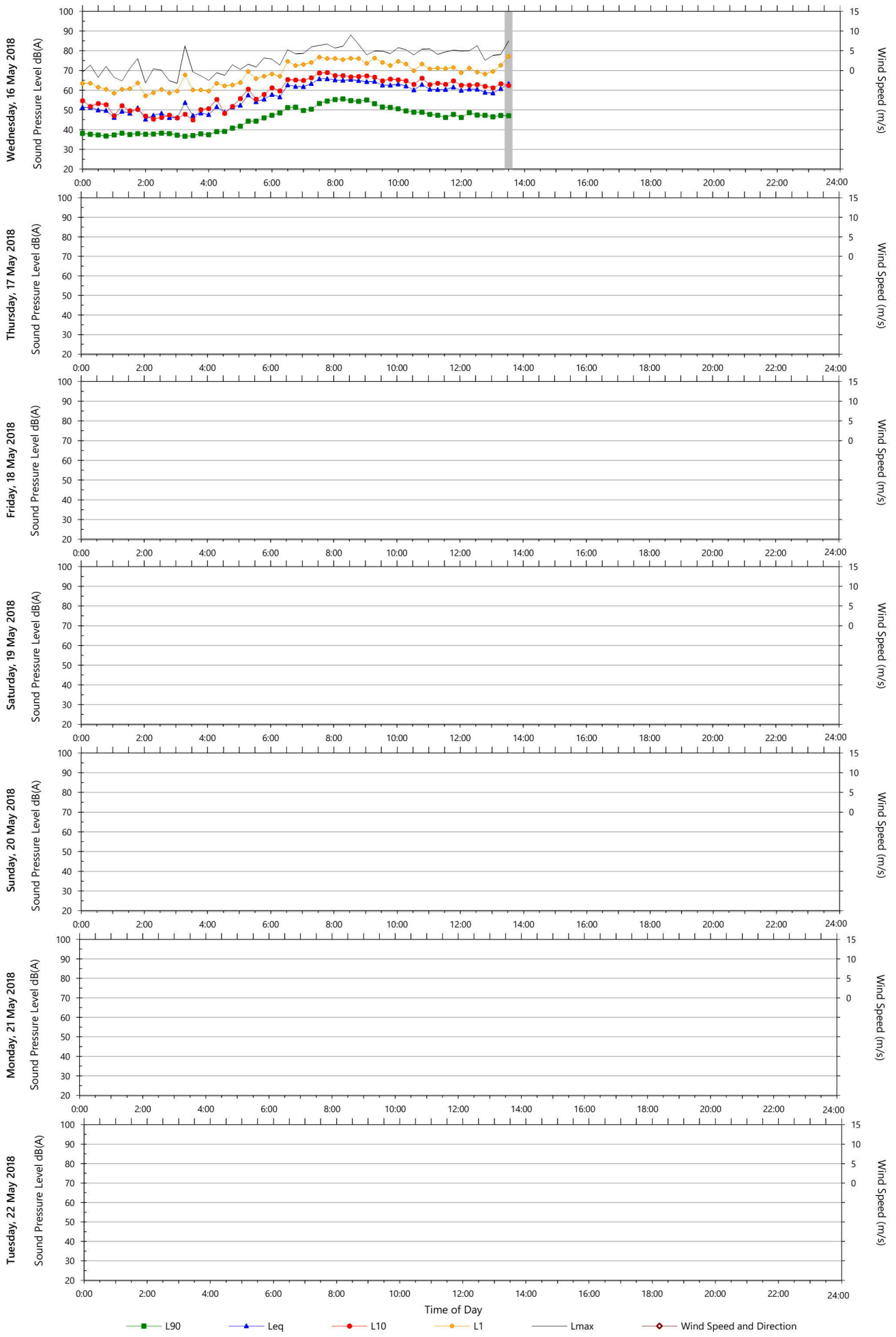

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