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SITE 2, SYDNEY OLYMPIC PARK

Construction Noise and Vibration Management Plan

14 August 2019

Ecove Site 2 Pty Ltd

TK563-01F04 CNVMP (r1)

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1 Introduction

Renzo Tonin & Associates was engaged to prepare a Construction Noise and Vibration Management Plant ('CNVMP') to assess potential noise and vibration impacts associated with the construction phase of the proposed mixed use development at Site 2A and 2B Australia Avenue, Sydney Olympic Park.

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.

1.1 Background

Construction activities associated with the proposed development will likely result in increased noise levels during construction hours. The works undertaken in the various stages of excavation and construction consist of a mixture of both high and low noise activities. This assessment identifies potentially noisy activities, their impacts on surrounding receivers, including the underground rail tunnel, and outlines management strategies to control the impacts of noise and vibration during the excavation and civil works, structure construction, building fit out and landscaping.

1.2 Acoustic assessment requirements

The Department of Planning and Environment issued Secretary's Environmental Assessment Requirements ('SEARs') for the site. The SEARs application SSD 9383 stipulate the following specific requirements regarding the assessment of construction noise and vibration for the project:

11. Noise, Odour and Vibration

The EIS shall:

- *Assess the noise impacts on the proposed development from all surrounding land uses, including from the Olympic Park Rail Line and Sydney Olympic Park events (including impact from fireworks and low frequency noise from amplified music), operations at the Homebush Liquid Waste Treatment Plant and other surrounding commercial and industrial activity.*
- *Identify appropriate noise mitigation measures and management practices to be adopted*
- *Identify the main noise and vibration generating sources and activities at all stages of construction, and any noise sources during operation, outlining measures to minimise and mitigate potential noise and vibration impacts on surrounding occupiers of land.*

13. Construction

The EIS shall include a Construction Pedestrian and Traffic Management Plan addressing:

- *Potential impacts of the construction on surrounding areas including the adjoining rail corridor and the public realm with respect to noise and vibration, air quality and odour impacts, dust and particle emissions, water quality, storm water runoff, groundwater seepage, soil pollution and construction waste*

1.3 Hours of operation

This assessment applies to the proposed construction hours from 7:00am to 6:00pm Monday to Friday and 7:00am to 3:30pm on Saturday. No work is permitted to be carried out on Sundays and Public Holidays.

Rock hammers during excavation will only be used from 8:00am to 5:00pm.

1.4 Summary of works

A preliminary program summary has been developed, as presented in Table 1.1.

Table 1.1: Preliminary program summary

Stage	Description	Estimated Duration (approx.)	
PHASE 1 – Excavation (items will overlap each other)			
2a. Excavation and shoring	• Retention wall piling • Bulk excavation and detailed excavation	22 weeks	
2b. Substructure & inground works	• Foundation piling • Slab construction	8 weeks	
PHASE 2 – Construction (items will overlap each other)		**2A Tower**	**2B**
3a. Structure	Construction of building	78 weeks	60 weeks
3b. Roofing, cladding & façade	Installing roofing & façade	50 weeks	45 weeks
3c. Finishes & services	Fit out works	75 weeks	55 weeks
3d. External works, landscape, & completion	External works & landscape Commissioning and completion	12 weeks	12 weeks

1.5 Construction traffic

The worksite will generate additional traffic movements in the form of:

- Light vehicle movements generated by construction personnel travelling to and from work
- Heavy vehicle movements generated by:
  - Delivery vehicles bringing raw materials, plant, and equipment to the site
  - Spoil trucks removing spoil from the site
  - Concrete trucks bringing concrete to the site

Construction traffic on the site is included as part of the construction noise assessment of the work activities identified in Section 1.4. When construction-related traffic moves on the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as additional road traffic on public roads rather than as part of the construction site's activities.

Access to the site will be from Parkview Drive via Australia Avenue and Homebush Bay Drive. The cumulative average peak vehicle truck movements to/from the site are anticipated to occur during excavation and be in the order of 10-12 trucks per day. This volume of truck traffic is not expected to significantly alter existing traffic noise. Furthermore, for the majority of the construction works (i.e. post excavation), movements are anticipated to be less.

There are no truck movements during the evening (between 6:00pm and 10:00pm) or night (between 10:00pm and 7:00am) periods. Construction traffic from the site on public roads is predicted not to be a significant noise impact and is not further addressed in this report.

1.6 Assessment locations

The nearest noise sensitive receiver locations have been identified and are outlined in Table 1.2 and Figure 1.

Table 1.2: Assessment locations

ID	Nearest Type	Address/description of Nearest Receiver
R1	Residential	11 Australia Avenue, Sydney Olympic Park Multi-storey residential premises located to the south, across Parkview Drive. The northern façade of the property is the assessment location.
R2	Residential	7 Australia Avenue, Sydney Olympic Park Multi-storey residential premises located to the south. The northern façade of the property is the assessment location.
R3	Residential	Botania by Meriton – 68/100 Bennelong Parkway Avenue, Sydney Olympic Park Multi-storey residential premises located to the south. The northern façade of the property is the assessment location.
C1	Commercial	8 Australia Avenue, Sydney Olympic Park Multi-storey commercial premises located to the west, across Australia Avenue. The eastern façade of the property is the assessment location.
C2	Commercial	2-4 Dawn Fraser Avenue Sydney Olympic Park Multi-storey commercial premises located to the west, across Australia Avenue. The eastern façade of the property is the assessment location.
C3	Commercial	Universities Admissions Centre 2/6 Parkview Drive, Sydney Olympic Park Multi-storey commercial premises located to the south west, across Parkview Drive. The northern façade of the property is the assessment location.

ID	Nearest Type	Address/description of Nearest Receiver
C4	Commercial	5 Parkview Drive, Sydney Olympic Park Commercial premises located to the east. The western façade of the property is the assessment location.
OSR1	Active Recreation	Sydney Showground – 1 Showground Road, Sydney Olympic Park A venue located to the north west, across Australia Avenue. The eastern façade of the property is the assessment location.
OSR2	Passive Recreation	Jacaranda Square A passive recreation area located to the west, across Australia Avenue. The eastern site boundary is the assessment location.
OSR3	Childcare	Woodstock Child Care Centre – Shop 5/ 11 Australia Avenue, Sydney Olympic Park A childcare located to the south, across Parkview Drive. The northern façade of the property is the assessment location.
OSR4	Community centre/Place of Worship	Soka Gakkai International Australian Buddhist Centre – 3 Parkview Drive, Sydney Olympic Park Community centre/Place of worship located along the eastern site boundary. The western façade of the property is the assessment location.

Figure 1: Site, receiver and noise monitoring locations

2 Existing noise environment

2.1 Noise monitoring location

Background noise monitoring was conducted at 11 Australia Avenue over the period from 9 November 2018 to 16 November 2018. The background noise monitoring data within this report has been adopted for this assessment and used to establish the existing acoustic environment at the sensitive receiver locations surrounding the construction site.

The long-term measurement locations are outlined in Table 2.1 and shown in Figure 1.

Table 2.1: Noise monitoring location

ID	Location	Description
L1	11 Australia Avenue	Noise monitor was located on the balcony of an apartment facing the road intersection between Australia Avenue and Parkview Drive. Results from this noise monitor represent the ambient and background noise environment for all residential receivers.

APPENDIX A of this report presents a description of noise terms. The long-term noise monitoring methodology is detailed in APPENDIX B. The graphical recorded outputs from long-term noise monitoring are included in APPENDIX F.

2.2 Existing background noise levels

Existing background noise levels are summarised Table 2.2 below.

Table 2.2: Measured existing background (L_{90}) noise levels, dB(A)

Location	L_{90} background noise levels		
	Day[1]	Evening[2]	Night[3]
Location L1 – 11 Australia Avenue	53	49	43

Notes: 1. Day represents the period from 7am to 6pm, Monday to Saturday and 8am to 6pm, Sunday & Public Holidays.
2. Evening represents the period from 6pm to 10pm, Monday to Sunday & Public Holidays
3. Night represents the period from 10pm to 7am, Monday to Saturday and 10pm to 8am, Sundays & Public Holidays

3 Criteria

3.1 Construction noise criteria

3.1.1 Guidelines

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.

Table 3.1 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 3.1: 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	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ 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.

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply
	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 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*.

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

Table 3.2 sets out the ICNG noise management levels for other noise sensitive receiver locations.

Table 3.2: 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.

3.1.2 Construction Noise Goals

Table 3.3 presents the construction noise management levels established for the nearest noise sensitive receivers based upon the long-term monitoring outlined in Section 2. The assessment locations are marked in Figure 1.

Table 3.3: Construction noise management levels at receivers

<table>
<tr><th rowspan="3">ID</th><th rowspan="3">Location description</th><th colspan="3">Noise management level $L_{Aeq(15min)}$[1]</th></tr>
<tr><th>Monday to Fridays</th><th colspan="2">Saturdays</th></tr>
<tr><th>7:00am to 6:00pm</th><th>8:00am to 1:00pm</th><th>7:00am to 8:00am
1:00pm to 3:30pm</th></tr>
<tr><td>R1 - R3</td><td>Residential premises</td><td>63</td><td>63</td><td>58</td></tr>
<tr><td>C1 – C4</td><td>Commercial premises</td><td>70[2]</td><td></td><td></td></tr>
<tr><td>OSR1</td><td>Active Recreation</td><td>65[2]</td><td></td><td></td></tr>
<tr><td>OSR2</td><td>Passive Recreation</td><td>60[2]</td><td></td><td></td></tr>
<tr><td>OSR3</td><td>Education</td><td>65[2,3]</td><td></td><td></td></tr>
<tr><td rowspan="2">OSR4</td><td>Passive Recreation</td><td>60[2]</td><td></td><td></td></tr>
<tr><td>Place of Worship</td><td>65[2,3]</td><td></td><td></td></tr>
</table>

Notes:
1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.
2. Noise management levels apply when receiver areas are in use only.
3. External level - based on assumed façade loss of 20dB(A)

3.2 Construction vibration criteria

3.2.1 Disturbance to Buildings Occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 3.4 provides definitions and examples of each type of vibration.

Table 3.4: Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.

Type of Vibration	Definition	Examples
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

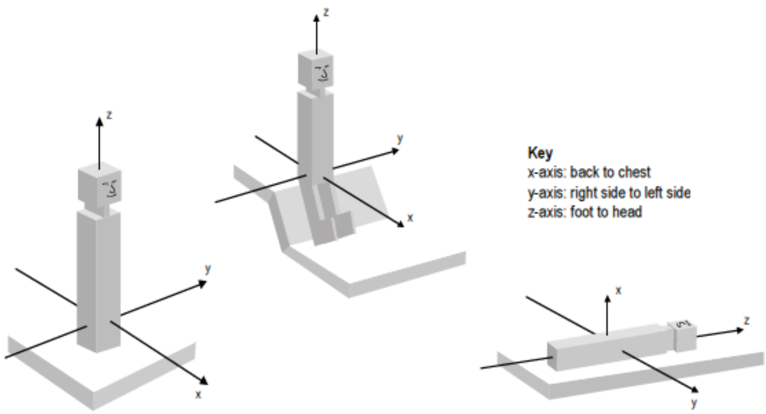
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2: Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 3.5.

Table 3.5: Preferred and Maximum Levels for Human Comfort

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s², 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s², 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 3.6.

Table 3.6: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous of impulsive criteria for critical areas.
Source: BS 6472-1992

3.2.2 Building Damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

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

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *"7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."*

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components*" (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which ‘cosmetic’, ‘minor’ and ‘major’ categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered ‘safe limits’ up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. ‘Minor’ damage is considered possible at vibration magnitudes which are twice those given and ‘major’ damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 3.7 sets out the BS7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, British Standard 7385 Part 2 (1993) notes that “*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*” (p.5).

To determine whether the site buildings are structurally unsound, we recommend a dilapidation survey be conducted. The results of the survey will determine the adoption of the criteria for major or minor damage, rather than cosmetic damage.

Table 3.7: BS 7385 Structural Damage Criteria

<table>
<tr><th rowspan="2">Group</th><th rowspan="2">Type of Structure</th><th rowspan="2">Damage Level</th><th colspan="3">Peak Component Particle Velocity[1], mm/s</th></tr>
<tr><th>4Hz to 15Hz</th><th>15Hz to 40Hz</th><th>40Hz and above</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Reinforced or framed structures Industrial and heavy commercial buildings</td><td>Cosmetic</td><td colspan="3">50</td></tr>
<tr><td>Minor[2]</td><td colspan="3">100</td></tr>
<tr><td>Major[2]</td><td colspan="3">200</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Un-reinforced or light framed structures Residential or light commercial type buildings</td><td>Cosmetic</td><td>15 to 20</td><td>20 to 50</td><td>50</td></tr>
<tr><td>Minor[2]</td><td>30 to 40</td><td>40 to 100</td><td>100</td></tr>
<tr><td>Major[2]</td><td>60 to 80</td><td>80 to 200</td><td>200</td></tr>
<tr><td>Notes:</td><td colspan="5">1. Peak Component Particle Velocity is the maximum peak particle velocity (PPV) in any one direction (x, y, z) as measured by a tri-axial vibration transducer
2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2</td></tr>
</table>

German Standard

German Standard DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases.

The structural damage vibration criteria adopted for this project is presented in Table 3.8.

Table 3.8: DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

3.3 Potential vibration impacts to existing rail tunnel

An existing rail tunnel is located below the construction site. Potential impacts onto the existing rail tunnel is assessed in accordance with the Transport Asset Standards Authority (ASA) document, *Development Near Rail Tunnels Version 2.0*, dated 15 November 2018 (DNRT).

Table 3 within the DNRT provides the construction restrictions that are applied to each protection reserve and is reiterated below.

Table 3.9: Construction restrictions

Types of construction	First Reserve[1]	Second reserve[1]
Excavations for basements, footings	Not allowed	• Excavations less than 2.0 m depth from surface level, assessment not required. • Excavations greater than 2.0 m depth, assessment required.
Shallow footings or pile foundations	Not allowed	Allowed, subject to load restrictions. Assessment required.
Tunnels and underground excavations	Not allowed	Allowed, subject to assessment
Ground anchors	Not allowed	Allowed, subject to assessment
Demolition of existing subsurface structures	Not allowed	Allowed, subject to assessment
Penetrative subsurface investigations	Allowed away from support zone. Assessment required.	Allowed, subject to assessment

Types of construction	First Reserve[1]	Second reserve[1]

Note [1] Reserves defined in Section 5 of DNRT

Furthermore, Section 9.4 of DNRT states the following:

> *Any development that occurs within a distance of 25 m horizontally from first reserve shall assess the vibration ono the rail tunnels. The assessment criteria shall be a maximum peak particle velocity (PPV) of 15 mm/s at the tunnel lining for brick or mass concrete in good condition or a maximum PPV of 20 mm/s at the tunnel lining for cast iron, steel or concrete segment lining.*

4 Construction noise assessment

4.1 Structure-borne noise

Structure-borne noise is a consequence of vibration excitation on a building element or surface causing the element to vibrate, generating noise within the receiving building.

Vibration resulting from the proposed items of construction equipment is unlikely to be audible at the majority of the surrounding receivers but may generate structure-borne noise within Soka Gakkai International Australian Buddhist Centre (OSR4) as this building shares a common boundary. Any potential impacts at this location is expected to primarily occur when excavation is occurring near the property boundary which is expected to be of intermittent duration.

Unlike airborne noise, structure borne noise is difficult to quantify. Noise monitoring maybe required in the event of a compliant to quantify the amount of structure borne noise associated with high impact activities. This will assist in reducing further noise complaints and will facilitate consultation to determine the frequency and duration of any adopted respite periods.

4.2 Proposed construction noise sources

The schedule of items of plant and equipment likely to be used during the excavation and construction of the proposed development is presented in Table 4.1 below.

The majority of the works will be done <u>without</u> concrete saws and <u>without</u> excavators with hammers. There may be minor areas of works for brief periods of time where these tools will be required for excavation. For completeness predictions have been undertaken for times when this equipment may be utilised.

Table 4.1: Typical construction equipment & sound power levels, dB(A) re 1pW

Plant item	Plant description	Sound power levels
Phase 1 - Excavation		
1.	Concrete saw (maybe used for brief periods)	119 (+5 penalty)
2.	20-tonne excavator with hydraulic hammer (maybe used for brief periods)	118 (+5 penalty)
3.	20-tonne excavator with ripper	110
4.	Piling (bored piles)	110
5.	Truck	108
6.	Concrete trucks	108
7.	Mobile crane	105
8.	Delivery Trucks	105
9.	20-tonne excavator with bucket	103
10.	Concrete Pump	102
11.	Whacker Packer	99

Plant item	Plant description	Sound power levels
Phase 2 - Construction		
12.	Truck - cement mixer	108
13.	Hand tools	107
14.	Delivery Trucks	105
15.	Tower crane	105
16.	Concrete pump	102
17.	Bobcat	102
18.	Concrete vibrator	100

The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the Interim Construction Noise Guideline (ICNG), information from past projects and/or information held in our library files.

4.3 Predicted Noise Levels

Noise levels at any receiver location resulting from construction works would depend on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Table 4.2 presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the proposed site. The noise level range presented represents the plant item operating at a location furthest from the receiver and a location closest to the receiver. Noise levels were calculated taking into consideration attenuation due to distance between the construction works and the receiver locations and any intervening structures. The noise predictions are conservative and do not include any reductions from the building façade, once built.

Table 4.2: Predicted $L_{Aeq(15min)}$ noise levels for typical construction plant, dB(A)

Plant Item	Plant Description	Predicted $L_{Aeq(15min)}$ Construction Noise Levels											
		R1	R2	R3	C1	C2	C3	C4	OSR1	OSR2	OSR3	OSR4	
Noise Criteria	*Mon-Fri – 7:00am to 6:00pm*	*63*	*63*	*63*	*70*	*70*	*70*	*70*	*65*	*60*	*65*[1]	*60*	*65*[1]
	Sat – 8:00am to 1:00pm	*63*	*63*	*63*									
	Sat – 7:00am to 8:00am *Sat – 1:00pm to 3:30pm*	*58*	*58*	*58*									
Phase 1 - Excavation													
1.	Concrete saw (maybe used for brief periods)	68-81	43-70	61-68	64-76	69-78	62-78	60-74	60-69	60-75	63-78	47-72	65-88
2.	20-tonne excavator with hydraulic hammer (maybe used for brief periods)	67-80	42-69	60-67	63-75	68-77	61-77	59-73	59-68	59-74	62-77	46-71	64-87
3.	20-tonne excavator with ripper	54-67	29-56	47-54	50-62	55-64	48-64	46-60	46-55	46-61	49-64	33-58	51-74
4.	Piling (bored piles)	54-67	29-56	47-54	50-62	55-64	48-64	46-60	46-55	46-61	49-64	33-58	51-74
5.	Truck	52-65	27-54	45-52	48-60	53-62	46-62	44-58	44-53	44-59	47-62	31-56	49-72
6.	Concrete trucks	52-65	27-54	45-52	48-60	53-62	46-62	44-58	44-53	44-59	47-62	31-56	49-72
7.	Mobile crane	49-62	24-51	42-49	45-57	50-59	43-59	41-55	41-50	41-56	44-59	28-53	46-69
8.	Delivery Trucks	49-62	24-51	42-49	45-57	50-59	43-59	41-55	41-50	41-56	44-59	28-53	46-69
9.	20-tonne excavator with bucket	47-60	22-49	40-47	43-55	48-57	41-57	39-53	39-48	39-54	42-57	26-51	44-67
10.	Concrete Pump	46-59	21-48	39-46	42-54	47-56	40-56	38-52	38-47	38-53	41-56	25-50	43-66
11.	Whacker Packer	43-56	18-45	36-43	39-51	44-53	37-53	35-49	35-44	35-50	38-53	22-47	40-63
Nosiest activity plant (including saw/hammer) operating		**68-81**	**43-70**	**61-68**	**64-76**	**69-78**	**62-78**	**60-74**	**60-69**	**60-75**	**63-78**	**47-72**	**65-88**
Nosiest activity (not including saw/hammer) operating		**54-67**	**29-56**	**47-54**	**50-62**	**55-64**	**48-64**	**46-60**	**46-55**	**46-61**	**49-64**	**33-58**	**51-74**
Phase 2 - Construction													
12.	Truck - cement mixer	52-69	26-54	28-52	49-64	53-67	46-62	44-58	45-54	47-59	47-64	32-56	47-73
13.	Hand tools	51-68	25-53	27-51	48-63	52-66	45-61	43-57	44-53	46-58	46-63	31-55	46-72
14.	Delivery Trucks	49-66	23-51	25-49	46-61	50-64	43-59	41-55	42-51	44-56	44-61	29-53	44-70
15.	Tower crane	49-66	23-51	25-49	46-61	50-64	43-59	41-55	42-51	44-56	44-61	29-53	44-70
16.	Concrete pump	46-63	20-48	22-46	43-58	47-61	40-56	38-52	39-48	41-53	41-58	26-50	41-67
17.	Bobcat	46-63	20-48	22-46	43-58	47-61	40-56	38-52	39-48	41-53	41-58	26-50	41-67
18.	Concrete vibrator	44-61	18-46	20-44	41-56	45-59	38-54	36-50	37-46	39-51	39-56	24-48	39-65
Nosiest activity operating		**52-69**	**26-54**	**28-52**	**49-64**	**53-67**	**46-62**	**44-58**	**45-54**	**47-59**	**47-64**	**32-56**	**47-73**

Note 1. External noise criteria

The predicted noise levels presented above indicate that the noise levels from the majority of the items of plant and equipment are predicted to exceed the established noise criteria, particularly when operating near the corresponding receiver location. There may be instances when residential receiver R1 will be highly noise affected when saws and hydraulic hammers are operating near the closest boundary to the receiver. It has been advised that saws and hammers will only be used during brief periods and that rippers will be predominantly used throughout the excavation, substantially reducing impacts.

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 4.4 below.

4.4 Construction noise mitigation measures

4.4.1 General engineering noise controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', are expected to reduce predicted construction noise levels.

Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 4.3 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 4.3: Relative effectiveness of various forms of noise control

Noise control method	Practical examples	Typical noise reduction possible in practice, dB(A)		Maximum noise reduction possible in practice, dB(A)	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as temporary or permanent noise barriers where barrier breaks line-of-sight between the source and receiver	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30

Noise control method	Practical examples	Typical noise reduction possible in practice, dB(A)		Maximum noise reduction possible in practice, dB(A)	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table 4.4 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 4.4: Possible noise control measures for likely construction plant

Plant Description	Screening	Acoustic enclosures	Silencing	Alternative process
Tracked excavator	✔	✖	✔	✖
Machine mounted hydraulic drill	✔	✖	✔	✖
Concrete truck	✔	✖	✔	✖
Delivery trucks	✔	✖	✔	✖
Electric crane	✔	✔	✖	✖
Hand tools	✔	✖	✔	✖

4.4.2 Noise Management Measures

The following recommendations provide feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. A strong justification must be provided for not implementing the proposed measures if they are later determined on-site not to be feasible or reasonable.

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.

General noise management measures

The following general noise management measures are recommended for all receiver locations:

- Use less noisy plant and equipment, where feasible and reasonable.
- Plant and equipment must be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.

- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work must be switched off.
- Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be limited/avoided where possible.
- The offset distance between noisy plant and adjacent sensitive receivers is to be maximised where practicable.
- Plant used intermittently to be throttled down or shut down when not in use where practicable.
- Noise-emitting plant to be directed away from sensitive receivers where possible.
- Staging of construction works so as to erect solid external walls first and utilising them to provide noise shielding to the noise sensitive receivers. However, the structural integrity of the external walls should be investigated prior to implementing this measure and should be prioritised over the noise benefits.
- In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint will need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community must be adequately trained and experienced in such matters.

Specific Noise Management Measures

Other potential mitigation measures include:

- Installation of 2.4m high hoardings (17mm plywood) along the site boundaries.
- The proposal has been carefully considered with regard to the length of time on-site, in order to reduce the amount of noise exposure to the identified receivers.
- The use of concrete saws and excavators with rock hammers will be limited. There may be minor areas of works for brief periods of time where these tools will be required during excavation but excavators with ripper attachments will primarily be used.

- A respite period can be agreed upon with the neighbouring premises if the residences/tenants occupy the surrounding premises during the construction periods. Potential respite periods would be limiting use of high impact activities, such as concrete sawing and hammering, to 8:00am to 5:00pm with a 1 hour break during this period.
- All employees, contractors and subcontractors are to receive site induction and toolbox talks and ongoing training so that the above noise management measures are implemented accordingly. Content within toolboxes will include, location of nearest sensitive receivers; relevant project specific and standard noise and vibration mitigation measures; permissible hours of work, truck route and truck loading restrictions and construction employee parking areas.

It is noted that most hand tools will likely be used when a part of the structure has been erected and this in-turn can be used to provide acoustic shielding to the identified receivers.

4.4.3 Noise Monitoring

The following approach must be adopted with regard to noise monitoring procedures during the construction works. Details of the procedures for noise monitoring are presented in APPENDIX C.

- Where potential noise impacts are predicted to be up to 10dB(A) above the noise criteria, all feasible and reasonable noise reduction measures must be investigated, where necessary.
- Where potential noise impacts are predicted to be more than 10dB(A) above the noise criteria, the potential construction noise nuisance is considered to be moderate. In the event of a compliant, noise monitoring may be carried out to confirm predicted noise impacts. Reasonable and feasible noise reduction measures must be investigated, where necessary.

5 Construction vibration assessment

5.1 Vibration Sources

The vibration generated from construction works will vary depending on the level and type of activity carried out at each site during each activity.

Potential vibration generated at receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver building's construction and structure. The recommended minimum working distances for vibration intensive plant are presented in Table 5.1.

Table 5.1: Recommended minimum working distances for vibration intensive equipment

Plant item	Minimum working distance, m			
	Cosmetic damage			Human disturbance
	Commercial and industrial buildings[1]	Dwellings and similar structures[1]	Sensitive structures (e.g. heritage)[1]	Residences Day[2]
Truck traffic (over irregular surfaces)	5	5	10	20
Excavator <=30 Tonne (travelling/ digging)	5	10	10	20
Excavator hydraulic hammer	5	10	10	20

Notes: 1. Criteria referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration.
2: Daytime is 7 am to 10 pm;

Site specific buffer distances for vibration significant plant items must be measured on site where plant and equipment is likely to operate close to or within the minimum working distances for cosmetic damage.

Unlike noise, vibration cannot be 'predicted' due to many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

5.2 Potential vibration impacts to residential and commercial uses

Based on the proposed plant items presented, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 5.2 below. The assessment is relevant to the identified residential buildings and other similar type structures in the project area.

Table 5.2: Potential Vibration for Residential and Commercial Properties

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
R1	20m	Commercial	Low risk of structural damage from construction works	Low to medium risk of adverse comment as a result of construction works	Vibration monitoring is recommended to be conducted at commencement of works to establish site specific minimum working distances and/or in the event of a complaint.
R2	110m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Vibration monitoring not required
R3	145m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Vibration monitoring not required
C1	35m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Vibration monitoring not required
C2	30m	Commercial	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required
C3	45m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Vibration monitoring not required
C4	80m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Vibration monitoring not required
OSR1	85m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Vibration monitoring not required
OSR2	30m	Commercial	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
OSR3	20m	Commercial	Low risk of structural damage from construction works	Low to medium risk of adverse comment as a result of construction works	Vibration monitoring is recommended to be conducted at commencement of works to establish site specific minimum working distances and/or in the event of a complaint.
OSR4	8m	Commercial	Low risk of structural damage from construction works	Medium risk of adverse comment as a result of construction works	Vibration monitoring is recommended to be conducted at commencement of works to establish site specific minimum working distances and/or in the event of a complaint.

Note: 1. The sources of vibration levels are the excavator hammering near the property boundaries. If alternative equipment with higher vibration levels are used, there is an additional risk.

Based on the above assessment for the receivers surrounding the site, Receiver OSR4 is at most risk from vibration impacts from the construction works. The main risks are from excavators. The establishment of site specific buffer distances is recommended for vibration inducing equipment.

Plant and equipment vibration measurement procedure is further detailed in APPENDIX D.

Recommendations for reducing potential vibration impacts are provided in the sections below.

5.3 Potential vibration impacts to existing rail tunnel

Excavation works is not proposed to occur within the First Reserve zone. The closest distance that excavation will occur to the rail tunnel is approximately 4m. Other construction works (i.e. landscaping and building construction) may occur in closer proximity, where the top of the rail tunnel approaches the surface.

Given the proximity of the construction works to the rail tunnel, vibration monitoring is recommended to be undertaken throughout the works. Monitoring will determine if the vibration limits, identified in Section 3.3, are exceeded. In the event of exceedance, construction techniques will need to be altered to ensure vibration limits are satisfied.

5.4 Vibration Mitigation Measures

The following vibration mitigation measures are recommended to minimise vibration impact from construction activities to the nearest affected receivers:

1. A management procedure must be implemented to deal with vibration complaints. Each complaint must be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures must be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures must be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Where construction activity occurs in close proximity to sensitive receivers or on material that will cause vibration to all identified receivers, vibration testing of actual equipment on site must be carried out prior to their commencement of site operation to determine acceptable buffer distances to the nearest affected receiver locations.

4. Dilapidation surveys must be conducted at all receivers within close proximity of the construction site. Notification by letterbox drop would be carried out for all buildings in the vicinity of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property. Notification is to be provided to all occupants prior to any works that may cause vibration.

6 Complaints Management

Noise and vibration levels generated by construction activities associated with the construction of the development must aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

The contractor is responsible for implementing this Construction Noise and Vibration Management Plan and ensuring that all reasonable measures are implemented such as the provision of a Noise and Vibration Complaints Program, to minimise the generation of excessive noise and/or vibration levels from the site to nearby sensitive areas.

Owners and occupants of nearby affected properties are to be informed by direct mail of a direct telephone line and contact person where any noise and/or vibration complaints related to the operation of the construction activities are to be reported.

All noise and/or complaints shall be investigated in accordance with the Noise / Vibration Complaint Management Procedure identified in of this report.

7 Conclusion

This CNVMP has been prepared by Renzo Tonin & Associates for the proposed mixed use residential development at Site 2A and 2B Australia Avenue, Sydney Olympic Park. The assessment has been prepared to address the requirements of SEARs application SSD 9383.

The expected construction noise levels have been predicted and presented in Section 4.3. Noise mitigation and management measures have been presented in Section 4.4 to aid in providing additional noise reduction benefits where exceedance of the objective occurs.

Vibration impacts and management measures have been presented in Section 5 to aid in minimising any potential vibration impacts.

The noise impact of construction traffic on the existing road network has been assessed within to not be significant.

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.

Absorption Coefficient α	The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective.
Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Air-borne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
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.
Amenity	A desirable or useful feature or facility of a building or place.
AS	Australian Standard
Assessment period	The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
Audible Range	The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
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. 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 LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Berm	Earth or overburden mound.
Buffer	An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use.
Bund	A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound.
BS	British Standard
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)"

Decibel [dB]	The units of sound measurement. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear, defined as 20 micro Pascal 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 110dB Operating a chainsaw or jackhammer 120dB Deafening
dB(A)	A-weighted decibel. 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 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. The dB(C) level is not widely used but has some applications.
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.
DIN	German Standard
ECRTN	Environmental Criteria for Road Traffic Noise, NSW, 1999
EPA	Environment Protection Authority
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion. A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.
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.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
IGANRIP	Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, NSW DEC 2007

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.
INP	NSW Industrial Noise Policy, EPA 1999
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.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
ISEPP	State Environmental Planning Policy (Infrastructure), NSW, 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	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).
LAeq or Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.
Noise	Unwanted sound
Pre-construction	Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads).
Reflection	Sound wave reflected from a solid object obscuring its path.
RING	Rail Infrastructure Noise Guideline, NSW, May 2013

RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australa. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, NSW, March 2011
Sabine	A measure of the total acoustic absorption provided by a material. It is the product of the Absorption Coefficient (alpha) and the surface area of the material (m2). For example, a material with alpha = 0.65 and a surface area of 8.2m2 would have 0.65 x 8.2 = 5.33 Sabine. Sabine is usually calculated for each individual octave band (or third-octave).
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 by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the Rw and the sound insulation between two rooms can be described by the DnT,w.
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 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 of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal.
Spoil	Soil or materials arising from excavation activities.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by Rw.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.

Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the Rw or R'w or DnT,w.

APPENDIX B Long-term noise monitoring methodology

B.1 Noise monitoring equipment

A long-term unattended noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave band data	Logger location
RTA07 (NTi XL2)	Type 1	1/1	L1

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 calibrator. No significant drift in calibration was observed.

B.2 Meteorology during monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NSW INP. Determination of extraneous meteorological conditions was based on data provided by the Bureau of Meteorology (BOM), for a location considered representative of the noise monitoring location(s). However, the data was adjusted to account for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10m above ground level, and the microphone location, which is typically 1.5m above ground level (and less than 3m). The correction factor applied to the data is based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B.3 Noise vs time graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually ten to fifteen minutes. The Noise -vs- Time graphs representing measured noise levels, as presented in this report, illustrate these concepts for the broadband dB(A) results.

APPENDIX C Specification for construction noise monitoring

C.1 Scope

This document specifies methods for undertaking noise monitoring during the construction phase of the project.

C.2 Referenced standards and guidelines

- Australian Standard AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters - Specifications*'
- Australian Standard AS 1259.2-1990 '*Acoustics - Sound Level Meters*'
- Australian Standard AS 1055-1997 '*Acoustics - Description and Measurement of Environmental Noise*'
- NSW '*Interim Construction Noise Guideline*' (Department of Environment and Climate Change 2009)
- NSW '*Industrial Noise Policy*' (Environment Protection Authority 2000)

C.3 Testing procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All noise monitoring equipment used must be at least Type 2 instruments as described in AS 1259.2-1990 and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of long-term noise monitoring, calibration levels shall be checked at minimum weekly intervals.

Long-term noise monitoring equipment or Noise Loggers, consist of sound level meters housed in weather resistant enclosures. The operator may retrieve the data at the conclusion of each monitoring period in person or remotely if the logger is fitted with mobile communications.

All environmental noise measurements shall be taken with the following meter settings:

- Time constant: FAST (ie 125 milliseconds)
- Frequency weightings: A-weighting
- Sample period: 15 minutes

All outdoor noise measurements shall be undertaken with a windscreen over the microphone. Windscreens reduce wind noise at the microphones.

Measurements of noise should be disregarded when it is raining and/or the wind speed is greater than 5m/s (18km/h).

C.4 Long-term (unattended) monitoring

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

Noise monitoring equipment shall be placed at positions which have unobstructed views of general site activities, while acoustically shielded as much as possible from non-construction site noise (eg. road traffic, rail noise and other surrounding noise).

Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory for later retrieval is the following A-weighted noise levels: L_{min}, L_{90}, L_{eq}, L_{10}, L_1 and L_{max}.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Meteorological conditions including wind velocity, wind direction and rainfall shall be monitored over the entire noise monitoring period, either on site or recorded from the nearest weather station to the project site.

C.5 Short-term (attended) monitoring

Where noise complaints or requests from relevant authorities are received, attended short-term noise monitoring shall also be conducted at the requested outdoor location (unless the issue is related to regenerated noise from tunnelling and driveage works) and at any other relevant noise receiver location with closest proximity to the construction activities.

Short-term noise monitoring shall be used to supplement long-term noise monitoring undertaken at nearby locations, and to establish whether noise levels measured by the long-term noise monitors are determined by construction activities carried out on site.

All attended short-term noise monitoring shall be recorded over 15 minute sample intervals. Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory and reported is the following A-weighted noise levels: L_{min}, L_{90}, L_{eq}, L_{10}, L_1 and L_{max}.

In addition to measuring and reporting overall A-weighted noise levels, statistical L_{90}, L_{eq}, L_{10} noise levels shall be measured and reported in third-octave band frequencies from 31.5Hz to 8kHz.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Outdoor noise monitoring is to be undertaken with the microphone at a height of 1.2 – 1.5m from the ground, unless noise measurements are taken from a balcony or veranda, in which case the same microphone height shall apply off the floor.

Noise measurements inside buildings should be at least 1m from the walls or other major reflecting surfaces, 1.2 m to 1.5m above the floor, and 1.5m from windows.

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Results of field calibration checks before and after measurements;
- Description of the time aspects of each measurement (ie sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Weather conditions during measurements, including wind velocity, wind direction, temperature, relative humidity and cloud cover
- Operation and load conditions of the noise sources under investigation
- Any adjustment made for presence or absence of nearby reflecting surfaces; and
- Noise due to other sources (eg traffic, aircraft, trains, dogs barking, insects etc).

APPENDIX D Construction vibration monitoring specification

D.1 Scope

This document specifies methods for undertaking vibration monitoring during the construction phase of the project, where it may be deemed to be required. The vibration monitoring shall be conducted in accordance with DIN 4150.3 Structural Vibration in Buildings – Effects on Structures.

D.2 Referenced Standards and Guidelines

- AS 2775 Mechanical Mounting of Accelerometers
- AS 2670.2 Part 2: Evaluation of human exposure to whole body vibration
- DECC NSW Assessing Vibration: A Technical Guideline
- DIN 4150.3 Structural Vibration in Buildings – Effects on Structures
- BS 7385:1 Evaluation and Measurement for Vibration in Buildings – Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings
- BS 7385:2 Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Groundborne Vibration
- ISO 4866 Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings

D.3 Testing Procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be calibrated at least once every two years to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The monitoring system should also have a measurement frequency range down to 1Hz.

D.3.1 Short-Term (Attended) Monitoring

Vibration monitoring shall be undertaken:

- at the commencement of operation for each plant or activity on site, which has the potential to generate significant vibration levels, so to refine the indicative minimum working distances and provide a site-specific table of minimum working distances

- vibration sensitive locations determined to fall within the 'buffer distances' established for each item of plant. Areas likely to require vibration monitoring are identified in this report; and
- where vibration complaints or requests from relevant authorities, at the requested location and at any other relevant vibration receiver location with closest proximity to the construction activities.

Vibration monitoring shall be undertaken over the following period(s):

- for plant operating within the 'buffer distances', during the commencement of use of each plant on site until site-specific minimum working distances are established; and
- for complaints or requests from relevant authorities, during the of use of requested plant until site-specific minimum working distances are established.

All attended short-term vibration monitoring shall be recorded over 15 minute sample intervals. The magnitude of vibration is to be recorded at a minimum rate of 10 samples per second. The minimum range of vibration metrics to be stored in memory and reported are the following:

- Vibration Dose Values (VDVs)
- root-mean-square (rms) – maximums and statistical levels
- peak-particle velocity (ppv) – maximums and statistical levels.

In addition to measuring and reporting overall vibration, statistical vibration shall also be measured and reported in third-octave band frequencies from 1Hz to 250Hz.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;
- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using either bees wax or a magnetic mounting plate onto a steel washer, plate or bracket which shall be either fastened or glued to the surface of interest; and
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Description of the time aspects of each measurement (i.e. sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Operation and load conditions of the vibrating plant under investigation; and
- Possible vibration influences from other sources (eg domestic vibrations, other mechanical plant, traffic, etc).

D.3.2 Long-Term (Unattended) Monitoring

Vibration monitoring shall be undertaken at vibration sensitive locations determined to fall within the 'minimum working distances' established for each item of plant during the commencement of use of each plant on site.

Vibration monitoring shall be undertaken over the following period(s):

- continuously whilst the vibrating plant is operational within the pre-determined 'minimum working distance' from the potentially affected building.

Vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.

Vibration is to be recorded at a minimum rate of 10 samples per second. The data is to be processed statistically and stored in memory. The minimum range of vibration metrics to be stored in memory for later retrieval is the following:

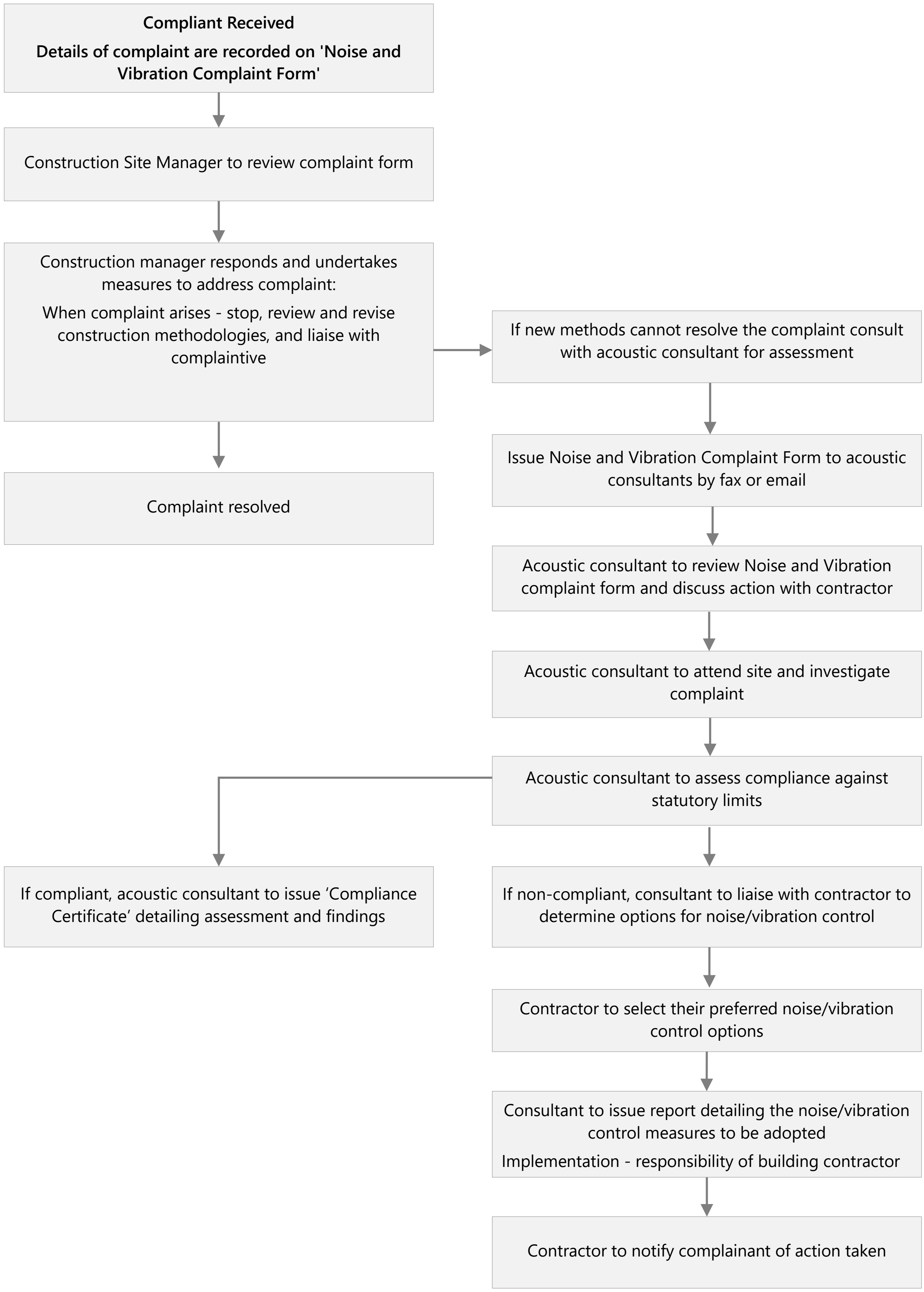
- Vibration Dose Values (VDVs)
- vector-sum root-mean-square (rms) – maximums and statistical metrics; and
- vector-sum peak-particle velocity (ppv) – maximums and statistical metrics.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;

- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using bees wax or a magnetic mounting plate onto a steel plate or bracket either fastened or glued to the surface of interest;
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that; and
- a flashing light alarm should be attached in a visible position from the construction work area. When vibration exceeds the set threshold, the light will flash notifying the operator that works in that area should cease immediately.

APPENDIX E Noise/Vibration Complaint Management Procedure



NOISE/ VIBRATION COMPLAINT FORM

Project title: ______________________ **Date:** ______________

Site contractor: ______________________ **Phone:** ______________

Site contact: ______________________ **Email:** ______________

Complaint details

Received by (circle): Phone / Email / In person / Other: ______________

Name: ______________________ H Ph: ______________

Address: ______________________ W Ph ______________

Email: ______________________ M Ph ______________

Describe when the problem occurred (date and time), what equipment caused the complaint (if known) and where person was standing when he/she experienced the noise/vibration:

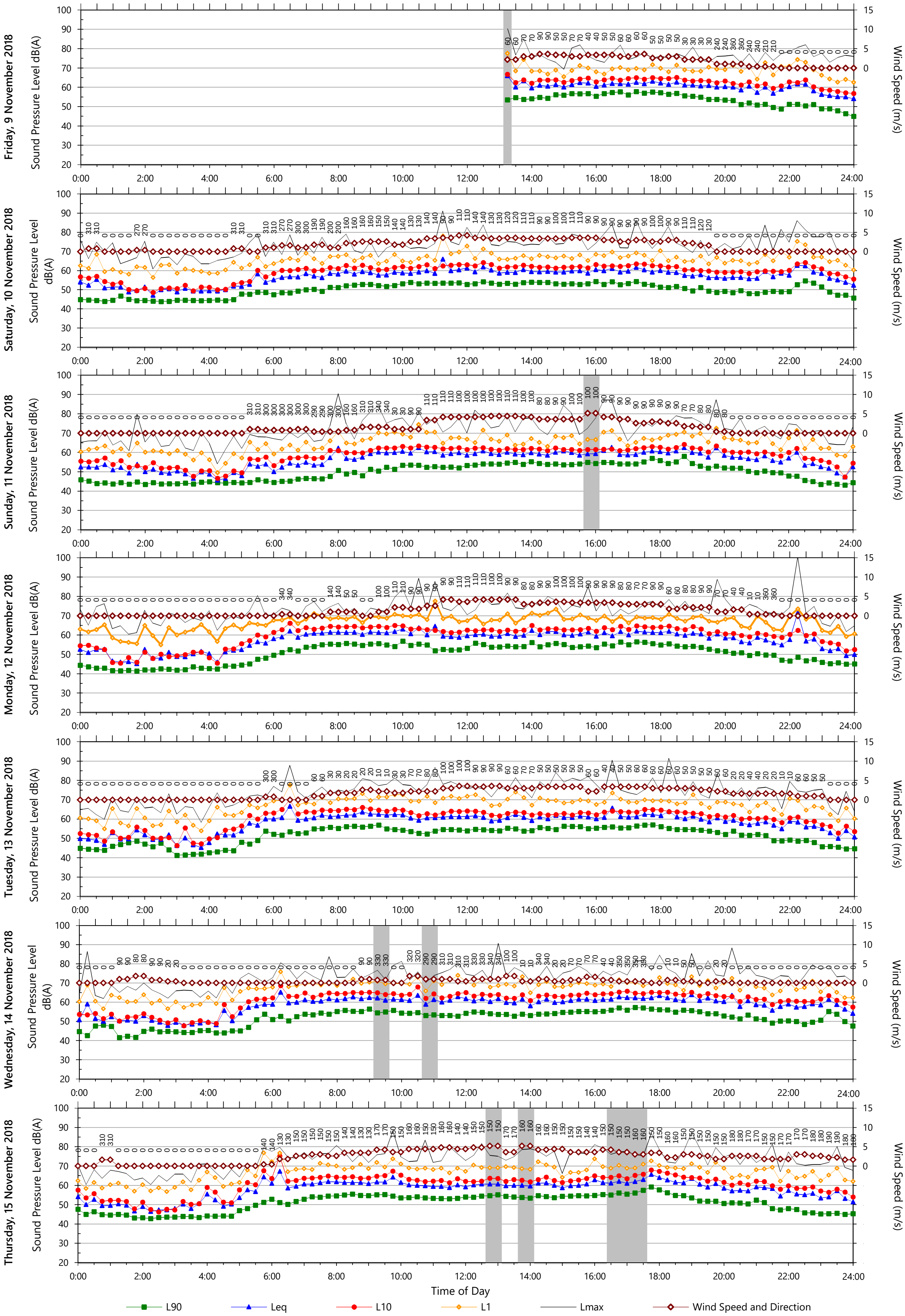
Investigation

Question foreman responsible on site and obtain information on what equipment or processes would most likely have caused the complaint:

Following approval from the Project Manager, email/fax this form to Renzo Tonin & Associates

APPENDIX F Long-term noise monitoring results

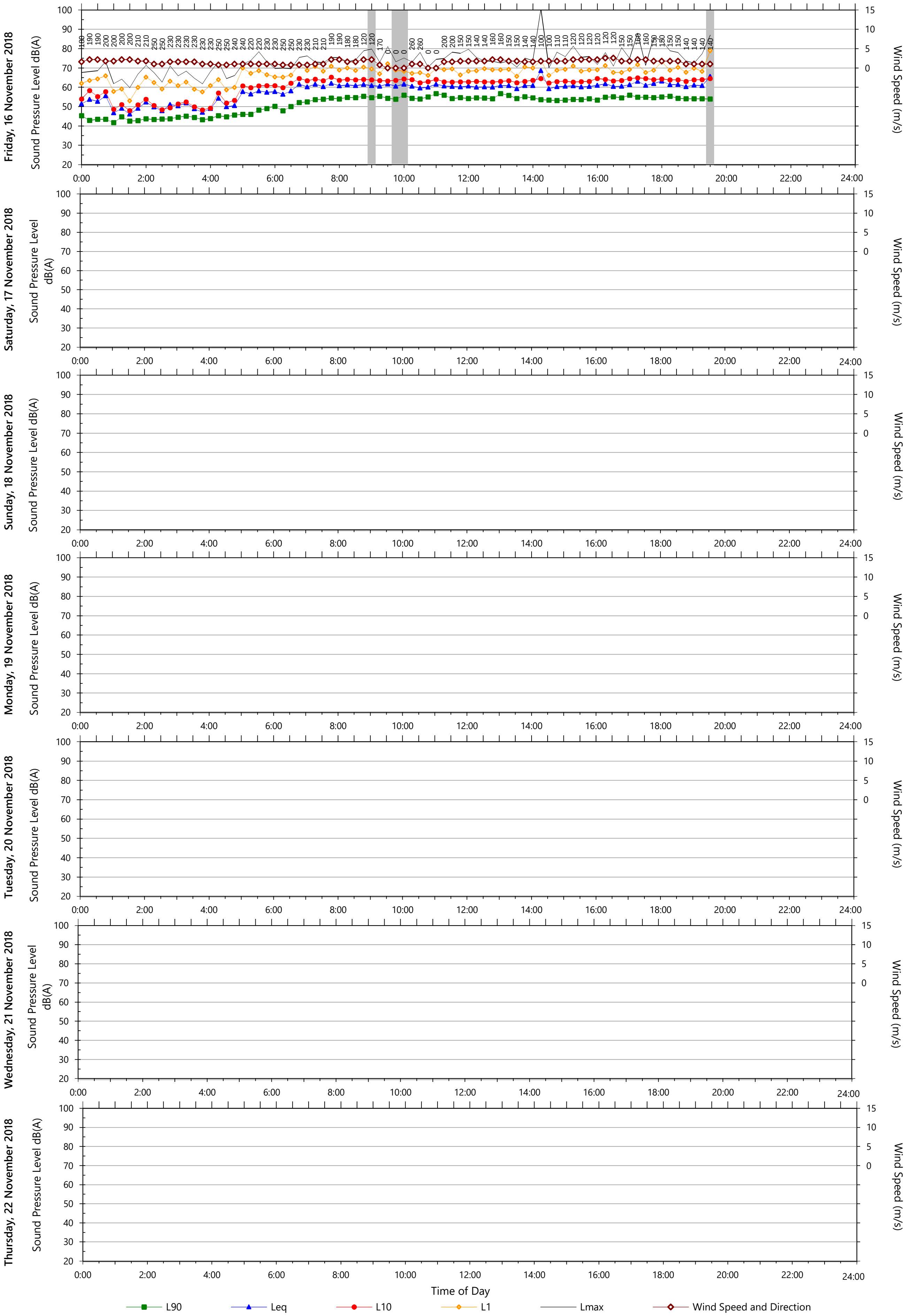
Unattended Monitoring Results | **Location: Balcony of 502/11 Australia Ave**



Data File: 2018-11-09_SLM_000_123_Rpt_Report.txt

Template: QTE-26 (rev 21) Logger Graphs Program

Unattended Monitoring Results **Location: Balcony of 502/11 Australia Ave**



Data File: 2018-11-09_SLM_000_123_Rpt_Report.txt

Template: QTE-26 (rev 21) Logger Graphs Program