Greenbox Architecture

Lane Cove West Data Centre

Acoustic Assessment - SSD 9741

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Job number 259234

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Contents

Appendices

1 Introduction

Arup has been engaged to prepare an acoustic assessment for the proposed datacentre at 1 Sirius Road, Lane Cove West. The assessment has been carried out in accordance with the requirements of the NSW Department of Planning and Environment (DPE), with reference to the following policy and guidelines:

- NSW *Noise Policy for Industry* [1]
- NSW *Interim Construction Noise Guideline* [2]
- NSW *Assessing vibration – a technical guideline* [3]

It is noted that this assessment does not evaluate noise levels within the building as it is not relevant to the approval process.

1.1 Project description

The proposed data centre is to be located at 1 Sirius Road in Lane Cove Business Park, on a previously undeveloped plot of land that has been zoned for industrial use.

The proposed data centre is comprised of the following major relevant components:

- Basement containing 78 x transformers and associated electrical plant.
- External rooftop plant consisting of 30 x water-cooled chillers / cooling towers, 34 x standby generators and 29 x transformers.
- Additional 14 x standby generators on external raised platform.
- Intermediate floors with Data Halls.
- Offices and amenities.

It is understood that the generators will be operational only during an emergency situation (i.e. power failure) or during monthly maintenance and testing, where only one unit will be operational at a time. The testing will occur during the daytime.

1.2 Scope of assessment

The following outlines the scope of assessment with respect to the above acoustic aspects and relevant policies and guidelines:

- Examine the proposed development plans to identify acoustic aspects of the construction and operation of the development.
- Identify the land use and development surrounding the site, which are to be assessed with regard to construction and operational activities.

- Conduct noise level monitoring to quantify the existing acoustic environment at relevant surrounding receiver locations to set project targets in accordance with relevant policy.
- Where appropriate, carry out a quantitative acoustic assessment of potential impacts and compare against the relevant noise and vibration targets.
- Identify where further design development is required and identify in-principle mitigation or management methods for the control of noise and vibration where required.
- Outline the processes to be adopted for the continued design development of acoustic aspects for the project.

2 Assessment locations

The subject site (S1) is on the edge of the Lane Cove Business Park and so the nearest receivers are commercial premises to the east and south, the closest commercial receiver being approximately 10 m away (C1). There are serviced apartments approximately 250 m to the north east of the proposed site (R1). Beyond the apartments, there are residential premises to the north. There are also residential premises to the northwest (R2) and west (R3) of the proposed development; approximately 450 m and 650 m distant, respectively. The Lane Cove Bushwalk (P1) runs alongside the river and passes the proposed development and is approximately 80 m away.

Table 1 and Figure 1 elaborate on the subject site (S1) and its surroundings.

Table 1: Assessment locations

Type	ID	Address	Description
Residential	R1	150 Epping Road, Lane Cove	Residential apartment complex to the northeast of the subject site
Residential	R2	65 Magdala Road, North Ryde	Residential building to the northwest of the subject site
Residential	R3	14 Jeanette Street, East Ryde	Residential building to the west of the subject site
Commercial	C1	1A Sirius Road	Commercial building to the east of the subject site
Passive Recreation	P1	Lane Cove Bushwalk	River walk to the west-northwest of the subject site

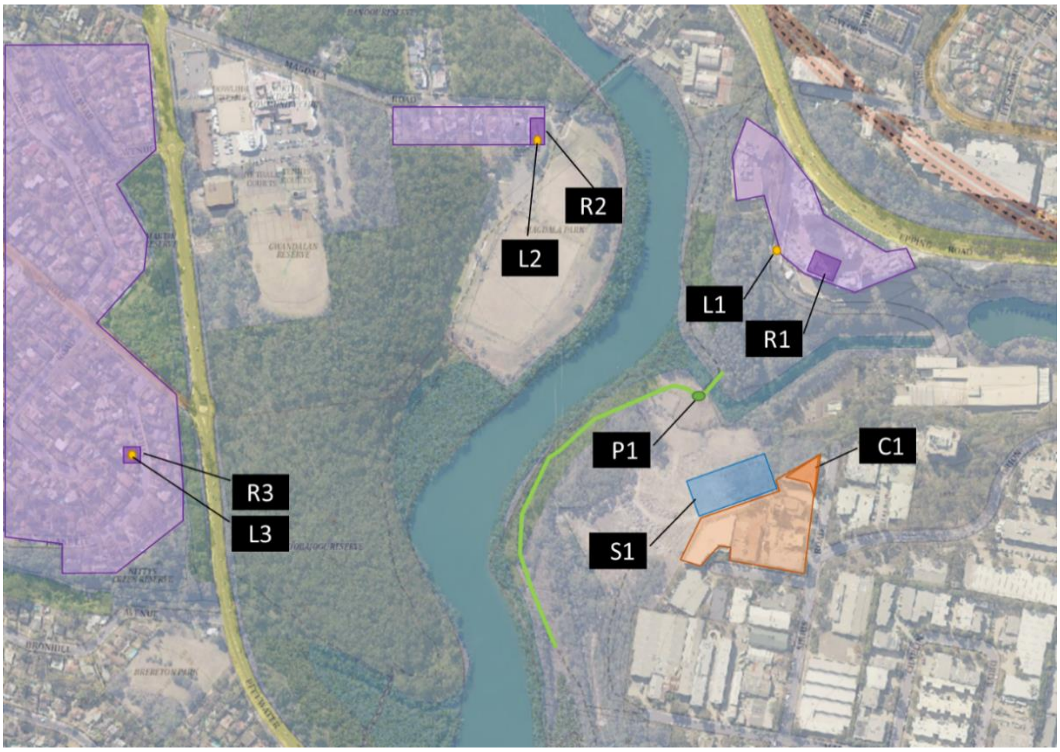


Figure 1: Site (S1), assessment (R1-3, P1, C1) and noise monitoring locations (L1-3)

3 Existing acoustic environment

Criteria for the assessment of operational noise are usually derived from the existing noise environment of an area, excluding noise from the subject site. Existing ambient noise levels are required for the establishment of the intrusive noise criteria, applying only to residential locations. All other receivers have fixed criteria applied.

3.1 Measurement methodology

Fact Sheet A of the NSW EPA *Noise Policy for Industry* (NPI) outlines two methods for determining the background noise level of an area, being Long-term and Short-term. This assessment has used a combination of long-term and short-term noise monitoring.

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

3.2 Long-term noise monitoring

Long-term measurements are identified in Table 2.

Table 2: Long-term logger location

Type	ID	Address	Description
Residential	L3	14 Jeanette Street, East Ryde	Residential building to the west of the subject site. The logger was located in the front garden, close to Jeanette Street. The microphone was approximately 1.5 m above the ground in the free-field.

Long-term noise monitoring was carried out from Friday, 23 November 2018 to Monday, 26 November 2018]. The long-term noise monitoring methodology and noise level-vs-time graphs of the data are included in Appendix B.

It should be noted that, due to severe adverse weather conditions, only four days of data was obtained during the long-term monitoring of the site. However, the data indicates limited spread of results across the days captured. Furthermore, as discussed further in Section 4.1, the operational noise criteria is largely determined by the amenity targets and therefore the background noise levels are of lower importance for the project assessment.

Table 3: Long-term noise monitoring results, dB(A)

Location	Time period	Rating background noise levels, dBL$_{A90}$	Ambient dB L$_{Aeq}$ noise levels
L3 - 14 Jeanette Street	Day	42	57
	Evening	42	57
	Night	31	49

Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays

Evening: 18:00-22:00 Monday to Sunday & Public Holidays

Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

As required by the NPI, the external ambient noise levels presented are free-field noise levels.

3.3 Short-term noise monitoring

Short-term attended noise measurements were undertaken on the morning of 21 November 2018 at locations L1-L3. The background noise was dominated by distant traffic noise, with aircraft flyovers, birds/insect sounds and the sound of children playing determining the ambient level.

The measured noise levels are given in Table 4.

Table 4: Short-term noise monitoring results, dB(A)

Location	Time period	Background noise levels, dB L$_{A90}$	Ambient noise levels, dB L$_{Aeq}$	Comments
L1 – 150 Epping Road	14:55-15:10	47	49	Traffic noise, child crying, occasional aeroplane pass-by
L2 – 65 Magdala Road	16:31-16:46	53	56	Traffic noise, car pass-by, children playing sports, birds and insects
L3 – 14 Jeanette Street	17:09-17:25	46	50	Traffic noise, birds and insects, car pass-by

While long-term measurements were not obtained for locations L1 and L2, the measurements suggest that the measurement results for L3 may be considered conservative assumptions for locations L1 and L2. As outlined discussed in Section 4.1, the criteria are largely determined by the amenity criteria.

4 Operational noise assessment

4.1 Standard operations noise criteria

Operational noise emissions from the project have been assessed in accordance with the Noise Policy for Industry (NPI), which is primarily concerned with controlling intrusive noise impacts in the short-term for residences, and maintaining long-term noise level amenity for residences and other land uses.

The NPI sets out the procedure to determine the project noise trigger levels relevant to an industrial development. The project noise trigger level is a level that, if exceeded would indicate a potential noise impact on the community and so ‘trigger’ a management response.

4.1.1 Intrusive noise trigger level

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

- $L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5 dB

  (where $L_{Aeq,15minute}$ represent the equivalent continuous noise level of the source)

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

4.1.2 Recommended and project amenity noise level

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from **all** industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPI where feasible and reasonable. An extract from the policy is given below in Table 5.

Table 5: NPI Recommended Amenity Noise Levels (RANLs)

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

Receiver	Noise amenity area	Time of Day	Recommended amenity noise levels (RANLs) L_{Aeq}, dB(A)
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, gold course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dB(A) to recommended noise amenity area

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

1. The NPI defines day, evening and night time periods as:
    - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
    - Evening: the period from 6 pm to 10 pm.
    - Night: the remaining period.

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

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

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

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

The NPI also provides the following exceptions to the above method for deriving the project amenity noise level:

1. *In areas with high traffic noise levels.*
2. *In proposed developments in major industrial clusters.*
3. *Where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10 dB below existing industrial noise levels if it*

can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

4. *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 area surrounding the site can be categorised as Suburban under the NPI. According to Section 3.3, the ambient noise levels at the sensitive receivers is controlled by distant traffic and aircraft noise (observed during the attended measurements). The NPI sets the PANLs to $L_{Aeq(period(traffic))}$ minus 15 dB(A) in the case that the level of transport $L_{Aeq(period(traffic))}$ exceeds the RANL by 10 dB or more.

Table 6 summarises the RANLs and the PANLs applicable for the project.

Table 6: NPI RANLs and PANLs

Receiver	Indicative Noise Amenity Area	Time of day[1]	Recommended Amenity Noise Level (RANL) $L_{Aeq(period)}$	Existing Traffic $L_{Aeq(period)}$ [2]	Project Amenity Noise Level (PANL) $L_{Aeq(period)}$
L1 -14 Jeanette St	Suburban	Day	55	57	50
		Evening	45	57	40[2,3]
		Night	40	49	35

Notes

1. The NPI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. Traffic noise is the dominant source of noise at the receiver location:
   a. the existing traffic noise is 10 dB(A) or more above the ANL for the area; and
3. It is unlikely that traffic noise will reduce over time however, due to the limited data set (see Section 3.2) and the fact that the evening period is the only one that qualifies as having traffic as the “dominant source”, the PANL has not been adjusted.

4.1.3 Sleep disturbance

The NSW NPI recommends the following screening criteria for the assessment of potential sleep disturbance, for the period between 10 pm and 7 am:

- $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or;
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater

4.1.4 NPI Project noise trigger levels

It is noted, the following Project Noise Trigger Levels represent the point at which mitigation should be considered. They are not intended to be applied as a mandatory limit as a range of other factors are required to be taken into account for decisions under both environment protection and environmental planning.

Based on the background and ambient noise monitoring, Table 7 summarises the derived Project Noise Trigger Levels based on the NPI.

The NPI recommends that all assessment is based on the $L_{Aeq,15min}$ parameter, with the amenity levels being estimated as $L_{Aeq,15minute} = L_{Aeq,period}$ levels + 3 dB. This is assumed to take into account the likely variation in noise emission over time when compared to the worst case 15-minute period assessed against the intrusive trigger levels. However, where the noise sources being assessed are building services equipment that will primarily be running at a steady-state level, it is not considered appropriate to adjust the $L_{Aeq,period}$ assessment criteria and therefore, the correction factor has not been applied when establishing the Project Noise Trigger Levels in Table 7.

Table 7: NPI Project noise trigger levels for residential receivers

Receiver	Time Period	Project Noise Trigger Levels			
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	Project Amenity Noise Level (PANL) $L_{Aeq,period}$	Project Noise Trigger Level $L_{Aeq,15min}$	Sleep Disturbance $L_{Amax(night)}$
R1-R3	Day	47	50	47	N/A[2]
	Evening	47	40	40	N/A[2]
	Night	36	35	35	52

Notes

1. The NPI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. N/A Not Applicable

4.2 Noise predictions

4.2.1 Noise sources – unmitigated

The Project includes the primary noise sources outlined in Table 8. Where equipment has yet to be selected, the sound power levels and octave band spectra have been estimated based on expected equipment power ratings and past project experience. It is understood that the building envelope will be primarily of concrete construction, therefore it is reasonable that noise breakout from the internal data halls and other spaces can be readily controlled. Therefore, the focus of this assessment for the planning stage relates to external equipment.

Table 8: Project equipment, quantities and unmitigated sound power levels (per unit)

Equipment	Equipment number			Overall dB(A)	Octave Band Centre Frequency – Hz, dB							
	Total installed	Total installed externally	Duty[1]		63	125	250	500	1 k	2 k	4 k	8 k
Water-cooled chillers	30	30	24	78	71	61	70	73	76	70	63	56
Cooling Towers[2]	30	30	24	95	108	108	97	88	84	75	67	62
Transformers	107	29	28	71	74	76	71	71	65	60	55	48
Diesel generators (backup power only) 75 dB(A) @ 1 m spec	48	48	1[3]	98	111	107	92	89	91	92	84	80

Note

1. Modelled worst case scenario based on number of externally located concurrently operational equipment during worst case 15 minutes.
2. Based on 100% capacity.
3. Represents daytime generator testing, not emergency operations.

Refer to architectural layouts for proposed location of rooftop equipment.

4.3 Operating scenarios

Noise modelling has assumed all equipment operating at full capacity and therefore the night time period is the most critical time period. In practice, mechanical systems will vary in load dependant on internal and external temperatures, and therefore operation is expected to be typically lower than presented herein.

The project also includes a number of backup power diesel generators that will not normally be in operation. These are to operate in a power failure only and would otherwise only operate for testing purposes. Testing would involve only one generator operating at a time and would occur during the daytime period. A separate modelling scenario is presented which include all generators in operation.

4.4 Modelling methodology

Noise levels have been predicted at the nearest sensitive receivers based on the noise levels and quantities of external plant equipment.

The noise levels have been predicted based on both the standard and the noise-enhancing weather conditions as specified in Table D1 of the NPI using Concawe algorithms. Note that since the likelihood of emergency conditions occurring is very low, standard meteorological conditions have been assumed when assessing noise levels from emergency operations.

4.5 Predicted noise levels – unmitigated

Initial noise predictions presented in Table 9 are based on the unmitigated equipment noise levels outlined in Table 8. The daytime predictions are based on standard meteorological conditions, while evening and night-time predictions reflect noise-enhancing meteorological conditions. Night-time predictions assume cooling towers operate at a lower capacity being estimated as 90% (approximated -1.4 dB).

Where excessive low frequency noise has been identified in accordance with the modifying factor corrections in Tables C1 and C2 of the NPI, a 5 dB penalty has been added. Equipment noise levels are assumed not to exhibit tonal characteristics.

Table 9: Normal operations, predicted noise levels (unmitigated)

Receiver	**Period**	**Predicted level $L_{eq,15min}$**		**Corrected level $L_{Aeq,15min}$ dB(A)**	**Criteria $L_{Aeq,15min}$ dB(A)**	**Meets criteria?**
		dB(A)	**dB(C)**			
R1 – 150 Epping Road, Lane Cove West	Day[1]	50	71	55	47	No (+ 8 dB)
	Evening[2]	55	73	60	40	No (+ 20 dB)
	Night[2]	52	70	57	35	No (+22 dB)

Receiver	Period	Predicted level $L_{eq,15min}$		Corrected level $L_{Aeq,15min}$ dB(A)	Criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
		dB(A)	dB(C)			
C1 – 1A Sirius Road	When in use[3]	72	88	77	65	No (+12 dB)
P1 – Lane Cove Bushwalk	Day[1]	63	78	68	50	No (+18 dB)

Notes:

1 – Prediction based on standard meteorological conditions.

2 – Prediction based on noise-enhancing meteorological conditions.

3 – Meteorological conditions do not affect the noise level due to the proximity of the receivers relative to the subject site.

The predictions for unmitigated standard operations indicate a substantial exceedance of the criteria, primarily resulting from the cooling towers. Discussion regarding the noise mitigation strategies is presented in Section 4.6.

Noise predictions for emergency back-up generator testing is presented in Table 10. This is based on a single generator in operation, with testing occurring during the daytime only. While normal operating equipment would also be in operation at the same time, as exceedances are predicted in Table 9 above, normal operating plant have not been included in the predictions, so that the contribution from the generator can be readily evaluated.

Table 10: Emergency generator testing (single generator), predicted noise levels

Receiver	Predicted level $L_{eq,15min}$		Corrected level $L_{Aeq,15min}$ dB(A)	Criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
	dB(A)	dB(C)			
R1 – 150 Epping Road, Lane Cove West	38	57	43	47	YES
C1 – 1A Sirius Road	64	78	64	65	YES
P1 – Lane Cove Bushwalk	51	65	51	50	NO (+ 1dB)

For power failure operations, in which all generators could be in operation, assessment is presented in Table 11. Due to the low likelihood of occurrence, non-noise enhancing conditions have not been considered. Regarding criteria, the NPI does not strictly apply to emergency operations, and typically less stringent criteria are adopted, based on the low likelihood of operation under such conditions. This is further discussed in Section 4.8.

Table 11: Emergency operations (all generators), predicted noise levels – standard meteorological conditions

Receiver	Period	Predicted level $L_{eq,15min}$ dB(A)	Predicted level $L_{eq,15min}$ dB(C)	Corrected level $L_{Aeq,15min}$ dB(A)	Standard operations criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
R1 – 150 Epping Road, Lane Cove West	Day	55	74	60	47	Refer to discussion in section 4.8
	Evening				40	
	Night				35	
C1 – 1A Sirius Road	When in use[1]	81	95	81	65	Refer to discussion in section 4.8
P1 – Lane Cove Bushwalk	Day	68	82	68	50	Refer to discussion in section 4.8

Notes:

1 – Meteorological conditions do not affect the noise level due to the proximity of the receivers relative to the subject site.

4.6 Mitigation measures

Preliminary noise mitigation measures have been recommended and incorporated into the project. Further detailed acoustic design will be required to finalise mitigation specifications during the detailed design phase of the development. The following, therefore provides an outline of the measures expected to be required for the project.

It is expected that the cooling towers will be the most challenging to attenuate and may require re-specification of the cooling tower type (such as use of centrifugal type) to address the overall noise requirements. The water-cooled chillers and transformers are capable of being attenuated with enclosures. For this reason, the chillers and transformers have been attenuated to a degree that the noise from those sources effectively will not contribute to the overall noise level at the nearest receivers. The purpose of this is to reduce the attenuation requirements for the cooling towers as far as practicable.

In developing the acoustic attenuation measures for the project, it is recommended that a detailed analysis of meteorological effects be carried out to confirm if noise-enhancing conditions are necessarily required to be considered.

Table 12: Indicative noise mitigation measures

Item	Location	Attenuation Details
Water-cooled chillers	Enclosure	Enclosure achieving 15-20 dB noise level reduction (See Diagram 1).

Item	Location	Attenuation Details
Cooling towers	Intake/discharge/equipment reselection	A collective noise level reduction of 25-30 dB is required. This is likely to require a reselection of the cooling tower type and intake/discharge attenuators (See Diagram 2). Selection may need to considered lower operation fan speeds for night-time operations. Cooling towers may also require an acoustically designed enclosure if plant selection alone cannot achieve compliance.
Diesel generators (backup power only)	Inlet/Discharge	Gensets recommended to be specified with a maximum emission of 72 dB(A) at 1m.[1] Discussed further below. (See indicative Diagram 3).
	Exhaust	
	Enclosure	
Transformers	Enclosure	Enclosure achieving 10-15 dB noise level reduction

Note

1. Based on achieving compliance during day-time hours for emergency generator testing (i.e. single generator operating).

At this preliminary stage of design, detailed descriptions of proposed mitigation measures are not possible, however indicative attenuation measures for each plant item are shown in the below diagrams.

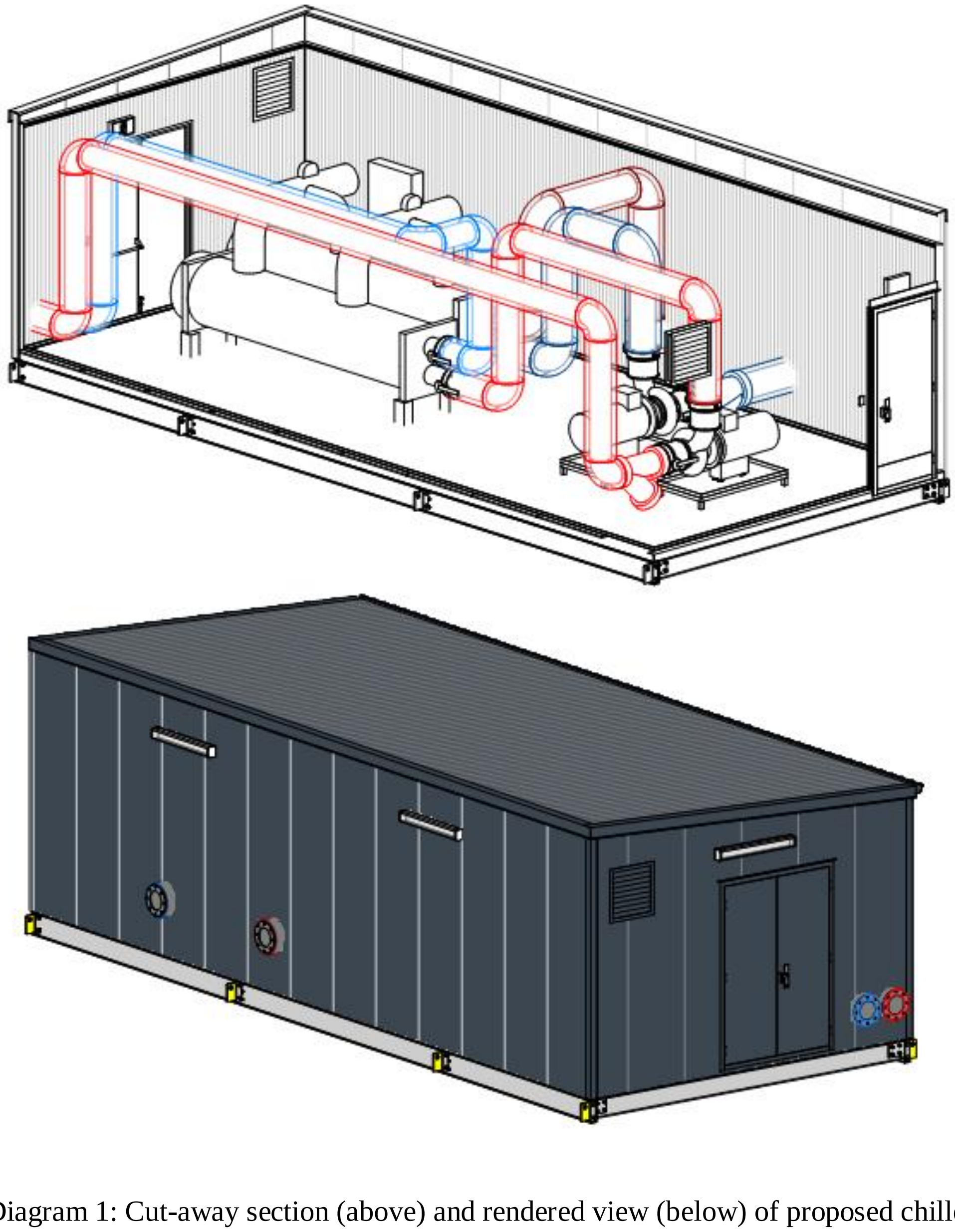


Diagram 1: Cut-away section (above) and rendered view (below) of proposed chiller enclosure.

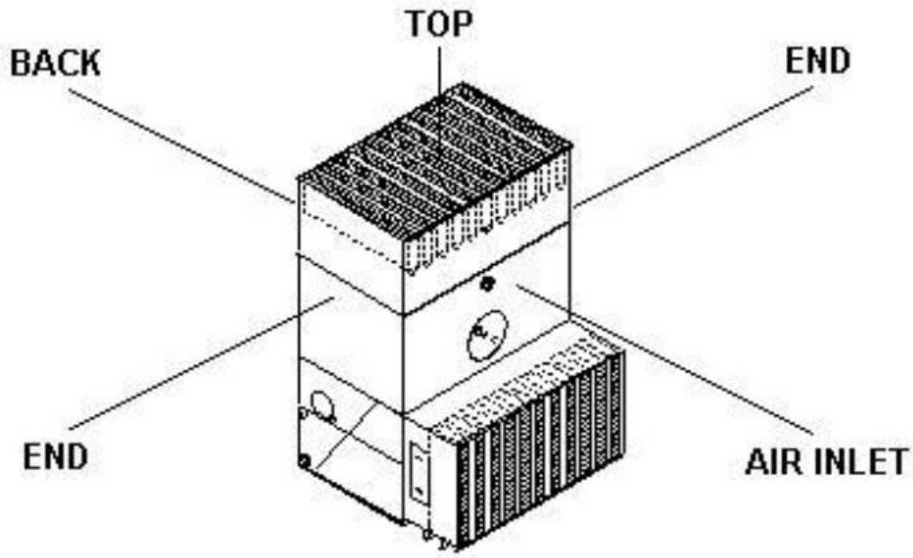
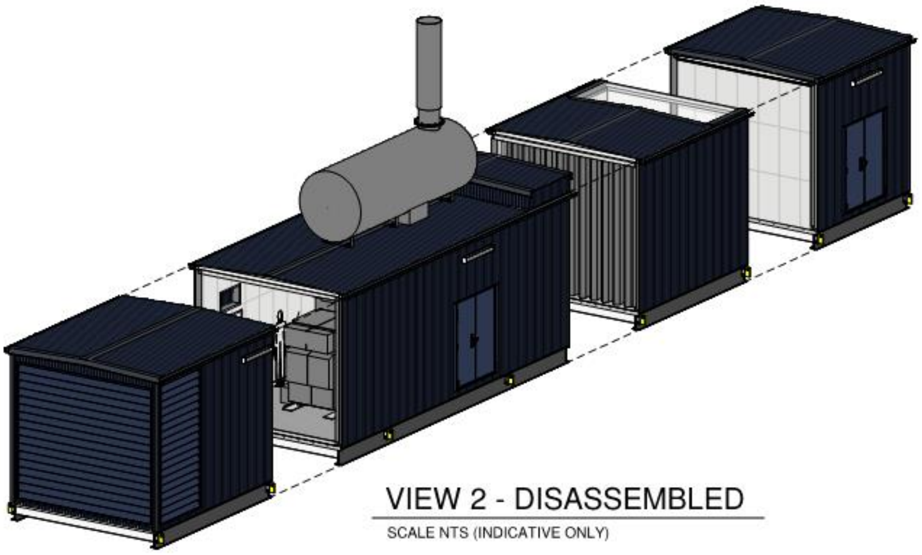


Diagram 2: Cooling tower with attenuators installed



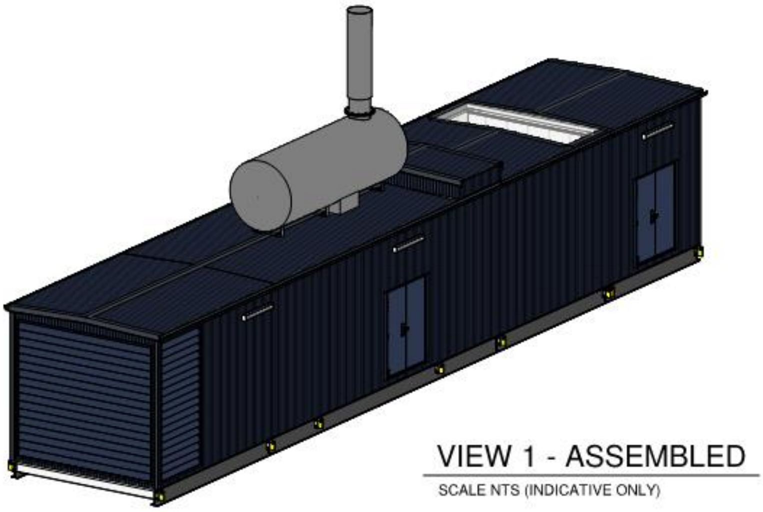


Diagram 3: Indicative generator enclosure (source: Cummings Power Generation)

4.6.1 Noise sources – mitigated

Table 13 presents the assumed mitigated sound power levels and octave band spectra based on the indicative noise mitigation measures outlined in Table 12.

Table 13: Project equipment, quantities and mitigated sound power levels (per unit)

Equipment	No. of plant (Duty)[1]	Overall dB(A)	Octave Band Centre Frequency – Hz, dB							
			63	125	250	500	1 k	2 k	4 k	8 k
Water-cooled chillers[2]	24	59	61	51	55	55	56	50	43	36
Cooling Towers – 100% capacity[3]	24	79	95	87	78	76	71	70	67	63
Cooling Towers – 66% capacity[3]	24	73	89	81	72	70	65	65	62	59
Cooling Towers – 50% capacity[3]	24	72	87	80	71	69	64	64	61	57
Transformers[2]	28	61	64	66	61	61	55	50	45	38
Diesel generators (backup power only) 72 dB(A) @ 1 m spec	1[4]	95	108	104	89	86	88	89	81	77

Note

1. Modelled worst case scenario based on number of concurrently operational equipment during worst case 15 minutes
2. Sound power levels adjusted by nominal reduction to account for acoustic enclosure.
3. BAC, Model VXT 800, Fan Motor 2 × 45 kW, with intake and discharge attenuators. Cooling towers have been modelled to operate at 100% fan speed during day, 66% fan speed in the evening and 50% fan speed at night.
4. Represents daytime generator testing, not emergency operations.

4.7 Predicted noise levels – mitigated

Table 14 presents revised predicted noise levels incorporating the preliminary mitigation measures and related sound power levels summarised in Table 12 and Table 13 respectively. It is noted, the modelling methodology, weather conditions and calculation assumptions outlined in Section 4.4 and 4.5 remain unchanged.

Table 14: Normal operations, predicted noise levels (mitigated)

Receiver	Period	Predicted level $L_{eq,15min}$		Corrected level[1] $L_{Aeq,15min}$ dB(A)	Criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
		dB(A)	dB(C)			
R1 – 150 Epping Road, Lane Cove West	Day[2]	33	54	38	47	YES
	Evening[3]	31	51	36	40	YES
	Night[3]	30	49	35	35	YES
C1 – 1A Sirius Road	When in use[4]	56	71	61	65	YES

Receiver	Period	Predicted level $L_{eq,15min}$		Corrected level[1] $L_{Aeq,15min}$ dB(A)	Criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
		dB(A)	dB(C)			
P1 – Lane Cove Bushwalk	Day[2]	46	62	48	50	YES

Notes:

1. In accordance with Table C1 of the NPI.
2. Prediction based on standard meteorological conditions.
3. Prediction based on noise-enhancing meteorological conditions.
4. Meteorological conditions do not affect the noise level due to the proximity of the receivers relative to the subject site.

Revised noise predictions for emergency back-up generator testing are presented in Table 15. As previously outlined, the below noise predictions are based on a single generator in operation, during daytime hours.

Normal operating plant have not been included in the below predictions, so that the contribution from the generator can be readily evaluated.

Table 15: Emergency generator testing (single generator), predicted noise levels

Receiver	Predicted level $L_{eq,15min}$		Corrected level $L_{Aeq,15min}$ dB(A)	Criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
	dB(A)	dB(C)			
R1 – 150 Epping Road, Lane Cove West	35	54	40	47	YES
C1 – 1A Sirius Road	61	75	61	65	YES
P1 – Lane Cove Bushwalk	48	62	48	50	YES

For power failure operations, in which all generators could be in operation, revised noise predictions are presented in Table 16. Due to the low likelihood of occurrence, non-noise enhancing conditions have not been considered. Regarding criteria, the NPI does not strictly apply to emergency operations, and typically less stringent criteria are adopted, based on the low likelihood of operation under such conditions.

Table 16: Emergency operations (all generators), predicted noise levels – standard meteorological conditions

Receiver	Period	Predicted level $L_{eq,15min}$		Corrected level $L_{Aeq,15min}$ dB(A)	Standard operations criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
		dB(A)	dB(C)			
R1 – 150 Epping Road, Lane Cove West	Day	52	71	57	47	Refer to discussion in section 4.8
	Evening				40	
	Night				35	

Receiver	Period	Predicted level $L_{eq,15min}$		Corrected level $L_{Aeq,15min}$ dB(A)	Standard operations criteria $L_{Aeq,15min}$ dB(A)	Meets criteria?
		dB(A)	dB(C)			
C1 – 1A Sirius Road	When in use[1]	78	92	78	65	Refer to discussion in section 4.8
P1 – Lane Cove Bushwalk	Day	65	79	65	50	Refer to discussion in section 4.8

Notes:

1 – Meteorological conditions do not affect the noise level due to the proximity of the receivers relative to the subject site.

4.8 Generator noise targets

The assessment presented in Table 16 is based on the mitigated noise specification for backup generators in Table 12. While the use of a single generator complies with the daytime criteria, operation of all 51 generators is predicted to exceed the day, evening and night time criteria.

However, it is noted that the project specific targets are particularly low and NPI targets are typically not adopted for such atypical operations. Furthermore, the likelihood of power failure is low, and if it was to occur, the duration of an outage would be expected to be hours rather than days.

5 Construction noise and vibration

5.1 Construction noise criteria

The NSW *Interim Construction Noise Guideline* [2] (ICNG or Guideline) provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction noise management levels above which all feasible and reasonable work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG provides two methods for assessing construction noise, varying typically on the basis of the project duration, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement of background noise levels for determination of noise management levels and prediction of construction noise levels. 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.

This development is expected to warrant a quantitative assessment.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These noise management levels (NMLs) for residential receivers and other sensitive receivers are reproduced in Table 17 and in Table 18 respectively.

Table 17: Construction noise management levels (NMLs) at residential receivers

Time of day	NML [1] $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ 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.
	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

Time of day	NML [1] $L_{Aeq\ (15\ min)}$	How to apply
		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.*

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

Table 18: Construction noise management levels (NMLs) at other noise sensitive land uses

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

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

5.1.1 Project construction noise targets

Construction noise criteria are set based the residential receiver areas identified in Section 2. Measured noise data obtained at the logger location most representative of each noise catchment area has been used to derive appropriate noise management levels for the project. These are summarised in Table 19.

Table 19: Construction Noise Management Criteria for Residential Premises

Time Period	**NML Description**	**NML Criteria $L_{Aeq\ (15\ min)}$**
During recommended standard hours	Noise affected	50
	Highly noise affected	75
Outside recommended standard hours	Noise affected	35

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

5.2 Construction vibration criteria

5.2.1 Disturbance to buildings occupants

Concerns regarding impacts on human occupants to buildings would generally be assessed in accordance with the 'intermittent' vibration criteria outlined in the DEC Guideline [3], however reference would typically be made to the Maximum levels. However due to the intermittent and low intensity works proposed, focus for management purposes is on structural damage, as outlined below.

5.2.2 Structural damage

5.2.2.1 Definition

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 [4] and/or German Standard DIN4150-3 [5]. British Standard 7385 Part 1: 1990, defines different levels of structural damage as:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*

- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

Table 1 of British Standard 7385 Part 2 (1993) sets limits for the protection against cosmetic damage, however the following guidance on 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', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures.

5.2.2.2 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 20 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 [4, p. 5] notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 20: BS 7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

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

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

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

5.2.2.3 German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure*' [5] are generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings. For the subject site, surrounding buildings are not deemed structurally sensitive and therefore the British Standard is considered appropriate for vibration management.

5.2.3 Buried services

It is not expected that the proposed works will impact upon buried services, however the following is nonetheless provided for guidance.

DIN 4150-2:1999 sets out guideline values for vibration effects on buried pipework and reproduced in Table 21 below.

Table 21: Guideline values for short-term vibration impacts on buried pipework

	Pipe material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note: For gas and water supply pipes within 2m of buildings, the levels given in DIN4150-3 [5] should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's *Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties* (report T/SP/SSW/22, UK National Grid, Rev

10/06, October 2006). This specification states that no piling is allowed within 15 meters of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/sec the ground vibration is required to be monitored.

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

5.3 Construction noise and vibration management

Appropriate detail on the construction methodologies required for quantitative assessment of the project are not yet known. However, given the distance from the site to the nearest sensitive receiver locations, it is expected that activities would comply with the Highly Affected Noise Targets, however may result in exceedance of the Noise Affected Levels. Accordingly, application of all reasonable and feasible mitigation measures should be adopted for the project. The following discusses in-principle management measures.

5.3.1 Construction noise and vibration management plan

For all construction works, the contractor would be expected to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan should include but not be limited to the following:

- Roles and responsibilities
- Noise sensitive receiver locations
- Areas of potential impact
- Mitigation strategy
- Monitoring methodology
- Community engagement strategy.

General guidance on the control of construction noise and vibration impacts relevant to this study are discussed in the following sections.

5.3.2 General

In general, practices to reduce construction noise impacts will be required, and may include;

- Adherence to the standard approved working hours as outlined in the Project Approval.
- Manage noise from construction work that might be undertaken outside the recommended standard hours

- The location of stationary plant (concrete pumps, air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using site sheds and other temporary structures or screens to limit noise exposure where possible.
- The appropriate choice of low-noise construction equipment and/or methods
- Modifications to construction equipment or the construction methodology or programme. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity, or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.
- Carry out consultation with the community and surrounding building owners/occupants during construction including, but not limited to; advance notification of planned activities and expected disruption/effects, construction noise complaints handling procedures.

5.3.3 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use.

5.3.4 Vibration – minimum working distances

Recommended minimum working distances for vibration intensive plant, which are based on international standards and guidance and reproduced in Table 22 below for reference. With regard to the proposed development works, vibration is not expected to impact upon surrounding development.

Table 22: Recommended minimum working distances for vibration intensive plant

Plant Item	**Rating / Description**	**Minimum working distance**	
		Cosmetic damage (BS 7385)	**Human response (OH&E Vibration Guideline)**
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m

Plant Item	**Rating / Description**	**Minimum working distance**	
		Cosmetic damage (BS 7385)	**Human response (OH&E Vibration Guideline)**
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg **-** 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

6 Conclusion

An acoustic assessment has been carried out for the proposed data centre in accordance with the requirements of the Department of Planning and Environment, which has included consideration of the operational and construction phases of the development.

The operational noise assessment established project noise goals and carried out noise predictions in accordance with the NSW *Noise Policy for Industry* [1], including consideration of noise-enhancing meteorological conditions.

Noise mitigation measures are required to both the generators and other primary equipment, including cooling towers, water-cooled chillers and transformers. Detailed acoustic design will be required during the design development phase to confirm the detailed specification of equipment and mitigation measures.

Regarding construction, while specific activities and work schedules are not yet known, criteria has been established in accordance with the NSW ICNG [2] and *Assessing Vibration: a technical guideline* [3]. Recommendations with regard to mitigation and management measures are also outlined, and are expected to be developed further in a formal Construction Noise and Vibration Management Plan, to be prepared prior to commencement of works.

References

[1] NSW EPA, “NSW Noise Policy for Industry,” EPA, Sydney, 2017.

[2] Department of Environment and Climate Change NSW, “Interim Construction Noise Guideline,” Department of Environment and Climate Change NSW, Sydney, 2009.

[3] Department of Environment and Conservation (NSW), “Assessing Vibration: A technical guideline,” Department of Environment and Conservation (NSW), Sydney, 2006.

[4] Bristish Standard Institution, “BS 7385-2: 1993 Evaluation and measurement for vibration in buildings - Pt 2: Guide to damage levels from groundborne vibration,” Bristish Standard Institution, London, 1993.

[5] Deutsches Institut fur Normung, “DIN 4150-3 (1999) Structural vibration - Effects of vibration on structures,” Deutsches Institut fur Normung, Berlin, 1999.

Appendix A

Glossary

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / $minL_{A90,1hour}$)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and $minL_{A90,1hour}$ in QLD.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting (“A-weighting”) to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the “average maximum” level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

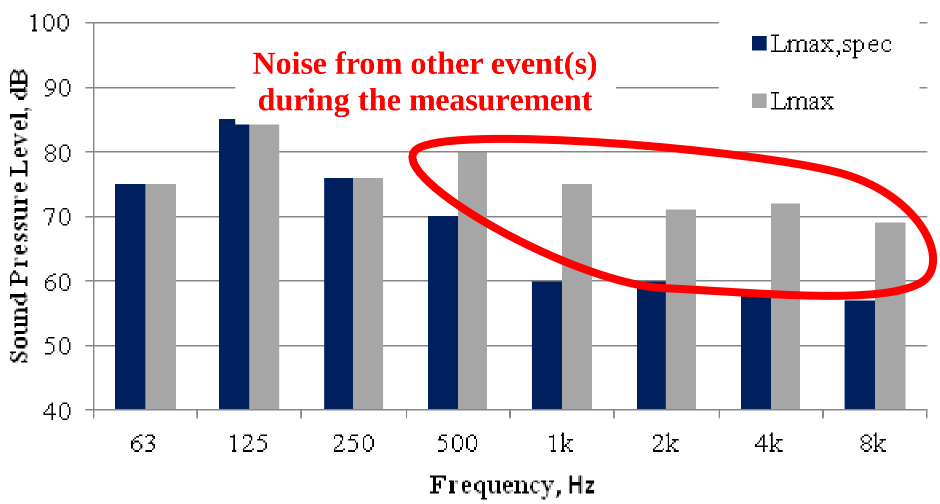
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

$L_{max\ spec}$

$L_{max\ spec}$ is another representation of the highest noise or vibration levels during the measurement period.

$L_{max\ spec}$ is the spectrum of the event that caused the highest overall sound or vibration level during the measurement period is denoted by dB $L_{max\ spec}$. An example of the relationship between dB L_{max} and dB $L_{max\ spec}$ is shown below.



L_{max} (see definition above), when measured on an octave band or 1/3 octave band meter, is the spectrum obtained by recording the highest measured value in each band. However, the highest measured values in each band may occur at different times.

Hence, $L_{max\ spec}$ represents a real event, while L_{max} is often the mathematical addition of frequency band values from different times and often does not represent a real-world event.

Since $L_{max\ spec}$ is caused by an instantaneous event, $L_{max\ spec}$ levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as “pitch”. Sounds towards the lower end of the human hearing frequency range are perceived as “bass” or “low-pitched” and sounds with a higher frequency are perceived as “treble” or “high pitched”.

Peak Particle Velocity (PPV)

Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean* *squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement.

PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Sound Exposure Level (SEL)

The Sound Exposure Level or Single Event Noise Exposure Level, denoted SEL or L_{AE}, is a measure of the total amount of acoustic energy contained in an acoustic event. The SEL is the constant sound pressure level that would produce in a period of one second the same amount of acoustic energy contained in the acoustic event. SEL is commonly used to quantify the total acoustic energy contained in transient events such as a vehicle pass-by.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, R_w, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

Speech Transmission Index (STI)

STI is a technical index, predictable and measurable using specialised equipment, for assessing speech and vocal intelligibility. STI takes into account the signal/noise ratio of the speech signal and the reverberation of the receiving environment. The higher the value of STI, the higher the expected speech intelligibility.

STI ratings are assigned subjective categories, as follows:

STI Range	Subjective Category
< 0.3	Bad
0.3 – 0.45	Poor
0.45 – 0.6	Fair
0.6 – 0.75	Good
0.8 – 1.0	Excellent

Spectrum Adaptation Terms (C and C_{tr})

The terms C and C_{tr} are spectrum adaptation terms (in dB) that are added to the R_w or D_w value of a partition in order to determine the overall sound insulation rating of a partition for various conditions. The overall performance of the partition is quoted as the sum of the Rw value and the spectrum adaptation terms, e.g. D_w + C 55 dB; R_w + C_{tr} 60 dB.

C is a spectrum adaptation term used to measure the performance of a partition for medium to high-frequency noise sources, such as speech.

C_{tr} is a spectrum adaptation term used to measure the performance of a partition for low-frequency noise sources such as traffic noise.

The values of C and C_{tr} are dependent on the construction of the partition. Because C and C_{tr} are (usually) negative quantities, they typically increase the Rw requirement of a partition (eg if C_{tr} is -6 dB, an R_w of 56 dB is required to achieve a rating of R_w + C_{tr} 50 dB).

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

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

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

Appendix B

Long-term monitoring

B1 Noise monitoring equipment

Unattended monitoring was carried out using the following equipment:

Measurement location	Equipment/model	Serial No.	SLM Type
L3 – 14 Jeanette St, East Ryde	ARL Ngara	878060	Class 1

Notes:

All meters comply with AS IEC 61672.1 2013 "Electroacoustics - Sound Level Meters" and designated either Class 1 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 4231 calibrator. No significant drift in calibration was observed.

B2 Extraneous/weather affected data

Measurement samples affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the procedures outlined in Fact Sheet A of the NSW Noise Policy for Industry [1] (INP).

Data provided by the Bureau of Meteorology (BOM), for the nearest representative weather station to noise monitoring location(s). Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

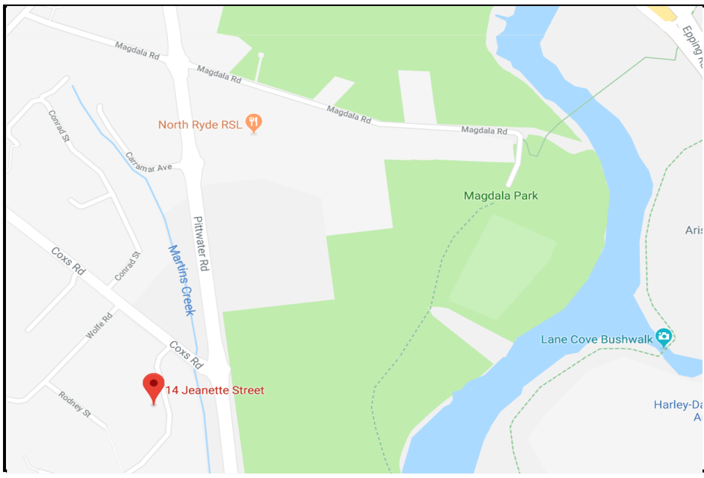
B3 Logger graphs

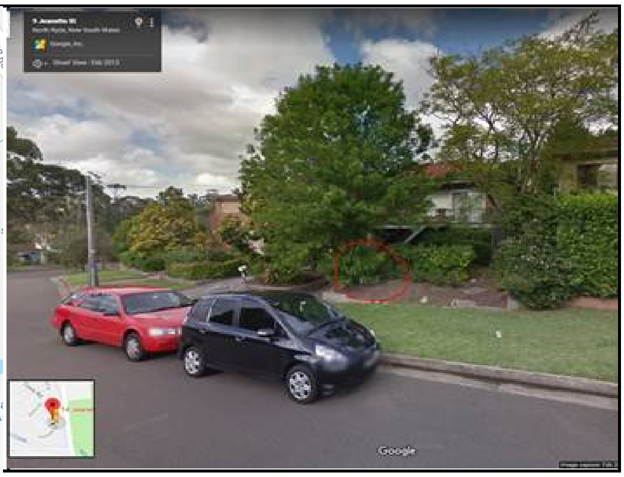
The following noise level vs time graphs present overall dB(A) levels recorded by the unattended logger(s) for a range of noise descriptors, including L_{Aeq}, L_{A90}, L_{A10} and L_{Amax}, While line graphs are presented, sampling is typically at 15 minute intervals.

Wind speeds are also show where relevant, and periods of excluded data are shaded grey.

L3 - 14 Jeanette St, East Ryde (Free Field)

Additional detail:





Background and ambient noise monitoring results - NSW 'Noise Policy for Industry', 2017

Date	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Wednesday-21-November-2018						
Thursday-22-November-2018						
Friday-23-November-2018			32			45
Saturday-24-November-2018	41	41	32	57	57	48
Sunday-25-November-2018	40	43	28	57	57	52
Monday-26-November-2018	45	42	31	58	58	48
Tuesday-27-November-2018	43			52		
Representative Week[5]	**42**	**42**	**31**	**57**	**57**	**49**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Unattended monitoring: L3 - 14 Jeanette St, East Ryde (Free Field)

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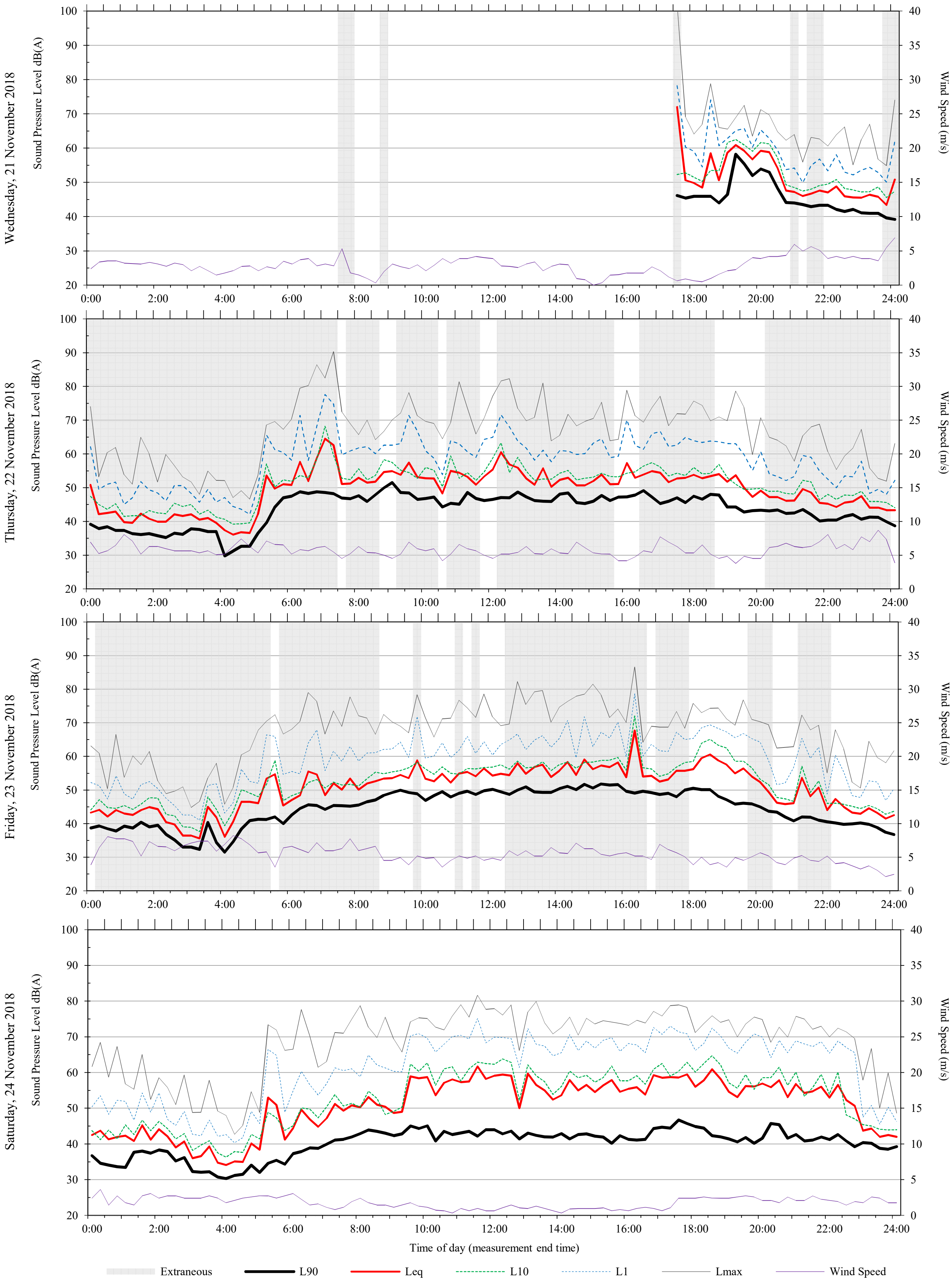

Unattended monitoring: L3 - 14 Jeanette St, East Ryde (Free Field)

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